

APPROVAL PAGE



**DEVELOPMENT OF AN AUXILIARY MACHINING MODULE FOR THE  
MACHINE TOOLS INDUSTRY**

**M.ENG. PROJECT**

**BY**

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**DECEMBER, 2010**

## CERTIFICATION

This work has not been presented elsewhere for the award of a degree or any other purpose.

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## DEDICATION

For mankind's sustainable benefit; in responsible productive industry and in diligent scholarship.



## ABSTRACT

Manufacturing competition has acted as a catalyst for the application of new technologies in industries. Successfully competitive manufacturing companies must be able to adapt quickly to changing conditions in the market, the environment and competitors' strategies within a shorter lead-time at a low cost. It is a logical deduction that due to the Manufacturing Industry's dependence on the Machine Tools Industry, an improvement in the machine tool sector would have either an immediate or a subsequent advantageous effect upon it. This project has developed a system, which will contribute to an improvement in workshop operations, by the provision of easily accessible and applicable machining operations data. Thus enabling and improving job accuracy and conformity to industrial standards. The design of the database for the prototype system is based on a relational frame with Microsoft Access Application package and Microsoft Structured Query Language Server; serving as the back end of the module. A user interface designed on the dot.net framework 3.5 and requiring the windows installer 3.1 running on windows XP operating system serves as the software front end. Performance Testing and implementation of the developed module, was done by carrying out query commands simulating real life and time applications. Integrity of results was checked by detailed comparison of results from the developed module, with standard values and confirming for strict adherence. A Paired t-Test was carried out to compare the results of manually calculated machine depreciation, with results generated by utilizing Software. Results from the developed module were accurate; module user-friendliness was achieved through the simplistic method employed for the module-user interaction. Module utilization enabled elimination of rule-of-thumb, aided efficient machining operations; through its provision of standard data. The developed database provides a beginning for development of machining operations expert system.



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## INTRODUCTION

## 1.1 General Introduction

The wealth of a nation depends on its ability to retrieve natural resources and manufacture goods Chang and Wysk (1991). It can be deduced from Chan, *et. al.*,(2000), that creation of goods, efficiency of the distribution system and service system are essential components of economic growth. A case in note, is the machine tool sector of Taiwan, ranking fifth worldwide with respect to manufacturing and engineering export. With more than 1400 companies (26,000 employees), the Taiwanese government prioritized this sector as one of the ten major industries for intense development. (Perng, *et. al.*, 2003). Important merits to the to the use of computer technology in industrial production engineering manufacture include; increased output requirements, with reduced workforce and still maintaining high-required quality, possibility of swifter response, in quality, quantity and type to customers' demands, the minimization of stock level inventory and work in progress, possibility of standardization of the relevant software packages in use thus achieving the transferability of information from engineering applications to commercial applications and vice versa, unhindered flow of production and management information throughout the entire organization to all levels, enabling effective communication link in interfacing all engineering hardware and software (Adejuyigbe, 2007).

Perng, *et. al.*, (2003), states that the machine tool sector faces extreme pressure from global competition and information technology change. The major pressure arising, from the need for broad delivery of relevant information to components of the business process, with rapid time-to market and low cost of ownership. Adejuyigbe, (2007) thus proffers the solution that automated manufacturing could provide a more effective engineering tool and environment for the manufacturing sector.

In production systems three factors considered in manufacturing planning and projection are; cost, time and quality. These factors also provide a structure for the profitability of the system in question. Accuracy and ease of access to and effective use of required data are important for efficient performance of machine tool workshop operations. The availability of such data, are strategic to the important production concerns of swift and efficient performance, of machining operations and subsequently, the overall costs of

manufacturing. Industrial products are appreciated by their quality, their price, their delivery periods and their availability. (Hamou, *et. al.*, 2006). Recent trends, have shown, that favouring the more consistent and faster tools of Computer-aided Design/ Drafting/ Manufacturing, Computerized Business Systems and the implementation of Computer Integrated Manufacturing, in the overall engineering process, enable and enhance overall optimal management of industrial engineering production procedures (Adejuyigbe, 2002). Adejuyigbe, (2007), also states amongst the major roles of manufacturing engineers; a good knowledge of more effective, new tools and concepts employed in the manufacturing sector. Computer technology, in the form of the application of Computer Aided Manufacturing and Computer Integrated Manufacturing (a generic term referring to the engineering functions performed by computer aided design and manufacturing and computer aided business functions in the manufacturing environment), as an approach to engineering production; is a main example of one of such new concepts.

This research, follows the approach of computer-integrated manufacture, in an attempt to develop a sustainable decision support system for machine operations.

Relevant knowledge was acquired, through oral interviews with experts on the subject matter, relevant literature, and relevant accessible information databases. The compilation of an updatable database; which supplies a major portion of the system's knowledge base, and 'powers' its intelligence, forms a core requirement for the development of the auxiliary machining operations module. Auxiliary in this context meaning supporting and aiding accurate machining

## **1.2 RELEVANCE OF THE PROJECT**

This study will:

- (a) provide a database of industrial cutting data for application in automated and non-automated machining operations;
- (b) enhance efficient machining operations through the established decision support tool.

## **1.3 BACKGROUND OF STUDY**

Chernov (1975), states that the availability of various machine tools, even the most up to date in sufficient quantities, does not itself ensure efficient and highly productive operation of an industrial enterprise, without appropriate organization and proper use of equipment and machinery (in this case machine tools). The proper use of machine tools has been seen to

yield results of enhanced job accuracy and optimum production output over the machinery service period. These tested and tried procedures are; appropriate packaging, transportation, shop installation, servicing, repair and modernization. Others include; correct selection of cutting tools, speeds, feeds and proper setting up and adjustment of the machine tool.

The very paradigm of work planning has changed from being plan-driven to interrupt-driven. Swift and intelligent response must be given to queries and on-the-spot-request for actions. This unplanned shift of priorities can derail the progress of the primary job (Zeldes, 2009). According to Ayag and Ozdemir, (2006), the improper selection of a machine tool parameters, results in problems affecting negatively on productivity, precision, flexibility and company's responsive manufacturing capabilities.

A provision of a readily available system aiding intelligent decision making is thus important. Work has been done and is ongoing on databases; for selection of machines in workshop operations, selection of machine tools purchases, database for machine tools after-sales services, and database for scheduling and manpower planning in the workshop. This work attempts to contribute to the development of an indigenous decision support tool for accurate machine tool operations.

#### **1.4 JUSTIFICATION**

The case for manufacturing efficiency has never been more important than it is today. Due to the Manufacturing Industry's dependence on the Machine Tools Industry, it can be deduced, that improvement in the machine tool sector would have an advantageous effect on it.

Manufacturers are faced with globalization, increased competition and other socio-economic pressures and must continuously look to increase asset utilization and reduce material costs, while at the same time address customers who are demanding faster delivery, better customer service and customized products (MOTOROLA, 2007) . The development of many technologies benign to the environment is intimately associated with the sustainable manipulation suitable materials. Advancement in the understanding of a material results in technological progress (Callister, 2007). It stands to reason then, that the proper combination of specific job materials with corresponding tool materials, enhances the production process. Accuracy and ease of access to required data are important for efficient performance machine

tool workshop operations. The availability of such data, advantageously influences the important production concerns of swift and efficient performance, of machining operations and subsequently, the overall costs of manufacturing.

The results of this work, would serve in aiding the reduction of maintenance by efficient application of machine tools. This is in agreement with Bunks *et al.*,(2000); and further prolonging machine life and diminishing the defects that could be introduced by the maintenance procedures. Also, reduction of the possibility of catastrophic failures which lead to the loss of life and equipment would have an important effect on insurance premiums.

## 1.5 OBJECTIVES OF THE STUDY

The aim of this study, is to develop an auxiliary machining module.

The specific objectives are to:

- (a) develop a database for aiding decision making in machining processes;
- (b) develop a decision support tool for both automated and non-automated machining operations;
- (c) test and implement the system developed in (i) and (ii) using available machine tools data.

## 1.6 METHODOLOGY

The development of the machining processes database was carried out by gathering the machining operation data to be set in the module. A knowledge engineering process of, collecting (through oral interviews with experts in machining (cutting) operations, visits to some University libraries, academic and industrial machine workshops and study of relevant literature), collating and compiling the machining operations data meeting industrial standards and analysis of the data retrieved. The machining data was word processed into detailed tables; these were linked to Microsoft Access 2007 files. The information contained in the files was embedded in a Microsoft Structured Query Language Database, driven by Microsoft Structured Query Language Server 2005. The tables represent information location for data required to aid conventional and non-conventional cutting operations in the workshop. Within the tables were included key indicators for machining operations such as; primary, secondary and tertiary cutting feed, depth and speed requirements, power required for turning and milling, cutting tool angles and geometry and cutting fluid requirements. These parameters were set in the database with respect to various engineering materials such

as; high speed steels, cast alloy steels, stainless steels, magnesium alloys, copper alloys, aluminium, bronze, carbides and titanium alloys,

Data required for help and troubleshooting guides in material selection and various conventional machining operations such as turning, drilling, milling, boring, reaming, broaching, tapping, welding in addition to non-traditional machining operations such as; ultrasonic and electron beam machining, was also embedded in the database.

The machining calculation sub-module was developed to aid in the following; speed requirements in turning, power and force requirements in turning, grinding calculations, shaping calculations, power and force requirements in milling, spur gears, determination of auxiliary angles (rake angle and clearance angle), and non-traditional machining process calculations, machine depreciation and machining operations scheduling.

The user interface was developed using the C-sharp programming language 3.0 in Visual Studio 2008 and 2010 on the Dot-net platform. The design of the database, which served as the software pseudo-inference engine, ensured ease of information retrieval. This was achieved by ensuring the program code included a relational framework linking each specific table heading with the data accessible in each embedded table and providing a structure for the user queries in a dropdown menu format directly linked to the database table headings. The integrity of the results retrieved from the developed software for successfully aiding decision making in the machine shop were checked through implementing the software by simulating real life machining operations queries. Considerations in the software design included factors such as user friendliness, flexibility, software portability (ease of installation), and ease of upgrading the database.

The high ease of upgrading the software was achieved by embedding within it a sub-module which receives into each table in the database via a simple interface new and relevant machining operations information. Testing and implementation of the developed software was carried out Hewlett-Packard 32-bit operating system with an Intel Core Duo processor of 1.67GHz and random access memory (RAM) of 2G. The purpose of the developed auxiliary machining module is to serve as a decision support system for aiding machining operations.





## LITERATURE REVIEW

### 2.1 Machine Tools

The basic elements of modern metal removal process, consists of the machine operator (at various skill levels), a machine tool, a control system and the cutting tool (Adejuyigbe, 2007). The results of machine tool operations, is either the production of a geometrical surface by cutting away metal (through turning, shaping, milling, etc) or by manipulating the metal in either hot or cold conditions (Kareem, 2004). According to NeeKamp (2006), Machine Tools are stationary power-driven machines, employed in the shaping and forming solid materials, especially materials referred by the generic term engineering materials.

Machine tools could be grouped into three classes; namely conventional chip-making machine tools, presses, and unconventional machine tools. (Microsoft Encarta, 2007). Conventional chip-making tools operate on the given work piece by the removal of parent material in form of chips. Machine tools in the Presses class perform shaping operations namely; shearing jobs, pressing jobs, and drawing jobs. The Machine tools grouped as Unconventional machine tools make use of energy sources such as light, electrical, chemical, and sonic i.e. focused sound energy; superheated gases; and high-energy particle beams to work on special materials and alloys being developed to meet the challenges of more recent technology.

Alternatively, cutting machine tools are also classified as Single Point Cutting Tools, Double point Cutting Tools and Multiple Point Cutting Tools. Examples of machine tools include; the lathe machine, the shaping machine, the planer machine, and the milling machine. Others include, the drilling and boring machines, grinders, saws, and various metal-forming machines. (Adejuyigbe, 2007). Unconventional machine tools include plasma-arc, laser-beam, electro-discharge, electrochemical, ultrasonic, and electron-beam machines. These machine tools were developed primarily to shape the ultra-hard alloys used in heavy industry and in aerospace applications and to shape and etch the ultrathin materials used in such electronic devices as microprocessors.

IBEF (2006), classifies machine tools based on technology, and divides machine tools into, Computerized Numerically Controlled (CNC) and Conventional tools; and states that CNC machine tools are highly productive and cost effective, comprising about seventy per cent of machine tools. Of these, CNC turning centres, machining centres and grinding centres

are the biggest segments, accounting for about eight-one percent of the total in 2004. Machine tools form the basis of modern industry and are used either directly or indirectly in the manufacture of machine and tool parts.

## **2.2 Machining and Machine Tool Operations**

Machining as carried out during machine tool operations or processes, serves as one of the core process of manufacture. The purpose of Machine operations, are to generate a certain part geometry and surface texture. The precise meaning of the term "machining" has evolved over the past 1.5 centuries as technology has advanced. During the Machine Age, it referred to (what we today might call) the "traditional" machining processes, such as turning, boring, drilling, milling, broaching, sawing, shaping, planing, reaming, and tapping, or sometimes to grinding. Since the advent of new technologies such as electrical discharge machining, electrochemical machining, electron beam machining, photochemical machining, and ultrasonic machining, the retronym "conventional machining" can be used to differentiate the classic technologies from the newer ones. The term "machining" without qualification usually implies conventional machining. A common feature of machine tool operations is the use of a cutting tool to form a chip that is removed from the workpiece, called swarf. To perform the operation, relative motion is required between the tool and work. This relative motion is achieved in most machining operation by means of a primary motion, called "cutting speed" and a secondary motion called "feed". The shape of the tool and its penetration into the work surface, combined with these motions, produce the desired shape of the resulting work surface. The three principal machining processes are classified as turning, drilling and milling. Other operations falling into miscellaneous categories include shaping, planing, boring, broaching and sawing. An unfinished workpiece requiring machining will need to have some material cut away to create a finished product. A finished product would be a workpiece that meets the specifications set out for that workpiece by engineering drawings or blueprints. Machine operations are usually distinguished by purpose and cutting conditions; Roughing cuts, and Finishing cuts. Roughing cuts are used to remove large amount of material from the starting workpiece as rapidly as possible, in order to produce a shape close to the desired form, but leaving some material on the piece for a subsequent finishing operation. Finishing cuts are used to complete the part and achieve the final dimension, tolerances, and surface finish. In production machining jobs, one or more roughing cuts are usually performed on the work, followed by one or two finishing cuts. Roughing operations are done at high feeds and depths — feeds of .04-1.25 mm/rev (0.015-

0.050 in/rev) and depths of 2.5-20 mm (0.100-0.750 in) are typical. Finishing operations are carried out at low feeds and depths - feeds of 0.0125-0.04 mm/rev (0.0005-0.0015 in/rev) and depths of 0.75-2.0 mm (0.030-0.075 in) are typical. Cutting speeds are lower in roughing than in finishing. A cutting fluid is often applied to the machining operation to cool and lubricate the cutting tool. Determining whether a cutting fluid should be used, and, if so, choosing the proper cutting fluid, is usually included within the scope of cutting condition.

A cutting tool has one or more sharp cutting edges and is made of a material greater hardness than the work material. The cutting edge serves to separate chip from the parent work material. Connected to the cutting edge are the two surfaces of the tool; the rake face; and the flank.

The rake face which directs the flow of newly formed chip, is oriented at a certain angle is called the rake angle " $\alpha$ ". It is measured relative to the plane perpendicular to the work surface. The rake angle can be positive or negative. The flank of the tool provides a clearance between the tool and the newly formed work surface, thus protecting the surface from abrasion, which would degrade the finish. This angle between the work surface and the flank surface is called the relief angle. There are two basic types of cutting tools; Single point tool; and Multiple-cutting-edge tool

A single point tool has one cutting edge and is used for turning, boring and planing. During machining, the point of the tool penetrates below the original work surface of the workpiece. The point is sometimes rounded to a certain radius, called the nose radius. Multiple-cutting-edge tools have more than one cutting edge and usually achieve their motion relative to the workpiece by rotating. Drilling and milling uses rotating multiple-cutting-edge tools. Although the shapes of these tools are different from a single-point tool, many elements of tool geometry are similar.

Relative motion is required between the tool and work to perform a machining operation. The primary motion is accomplished at a certain cutting speed. In addition, the tool must be moved laterally across the work. This is a much slower motion, called the feed. The remaining dimension of the cut is the penetration of the cutting tool below the original work surface, called the depth of cut. Collectively, speed, feed, and depth of cut are called the cutting conditions. They form the three dimensions of the machining process, and for certain operations, their product can be used to obtain the material removal rate for the process.

As a commercial venture, machining is generally performed in a machine shop, which consists of one or more workrooms containing major machine tools. Although a machine shop can be a stand-alone operation, many businesses maintain internal machine shops which support specialized needs of the business. (Kareem, 2004, Adejuyigbe, 2007 and Wikipedia, 2010)

### 2.3 Traditional (Conventional) Machine Tool Operations

Conventional machining; one of the most important material removal methods, is a collection of material-working processes in which power-driven machine tools, such as lathes, milling machines, and drill presses are employed in the metal cutting process.

The term "machining" without qualification usually implies conventional machining. These include;

**Turning operations:** the rotation of workpiece as the primary method of moving metal against the cutting tool. In turning, a cutting tool with a single cutting edge is used to remove material from a rotating workpiece to generate a cylindrical shape. The speed motion in turning is provided by the rotating workpiece, and the feed motion is achieved by the cutting tool moving slowly in a direction parallel to the axis of rotation of the workpiece. Lathes are the principal machine tool used in turning.

**Milling operations:** the cutting tool rotates to bring cutting edges to bear against the workpiece. In milling, a rotating tool with multiple cutting edges is moved slowly relative to the material to generate a plane or straight surface. The direction of the feed motion is perpendicular to the tool's axis of rotation. The speed motion is provided by the rotating milling cutter. The two basic forms of milling include; Peripheral milling and Face milling. Milling machines are the principal machine tool used in milling.

**Drilling operations:** holes are produced or refined by bringing a rotating cutter with cutting edges at the lower extremity into contact with the workpiece. Drilling is used to create a round hole. It is accomplished by a rotating tool that is typically has two or four cutting edges. The tool is fed in a direction parallel to its axis of rotation into the workpiece to form the round hole. Drilling operations are done primarily in drill presses but sometimes on lathes or mills.

**Boring Operations:** In boring, the tool is used to enlarge an already available hole. It is a fine finishing operation used in the final stages of product manufacture.

Other conventional machining operations include, thread cutting, gear cutting, reaming, broaching, tapping, dyeing, shaping, planning and sawing. Also, grinding and similar abrasive operations are often included within the category of machining

**Miscellaneous operations:** are operations that strictly speaking may not be machining operations in that they may not be swarf producing operations but these operations are performed at a typical machine tool. These include; Burnishing is an example of a miscellaneous operation. Burnishing produces no swarf but can be performed at a lathe, mill, or drill press.

## **2.4 Non-Traditional Machining Processes**

Recent developments in the aerospace and nuclear engineering industries are partly due to the increasing use of difficult-to-machine materials such as hastalloy, nitralloy, waspalloy, nimonics, carbides, stainless steels, heat-resisting steels, etc. These materials find application due to their high strength-to-weight ratio, hardness and heat-resisting qualities. From the standpoint of economical production (in addition to uneconomic time consumption, difficulty and impossibility-in some cases of machining to complex shapes) the conventional machining processes are inadequate to machine these materials.

Non-traditional machining techniques have emerged to overcome these difficulties. They are classified according to the nature of the energy employed in machining, namely; thermal and electrothermal, chemical and electrochemical, and mechanical.

### **2.4.1 Thermal and Electrothermal Methods of Non-Traditional Machining Processes**

The thermal energy is employed to melt and vaporize minute bits of work material by concentrating the heat energy on a small area of the workpiece. By a continued repetition of this process, the required shape is machined. These methods include; electrical discharge machining (EDM), laser beam machining (LBM), plasma arc machining (PAM), electron beam machining (EBM), and ion beam machining (IBM).

### **2.4.2 Chemical and Electrochemical Methods of Non-Traditional Machining Processes**

The chemical and electrochemical machining methods involve a controlled etching or anodic dissolution of the workpiece material in contact with a chemical solution. These processes include; chemical machining (milling and blanking), electrochemical machining (ECM), electrochemical grinding (ECG), electrochemical honing (ECH), and electrochemical deburring (ECD).

### 2.4.3 Mechanical Methods of Non-Traditional Machining Processes.

In the mechanical methods of non-traditional machining, the material is removed principally by mechanical erosion of the workpiece material. The methods include; ultrasonic machining (USM), abrasive jet machining (AJM), and water jet machining (WJM)

The suitability of any non-traditional machining process, for any specific application, should only be judged with respect to, increased reliability of the process, better quality assurance, and its ability to machine workpieces that cannot be easily worked by conventional machining methods (Bangalore, 1980).

It is of important note, that a new machining method is recommended, when it optimizes or provides a more efficient means to a previously available one. Merits of new machining methods could be seen via, effectiveness with respect to ease of use and compatibility with various engineering materials, availability of the technology (machinery and skill). Also via efficiency, with respect to the considerations of overall cost effect on production (time and acceptability in the market and). Table 2.1 provides a means for showing the merits of employing some non-traditional machining processes by showing the compatibility of various non-traditional machining processes with some engineering materials.

Table 2.1; Application of Non-Traditional Machining Methods With Various Work materials

Workpiece Material	Ultrasonic Machining (USM)	Abrasive Jet Machining (AJM)	Electrochemical Machining (ECM)	Chemical Machining (CHM)	Electrical Discharge Machining (EDM)	Electron Beam Machining (EBM)	Laser Beam Machining (LBM)	Plasma Arc Machining (PAM)
Aluminum	Poor	Fair	Fair	Good	Fair	Fair	Fair	Good
Steel	Fair	Fair	Good	Good	Good	Fair	Fair	Good
Super Alloys	Poor	Good	Good	Fair	Good	Fair	Fair	Good
Titanium	Fair	Fair	Fair	Fair	Good	Fair	Fair	Fair
Refractories	Good	Good	Fair	Poor	Good	Good	Poor	Poor
Ceramic	Good	Good	Not Applicable	Poor	Not Applicable	Good	Good	Not Applicable

Plastic	Fair	Fair	Not Applicable	Poor	Not Applicable	Fair	Fair	Fair
Glass	Good	Good	Not Applicable	Fair	Not Applicable	Fair	Fair	Not Applicable

Source; Bangalore, 1980

## 2.5 Optimizing Machine Tool Operations

According to Kareem, (2004), is important that metal cutting principles be well understood in order to achieve economical machine tool operations. In addition, cost of machining operations, and the technical intelligence in selection of cutting tools with respect to workpiece material, and the cutting operation parameters (type of machine tool, tool geometry, use of cutting fluids and the machinist's expertise) are critical factors in the eventual result and final costs. Adejuyigbe, (2007). Machining (Machine tool operations) require attention to detail for jobs to meet the specifications (correct dimensions and surface finishes) set out in the engineering drawings or blueprints. Studies confirm that the inferior finish found on the machined surface of a workpiece may be caused by incorrect clamping, a dull tool, or inappropriate presentation of a tool. Frequently, this poor surface finish, known as chatter, is evident by an undulating or irregular finish, and the appearance of waves on the machined surfaces of the workpiece.

In addition to the prove effective methods of condition-based maintenance (CBM) (to signify the monitoring of machines for the purpose of diagnostics and prognostics; to prevent equipment breakdown) Bunks, *et. al.*, (2000). Research is been done to show the usefulness of software in enabling the efficient use of equipment resource in machine tool operations. According to Childs, *et. al.*, (2000) selection of optimum cutting conditions, whether they be for singular or the combined considerations of minimum production times or minimum cutting costs, provide a framework for the optimization of machine tool operations Cakir and Gurarda (2000), state that the variables involved in the economics of machining operations include, required workpiece geometry, cutting conditions of velocity, feed rate, depth of cut. They developed a procedure to optimize machine tool operations. They recommended calculating the machining conditions for milling operations according to minimum production cost as the objective function. Optimum values of machining conditions for each tool pass were determined based on the objective function criteria by circular

direction search method which was specifically developed for their study. The effects of constraints on the objective function were evaluated by graphical representation of the objective function and the constraints in the developed software

An optimization analysis, strategy and CAM software for the selection of economic cutting conditions in single pass turning operations utilizing a deterministic approach were developed by Kuriyagawab, *et. al.*, (2002). The optimization was based on criteria typified by the maximum production rate and includes a host of practical constraints. It was shown that the deterministic optimization approach involving mathematical analyses of constrained economic trends and graphical representation on the feed-speed domain provided a viable strategy that not only provides both a unique global optimum solution, and a software that suitable for on-line CAM applications.

Quality has been defined as; being within specifications, zero defects, or customer satisfaction, the (minimum) loss imparted by the product to the society from the time product is shipped. This economic loss is associated with losses due to rework, waste of resources during manufacture, warranty costs, customer complaints and dissatisfaction, time and money spent by customers on failing products, and eventual loss of market share ( Dean and Unal, 1991). Dean and Unal, (1991) further states, that product and process design has a great impact on life cycle cost and quality and thus suggests the Taguchi principle which emphasizes pushing quality back to the design stage.

### **2.5.1 Optimizing Machine Tool Operations By Utilizing Databases**

Wong and Siua, (1995) developed an expert module (The module was part of a prototype expert process planning system for the machining of prismatic parts) for automatic process selection and sequencing. The process selection and sequencing algorithm comprised of three sub-algorithms, the transformation algorithm, the refinement algorithm and the linearization algorithm; the system was equipped with a sequence knowledge-base which records various types of information including the process capabilities, filling knowledge, surface priority, surface knowledge, refinement knowledge.

Chep, *et. al.*, (1998), designed an Object Oriented Database (OOD) to function in a generative Computer Aided Process Planning (CAPP) system. One of their objectives was to enable a database which allows the CAPP system to use manufacturing features to define machining operation sequences of 3D (3-dimensional) workpieces.

Xue, et, al., (1999) presented methods for modelling database for core processes of intelligent manufacturing. They addressed; modelling product life-cycle aspects using aspect primitives called features, generating product life-cycle aspects using a knowledge-based system, maintaining consistency of product life-cycle aspects using the relations among these aspects, and identifying the optimal design considering relevant product life-cycle aspects.

A machining database constructed based on polynomial networks able to learn the relationships between cutting parameters (cutting speed, feed rate, and depth of cut) and cutting performance (tool life, surface roughness, and cutting force) through a self-organizing adaptive modelling technique was developed by Liic and Leea,(2000).

Taking into consideration industries dealing with machine tools manufacture and the large data generated by the machine process, Ribeirrol and Coppinib,(2000) discovered, that the un-optimized use of the generated data was due to the lack of a system dedicated to storing and manipulating the said data. They developed a machining database system involving procedures to make comparative tests using different tools and optimize the attained results. With the objective of finding suitable cutting conditions for application at industrial scale. The selection of the conditions and cutting tools was based on the maximum production conditions achieved in the industrial plants.

Logothetis and Haigh, (2007), demonstrated the application of the Taguchi method in Process optimization The Taguchi technique was utilized employing suitable data-transformations, to accurately to characterize and successfully to optimize complicated multi-response processes. Although conditions, that simple statistical techniques to ensure valid, and definitive results were used. They also suggested a systematic procedure for establishing the optimal operating conditions.

## **2.6 Machine Tool Industry**

IBEF (2006) classifies the machine tool industry into metal-cutting and metal-forming tools, based on the type of information. As stated earlier, key metal cutting tools include turning centres, machining centres and grinding centres, which account for about two-thirds of the total metal-cutting produce. Metal forming is dominated by presses, which account for 51 per cent share. From studies carried by IBEF (2006), the global machine tools industry had a turnover of about US\$ 45.3 billion in 2004, a 23 per cent growth by value over the previous year. Japan is the leading machine tool manufacturer in the world with a production of over US\$ 10.5 billion in 2004, which forms nearly 23 per cent of the total world production. Germany, Italy and China are second, third and fourth respectively in the

machine tools industry. In terms of consumption, China is the leader, with US\$ 9.3 billion worth of consumption, accounting for over 20 per cent of machine tools consumed worldwide. India ranks nineteenth in production and sixteenth in consumption of machine tools in the world. The Indian machine tool industry averaged more than 35 per cent growth in 2004-05. Imports exceeded production in the year 2004 with US\$ 356 million worth machine tools being imported while the production was only US\$ 225 million. Machine Tools form 1 per cent of India's engineering industry and contribute 0.3 per cent of total machinery exports.

The tooling and machining industry is critical to national economic health as it makes possible the existence of virtually every other manufacturing industry (NeCamp, 2006).

## **2.7 The Nigerian Machine Tool Industry**

The revitalization of the industrial sector with the objective of promoting the development of other sectors and the entire economy has been a major consideration in the National Development Plans. Policy objectives include the achievement of maximum growth in investment and output, and expansion of employment. Other related policy measures include strengthening administrative machinery, implementation of the privatization and commercialization policy, local sourcing of material raw materials, and the promotion of small-scale industries (Dickson, 2007). The Nigeria Machine Tools Limited, Oshogbo was conceived in the Nation's fourth National Development Plan (1976 – 1980) which supported the establishment of industries for the production of capital and engineering goods of intermediate technology content. As a springboard for industrial development. The Federal Government's objectives in setting up the project included to:

- Establish a self-reliant machine tools complex in Nigeria for the local manufacture and marketing of machine tools, spares and accessories. (BPENG, 2009)
- Support and influence the country's drive towards industrialization and self-reliance in the manufacture of engineering goods.
- Train Nigerian Engineers and technicians in the art of machine tools production.
- Assist entrepreneurs and user industries by offering total project engineering/turnkey consultancy services for the Nigerian and ECOWAS sub-regional market and provide effective after-sales service for the products. (BPENG,2009)

## 2.8 Decision Support Systems

The concept involved in decision support systems was first developed in the 70s by Scott Marton under the term management design systems. He defined such systems as interactive computer based systems, to assist the decision maker to effectively utilize data and models to solve unstructured problems. Decision support systems also combine the intellectual resources of the individual with the capabilities of the computer to improve the quality of decisions. Decision support systems consists of three interacting components;

- A language system mechanism to provide communication between the user and other component of the decision support system,
- A knowledge system – the repository of problem domain knowledge embedded in the system, as data or procedure,
- A problem process system – the link between the other two component containing one or more of the general problem manipulatory capability required for decision making.

Intelligent Decision Support Systems (DSSs) use expert systems technology to enhance the capabilities of decision makers (DMs) in understanding a decision problem and selecting a sound alternative (Papamichail and French, 2004).

### 2.8.1 Characteristics of Decision Support Systems

- Decision support systems specifically aim to aid and not replace the decision maker.
- Decision support systems are easy to use, flexible, strong graphic capability. Its English-like human machine interface language increases its effectiveness,
- Support is provided to individuals as well as groups.
- Decision support systems attempt to improve the effectiveness of decision making in accuracy, response and quality.
- The decision maker has full control over all steps of the decision making process in solving a problem.
- A Decision support system precipitates new demands in its refinement, thus leading to a continuous process of developing and improving the Decision support system.

Other distinguishing factors of decision support systems as shown in Figure 2.1 include; its possessing a knowledge semi-structured design, the possibility of utilization its resources for management at different levels, its mode of independent or sequential decision making procedural process, its capability of supporting intelligence, design and choice, its capability of supporting variety of decision styles, its possession of adaptability and flexibility, its provision of effectiveness in place of efficiency, its enabling more effective human control of the machine, and its evolutionary nature in usage. An efficient decision support system would exhibit these capabilities or at the least potential of the possibilities for possessing these resources, as shown in figure 2.1 theses characteristics provide a means for the effective expression of a decision support system.



**Figure 2.1: Characteristics and Capabilities of Decision Support Systems**

Source; Igbasan, 2009

## 2.8.2 Developmental Strategies of a Decision Support System

The construction of a decision support system involves technical factors (selection of hardware and networking), behavioural factors (behavioural; person-machine interface) and the potential impact of the decision support system on individuals and groups. The basic strategies for decision support system include,

- Write a customized decision support system in purpose programming language such COBOL or PASCAL. This strategy was viable in the 70s. Very few organizations employ this in the 90s, in large scale decision support systems where multiple interfaces are use in the business information system (BIS) from scratch.
- Use a fourth generation language (either Data Oriented Languages, Spread Sheets, Financial Oriented languages, etc) These tools improve the programmer's productivity over general purpose languages.
- Use of decision support system generators (Lotus1-2-3, Excel, Q, etc.); these packages eliminate the need to apply multiple fourth generation languages. By integrating several tools into one package.
- Use a domain specific decision support system. Domain specific generators are designed to build structured systems in the functional area.

## 2.9 Overview of Database Design

A database is a collection of relevant, required and interrelated data organized to correspond to present and projected needs of an organisation. These are sourced in form domain experts in addition to other sources. The quality and integrity of embedded data are critical for the system's function and acceptability and the knowledge engineer must ensure this. Relation Data Model is used to represent the data in the system. Relational Data Management System provides high flexibility in retrieving information and is thus better suited for decision support systems. The database components as shown in figure 2.2 below, provide a basis and framework for the database design. These components include; the query facility, database management unit and database directory, and are interconnected via the control structure, knowledge structure and user interface. As aforementioned in section 1.5, the knowledge engineer is performs the functions of retrieving (form the domain experts and other sources of the required information), collating and information to be contained within the system. Although the user interface is not an actual component of the database it is critical to the effective performance of the database resources. The user interface is

environment where the user is provided with an overview of the resources available in the system, where interaction with the developed system occurs and the platform for observing solutions.

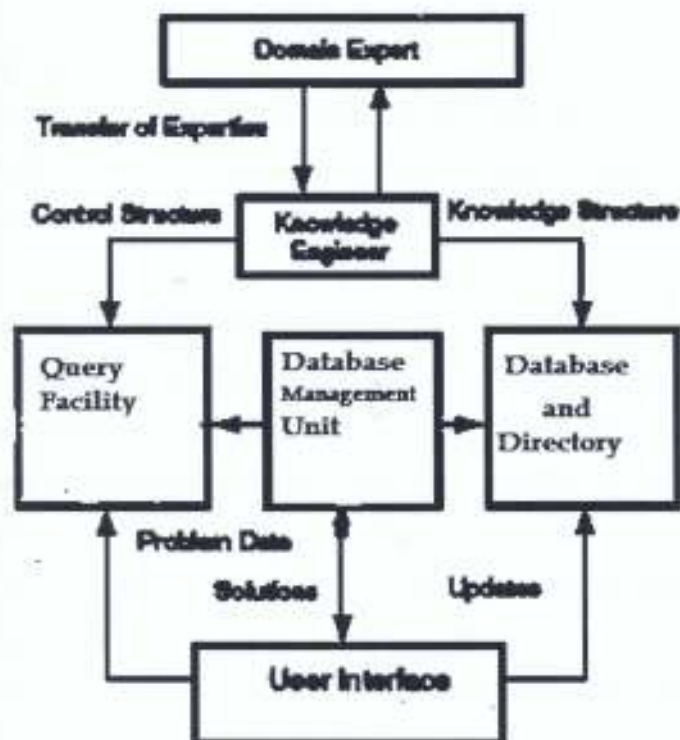


Figure2.2: Overview of Database Design

Source; The Study

### 2.9.1 Database Management Unit

The database created, accessed and by database management unit (DBMU). A database management unit, performs the functions of;

- enabling storage of data in the database,
- retrieval of data from the database,
- control of the database resources.

### 2.9.2 The Directory

The data directory is a catalogue of all the data in the database. It contains the data and functions mainly to reply queries on availability of data items, their sources or their exact meaning. The directory supports the 'intelligence' phase of the decision making process, by

scanning data and locate problem areas. It supports the addition of new entries and retrieval of information on specific objects.

### 2.9.3 The Query Facility

The Query facility element provides the basis for access to data. It accepts requests for information (decision), determines system's response to these requests. The query facility includes a query language.

## 2.10 Application of Decision Support Systems in Machine Tool Operations

In manufacturing industries, cases of utilizing information technology to promote production system overall performance are growing significantly. Examples include, the development of a knowledge-based system for selection of cutting tools and conditions of turning operations, by Arezoo, *et al*,(2000). The system developed was aimed at aiding selection of the tool holder, insert and cutting conditions (feed, speed and depth of cut) through the system's ability to analyse and optimise cutting tools and condition selection. In addition, the user or tool supplier is able to modify and enhance the system to meet their individual requirements. The system was constructed and implemented using PROLOG. An inference engine, a user interface and explanation facility (a complete shell), a knowledge base, and an optimisation model for machining conditions, were embedded in the system. Part and tool files, which include the representation of the part features and cutting tools, serve as system inputs.

After-sale Service Management Information System for the machine tool industry proposed by Tsai, *et al*. (2001), an Analytical Hierarchical Process (AHP), based on fuzzy numbers multi-attribute for the evaluation and justification of an advanced manufacturing system and consequent selection of appropriate machine tools (Duran and Aguilo, 2008). Arslan, *et al* (2004), also developed an decision support system for machine tool selection. The system guided the selection process and aided decision makers solve selection problems. It employed multi-criteria weighted average in ranking machines evaluated with respect to several studied criteria. In the development of intelligent decision support tools to aid the design of flexible manufacturing systems.

Chan, *et.al*,(2000), implemented an integrated approach of construction and testing alternative designs using simulation methods. The most suitable design based on the multi-criteria decision making technique, the analytic hierarchy process (AHP) was employed to

analyse the output from the flexible manufacturing (FMS) simulation models. Intelligent tools such as expert systems, fuzzy logic and neural networks were also developed for supporting the design process. The "active X" technique was used for the actual integration of the FMS automatic design process and the intelligent decision support process.

OPTIMUM (Optimized Planning of Tooling and Intelligent Machinability evaluation for Milling); a computer based system for automated machinability assessment and tool selection and cutting data for a range of milling operations milling, was developed by Carpenter and Marpoulos, (2000). Their work aimed at meeting increased demand for the supply of a comprehensive advice service with relation to selection of appropriate tools and cutting data for a wide variety of workpiece materials and component geometries. The machinability assessment method utilized, employs rule based decision logic and multiple regression techniques to produce feasible initial cutting conditions for a wide range of workpiece materials. A variety of input data is permitted, including imprecise or incomplete workpiece descriptions. The tool selection process features the selection of tools based upon optimised machining performance. A new optimisation criterion related to initial average chip thickness, called harshness, was proposed. Their combination of knowledge based logic and statistical methods provided a flexible support tool for the process planning of milling operations.

Wang and Zhanqiang, (2003) employed case-based reasoning, in solving the difficulty of establishing a high-speed machining database system and the limitations of shortage and sufficient appropriate high speed parameters in high speed machining technology. By the method utilized, the high speed machining database system is developed where cutting data and experience are stored for machining new part by high speed machining technology. The case-based reasoning presented a kind of feasible and effective method for establishing high-speed machining database system in which prior cutting data and experience accumulated are accumulated to provide a reference solving scheme for machining new part by HSM technology. They also proposed a feasible case model described by structured data.

Ozbayrak and Bell, (2003) developed a knowledge-based decision support system (KBDSS) for short term scheduling in flexible manufacturing systems (FMS) (complex manufacturing systems with large part, tool, and information flows). The core principle utilized was the tool management concept. To provide a significant operational control tool for a wide range of machining cells, where a high level of flexibility is demanded, with benefits of more efficient cell utilization, greater tool flow control, and a dependable way of rapidly adjusting short-

term production requirements. The development of a knowledge-based system to support the decision making process was justified by the inability of decision makers to diagnose efficiently many of the malfunctions that arise at machine, cell, and entire system levels during manufacturing. The work proposed three knowledge-based models to ease the decision making process: an expert production scheduling system, a knowledge-based tool management decision support systems, and a tool management fault diagnosis system. The entire system was created in a hierarchical structure, comprising of above 400 rules. The expert system (ES) was implemented in a commercial expert system shell, Knowledge Engineering System (KES) Production System (PS).

A decision support tool, for automated-intelligent selection of cutting processes and tools within a concurrent engineering environment, by calculating cutting conditions and estimating component cost was developed by Edalew, *et al.* (2001). The major aim was to develop a procedure for the selection of cutting tools, a dynamic programming-based system utilizing mathematical modules and heuristic data to determine and calculate cutting parameters and total component cost. To help the designers and manufacturing planners to select an optimal set of cutting tools and cutting conditions for different material properties and to give users alternatives on how to reduce cost and time. The system comprised of several modules; the knowledge acquisition module, the knowledge base module, the inference engine, the user interface, and the database. The developed system, which was designed to cover different component shapes including cylindrical, prismatic, different types of machining techniques, conventional and less conventional, has the potential to deal with complex products that are made up of multiple components. The system calculates cutting conditions and estimates component cost, based on the properties of the work piece material and features attributes, which include surface finish and tolerances, as well as using a number of production criteria such as material removal rate, tool life, machining time, and cost

A decision support tool to aid selection of parameters in milling cutting process was also developed by Vidal, *et al.* (2005). The algorithm used was based on optimizing cost of the operation. The results were the selection of parameters that take into account all the existing restrictive factors of material, geometry, roughness, machine and tool.

A wide range of parts were evaluated, using group technology in order to choose representative cases. Determination of relationships between the factors that influence milling operations and the features which permit the wide range of geometrical possibilities existing for all the pieces considered was done. The method purposed to aid right decisions on the optimal parameters in mill operations as applied to the machining processes. A

reduction of about 35% in processing times while ensuring optimal finishing conditions was achieved.

Cimeren, *et.al.*, (2006) proposed a decision support system for machine tool selection propose a decision support system for machine tool selection using the algorithm procedure of an analytic hierarchy process. In the selection process, qualitative decision criteria that are related to the machine properties were first considered. In the study, the machine tool selection problem was addressed and an AHP-based methodology proposed. Machine properties and main and sub-decision criteria were investigated to apply the proposed methodology. Visual-Basic and Microsoft Access were employed in implementing the proposed methodology. The database included specifications of 236 machine tools. The developed software consists of six modules; Selection (SM), sensitivity analysis (SAM), reliability analysis (RAM), precision analysis (PAM) and cost analysis(CM) modules are used for the decision process while the sixth module (AM) is used for administrative purposes, define/update a machine, manufacturer, or user and t omanage default values for each user. The flexibility of the proposed methodology was supported by it potential applications in other types of selection problems, e.g., selection of a vehicle hardware, appliances, etc. It was further concluded, that productivity, precision, flexibility, and responsive manufacturing capabilities of the company depended on the machine properties and importantly ability to make accurate decisions.

## METHODOLOGY

## 3.1 Collection, Collation And Compilation and Documentation Of Relevant Data.

The pre-development of the machining processes database was carried out by gathering the machining operation data to be set in the module. A knowledge engineering process of, collecting (through oral interviews with experts in machining (cutting) operations, visits to academic and industrial machine workshops and libraries, and study of relevant literature), collating and compiling the machining operations data meeting industrial standards and analysis of the data retrieved (Appendix 2). According to Wu and Zhang, 1998, a framework is a set of classes designed to work together to solve a problem or supply some capabilities. Figure 3.1. provide an example of such a framework. The module development procedural stages of, research and documentation, algorithm design, design of application interface, writing of programming language codes, debugging of written the codes and application package, publishing of application package and testing and implementing of developed software; followed a sequential process as shown in figure 3.1.

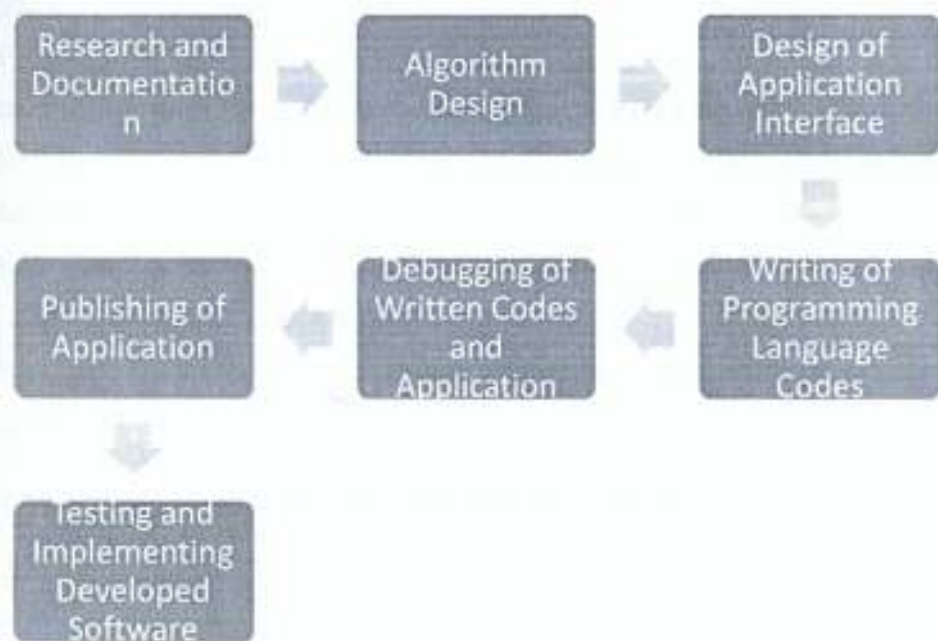


Figure 3.1: System Developmental Process

Source; The Research

Each stage in figure 3.1 above, requiring the completion of the preceding process and resources developed in that stage, for the successful beginning and completion of the next.

Information to be embedded in the module was gotten through oral interviews with experts in the machine tool industry, visits to various university libraries and machine tool workshops. The raw data was then compiled and coded using the C Sharp programming Language on the VB dot Net Platform utilizing the Windows Presentation Format (WPF). An essential property of the framework is its reusability. Framework reuse can lead to important gains in productivity, quality, consistency, portability and maintainability. It is important to categorize the different levels of data completeness to ensure that the final data collection includes a fair representation of each component (Hale and Arno, 2009). The framework of the developed module was designed with these principles in mind.

The machining data was word processed into detailed tables; these were hosted on Microsoft Access 2007 files. The tables represent information location for data required to aid conventional and non-conventional cutting operations in the workshop.

### **3.2 Module Development**

The Front end (user interface and application physical features) of the application was developed on the Dot Net platform; employing the Windows Presentation Foundation. This platform was chosen, as it provides an enhanced graphical background with the potential for 3-D graphics. Development of the whole module platform was done with C-Sharp 3.0 in Visual studio 2008 with service pack 1. The user interface was developed using the C-sharp programming language 3.0 in Visual Studio 2008 and 2010 on the Dot-net platform.

Figure 3.2 describes the flow chart for the proposed operation of the system. It is of important note that processes in the system are structured (as shown in the flowchart) and the displayed results from the machining operations and help sub-module, are derived from the embedded stored data. However as would be discussed section 4.1.4, the displayed results from the machining calculations sub-module are powered by the source codes (Appendix 1) and are not dependent upon any stored data.

#### **Coded Algorithm Developed for the Operation of the Modules**

INPUT - Select Machine Operation

INPUT - Select Tool Material

INPUT - Select Working Conditions

DO - Generate SQL Query

DO - Send SQL Query to the Server

DO - Receive Response From the Server

DO - Display the results

EVENT - X Machine Operation is Selected From ComboBox

EVENT - Y Tools Operation is Selected From ComboBox

EVENT - Z Machining Condition is Selected From ComboBox

GENERATE SQL QUERY

SELECT X Machine Operation FROM Machine Operations Table WHERE

Tool Material is Y and Machine Condition is Z

SEND QUERY TO SERVER

Receive Response From Server

Display Results On The Graphic User Interface

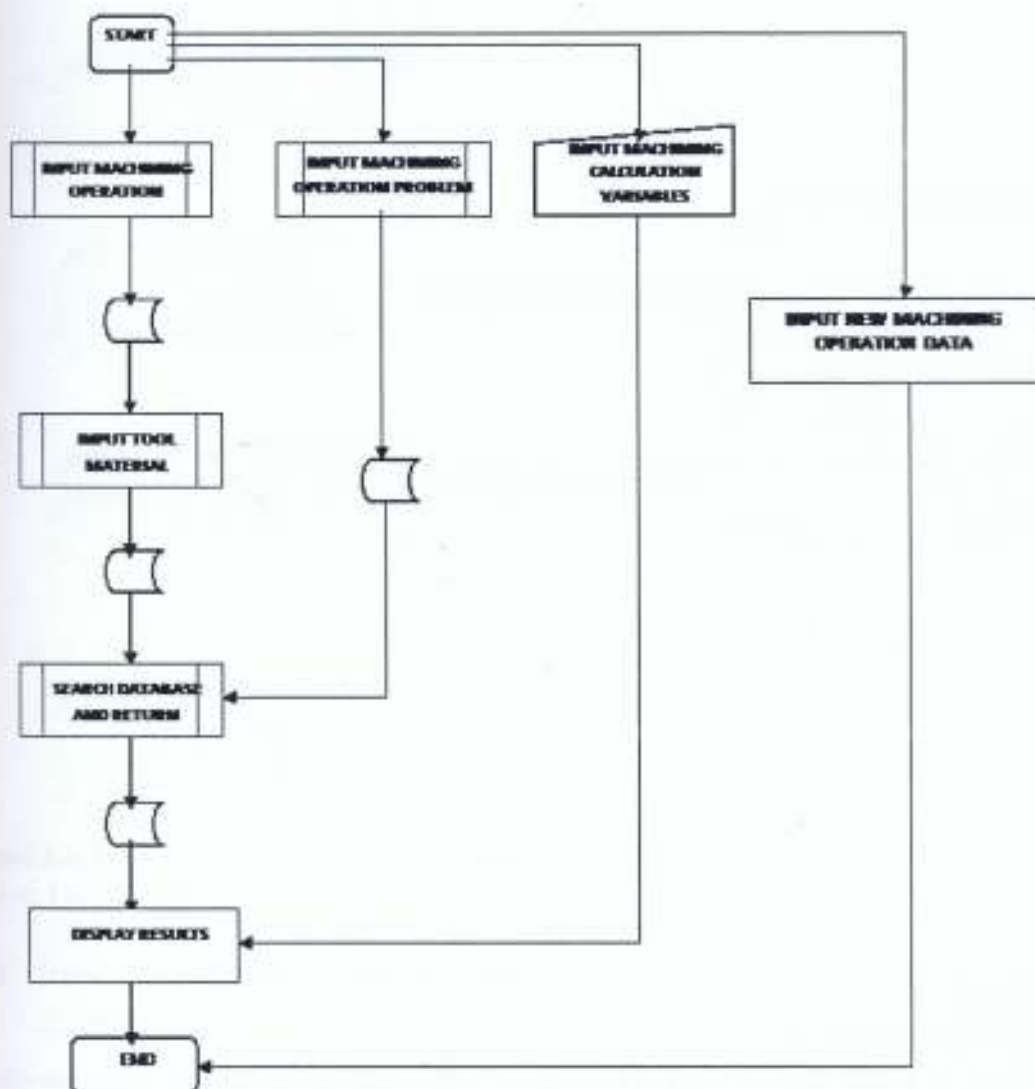
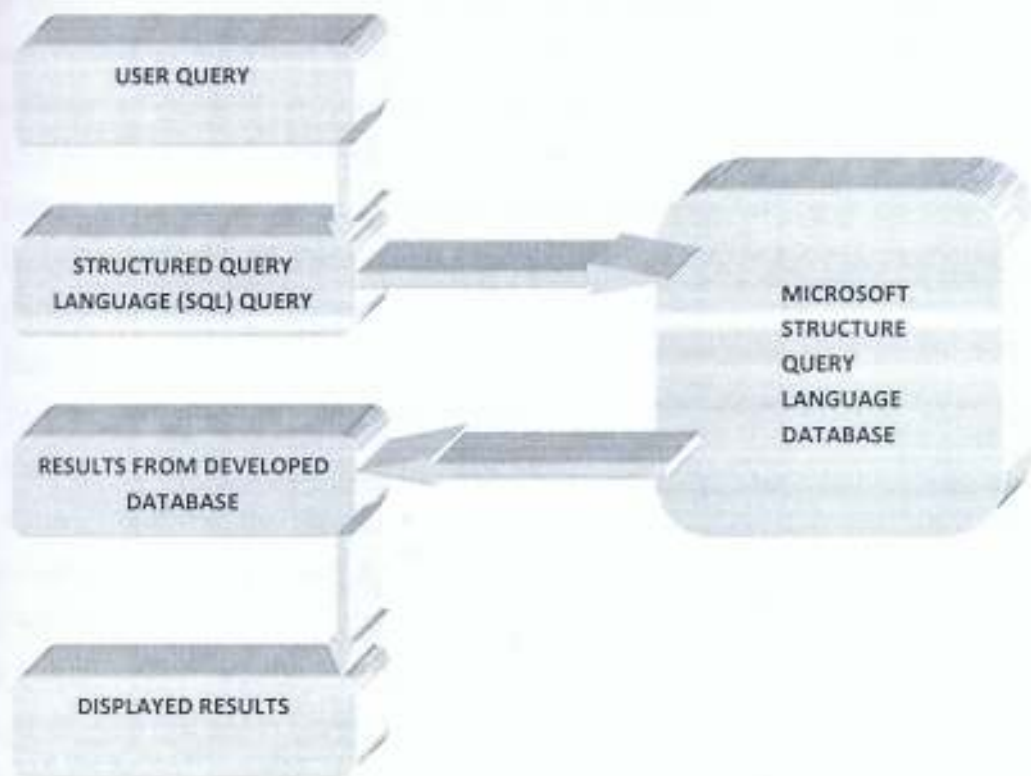


Figure 3.2; Generalized Process Flowchart For The Developed Module  
Source; The Research.

For the system to perform as expected, a simple operational principle as shown in figure 3.3 was set as a framework for the functioning of the developed module. The User queries were set to interact directly, utilizing structure query language, with the Microsoft structure query language database and results from developed database, displayed for the application user.



**Figure 3.3; Operational Principle of the Developed Module**

Source; The Research

### 3.2.1 Development of The Module Database.

In addition to serving as the developed module's base-end, the database serves as the pseudo-inference engine where pre-processed user queries are received, further processed, relevant information retrieved and results sent. The procedure and interaction of the module components from the user query through the database to the results are shown in figure 3.3. Microsoft Access 2007 and Microsoft SQL(Structured Query Language) Database and Microsoft SQL Server 2005 were utilized in the development of the database.

The data used was first prepared in Microsoft Access 2007 as a database before it was converted into a Microsoft SQL Server Database. This conversion was done, due to ease of manipulation of data in a Microsoft SQL Server database, than in a Microsoft Access database in Visual Studio.

Within the database are included key indicators for machining operations such as; primary, secondary and tertiary cutting feed, depth and speed requirements, power required for turning and milling, cutting tool angles and geometry and cutting fluid requirements. These parameters were set in the database with respect to various engineering materials such

as; high speed steels, cast alloy steels, stainless steels, magnesium alloys, copper alloys, aluminum, bronze, carbides and titanium alloys. These data were located in the database tables as shown in figures 3.12 – 3.15 under the headings;

PDB1: Unit Power for Turning and Milling With Corresponding Chip Thickness

PDB2: Lathe Cutting Speeds With High Speed Tool Bit for Facing Turning and Boring

PDB3: Lathe Feeds With High Speed Cutting Tools

PDB4: Cutting Conditions for Turning

PDB5: Rake and Relief Angles for Tool Lathes Operations

PDB6: Tool Angles for Single Point Cutting Tools

PDB7: Cutting Angles for Machining Cast Alloy Steels

PDB8: Cutting Conditions for Milling

PDB8b: Cutting Speeds and Feeds for Milling Cutters

PDB8c: Milling Cutting Speeds

PDB8d: Cutting Speeds and Feeds for Face and Shoulder Mills

PDB8e: Cutting Speeds and Feeds for Face and Square Shoulder Mills

PDB8f: Cutting Speeds and Feeds for Side and Face Cutters

PDB8g: Cutting Feeds for High Speed Steel Cutters

PDB8h: Feed per Tooth for High Speed Mills

PDB8i: Tool Geometry for Milling

PDB8j: Radial Relief Angles for End Mills Operation

PDB9: Cutting Conditions in Drilling, Reaming and Tapping

PDB9b: Cutting Conditions in Drilling and Reaming

PDB9c: Cutting Speeds for High Speed Drills

PDB9d: Drill Feed and Corresponding Parameters

PDB9e: Center Drilling Sizes and Corresponding Parameters

PDB9f: Drill Lip Clearance at Periphery and Corresponding Parameters

PDB9g: Machining Conditions in Gun Drilling

PDB9h: Cutting Fluids Requirements of Pressure and Viscosity in Chip Removal

PDB9i: Cutting Fluid Requirements of Pressure and Viscosity in External Chip Removal Gun Drills

PDB9j: Cutting Fluid Requirements of Pressure and Viscosity in Internal Chip Removal Gun Drills

PDB10: Fluid Pressure and Volume Requirements for Internal Chip Removal in Trepanning Heads

- PDB11: Boring Conditions and Corresponding Parameters
- PDB11b: Fine Boring Requirements With Carbide Tools
- PDB12: Threading Requirements with High Speed Tool Bit
- PDB13: Shaping Feeds and Speeds with Corresponding Parameters
- PDB13b: Shaping Speeds for Roughing and Finishing
- PDB13c: Shaping Requirements for Annealed Carbon Steel and Grey Cast Iron
- PDB14: Planing Conditions and Corresponding Parameters
- PDB15: Reaming Speeds and Corresponding Parameters
- PDB15b: Machine Reaming Allowance Requirements
- PDB15c: Stock Allowance Requirements in Reaming
- PDB16: Tapping Speeds Requirements with High Speed Taps
- PDB17: Effect of Work Material Type on Roughing by Ultra Sonic Machining
- PDB18: Electron Beam Machining Requirements for Drilling
- PDB18b: Electron Beam Machining Requirements in Slot Cutting.

Data required for help and troubleshooting guides in material selection and various conventional machining operations such as turning, drilling, milling, boring, reaming, broaching, tapping, welding in addition to non-traditional machining operations such as; ultrasonic and electron beam machining, was also embedded in the database. These data were located in the database tables as shown in figures 3.16–3.18 under the headings;

- PDBHelp1: Trouble Shooting in Turning Operation
- PDBHelp2: Trouble Shooting in Milling
- PDBHelp2b: Trouble Shooting in Milling with Carbide Tools
- PDBHelp3: Trouble Shooting in Drilling
- PDBHelp3b: Trouble Shooting in Gun-Drilling
- PDBHelp4: Trouble Shooting in Trepanning
- PDBHelp5: Trouble Shooting Boring
- PDBHelp6: Trouble Shooting in Reaming
- PDBHelp6b: Trouble Shooting in Reaming Applications
- PDBHelp7: Trouble Shooting in Tapping Applications
- PDBHelp8: Trouble Shooting in Broaching Applications
- PDBHelp9: Trouble Shooting in Grinding Wheel Applications
- PDBHelp10: Trouble Shooting in Cutting Fluids Application
- PDBHelp11: Trouble Shooting in Electrode Material Selection
- PDBHelp11b: Trouble Shooting in Electrode Material Properties

PDBHelp12: Trouble Shooting in Electrolyte Solution Application

PDBHelp13: Materials' Guide in Non-Traditional Machining

PDBHelp14: Non-Traditional Machining Relationships with Workpiece Shape

PDBHelp15: Comparing Traditional and Non-Traditional Machining Performance

PDBHelp16: Non-Traditional Machining Surface Finish Characteristics

The machining calculation sub-module was developed to aid in the following; speed requirements in turning, power and force requirements in turning, grinding calculations, shaping calculations, power and force requirements in milling, spur gears, determination of auxiliary angles (rake angle and clearance angle), and non-traditional machining process calculations, machine depreciation and machining operations scheduling. The various formula are shown in table 3.1.

Figures 3.4 – 3.12 shows further module development procedures. In addition to the design view the figures show the folder structure (which at design time contains the resources utilized in the development process; the folder structure is also referred to as the solution explorer) and the server structure (which shows the respective tables and databases available in the developing application; the server structure is also referred to as the server explorer).

Figure 3.4 shows the module design view of the development of the database of boring conditions with centre drill size parameters, cutting angles used for cast alloy steels and cutting fluid volume and pressure requirements for internal chip removal. Figure 3.5 shows the module design view of the development of the database of cutting conditions with respect to cutting speeds and cutting feeds in milling operations. Figure 3.6 shows the module design view of the development of the database of cutting conditions with respect to cutting speeds and feeds in milling operations, drill lip clearance and the development of the database of the data for the effect of workpiece material on ultrasonic machining. Figure 3.7 shows the module design view of the development of the database of cutting conditions with respect to cutting speeds and feeds in milling and drilling operations, and the development of the database of data for drilling with electron beam machining. Figure 3.8 shows the module design view of the development of the database of cutting conditions, with respect to cutting speeds, feeds and tool geometry in milling and drilling operations in addition to rake relief angles. Figure 3.9 shows the module design view of the development of the database of cutting conditions with respect to cutting speeds and tool relief angles in planing and reaming operations and tool rake relief angles in addition to development of the database of data for cutting fluid viscosity and pressure requirements for external chip removal.

Figure 3.10 shows the module design view of the development of the database of cutting conditions with respect to cutting speeds and feeds in shaping operations and slot cutting with electron beam machining. Figure 3.11 shows the module design view of the development of the database of cutting conditions with respect to cutting speeds and feeds in turning, reaming and tapping operations. Figure 3.12 shows the module design view of the development of cutting conditions with respect to cutting speeds and feeds in turning, facing and threading operations and the development of the database for tool angles data required for single point cutting tools.

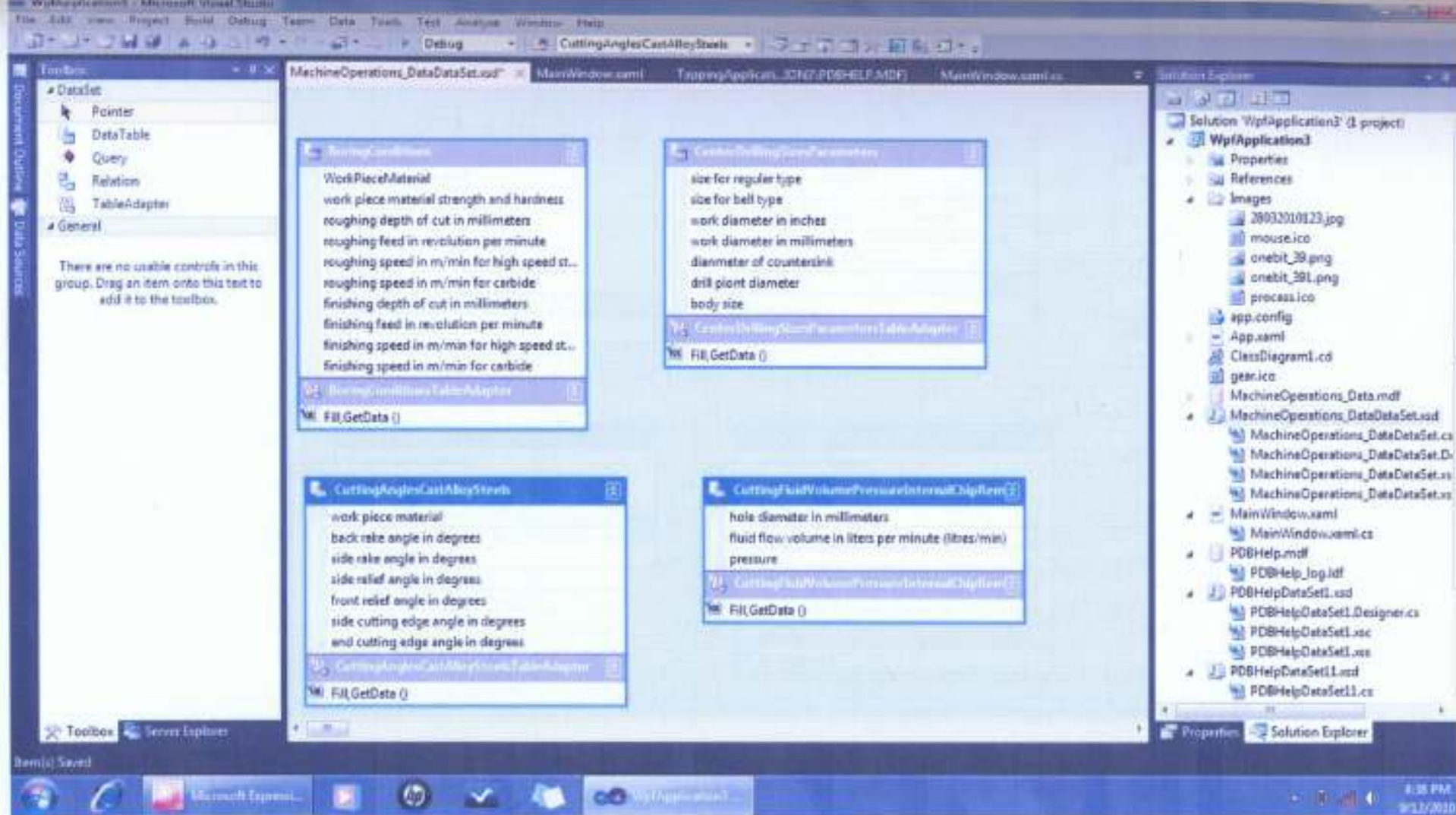


Figure 3.4; Interface for the Determination of Boring and Drilling Parameters.

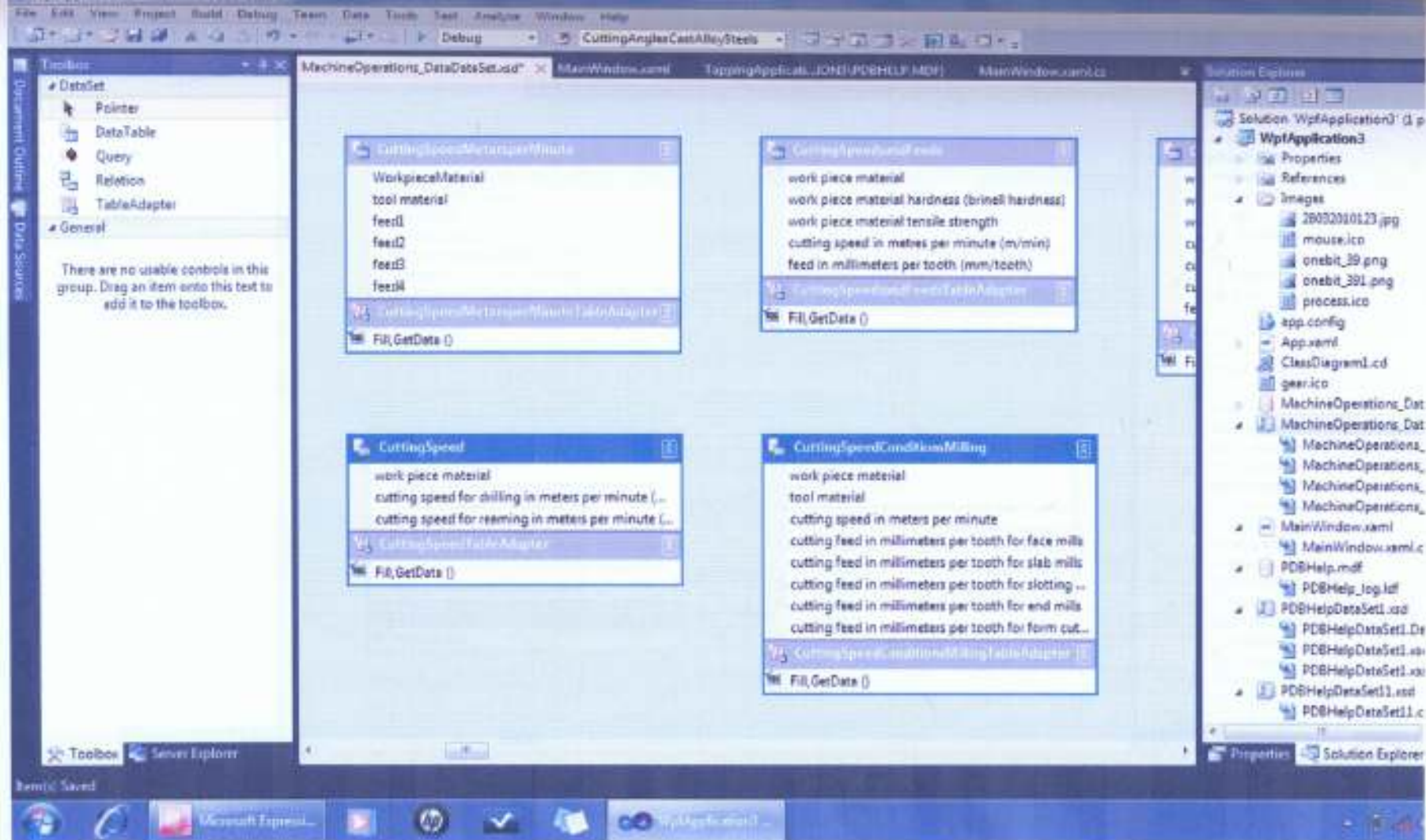


Figure 3.5; Interface for the Determination of Milling Parameters.

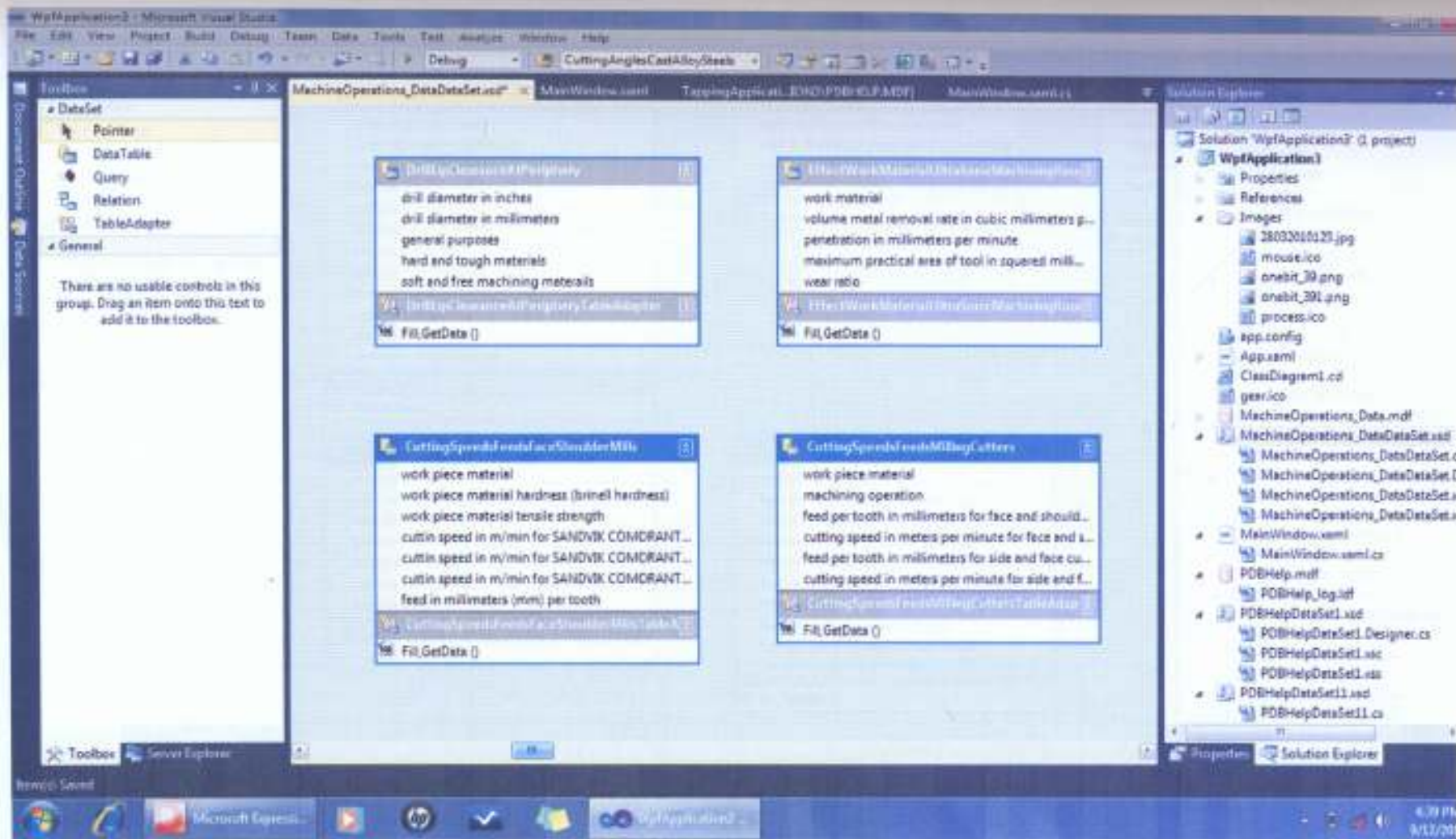


Figure 3.6; Interface for the Determination of Milling, Drilling and Ultrasonic Machining Parameters.

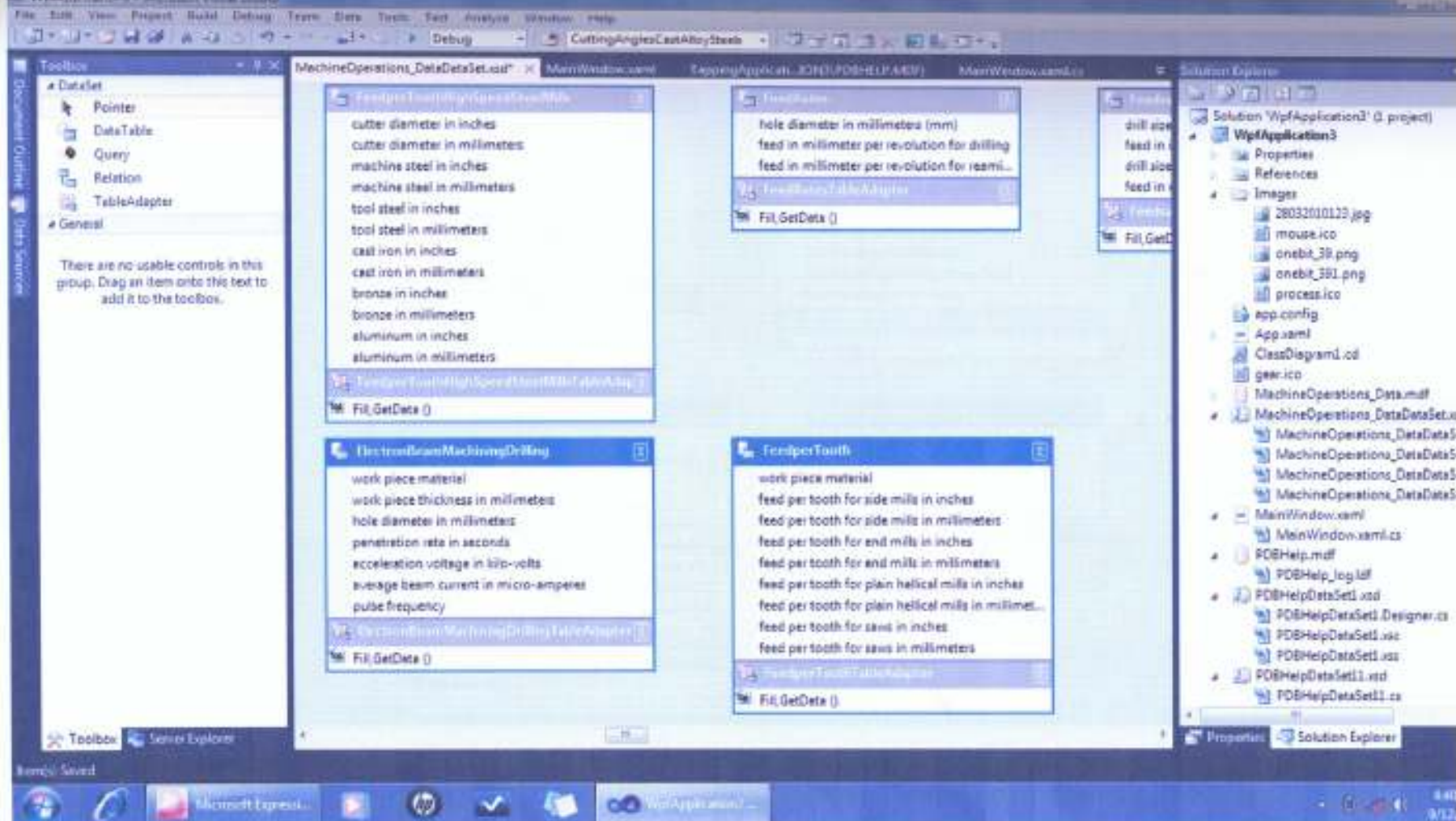


Figure 3.7; Interface for the Determination of Milling, Drilling and Electron Beam Machining Parameters.



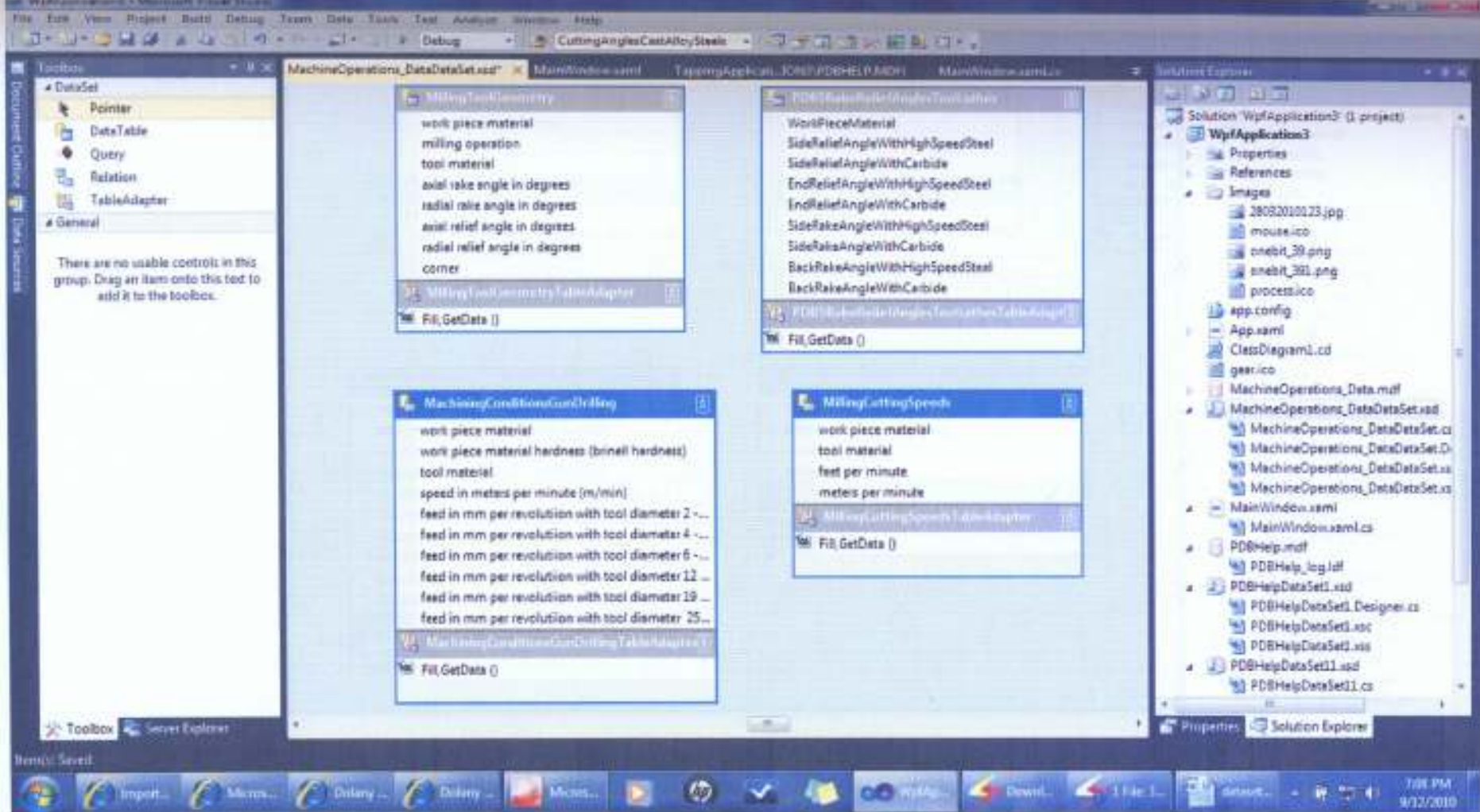


Figure 3.8; Interface for the Determination of Milling, Drilling and Tool Angle Parameters.

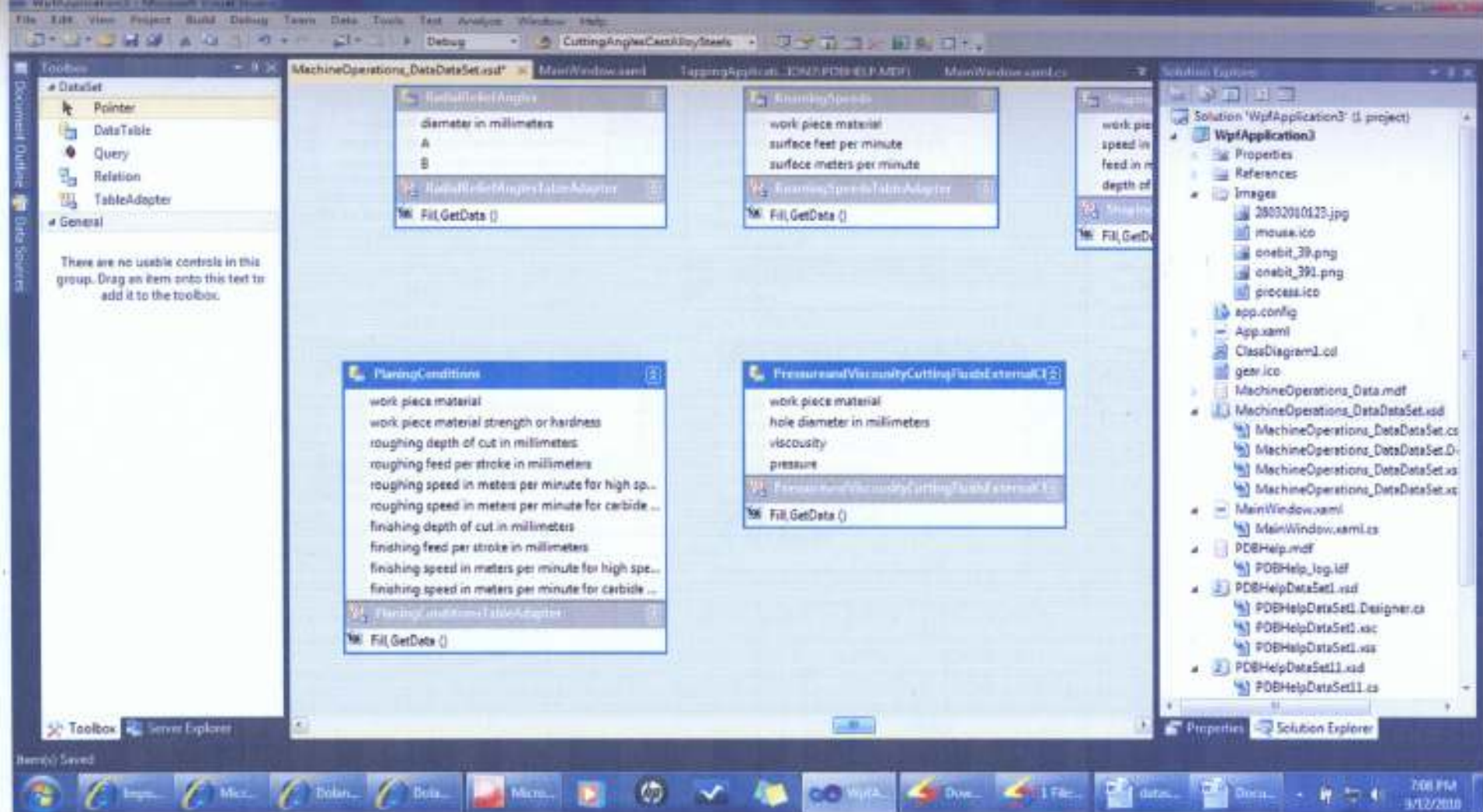


Figure 3.9; Interface for the Determination of Planing, Reaming Tool and Lubrication Parameters.

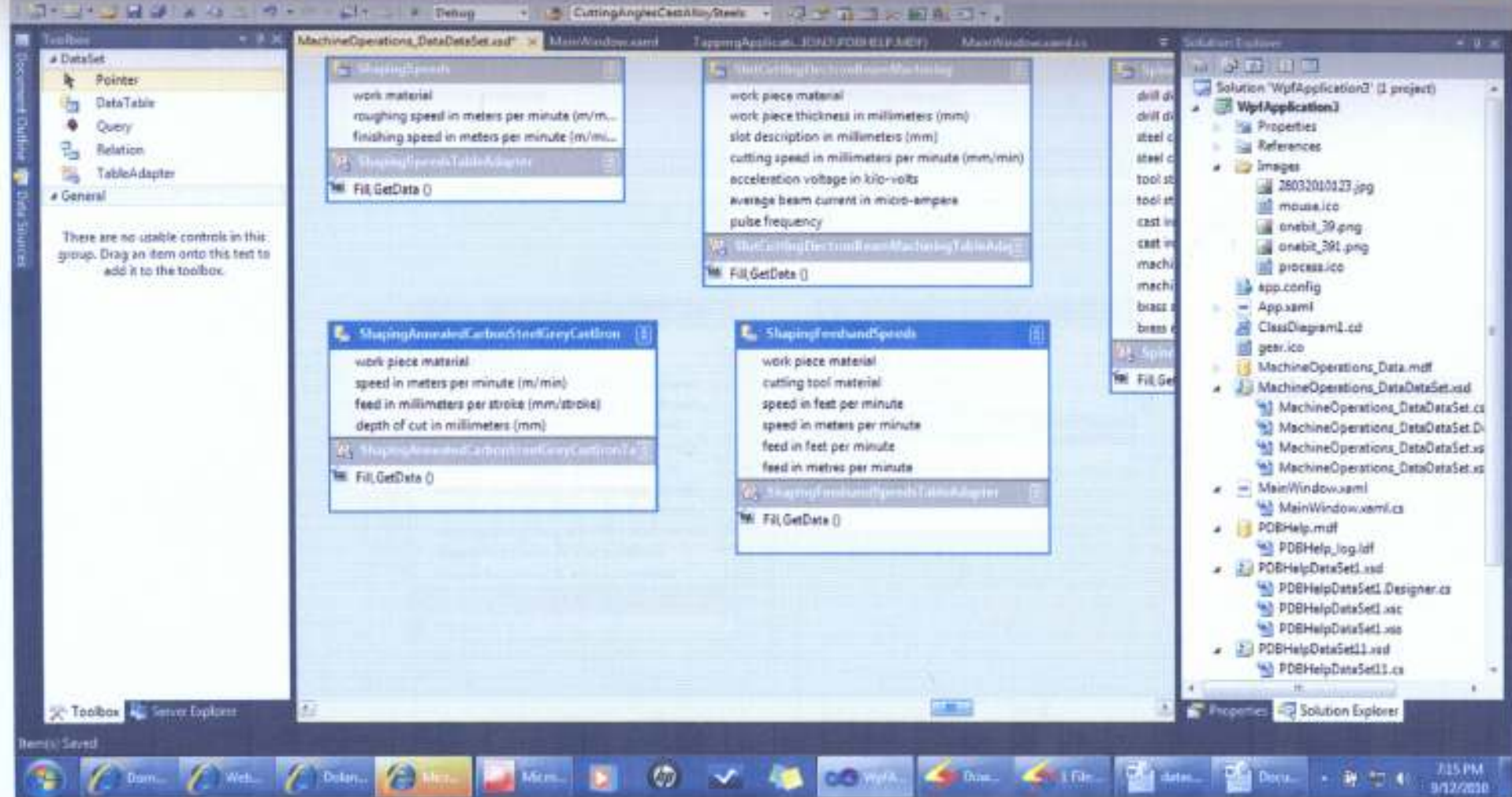


Figure 3.10; Interface for the Determination of Shaping and Electron Beam Machining Parameters.

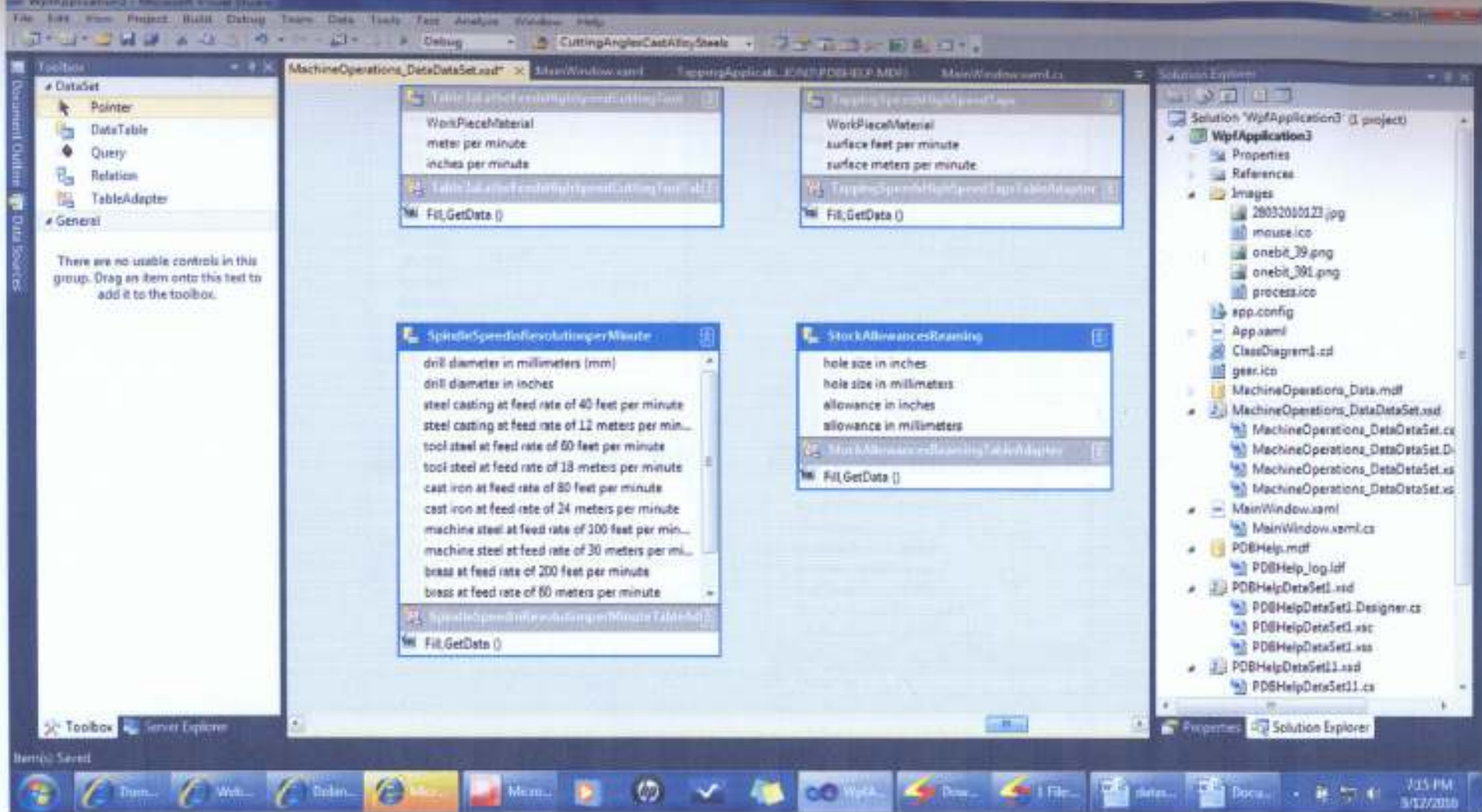


Figure 3.11; Interface for the Determination of Turning, Reaming and Tapping Parameters.

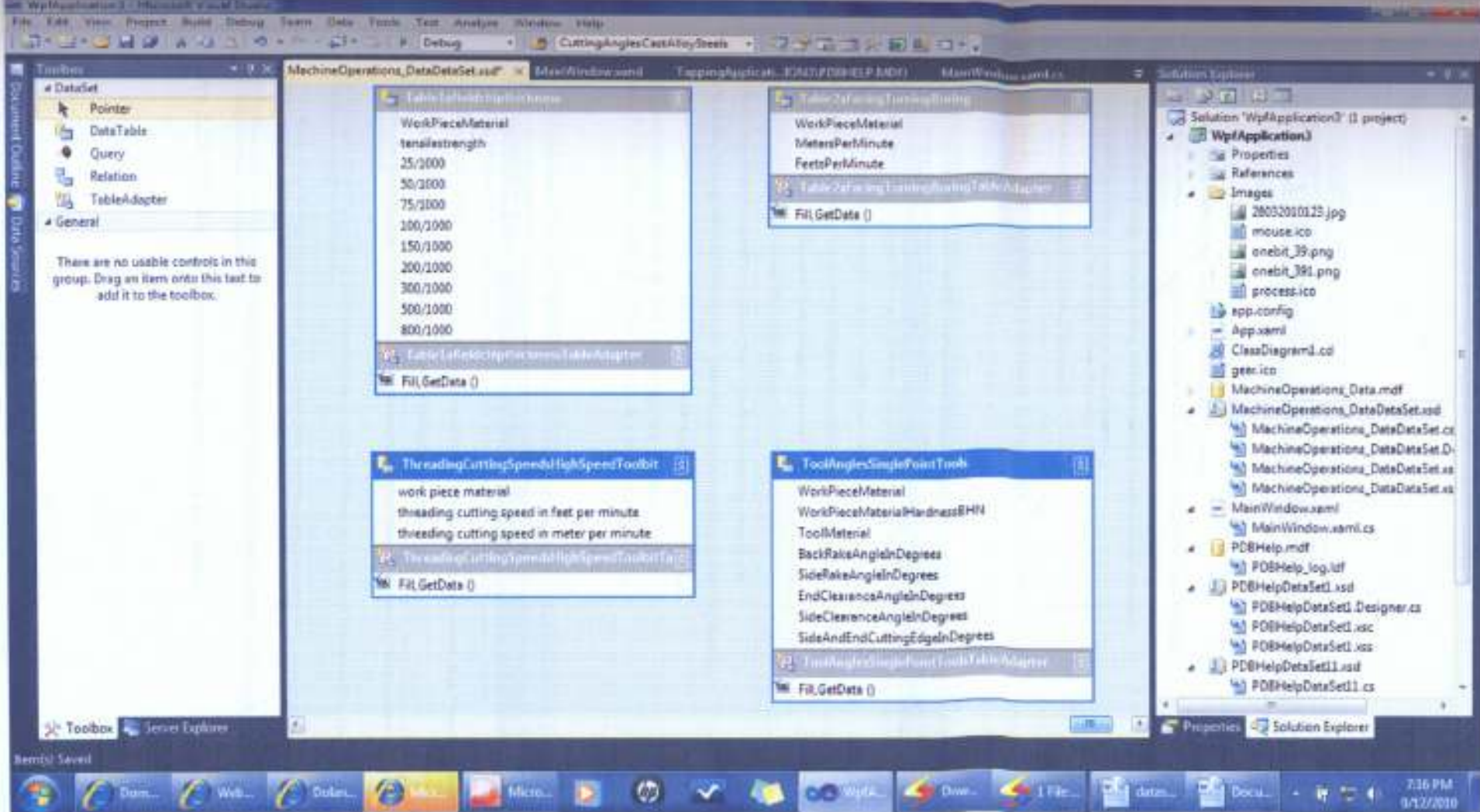


Figure 3.12; Interface for the Determination of Turning Operations' and Single Point Tool Angle Parameters.

Figures 3.13 – 3.19, show the table headings as they are embedded within the database, the prefix “PDB” as earlier explained in section 3.2.1 are seen. As also earlier explained in section 3.2.1, each table heading determines the information retrievable from that portion of the database.

**SUB-MODULE ONE: Machining Operation Module Data**

**PDBa: Unit Power for Turning and Milling With Corresponding Chip Thickness**

**PDBa<sub>1</sub>: Lathe Cutting Speeds With High Speed Tool Bit for Facing Turning and Boring**

**PDBa<sub>2</sub>: Lathe Feeds With High Speed Cutting Tools**

**PDBa<sub>3</sub>: Cutting Conditions for Turning**

**PDBa<sub>4</sub>: rake and Relief Angles for Tool Lathes Operations**

**PDBa<sub>5</sub>: Tool Angles for Single Point Cutting Tools**

**PDBa<sub>6</sub>: Cutting Angles for Machining Cast Alloy Steels**

**PDBa<sub>7</sub>: Cutting Conditions for Milling**

**PDBa<sub>8</sub>: Cutting Speeds and Feeds for Milling Cutters**

**PDBa<sub>9</sub>: Milling Cutting Speeds**

Figure 3.13; Machining Operations Execution Interface

**SUB-MODULE ONE: Machining Operation Module Data CONTD.**

**PDBb<sub>1</sub>: Cutting Speeds and Feeds for Face and Shoulder Mills**

**PDBb<sub>2</sub>: Cutting Speeds and Feeds for Face and Square Shoulder Mills**

**PDBb<sub>3</sub>: Cutting Speeds and Feeds for Side and Face Cutters**

**PDBb<sub>4</sub>: Cutting Feeds for High Speed Steel Cutters**

**PDBb<sub>5</sub>: Feed per Tooth for High Speed Mills**

**PDBb<sub>6</sub>: Tool Geometry for Milling**

**PDBb<sub>7</sub>: Radial Relief Angles for End Mills Operation**

**PDBb<sub>8</sub>: Cutting Conditions in Drilling, Reaming and Tapping**

**PDBb<sub>9</sub>: Cutting Conditions in Drilling and Reaming**

**PDBb<sub>10</sub>: Cutting Speeds for High Speed Drills**

Figure 3.14; Machining Operations Execution Interface

**SUB-MODULE ONE: Machining Operation Module Data CONTD.**

**PDBc<sub>1</sub>: Drill Feed and Corresponding Parameters**

**PDBc<sub>2</sub>: Center Drilling Sizes and Corresponding Parameters**

**PDBc<sub>3</sub>: Drill Lip Clearance at Periphery and Corresponding Parameters**

**PDBc<sub>4</sub>: Machining Conditions in Gun Drilling**

**PDBc<sub>5</sub>: Cutting Fluids Requirements of Pressure and Viscosity in Chip Removal**

**PDBc<sub>6</sub>: Cutting Fluid Requirements of Pressure and Viscosity in External Chip Removal Gun Drills**

**PDBc<sub>7</sub>: Cutting Fluid Requirements of Pressure and Viscosity in Internal Chip Removal Gun Drills**

**PDBc<sub>8</sub>: Fluid Pressure and Volume Requirements for Internal Chip Removal in Tapping Heads**

Figure 3.15; Machining Operations Execution Interface

**SUB-MODULE ONE: Machining Operation Module Data CONTD.**

**PDB1a: Boring Conditions and Corresponding Parameters**

**PDB1a1: Fine Boring Requirements With Carbide Tools**

**PDB1a2: Threading Requirements with High Speed Tool Bit**

**PDB13: Shaping Feeds and Speeds with Corresponding Parameters**

**PDB13b: Shaping Speeds for Roughing and Finishing**

**PDB13c: Shaping Requirements for Annealed Carbon Steel and Grey Cast Iron**

**PDB14: Planing Conditions and Corresponding Parameters**

**PDB15: Reaming Speeds and Corresponding Parameters**

**PDB15b: Machine Reaming Allowance Requirements**

Figure 3.16; Machining Operations Execution Interface

**SUB-MODULE TWO: Help and Troubleshooting Guide Module**

**PDBHelp1: Trouble Shooting in Turning Operation**

**PDBHelp2: Trouble Shooting in Milling**

**PDBHelp2b: Trouble Shooting in Milling with Carbide Tools**

**PDBHelp3: Trouble Shooting in Drilling**

**PDBHelp3b: Trouble Shooting in Gun-Drilling**

**PDBHelp4: Trouble Shooting in Trepanning**

**PDBHelp5: Trouble Shooting Boring**

**PDBHelp6: Trouble Shooting in Reaming**

**PDBHelp6b: Trouble Shooting in Reaming Applications**

Figure 3.17; Help and Troubleshooting Execution Interface

**SUB-MODULE TWO: Help and Troubleshooting Guide Module CONTD.**

**PDBHelp7: Trouble Shooting in Tapping Applications**

**PDBHelp8: Trouble Shooting in Broaching Applications**

**PDBHelp9: Trouble Shooting in Grinding Wheel Applications**

**PDBHelp10: Trouble Shooting in Cutting Fluids Application**

**PDBHelp11: Trouble Shooting in Electrode Material Selection**

**PDBHelp11b: Trouble Shooting in Electrode Material Properties**

**PDBHelp12: Trouble Shooting in Electrolyte Solution Application**

**PDBHelp13: Materials' Guide in Non-Traditional Machining**

Figure 3.18; Help and Troubleshooting Execution Interface

## **SUB-MODULE TWO: Help and Troubleshooting Guide Module CONTD.**

**PDBHelp14: Non-Traditional Machining Relationships with Workpiece Shape**

**PDBHelp15: Comparing Traditional and Non-Traditional Machining Performance**

**PDBHelp16: Non-Traditional Machining Surface Finish Characteristics**

Figure 3.19; Help and Troubleshooting Execution Interface

As aforementioned the database was developed to power the developed module. The system responds to the user by displaying requested information when queried by referring to the data embedded in database. By utilizing the given table headings with the prefix PDB as shown in Figures 3.13–3.19, information retrievable from that portion of the database is determined and accessed.

The application is developed to permit changes and addition to the database data. New data is added to the database through this section. This makes the application to evolve overtime in unique response to its user and to the dynamic engineering materials domain.

### **3.2.1.1 Programming Language Utilized in System Development**

The programming language used to develop the application is C-sharp. C-sharp works seamlessly with ASP.NET to perform a robust programming work. Microsoft Visual Studio makes it possible to design and develop applications in a very friendly environment. The Visual Studio interface has a design and code view. The design view is used for working on the physical outlook of the application while the code view is used for writing the programming code that controls the Application.

Furthermore, the C Sharp programming language was employed because it combines the robust user controls and the simplicity of Visual Basic. Net. C-Sharp also has Visual Basic. Net's Rapid Application Development, the capabilities of C++ and the highly object orientation paradigms of Java. C-Sharp further enabled the combination of rich graphic environment, a lightweight database, and a fast running application development platform (.Net Framework 3.5). Considerations in the software design included factors such as user friendliness, flexibility, software portability (ease of installation), and ease of upgrading the database.

### 3.2.1.2 Structural Query Language

Structural Query Language (SQL), is a simple language for communication with a database from an application. A few snippets of SQL codes were written within the C-sharp code in order to retrieve data from the MSSQL Server database. SQL can be used to request for data. The SQL serves as an intermediary between the application and the database.

### 3.2.2 Applications Embedded in The Developed Module

- Application for Traditional and Non-Traditional Machining Operations Calculations, table 3.1 shows the various machining operations calculations formulae utilized in building the calculation sub-module.
- Application for Calculations aiding Scheduling of Machining Operations, utilizing the principles of Johnson's Algorithm for Scheduling (discussed in section 3.2.2.1),
- Application for Calculations aiding Machine Depreciation Planning (discussed in section 3.2.2.2).

### Formulae Utilized in Developing The Calculations Sub-Module

Speed Requirements In Turning:

$$r = \frac{CS \text{ (in meters)} \times 1000}{\pi \times D \text{ (in millimeters)}} \quad (1)$$

Where;  $r$  = revolutions of spindle per minutes,  $CS$  = cutting speed and  $D$  = large/ major diameter of drill in inches

Power And Force Requirements In Turning:

$$P_z = K_s \cdot s \cdot t \cdot K_r \cdot K_w \cdot K_v \quad (2)$$

$$N_c = U \cdot Q \cdot (K_h \cdot K_r) \text{ kW} \quad (3)$$

$$Q = s \cdot t \cdot v \quad (4)$$

$$N_c = P_z \times v \text{ (kg m/min)} \quad (5)$$

$$N_c = \frac{P_z \times v}{102 \times 60} \text{ kW} \quad (6)$$

$$N_c = \frac{N_c}{\eta} \quad (7)$$

$$N_c = \frac{P_z \times v}{102 \times 60 \times \eta} \text{ kW} \quad (8)$$



$$M_t = \frac{974 \times N_c}{n} \text{ (kg . m)} \quad (9)$$

Where;  $P_z$  = tangential cutting force,  $U$  = unit power; the power required in kilowatt to remove one  $\text{cm}^3$  of material in one minute,  $Q$  = volume of material removed in  $\text{cm}^3/\text{min}$ ,  $K_s$  = specific cutting resistance at considered chip thickness,  $s$  = feed, in mm per revolution,  $t$  = depth of cut, in mm,  $K_r$  = correction factor for rake angle,  $K_w$  = correction factor for wear,  $K_v$  = correction factor for speed,  $K_h$  = correction factor flank wear,  $K_f$  = correction factor rake angle,  $N_c$  = required power at the tool,  $P_z$  = tangential cutting force,  $v$  = cutting speed in  $\text{m}/\text{min}$ ,  $N_c$  = power of the lathe,  $\eta$  = efficiency (taken as from 0.7 to 0.8),  $M_t$  = Torque,  $n$  = revolution per minute.

Grinding Calculations:

$$T = \frac{TWT}{FR} \quad (10)$$

Where;  $T$  = machining time for cylindrical grinding,  $TWT$  = total wheel travel in mm,  $FR$  = feed rate in  $\text{mm}/\text{min}$

Shaping Calculations;

$$s = \frac{l}{t} \quad (11)$$

$$s = \frac{dl(1+m)}{1000} \quad (12)$$

$$s = \frac{dl}{1000} \quad (13)$$

$$d = \frac{1000}{l(1+m)} \quad (14)$$

$$d = \frac{1000s}{2l} \quad (15)$$

$$t = \frac{ld(1+m)}{1000fs} \quad (16)$$

$$t = \frac{\text{width of work}}{\text{transverse rate} \times \text{nos. of double stroke per min.}} \quad (17)$$

$$m = \frac{\text{cutting time}}{\text{return time}} \quad (18)$$

Where;  $s$  = average cutting speed, in  $\text{m}/\text{min}$ ,  $t$  = time taken in min,  $l$  = length of stroke, in m,  $d$  = stroke speed or double stroke, in cycles/min,  $f$  = feed, in  $\text{mm}/\text{double strokes}$ ,  $m$  = cutting time return ratio

Power And Force Requirements In Milling:

$$P_z = Z_s \cdot K_s \cdot a_s \cdot b \quad (19)$$

$$P_z = \frac{6120N}{v} \quad (20)$$

$$M_t = P_z \times \frac{D}{2} \quad (21)$$

$$N = (U \cdot K_y \cdot K_h) Q \quad (22)$$

$$Z_s = \frac{Z}{360} \phi_s \quad (23)$$

$$a_s = \frac{57.3 S_z}{\phi_s} \times \sin \chi (\cos \phi_1 - \cos \phi_2) \quad (24)$$

$$b = \frac{t}{\sin \chi} \text{ in millimetres} \quad (25)$$

$$Q = \frac{b \cdot t \cdot S_m}{1000} \text{ in cm}^3 / \text{min} \quad (26)$$

$$S_m = S_z \cdot Z \cdot n \text{ in mm / min} \quad (27)$$

Where;  $P_z$  = aggregate tangential force,  $N$  = power at the spindle, in kilowatts,  $M_t$  = torque,  $D$  = diameter of cutter, in mm,  $U$  = unit power in kW / cm<sup>3</sup> / min,  $Q$  = metal removal rate in cm<sup>3</sup> / min,  $v$  = cutting speed, in m/min,  $Z_s$  = number of teeth in simultaneous engagement of work piece,  $Z$  = number of teeth,  $\phi_s$  = angle of contact with work piece in degrees,  $K_s$  = specific cutting force in kgf, corresponding to the given material and chip thickness,  $K_h$  = correction factor for flank wear,  $K_y$  = correction factor for radial rake angle,  $S_m$  = feed,  $a_s$  = average value for chip thickness,  $S_z$  = feed tooth, in mm,  $\phi_1$  = angle subtended at entry of teeth,  $\phi_2$  = angle subtended at exit of teeth,  $b$  = chip width,  $t$  = depth of cut, in mm,  $n$  = rev / min,  $\chi$  = approach angle, in degrees

$$T.D.S. = D - \left(\frac{1}{N}\right) \quad (28)$$

$$T.D.S. = D - P \quad (29)$$

$$t \text{ per feet} = \frac{(D-d) \times 12}{T.L.} \quad (30)$$

$$t \text{ per millimeters} = \frac{(D-d)}{T.L.} \quad (31)$$

$$T.O. = \frac{t \text{ per feet} \times O.L.}{24} \quad (32)$$

$$T.O. = \frac{t \text{ per millimeters} \times O.L.}{24} \quad (33)$$

$$\text{guide bar steover} = \frac{(D-d) \times 12}{T.L.} \quad (34)$$

$$\text{guide bar steover} = \frac{(D-d) \times 12}{T.L.} \times \frac{G.L.}{T.L.} \quad (35)$$

$$\text{milling feed (inch per min.)} = N \times c.p.t \times r \text{ per min.} \quad (36)$$

$$\text{milling feed (millimeters per min.)} = N \times \text{c.p.t} \times r \text{ per min.} \quad (37)$$

$$N(\text{shaper}) = \frac{\text{CS}(\text{feet}) \times 7}{L(\text{inch})} \quad (38)$$

$$N(\text{shaper}) = \frac{\text{CS}(\text{meters}) \times 0.6}{\text{S.L.}(\text{meter})} \quad (39)$$

$$\text{CS} = \text{cutting speed} \quad (40)$$

$$\text{S.L.} = \text{length of stroke} \quad (41)$$

Where; T. D. S. = tap drill size in inches, D = large/major diameter, N= number of threads per diameter, P=pitch, D = large/major diameter, d = small diameter, T. L = taper length, D = large/major diameter, d = small diameter, T. L = taper length, T. O. = tail stock offset, t = taper, O. L. = overall length of work, D = large/major diameter, d = small diameter, T. L. = taper length, G. L. = guide bar length, N= number of teeth in cutter, r=revolutions per minute, c.p.t.= chip per tooth, N= number of teeth in cutter, r=revolutions per minute, c.p.t.= chip per tooth, N= number of strokes per minute

#### Rules And Fromulae For Spur Gears

$$A = \frac{1}{DP} \quad (42)$$

$$CD = \frac{N+n}{2 \times DP} \quad (43)$$

$$CP = \frac{3.1416}{DP} \quad (44)$$

$$Cl = \frac{.357}{DP} \quad (45)$$

$$D = \frac{1.157}{DP} \quad (46)$$

$$DP = \frac{N}{PD} \quad (47)$$

$$DP = \frac{N+2}{OD} \quad (48)$$

$$N = OD \times DP - 2 \quad (49)$$

$$N = PD \times DP \quad (50)$$

$$PD = \frac{N}{DP} \quad (51)$$

$$PD = \frac{N \times OD}{N+2} \quad (52)$$

$$OD = \frac{N+2}{DP} \quad (53)$$

$$T = \frac{1.5708}{DP} \quad (54)$$

$$WD = \frac{2.157}{DP} \quad (55)$$

Where; Addendum =A, Center distance= CD, Circular pitch= CP, Clearance=Cl, Dedendum=D, Diametral pitch =DP, Number of teeth =N, Number of teeth =N, n=number of teeth smaller gear, Pitch diameter =PD, Pitch diameter =PD, Outside diameter =OD, Tooth thickness=T, Whole depth= WD

Determination Of Auxillary Angles (Rake Angle and Clearance Angle)

$$\tan \gamma_x = \sin \chi \tan \alpha - \cos \chi \tan \lambda \quad (56)$$

$$\tan \gamma_y = \cos \chi \tan \alpha + \sin \chi \tan \lambda \quad (57)$$

$$\cot \alpha_x = \sin \chi \cot \alpha - \cos \chi \tan \lambda \quad (58)$$

$$\cot \alpha_y = \cos \chi \cot \alpha + \sin \chi \tan \lambda \quad (59)$$

$$\text{approach angle} = 90 - \text{side cutting edge angle} \quad (60)$$

$$\tan \mu = \frac{s}{\pi D} \quad (61)$$

Where;  $\lambda$  = side rake angle,  $\chi$  = approach angle,  $\gamma_x$  = rake angle perpendicular to the tool shank,  $\gamma_y$  = rake angle parallel to the tool shank,  $\alpha_x$  = clearance angle perpendicular to the tool shank,  $\alpha_y$  = clearance angle parallel to the tool shank,  $s$  = feed per revolution,  $D$  = diameter of work piece,  $\mu$  = helix angle of the surface of cut

Non -Traditional Machining Process Calculations

$$b_r = \frac{\text{vol. of material removed from work}}{\text{vol. of material eroded from tool}} \quad (62)$$

$$D = \frac{4P}{\pi f^2 \theta^2 T} \quad (63)$$

$$C = K \frac{P}{E A \tau_1} \quad (64)$$

Where;  $b_r$  = wear ratio ultrasonic machining,  $D$  = power density,  $W/cm^2$ ,  $f$  = focal length of lens,  $\theta$  = beam divergence, radian,  $T$  = laser pulse duration, sec,  $P$  = laser energy output,  $W$ ,  $C$  = cutting rate, mm/min,  $K$  = constant characteristic of the material and the conversion efficiency of laser energy into the material, mm/min.,  $P$  = laser power incident on surface,  $W$ ,  $E$  = vaporization energy of material,  $W/mm^3$ ,  $\tau_1$  = thickness of material, mm,  $A$  = area of laser beam at focal point,  $mm^2$

(Adejuyigbe, 2007, Bangalore, 1980, Kareem, 2004, Fasan, 2007 and Krar et. al, 1995).

### 3.2.2.1 Johnson's Algorithm For Scheduling Operations

The scheduling activity is one of the most complex tasks in operations management. Schedulers must deal with several different types of resource simultaneously (Slack, *et al.*, 2004). Although available job-sequencing algorithms optimize one or more measures of schedule performance, they utilize a restrictive set of assumptions, such as constant processing times, no passing of jobs, no lot splitting, etc. The common  $m$  by  $n$  machine-scheduling problem where  $m$  is the number of machines and  $n$  is the number values of jobs. Has been solved for  $m = 1,2,3$  and arbitrary values of  $n$ . Efficient algorithms have not been developed for  $m \geq 4$  because of the extremely large number of possible outcomes. However, satisfactory heuristics which seem to develop passable solutions for any values of  $m$  and  $n$  are available. The algorithm for solving this problem was developed by S.M. Johnson in 1954 and it has been called the left-hand-right-hand rule by Woolsey in 1975 (Schroeder, 1985). Johnson's algorithm provides one of such methods for the  $m$  by  $n$  machine-scheduling problem. It constructs a schedule which minimizes the maximum flow time for a two machine flow shop. The algorithm tries to push products with the shortest possible times to the first machine (machine 1) as close to the beginning of a sequence as possible, so that the first job will be available as soon as possible for machine 2 to start work. The algorithm further attempts to push jobs with the shortest processing times on to machine 2 as near to the end of the schedule as possible. This is to reduce the time that machine 1 is left idle having completed its schedule, compared to the time that machine 2 takes to complete its schedule (Browne *et al.*, 1996)

Johnson's algorithm also provides the means to determining the shortest paths between all pairs of vertices in a sparse directed graph. It functions utilizing the Bellman-Ford algorithm to compute a transformation of the input graph that removes all negative weights, allowing Dijkstra's algorithm to be used on the transformed graph.

According WIKIPEDIA,2009, it is named after Donald B. Johnson, who published the technique in 1977. This software, though, restricts its application to simple machining operations scheduling

#### For a Case of Two Machines, N Parts:

Part  $P_i$  has two operations, of duration  $P_{i1}$ ,  $P_{i2}$ , to be done on Machine M1, M2 in that sequence.

Step 1. List A = { 1, 2, ..., N }, List L1 = {}, List L2 = {}.

Step 2. From all available operation durations, pick the minimum.

If the minimum belongs to  $P_{k1}$ ,

Remove K from list A; Add K to end of List L1.

If minimum belongs to  $P_{k2}$ ,

Remove K from list A; Add K to beginning of List L2.

Step 3. Repeat Step 2 until List A is empty.

Step 4. Join List L1, List L2. This is the optimum sequence.

Let's see this with the help of another example,

Table 3.1; Johnson's Algorithm Principle For 2 Machines And N Parts

	Parts					
Machine	P1	P2	P3	P4	P5	P6
M1	6	10	4	7	6	5
M2	4	8	9	2	3	6

Step 1.

$A = \{ 1, 2, 3, 4, 5, 6 \}$ ,  $L1 = \{ \}$  and  $L2 = \{ \}$

Step 2.1.

Shortest job is  $P_{42}$ ; Remove Part 4 from list A, and add Part 4 to beginning of list L2

$A = \{ 1, 2, 3, 5, 6 \}$ ,  $L1 = \{ \}$ ,  $L2 = \{ 4 \}$

Step 2.2.

Of remaining parts, shortest operation is  $P_{52}$ , Remove Part 5 from A; Add Part 5 to beginning of List L2.

$A = \{ 1, 2, 3, 6 \}$ ;  $L1 = \{ \}$ ,  $L2 = \{ 5, 4 \}$ .

Step 2.3.

Now, there are two shortest remaining operations:  $P_{12}$ ,  $P_{31}$ . Since they are on different machines, we can randomly pick either; If both choices are on machine 1, pick the one with the longer operation 2 first; If both are on machine 2, pick the one with the longer operation 1 first. We select (randomly) Part 1. Remove Part 3 from list A, add Part 3 to end of List L1.

$A = \{ 1, 2, 6 \}$ ,  $L1 = \{ 3 \}$ ,  $L2 = \{ 5, 4 \}$

Step 2.4.

Shortest remaining operation is  $P_{12}$ , so we remove Part 1 from List A, and add it to beginning of List L2.

$A = \{ 2, 6 \}$ ,  $L1 = \{ 3 \}$ ,  $L2 = \{ 1, 5, 4 \}$

Step 2.5.

Shortest remaining operation is  $P_{61}$ ; Remove Part 6 from A, add to end of List L1.

$A = \{ 2 \}$ ,  $L1 = \{ 3, 6 \}$ ,  $L2 = \{ 1, 5, 4 \}$

Step 2.6.

Shortest remaining operation is  $P_{22}$ . Remove Part 2 from A, add to beginning of L2.

$A = \{ \}$ ,  $L1 = \{ 3, 6 \}$ ,  $L2 = \{ 2, 1, 5, 4 \}$

Step 3. List A is exhausted. Join L1 and L2, to get the optimum sequence:

$\{ 3, 6, 2, 1, 5, 4 \}$ .

### For a Case of Multiple Machines

Johnson's method only works optimally for two machines. However, since it is optimal, and easy to compute, some researchers have tried to adopt it for  $M$  machines, ( $M > 2$ .) The idea is as follows: Imagine that each job requires  $m$  operations in sequence, on  $M_1, M_2 \dots M_m$ . We combine the first  $m/2$  machines into an (imaginary) Machining centre, MC1, and the remaining Machines into a Machining Centre MC2. Then the total processing time for a Part  $P$  on MC1 = sum( operation times on first  $m/2$  machines), and Processing time for Part  $P$  on MC2 = sum( operation times on last  $m/2$  machines).

	Time for each other to be processed (mins)		
	Machine Centre 1	Machine Centre 2	
A	60	46	5th
B	1st ← 35	65	
C	65	58	4th
D	57	40	6th
E	2nd ← 50	60	
F	3rd ← 53	70	

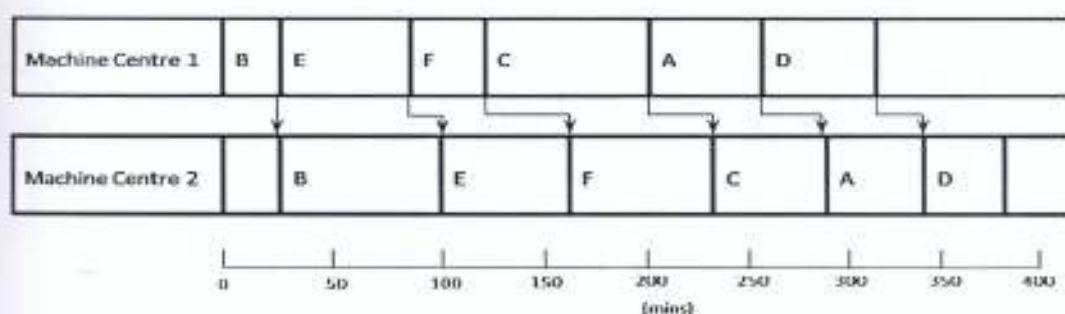


Figure 3.20: Application of Johnson's Rule for Scheduling  $n$  Jobs through two Work centres  
Source; Slack et, al., 2004.

Since the choice to combine the first  $m/2$  machines into a machining centre is purely arbitrary, it is acceptable to break (partition) the list  $\{ 1, 2, \dots, M \}$  at any point to generate the imaginary Machining centres. Some researchers have suggested a method that involves trying several different alternatives, tests the sequence resulting from each option through Gantt

charts, and picks the best option from among these choices.

An important restriction of the Johnson's method, is that it only works when each workpiece has the same set of machines to visit, in the same sequence. Clearly, this is an important restriction. In practical conditions, Johnson's method is most useful in scheduling operations for a family of parts within a group (since most parts of a family require similar processing) - and hence its use in Group Technology

The Module in the Software attempts to provide a platform for dealing with n-jobs and m-machines. Figures 3.21a, b and c show the detailed Flow Chart developed based on Johnson's Algorithm for Scheduling Machining Operations, used in the software.

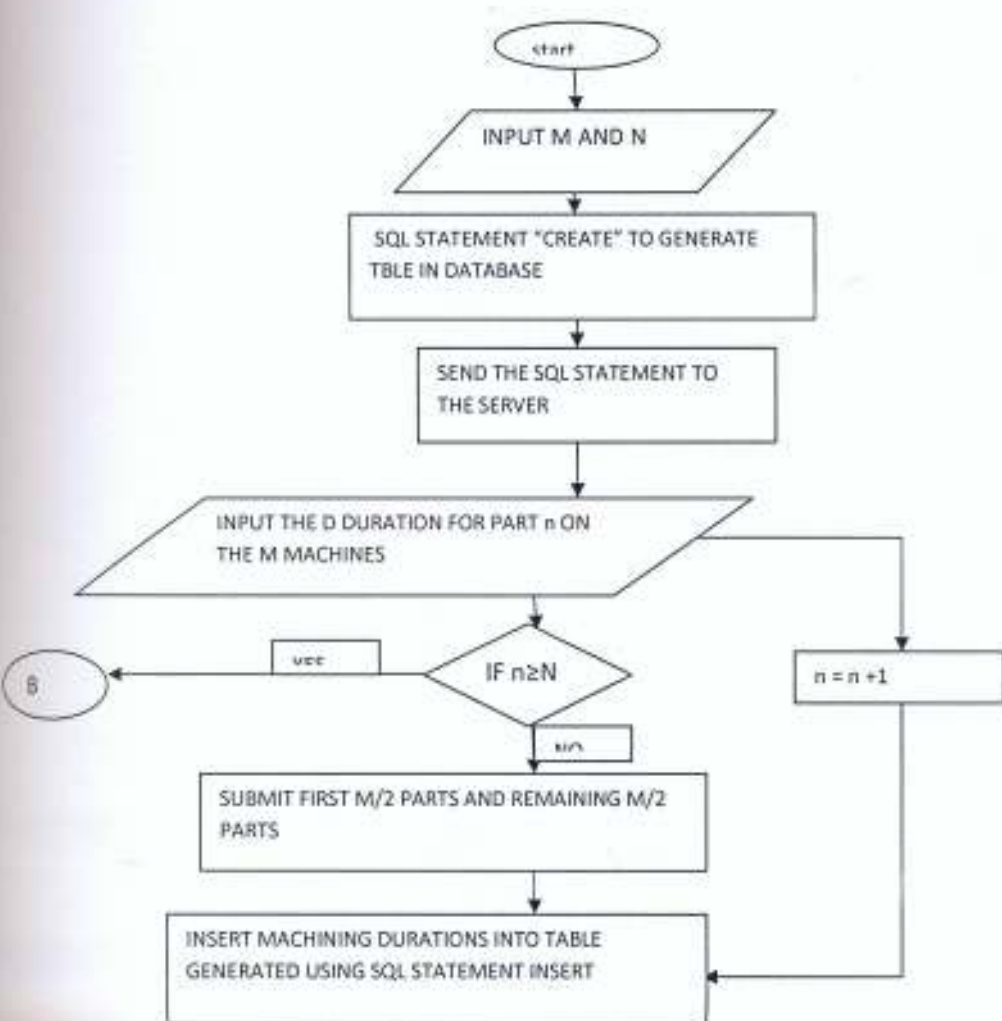


Figure. 3.21a; Flow Chart Based on Johnson's Algorithm for Scheduling Machining Operations.

Source; The Research

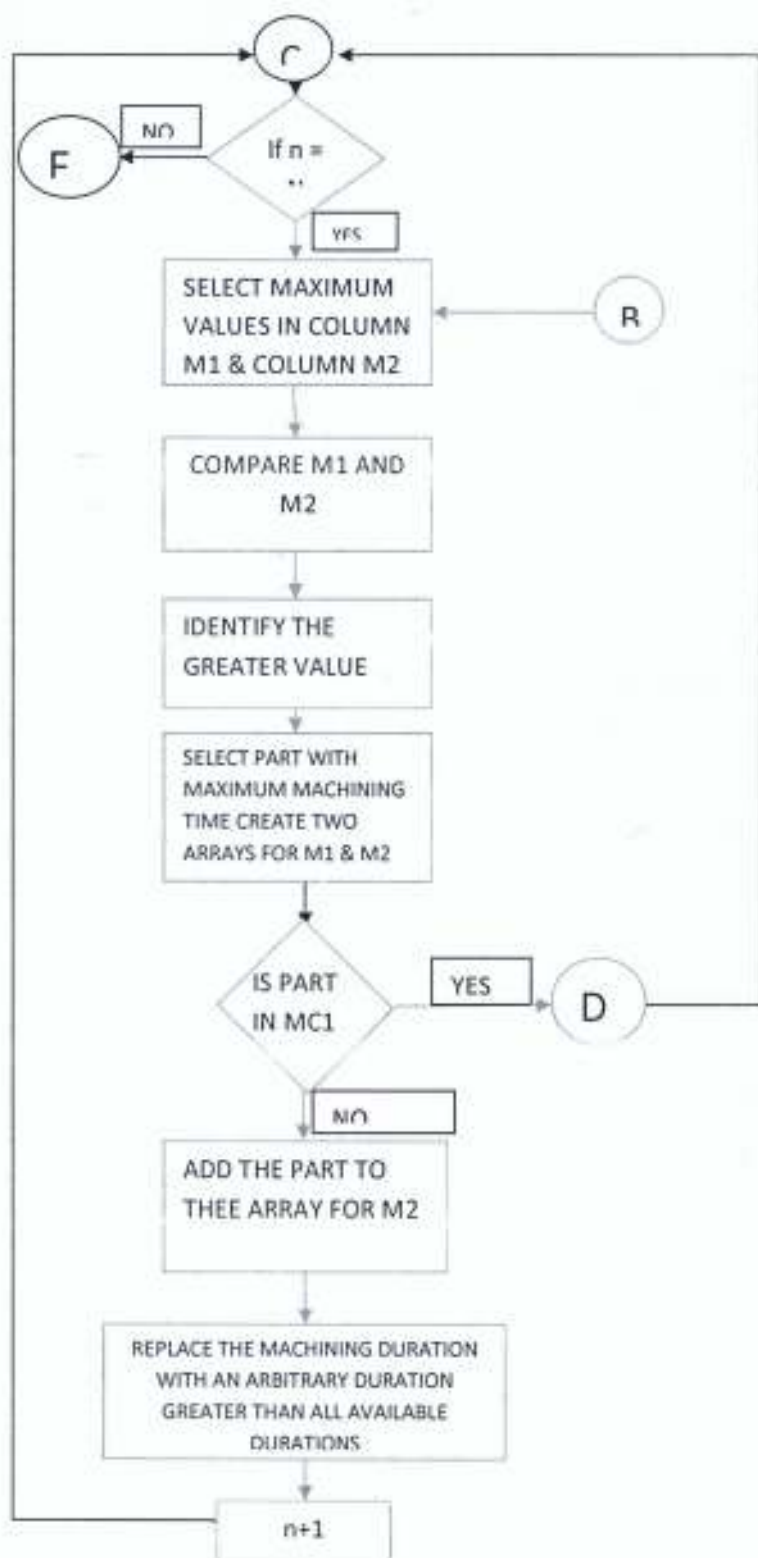


Figure. 3.21b; Flow Chart Based on Johnson's Algorithm for Scheduling Machining Operations.

Source; The Research

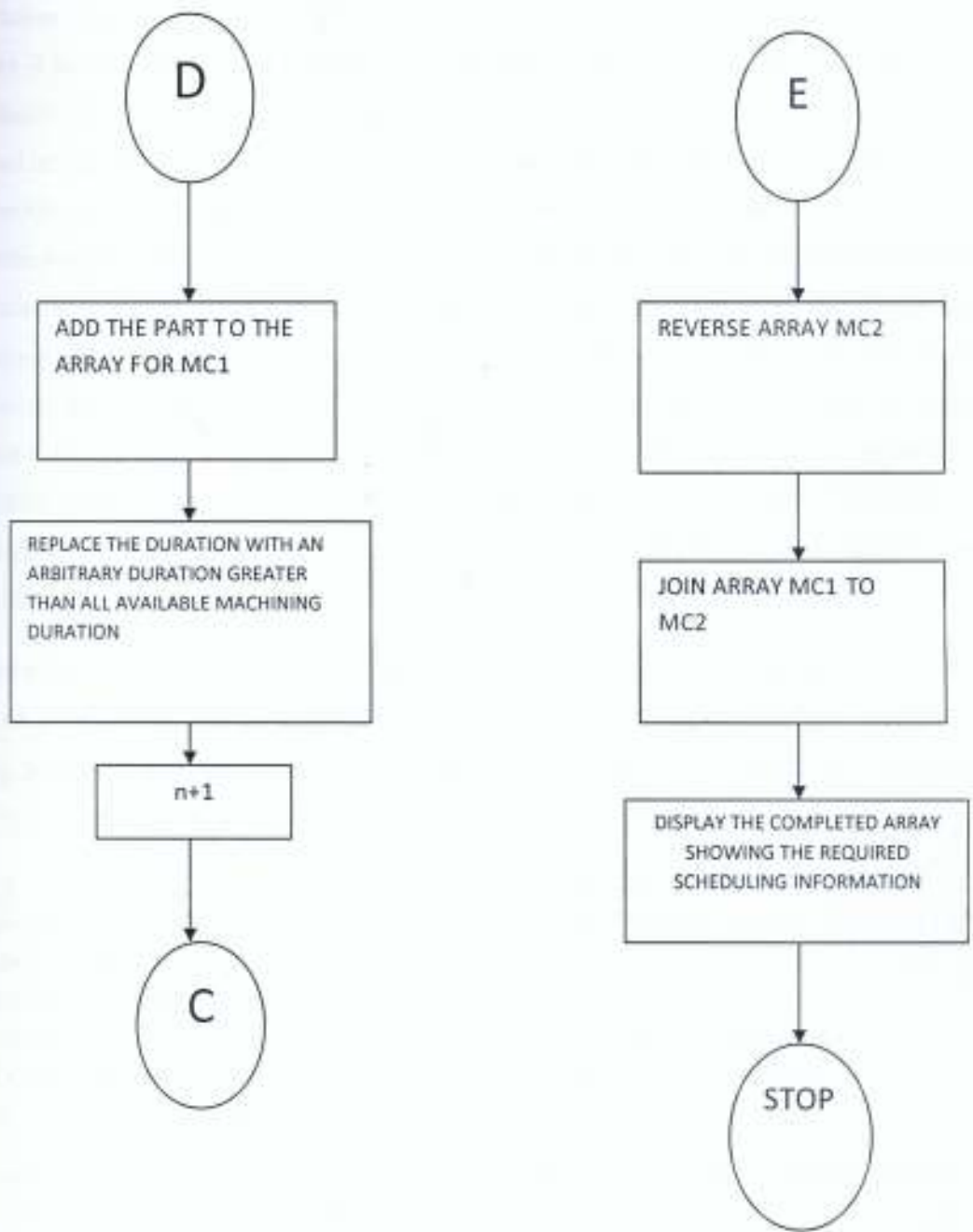


Figure. 3.21c; Flow Chart Based on Johnson's Algorithm for Scheduling Machining Operations (Source; The Research)

### 3.2.2.2 Machine Depreciation

Depreciation is a measure of the gradual certain wear out of fixed assets in this context reference is being made to plant machinery and equipment, buildings and other fixed assets in the industry. All fixed assets have a useful economic life; thus they reach a given period estimated or certain, when these assets require replacement. The setting of an annual charge to the profit and loss accounts for the calculated depreciation values. Level profit available for distribution to establishment shareholders is reduced and the funds are retained (ploughed back) into the business or employed for equipment replacement. The institute of cost and management Accountants lists nine methods of calculating depreciation. The choice of depreciation method is dependent on convenience, and the effect of prevailing tax laws. Common methods include Straight-line or linear depreciation, Reducing balance method of depreciation. (Dakland *et. al*,1992). The module deals with the Annual Rate of Depreciation method and the Sum-of-digits method. Which are more commonly used by engineering organizations.

A Paired t Test (Hershon and Weiss, 1989 and Taha, 1989) was carried out to compare the results of a manually calculated 10-year estimated useful life, with results generated by utilizing Software. This method was chose due to its simplicity in comparing calculated results for any significant difference in the means.

#### 3.2.2.2.1 Sum of Digits Method for Calculating Machine Depreciation

GIVEN= COST PRICE (CP), ESTIMATED SELLING PRICE (ESP), ESTIMATED USEFUL LIFE (N),

REQUIRED= DEPRECIATION CHARGES (DC),

**Determine the depreciation charges (DC) for each year of useful life;**

Depreciation charge for year 1 =  $(CP - ESP) * N / \{N + (N-1) + (N-2) + (N-3) + (N-4) + (N-5) + \dots + (N-(N-1))\} = DC1$

Depreciation charge for year 2 =  $(CP - ESP) * (N-1) / \{N + (N-1) + (N-2) + (N-3) + (N-4) + (N-5) + \dots + (N-(N-1))\} = DC2$

Depreciation charge for year 3 =  $(CP - ESP) * (N-3) / \{N + (N-1) + (N-2) + (N-3) + (N-4) + (N-5) + \dots + (N-(N-1))\} = DC3$

Depreciation charge for year N =  $(CP - ESP) * \{N-(N-1)\} / \{N + (N-1) + (N-2) + (N-3) + (N-4) + (N-5) + \dots + (N-(N-1))\} = DCN$

**Determine total depreciation charges (TDCN) for the useful life:**

$TDCN = DC1 + DC2 + DC3 + DC4 + \dots + DCN$

### 3.2.2.2.2 Annual Rate of Depreciation Method (Declining Balance Method) for Calculating Machine Depreciation

GIVEN = COST PRICE (CP), ESTIMATED SELLING PRICE (ESP), ESTIMATED USEFUL LIFE (N),

REQUIRED= DEPRECIATION CHARGES (DC):

**Determine the rate of depreciation (R) for the given useful life:**

$$R = 1 - \left( \frac{\text{Estimated Selling Price}}{\text{Cost price}} \right)^{\frac{1}{\text{Estimated Useful life}}}$$

**Determine the depreciation charges (DC) for each year of useful life:**

$$\text{Annual depreciation charge for year 1} = R * CP = DC_1$$

$$\text{Annual depreciation charge for year 2} = R * (CP - DC_1) = DC_2$$

$$\text{Annual depreciation charge for year 3} = R * (CP - DC_1 - DC_2) = DC_3$$

$$\text{Annual depreciation charge for year 4} = R * (CP - DC_1 - DC_2 - DC_3) = DC_4$$

$$\text{Annual depreciation charge for year 5} = R * (CP - DC_1 - DC_2 - DC_3 - DC_4) = DC_5$$

$$\text{Annual depreciation charge for year N} = R * (CP - DC_1 - DC_2 - DC_3 - DC_{N-1}) = DC_N$$

**Determine total depreciation charges (TDCN) for the useful life**

$$TDCN = (DC_1 + DC_2 + DC_3 + DC_4 + \dots + DC_N)$$

## RESULTS AND DISCUSSION

## 4.1 The Auxiliary Machining Module

The functioning auxiliary module can be broadly broken into; the graphic user interface, the Microsoft structured query language server and the C-sharp programming codes () behind the operating files. Each of these components of the functioning system interact and are related through the performance of expected functions as shown in Figure 4.1 below.

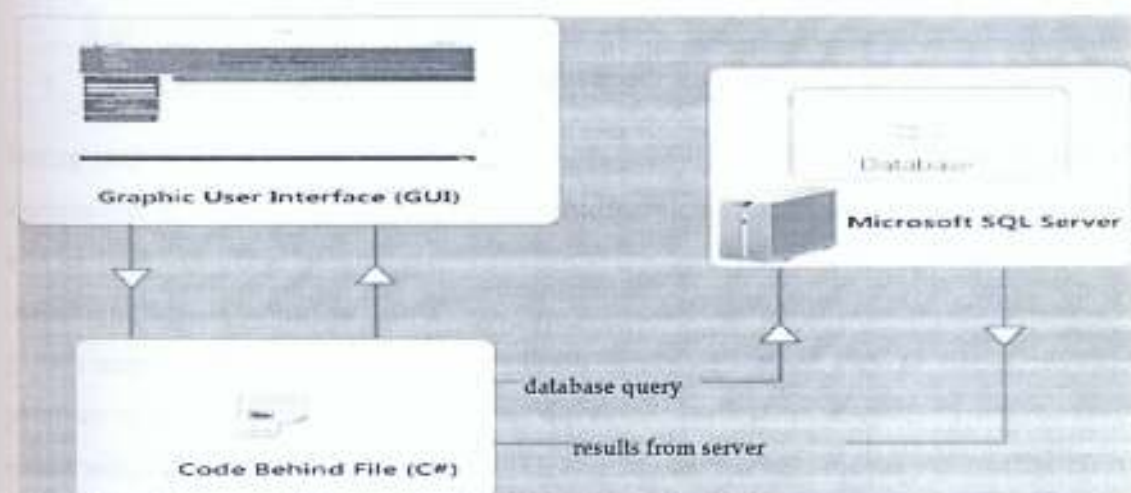


Figure 4.1: Functional Schematics of the Developed Module

The user interface of the module provides an interactive platform for the machinist to input the following information about each machine operation:

1. Machine tool operation
2. Job or work piece material,
3. Tool material,
4. Available data on cutting conditions,
5. Other information required

The software was able to search the required locations within the cutting conditions database and/or other relevant portions of its database and provided in easily understandable format, specific data further required for the successful and accurate machining operation at hand.

#### 4.1.1 Implementation Of The Developed Module

Query commands simulating real life and time applications were utilized as seen in the figures 4.3 – 4.25. The process of searching for data in the database and display on the user interface is as follows:

- The user is prompted to choose what machining operation is to be done and what kind of data is requested
- The application reads the user input and converts it to an SQL code using C-sharp.
- The SQL (structure query language)code generated is sent to the database and a result is generated as a result of the query.
- The results are returned to the application and it is displayed on the user interface.

Testing and implementation of the developed software was carried out on computer workstations with the following specifications; Hewlett-Packard 32-bit operating system with an Intel Core Duo processor of 1.67GHz and memory of 2G,Hewlett-Packard 32-bit operating system with an Intel Core Duo processor of 2.0GHz and random access memory (RAM) memory of 3G, Hewlett-Packard 32-bit operating system with an Intel Core Duo processor of 2.2GHz and random access memory (RAM) of 3G and ASUS 32-bit operating system with an Intel Atom Processor of 1.6 GHz and random access memory (RAM) of 1G. Integrity of results was complied with available machine tools data and confirming for strict adherence (Appendix 2). The interface was designed predominantly in blue for user ergonomic considerations.

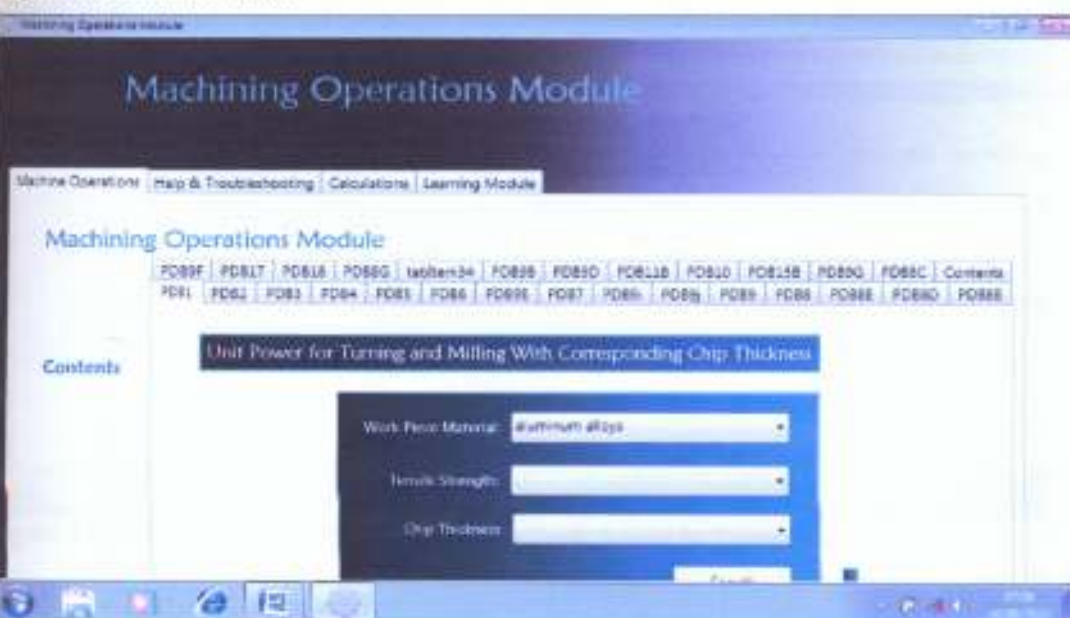


Figure 4.2: Interface for Determining Unit Power for Machining.

The Auxiliary Machining Module is composed of 3 major sub-modules as seen in figure 4.2;

- the Machine Operations Sub-Module,
- the Help and Troubleshooting Sub-Module and,
- the Machine Operations Calculations Sub-Module.

The extreme left tab on the interface ensures high ease of upgrading the software. The developed module has the capability of receiving into each table in the database via a simple interface new and relevant machining operations information.

#### 4.1.2 The Machine Operations Sub-Module

Within the machine operations sub-module, is embedded the Cutting Conditions Database; this consists of a compilation and systematic documentation of primary, secondary and tertiary machining operations data and the compilation and documentation of Cutting Conditions for Non-Traditional Machining Operations.

The Machine Operations Sub-Module is powered by database of values for different Machining Operations in the Workshop. The application performs queries to the database and displays the requested data on the interface as shown in figures 4.3 – 4.17. A Microsoft Structure Query Language (MSSQL) database hosted on a Microsoft SQL Server 2005 Express was used in this application.

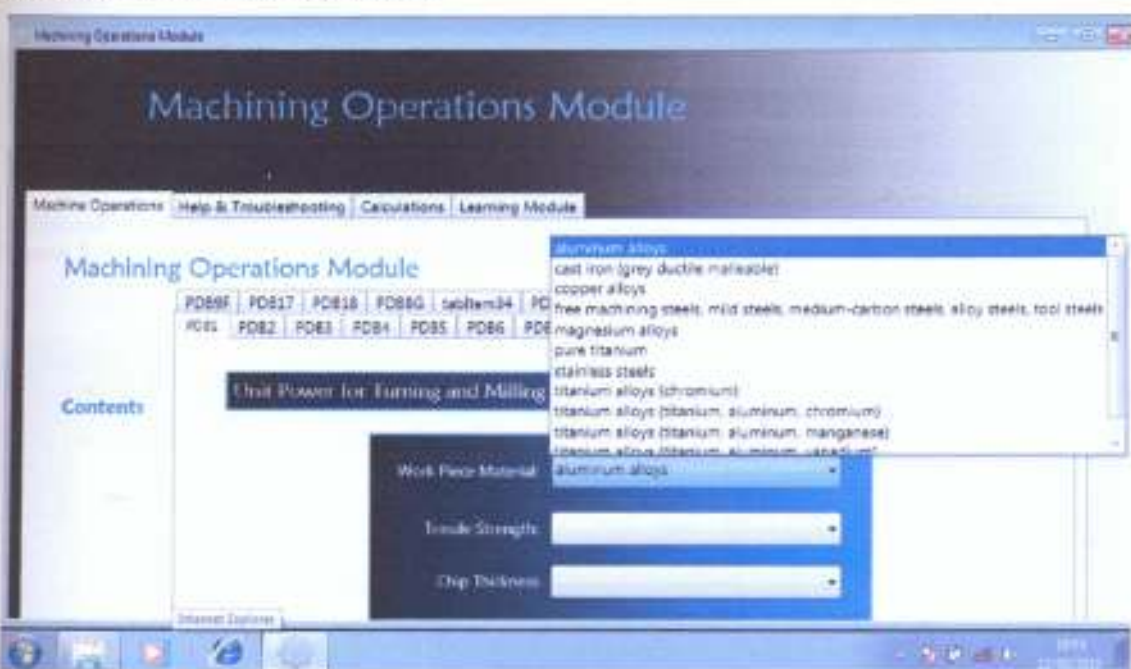


Figure 4.3: Interface for Material Selection, Unit Power in Turning and Milling

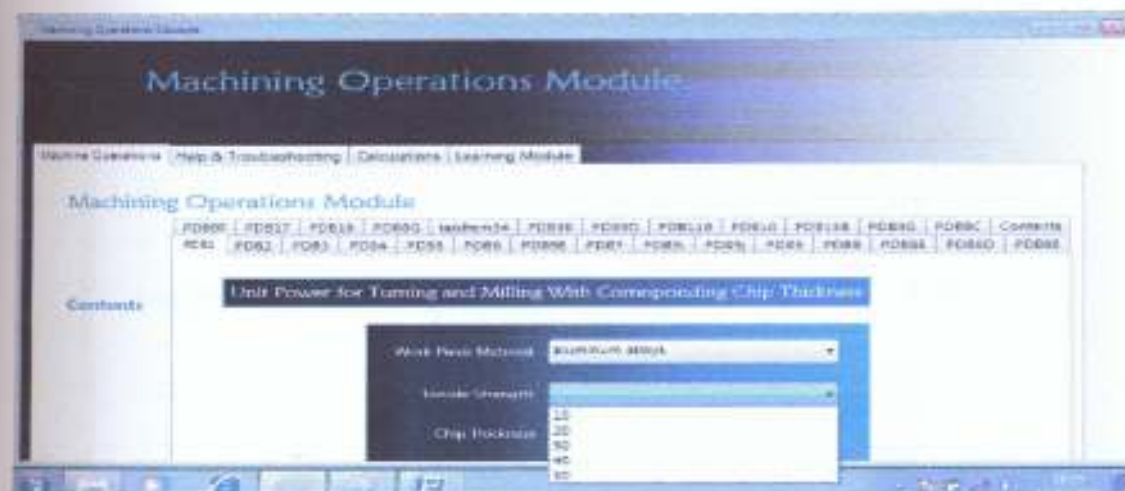


Figure 4.4: Interface for Determination of Tensile Strength of Work Piece Material in Turning and Milling

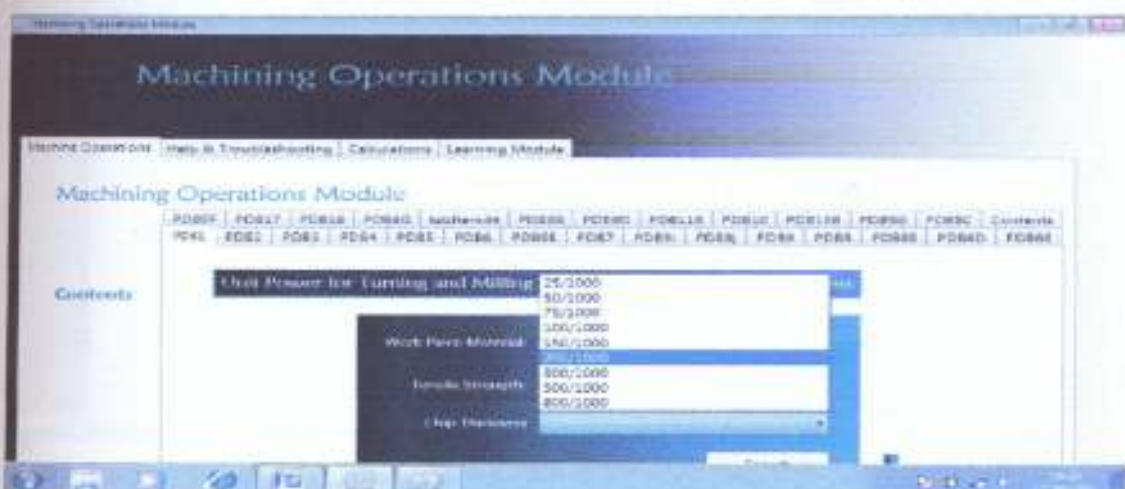


Figure 4.5: Interface for Selecting Specific Chip Thickness in Turning and Milling

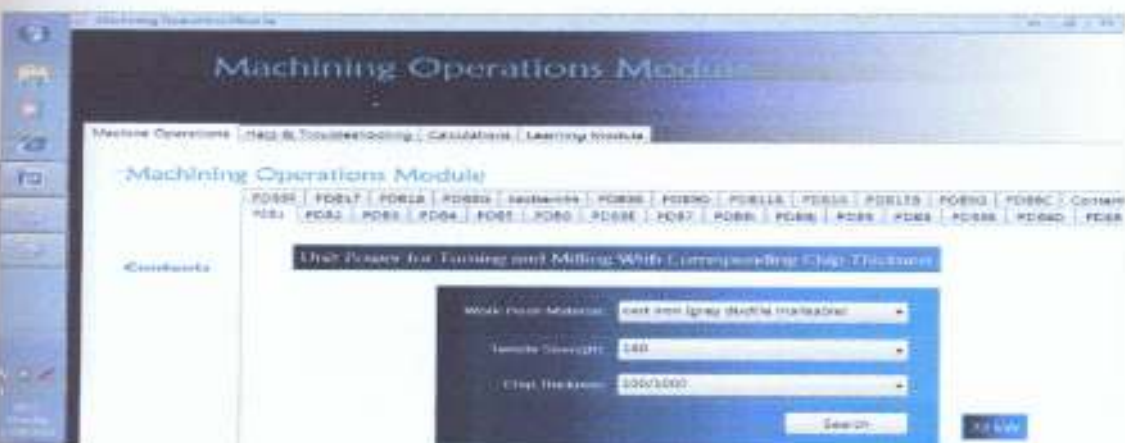


Figure 4.6: Interface of Result: Unit Power Required For Turning and Milling.

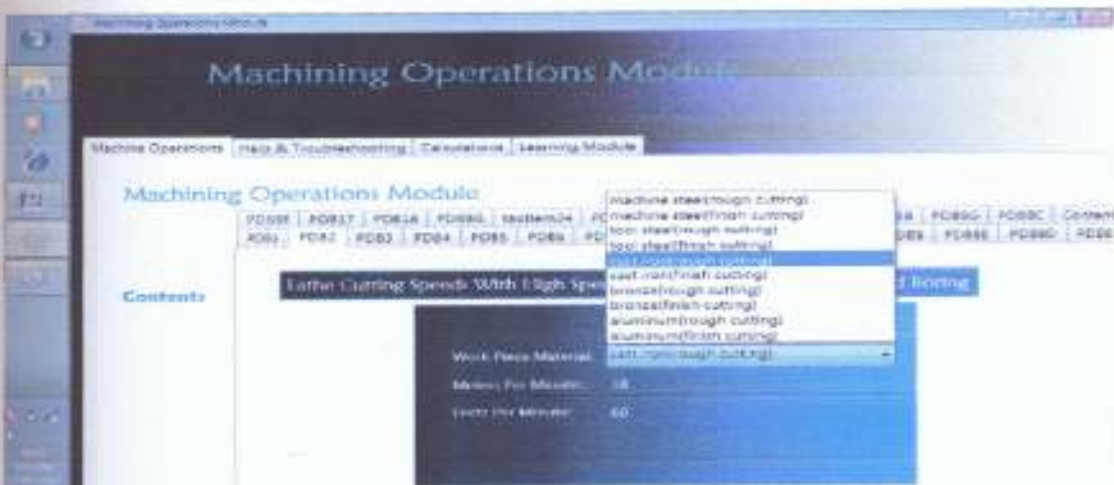


Figure 4.7: Interface for Selection of Workpiece Material in Turning and Boring.

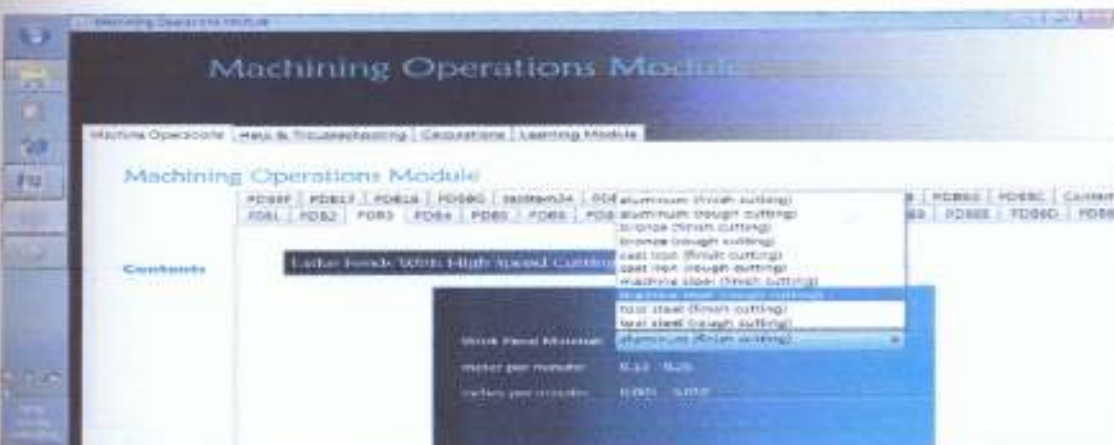


Figure 4.8: Interface for Selecting Recommended Cutting Conditions in High Speed Cutting



Figure 4.9: Interface for Selecting Tool Material and Determining Cutting Conditions in Turning.

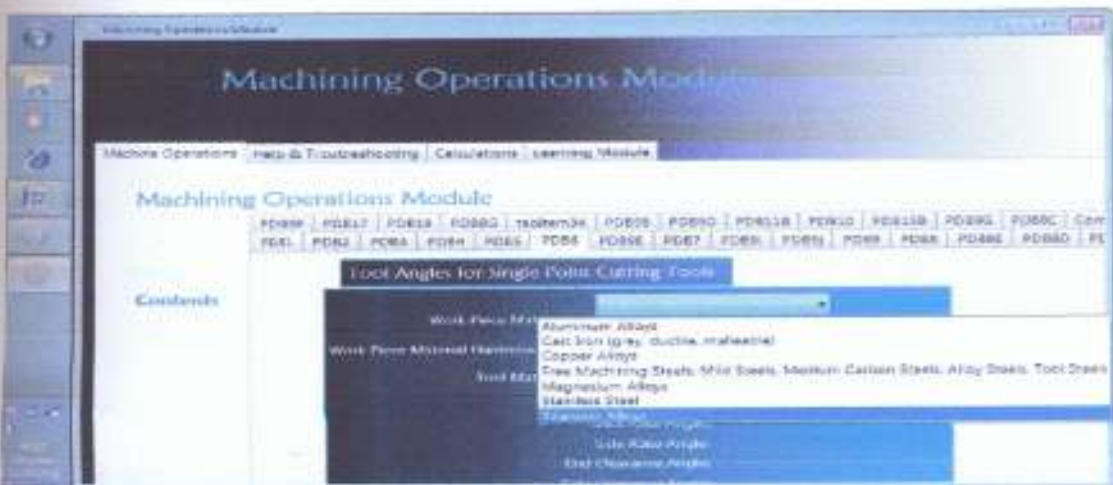


Figure 4.10: Interface for Selecting Workpiece Material in Determining Single Point Cutting Tools Angles

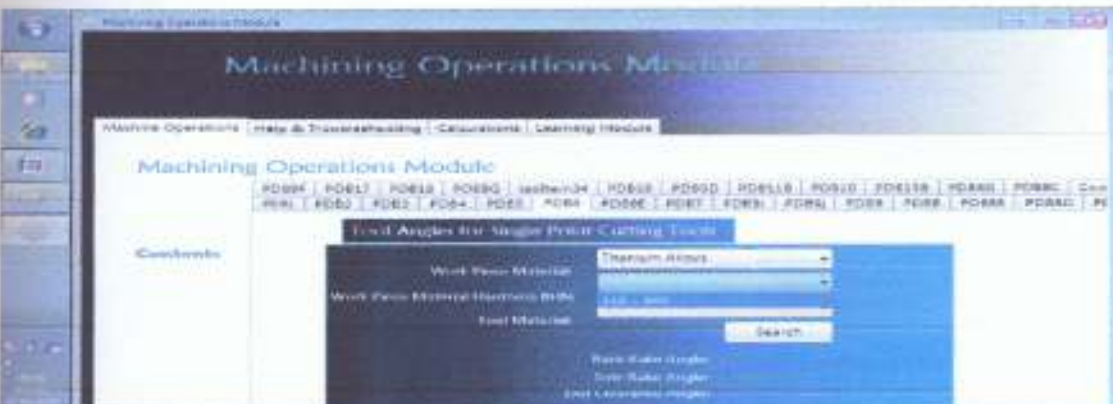


Figure 4.11: Interface for Selecting Workpiece Material Hardness in Determining Single Point Cutting Tools Angles.



Figure 4.12: Interface for Selecting Tool Material in Determining Single Point Cutting Tools Angles.

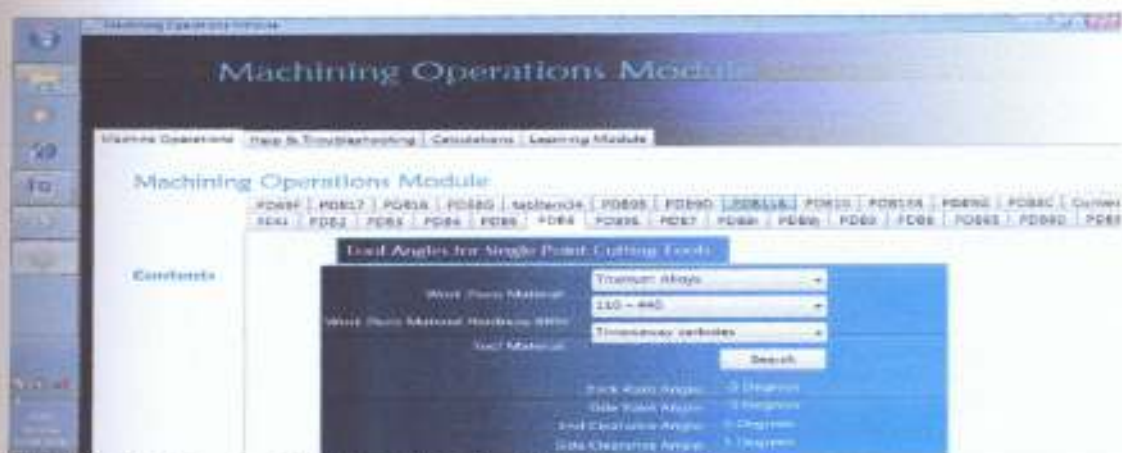


Table 4.13: Interface for Single Point Cutting Tools Angles' Results.

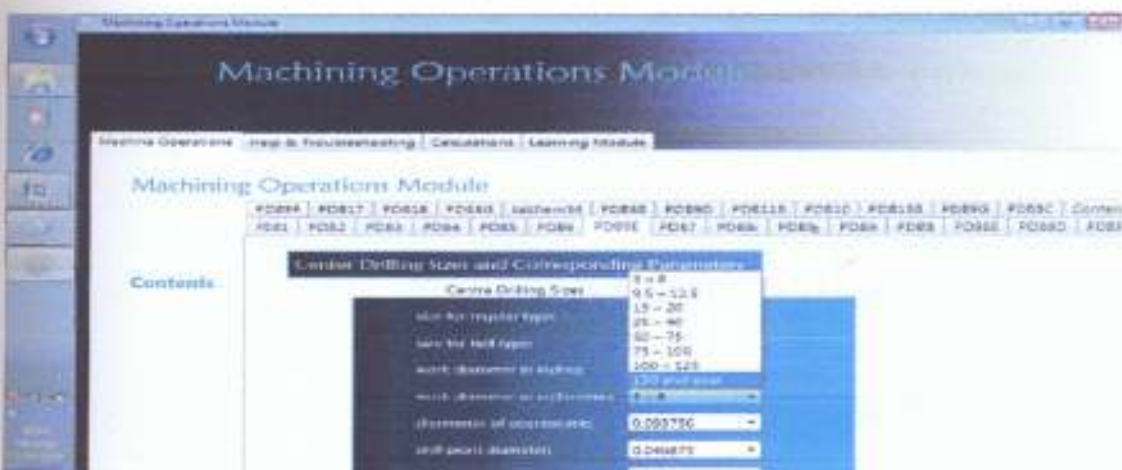


Figure 4.14: Interface for Drilling Parameters.

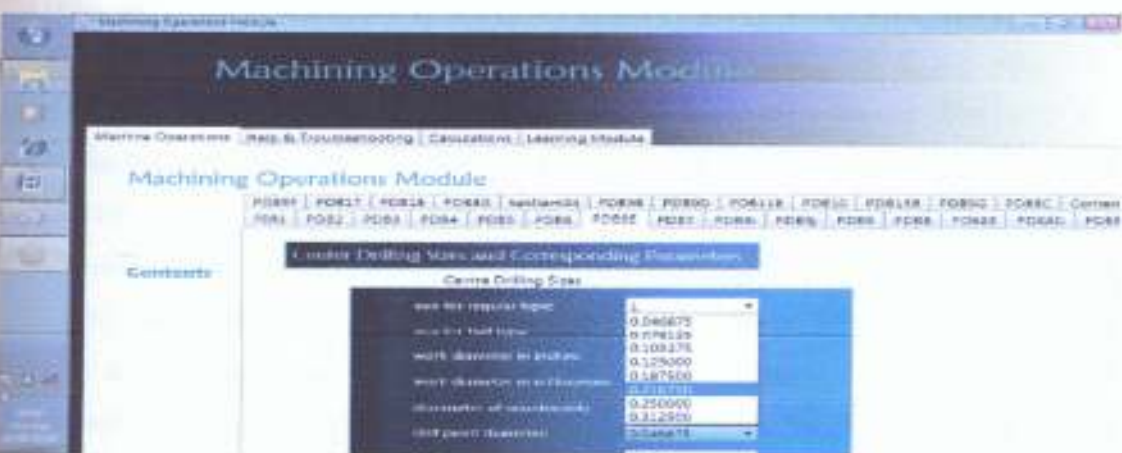


Figure 4.15: Interface for Selecting Drill Point Diameter in Determining Drilling Parameters.

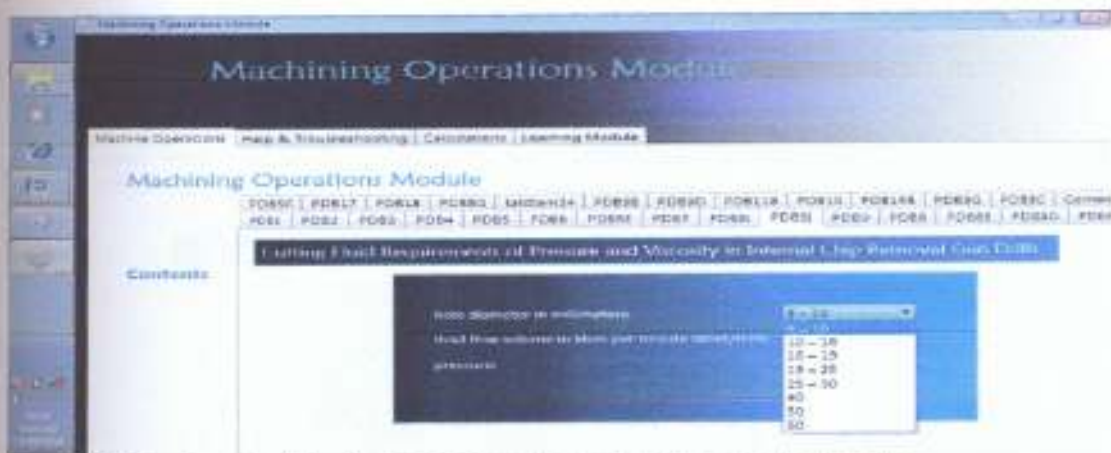


Figure 4.16: Interface for Selecting Hole Diameter and Lubricating Parameters.



Figure 4.17: Interface for Selecting Lubricating Parameters in Drilling.

### 4.1.3 The Help and Troubleshooting Sub-Module

The Help and Troubleshooting Sub-Module as seen in figure 4.18 consists of a machining operations trouble shooting guide; of likely problems encountered during machining operations, probable causes of these problems and recommended solutions. The Help and Troubleshooting Sub-Module, functions in a similar way to the Machining Operations Sub-Module. The user is prompted to select a type of Machining Operation and the problem that is being encountered and in a similar way to the Machining Operations Sub-Module, the application creates an SQL query from the selection and sends it to the MSSQL Server Database and the results are returned from the database is displayed as the solution or recommendation to the problems encountered. Results from the Implementing of the developed module are shown in figures 4.19 – 4.25 .

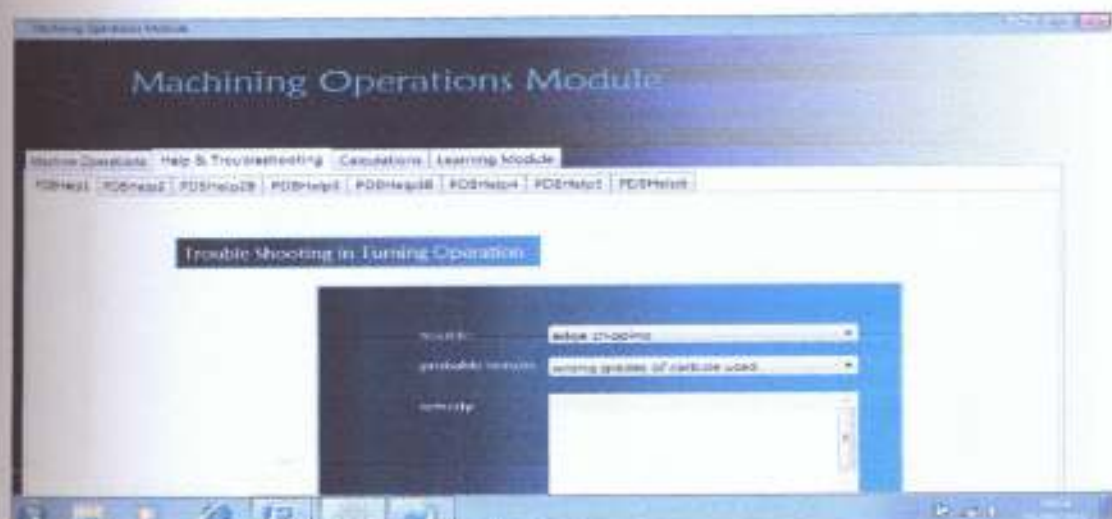


Figure 4.18: Interface of The Help Sub-Module.

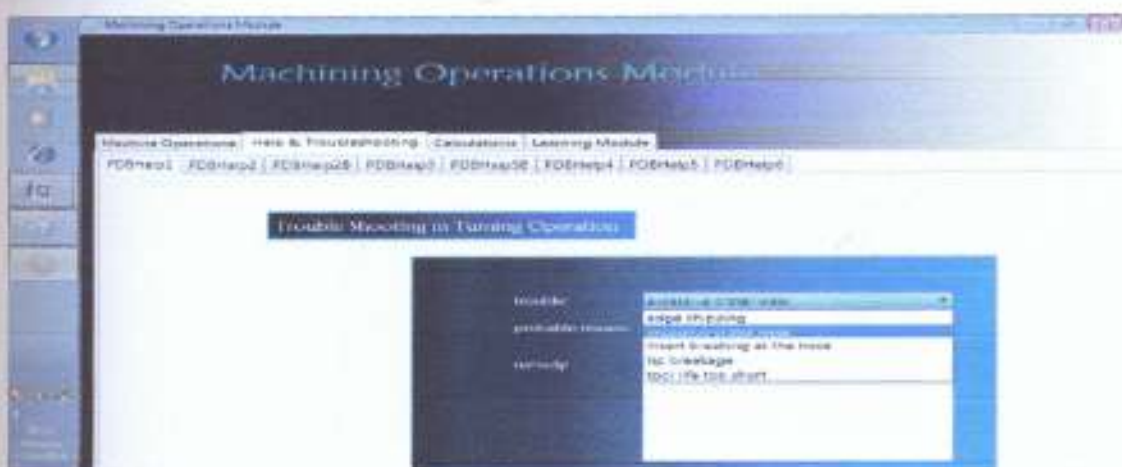


Figure 4.19: Interface Showing Trouble Shooting Query: Turning Operation.

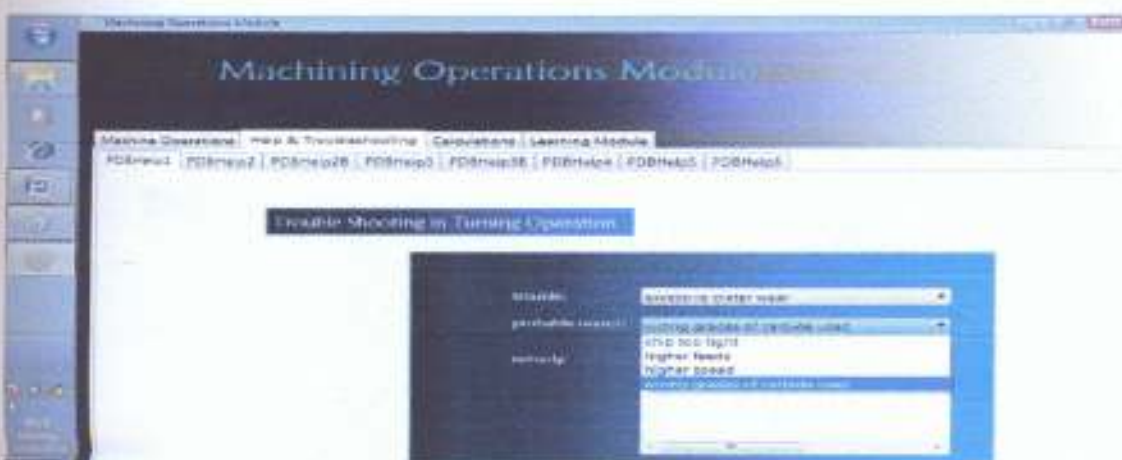


Figure 4.20: Interface Showing Response to Query.

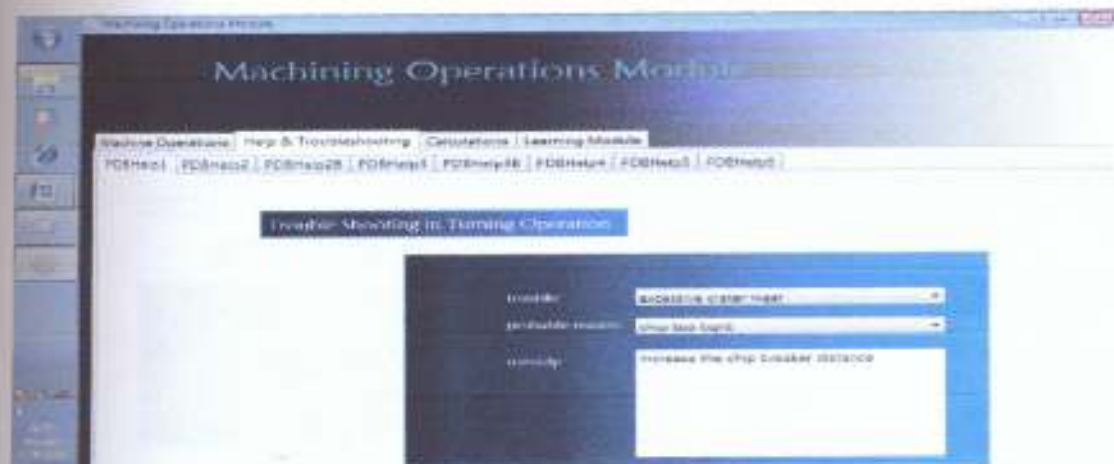


Figure 4.21: Interface Showing Recommendation.

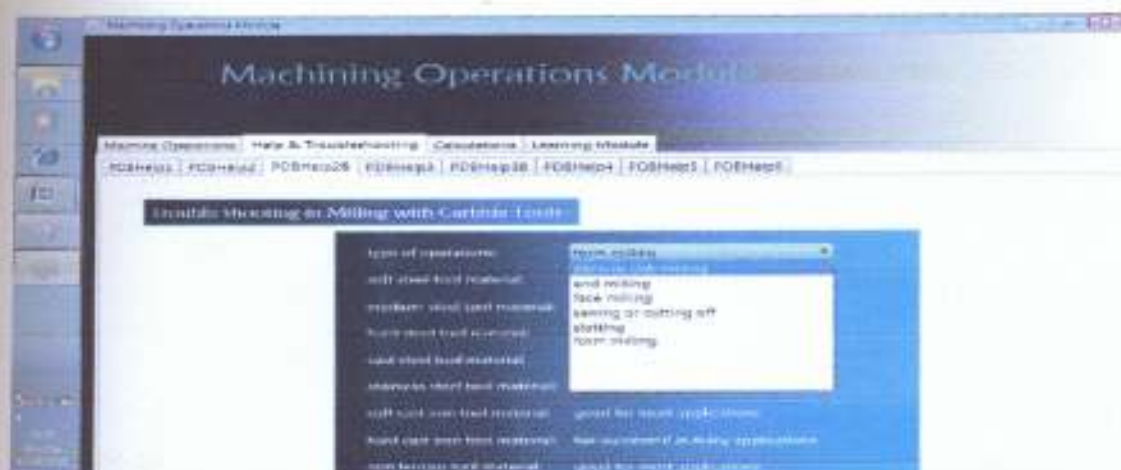


Figure 4.22: Interface Showing Trouble Shooting in Milling Operation

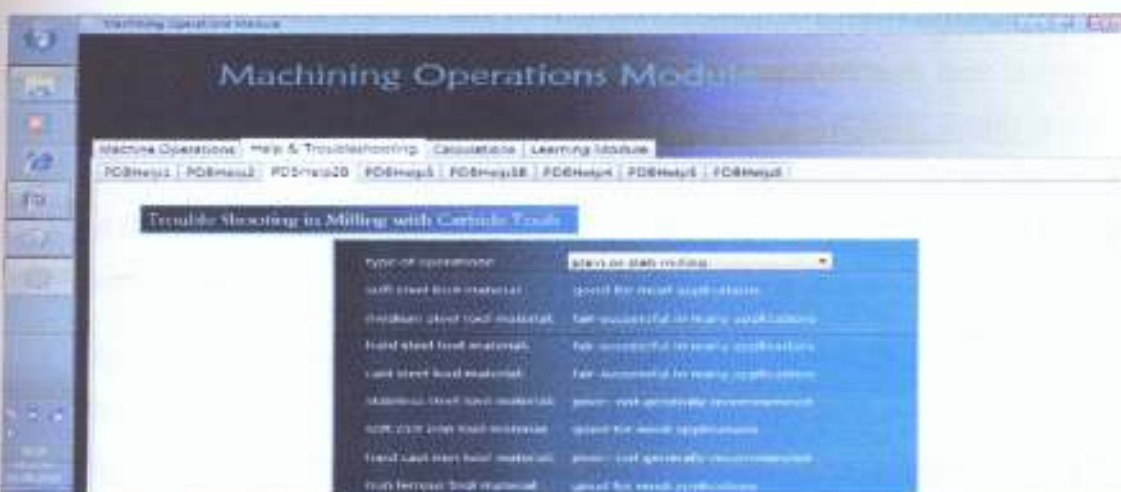


Figure 4.23: Interface Showing Trouble Shooting in Milling Operation: Recommendation.



Figure 4.24: Interface for Machining Calculations: Determining Spur Gear Centre Distance.

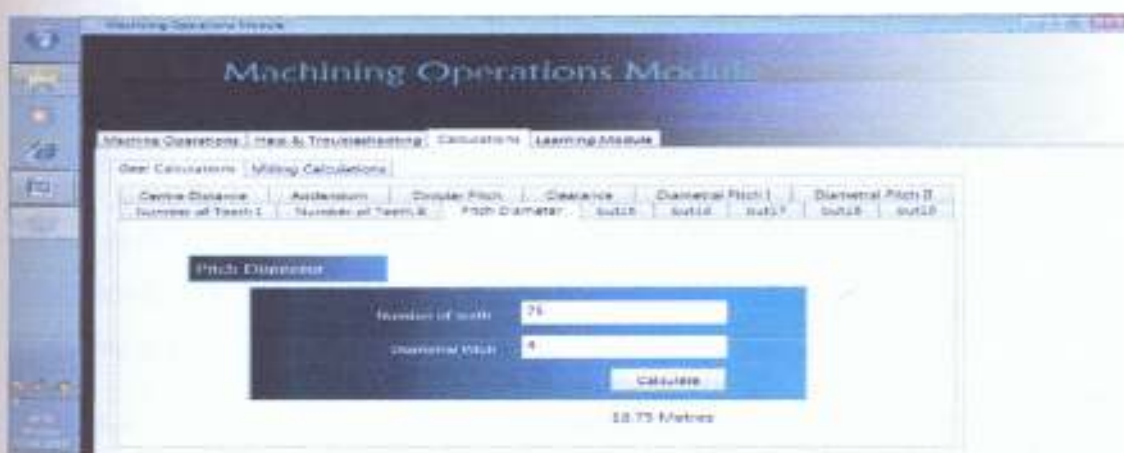


Figure 4.25: Interface for Machining Calculations: Determining Spur Gear Pitch Diameter

The design of the database also ensured ease of information retrieval thus swift response by the developed module. This was achieved by ensuring the program code included a relational framework linking each specific table heading with the data accessible in each embedded table and providing a structure for the user queries in a dropdown menu format directly linked to the database table headings. The integrity of the results retrieved from the developed software for successfully aiding decision making in the machine shop were in full compliance with accepted standards (Appendix 2).

#### 4.1.4 The Machine Operations Calculations Sub-Module

The Machine Operations Calculations Sub-Module, deals swiftly, with calculations carried out during machining operations. The development of this section is less complicated than the previous modules above. No trip is made to be made to the database. The user is simply required to select what calculation needs to be made. The user is then required to input the

variables needed for the calculation. The C-sharp code carries out the calculation and the result is immediately displayed to the user. This consists in addition to simple machining calculations,

- (a) capability to aid in Machine Depreciation Planning,
- (b) capability to aid in a Scheduling Operations, by employing a simple upgrade to the 2-by-2 Johnson's Algorithm.

#### 4.1.4.1 Machine Depreciation Calculation

Utilizing the hypothetical data provided below as a case study for the performance of the developed software;

COST PRICE OF MACHINERY= ₦1 500 000

ESTIMATED SALVAGE VALUE OF MACHINERY= ₦50 000

ESTIMATED USEFUL LIFE (N) OF MACHINERY = 10 YEARS

Results from utilizing manual calculation and software developed by employing the Sum of Digits Method (discussed in section 3.2.2.2.1) and Annual Rate of Depreciation Method (discussed in section 3.2.2.2.2) are presented in the table 4.1 below;

**Table 4.1; Comparison of Manually and Software Calculated Results from Sum of Digits and Annual Rate of Depreciation Method**

	Sum of Digits Method		Annual Rate of Depreciation Method	
	Depreciation Charge For Each Year (₦)			
	Manual Calculations	Software Calculations	Manual Calculations	Software Calculations
Year 1	263 636	263 636.36	435 000	432 427.35
Year 2	237 272	237 272.73	308 000	307 784.10
Year 3	210 909	210 909.09	219 284	219 045.40
Year 4	184 545	184 545.45	155 691	155 891.30

Year 5	158 181	158 181.82	110 541	110 945.60
Year 6	131 818	131 818.18	78 484	78 959.28
Year 7	105 455	105 455.55	55 724	56 193.44
Year 8	79 091	79 091.91	39 564	39 992.02
Year 9	52 727	52 727.27	28 090	28 461.73
Year 10	26 364	26 364.64	19 944	20 255.78
Total	1 449 998	1 450 000	1 451 172	1 351 744.99

#### 4.1.4.1.1 Comparison of Manually calculated results for the Sum-of-Digits Method With Calculated Results Utilizing The Software; Using Paired t-Test.

$n = 10$ ;  $X_A$  = Annual Depreciation Charges Calculated Manually

$X_B$  = Annual Depreciation Charges Calculated Using Visual Basic Program

**Table 4.2; Table Showing Annual Depreciation Charges Calculated Manually and Annual Depreciation Charges Calculated Utilizing The Software.**

Years	$X_A$ in Naira	$X_B$ in Naira	$d = X_A - X_B$	$d^2$
1	263 636	263 636.36	-0.36	0.1 296
2	237 272	237 272.73	-0.73	0.5 329
3	210 909	210 909.09	-0.09	0.0 081
4	184 545	184 545.45	-0.45	0.2025
5	158 181	158 181.82	-0.82	0.6 724
6	131 818	131 818.18	-0.18	0.0 324
7	105 455	105 454.55	0.45	0.2 025
8	79 091	79 090.91	0.09	0.0 081
9	52 727	52 727.27	-0.27	0.0 729
10	26 364	26 363.64	0.36	0.1 296

$\Sigma$	1 449 998	1 450 000	-2.00	1.9 910
----------	-----------	-----------	-------	---------

$$n = 10$$

$$\Sigma d = -2$$

$$\bar{d} = \frac{\Sigma d}{n} = \frac{-2}{10} = -0.2$$

$$\Sigma d^2 = 1.991$$

$$\text{Var } \bar{d} = \frac{\text{Var } d}{n}$$

$$\text{Var } \bar{d} = \frac{\Sigma d^2 - \frac{(\Sigma d)^2}{n}}{n-1} = \frac{1.9910 - \frac{(-2)^2}{10}}{9} = 0.2657$$

$$\text{Variance of Mean } (\bar{d}) = \text{Var } \bar{d} = \frac{0.2657}{10} = 0.02657 = S_{\bar{d}}^2$$

$$\sqrt{\text{Var } \bar{d}} = \sqrt{0.02657} = 0.1630 = S_{\bar{d}}$$

$$\bar{X}_A = \frac{1449998}{10} = 144999.8$$

$$\bar{X}_B = \frac{1450000}{10} = 145000$$

$$\text{Difference in Mean} = 0.2$$

$$0.2 \pm t_{df, \text{Confidence level}} (S_{\bar{d}})$$

$$df, \text{Degree of freedom} = n-1 = 10-1 = 9$$

$$\text{Confidence level} = 0.95 \quad \text{from tables } t_{9, 0.95} = 1.833$$

$$0.2 \pm t_{9, 0.95} (0.1630) = 0.2 \pm (1.833)(0.1630)$$

$$= 0.2 \pm 0.2988$$

This shows a low variance between the results gotten from the manual calculation of results for the sum-of-digits method with calculated results utilizing the software. The low variance suggests a good agreement between the results obtained from the software and actual calculations.

Using Paired t-Test. The analysis would thus imply, an immediate lack of merit in using the software for the calculations.

4.1.4.1.2 Comparison using the Paired t-Test, of the manually calculated results for the Annual Rate of Depreciation Method with results from utilizing the developed Software.

$$n = 10$$

$X_A$  = Annual Depreciation Charges Calculated Manually

$X_B$  = Annual Depreciation Charges Calculated Using Visual Basic Program

Table 4.3; Table Showing Annual Depreciation Charges Calculated Manually and Annual Depreciation Charges Calculated Utilizing The Software.

Years	$X_A$ in ₦	$X_B$ in ₦	$d = X_A - X_B$	$d^2$
1	435000	432472.35	2527.65	6389014.52
2	308850	307784.10	1065.90	1136142.81
3	219284	219045.40	238.60	56644.00
4	155691	155891.30	-200.30	40120.09
5	110691	110945.60	-254.60	64821.16
6	78484	78958.28	-474.28	224941.52
7	55724	56193.44	-469.44	220373.91
8	39564	39992.02	-428.02	183201.12
9	28090	28461.73	-371.73	138183.19
10	19944	20255.78	-311.78	97206.77
$\Sigma$	1451172	1449999.40	1321.40	8550649.09

$$n = 10$$

$$\Sigma d = 1321.40$$

$$\bar{d} = \frac{\Sigma d}{n} = \frac{1321.40}{10} = 132.14$$

$$\Sigma d^2 = 8550649.09$$



$$V\hat{a}r\bar{d} = \frac{V\hat{a}r d}{n}$$

$$V\hat{a}r d = \frac{\sum d^2 - \frac{(\sum d)^2}{n}}{n-1} = \frac{8550649.09 - \frac{(1921.40)^2}{10}}{9} = 930671.03$$

$$\text{Variance of Mean } (\bar{d}) = V\hat{a}r\bar{d} = \frac{930671.03}{10} = 93067.10 = S_{\bar{d}}^2$$

$$\sqrt{V\hat{a}r\bar{d}} = \sqrt{930671.10} = 305.07 = S_{\bar{d}}$$

$$\bar{X}_A = \frac{1451172}{10} = 145117.20$$

$$\bar{X}_B = \frac{1449999.40}{10} = 144999.94$$

Difference in Mean = 117.26

$$117.26 \pm t_{df, \text{Confidence level}}(S_{\bar{d}})$$

$$df, \text{ Degree of freedom} = n-1 = 10 - 1 = 9$$

Confidence level = 0.95

from tables  $t_{9, 0.95} = 1.833$

$$117.26 \pm t_{9, 0.95} (305.07) = 117.26 \pm (1.833)(305.07)$$

$$= 117.26 \pm 599.19$$

The analysis of results, show a variance ( $117.26 \pm 599.19$ ) between, the results gotten from manual calculation and results gotten from employing the developed module. The variance suggests no agreement between the results obtained from the software and actual calculations

The implied reasons for this variance, could be attributed to factors such as random error in some results form the developed software, human error in the

manual calculations and higher accuracy and degree of precision present in the computer employed calculations (round-off errors).

A variance is observed ( $0.2 \pm 0.2988$ ) from analysis gotten from comparing manually calculated results for the sum-of-digits method with calculated results utilizing the software. Although, this results would imply, an immediate lack of merit in using the software for the calculations. When factors such as the inevitable occurrence of human errors when prolonged mathematical processes are done, the critical requirement for the optimization of time, personnel work hours, documentation, portability and security of sensitive results, are considered; the merits of utilizing the software for calculating required machining calculations would be seen.

Evaluating the database headings showed that the user requires a good knowledge of machining operations syntax for effective communication with the system. Knowledge of how sequencing of machine operation affected profitability of jobs is also a requirement if the combined module tools of depreciation and scheduling are to be fully utilized.



## CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

The three main factors considered in manufacturing; cost time and quality provide a structure for planning and projection in production systems. According to Driscoll, *et. a.*, (2010), the possibility for solutions through creative engineering may present themselves, depending on the challenges of the specific applications. The aforementioned three factors form a continuous challenge to the machine tools industry. The machining data embedded in the database and formulae based algorithms of the machining calculations sub-module ensure that the Developed module by its utilization aids the requirements of the factor manufacturing standards quality.

By the use of the developed module,

- Decisions requiring the knowledge of industrial standards in machining operations can be met,
- Errors from “rule-of-thumb” are eliminated ensuring higher quality products,
- Loss of materials due to scrapage can be reduced,
- An easily machining operations data capture system is provided.

The rationale for instituting a data-capture system its capability to reduce the cost of acquiring and moving information around. Auto data-collection (AIDC) technologies eliminate the labour-intensive and costly paper pushing that typically permeates shop floor processes, which enables companies to reduce costs (Campbell, 2004).

According to Papamichail and French, (2004), Intelligent Decision Support Systems (DSSs) use expert systems technology to enhance the capabilities of decision makers (DMs) in understanding a decision problem and selecting a sound alternative. The developed module makes a satisfactorily attempt to enhance and aid the capabilities of the user.

The three core interacting components of decision support systems as stated by Papamichail and French, (2004), namely;

- A language system mechanism to provide communication between the user and other component of the decision support system,
- A knowledge system – the repository of problem domain knowledge embedded in the system, as data or procedure,
- A problem process system – the link between the other two component containing one or more of the general problem manipulatory capability required for decision making.

Are provided in the components of the developed module via, the simple user interactive queries, the compilation of machining operations data and the design of the database and its conversion into the Microsoft Structure Query Language Database. Wu, (2002) defines reliability assessment (an important issue in knowledge engineering) of a knowledge based system's inference quality as knowledge validation; which evaluates and determines comprehensively if a knowledge based system performs expected functions with expected performance. According to Zlatareva, (1998) validation of a KBS is intended to ensure that the system is error free and performs above a certain level of acceptance throughout its entire life cycle. Three fundamental tasks involved in this process are testing, refinement, and maintenance of the Knowledge Base (KB).The developed software's performance was evaluated by comparing the results received from queries carried out with data documented in the database and verifying for strict conformity with expected results. The integrity of the results showed a zero-tolerance for errors; thus, the developed module performed satisfactorily.

It can be safely deduced, that due to the Manufacturing Industry's relationship with the Machine Tools Industry implies, improvement the machine tool sector would have an advantageous effect upon manufacturing industry. The speed, accuracy and ease of access to required data for efficient performance of operations performed in the machine tool workshop will advantageously influence the factors of speed, accuracy in subsequently the overall costs of manufacturing.

This project has provided such a contribution albeit in nascent form to such an improvement; by developing an auxiliary machining module which serves as a decision support tool in the machine workshop for machining operations.

## 5.2 Recommendation

The following recommendations are hereby suggested:

- Deployment of the developed module into the academic workshop environment for real life testing,
- Improvement of the Module by acceptability ,use and required upgrades thus increasing and hence improving the database, and by consequence the module robustness. Smallwood and Wennermark, (2010), also state, that a major consideration in implementation of software technology, is the ongoing need for human resources to continue to maintain and extend the application developed.

The need for accurate and proper decisions cannot be neglected in industrial/economic development. Unprecedented and abrupt changes in market demands represent new operational conditions for manufactures of consumer goods. Several factors are simultaneously contributing to these market changes, including globalisation of the world economy, saturated market and rapid advances in technology. The developed module showed that through its use decisions requiring the knowledge of industrial standards in machining

operations are easily met. Providing through its deployment in the workshop a viable means for aiding machining operation decisions.

Sharp decrease in product cycles, a result of rapid engineering advances require higher quality products at lower cost and timely response to market changes. To achieve necessary competitive advantage, appropriate business strategies and manufacturing technologies are required. The developed module presents such a viable strategy by its provision of easily accessible and accurate data. (Masekamel, *et. al*, 2008).

Although the database is designed with a module for accumulation of more data; its evolution in robustness, would be enhanced only if attention is given to the "learning" portion of the module. Evaluating the database headings showed that the user requires a good knowledge of machining operations syntax for effective communication with the system. Knowledge of how sequencing of machine operation affected profitability of jobs is also a requirement if the combined module tools of depreciation and scheduling are to be fully utilized. Industrialization has always constituted a major objective of development strategy and government policy. Through industrialization, developing nations aspire to achieve higher economic growth, and to eventually attain developed nation status (Arizona-Ogwu, 2009).

An objective of the "vision 20-20-20" is for Nigeria to attain status of a major industrial (manufacturing) country in the West African sub-region and Africa south of the Sahara.

However, according to Dickson, (2007) few studies have considered manufacturing activities within the country, most of these have largely focused on some aspects of manufacturing, especially at the regional level, small-scale industries and handicrafts. It can be safely inferred from his research that more focused attention in the manufacturing and industrial sectors are welcome.

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APPENDIX I  
SOURCE CODES.

MACHINE OPERATIONS SUB-MODULE

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Windows;
using System.Windows.Controls;

using System.Windows.Documents;
using System.Windows.Input;
using System.Windows.Media;
using System.Windows.Media.Imaging;
using System.Windows.Navigation;
using System.Windows.Shapes;
using ControlCentre.machining_Calculations;
using System.Xml.Linq;

using System.Data.SqlClient;
using System.Data;
using System.Windows.Data;

namespace MpfApplication3
{
    /// <summary>
    /// Interaction logic for MainWindow.xaml
    /// </summary>
    ///
    public partial class MainWindow : Window
    {
        Gears gears = new Gears();
        public MainWindow()
        {
            InitializeComponent();
        }

        private void textBox1_TextChanged(object sender, TextChangedEventArgs e)
        {
        }

        private void button1_Click(object sender, RoutedEventArgs e)
        {
            gears.N = Convert.ToSingle(textBox1.Text);
            gears.n = Convert.ToSingle(textBox2.Text);
            gears.DP = Convert.ToSingle(textBox3.Text);
            gears._CD();
            label6.Content = Convert.ToString(gears.CD) + " Metres";
        }

        private void button2_Click(object sender, RoutedEventArgs e)
        {
            gears.DP = Convert.ToSingle(textBox4.Text);
        }
    }
}
```

```
gears._A();  
label8.Content = Convert.ToString(gears.A) + " Metres";  
}
```

```
private void button3_Click(object sender, RoutedEventArgs e)  
{  
    gears.DP = Convert.ToSingle(textBox5.Text);  
    gears._CP();  
    label12.Content = Convert.ToString(gears.CP) + " Metres";  
}
```

```
private void button4_Click(object sender, RoutedEventArgs e)  
{  
    gears.DP = Convert.ToSingle(textBox6.Text);  
    gears._Cl();  
    label15.Content = Convert.ToString(gears.Cl) + " Metres";  
}
```

```
private void tabControl1_SelectionChanged(object sender,  
SelectionChangedEventArgs e)  
{  
}
```

```
private void button5_Click(object sender, RoutedEventArgs e)  
{  
    string cs = @"Data Source=.\SQLEXPRESS;" +
```

```
@"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"  
    @"Connect Timeout=30;" +  
    @"User Instance=True";
```

```
string a = comboBox2.Text;  
string b = Convert.ToString(comboBox3.Text);  
string sql = "SELECT [" + b + "] FROM Table1afieldchipthickness WHERE  
workPieceMaterial = N'" + workPieceMaterialComboBox4.Text + "' AND ([tensilestrength] =  
" + a + ")";
```

```
SqlConnection con = new SqlConnection(cs);
```

```
con.Open();
```

```
SqlCommand cmd3 = new SqlCommand(sql, con);
```

```
label19.Content = cmd3.ExecuteScalar().ToString() + " kW";
```

```
// label19.Content = vtn;
```

```
}  
private MachineOperations_DataDataSet Machine = new
```

```
MachineOperations_DataDataSet();
```

```
private
```

```
MachineOperations_DataDataSetTableAdapters.Table1afieldchipthicknessTableAdapter
```

```
taMachine = new
```

```
MachineOperations_DataDataSetTableAdapters.Table1afieldchipthicknessTableAdapter();
```

```

private MachineOperations_DataDataSetTableAdapters.TableAdapterManager TaManager
= new MachineOperations_DataDataSetTableAdapters.TableAdapterManager();
private WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;
WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;
private WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;
private WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;
private WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;
private WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;

private MachineOperations_DataDataSet Bore = new MachineOperations_DataDataSet();
private MachineOperations_DataDataSetTableAdapters.BoringConditionsTableAdapter
BoringConditionsTableAdapter = new MachineOperations_DataDataSetTableAdapters.BoringConditionsTableAdapter();
private MachineOperations_DataDataSetTableAdapters.TableAdapterManager
BoringConditionsTableAdapterManager = new MachineOperations_DataDataSetTableAdapters.TableAdapterManager();
private MachineOperations_DataDataSet.BoringConditionsDataTable nwa = new
MachineOperations_DataDataSet.BoringConditionsDataTable();

private void Window_Loaded(object sender, RoutedEventArgs e)
{
WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;
WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;

WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager;
WkMatMachineOperations_DataDataSet1.TableAdapterManager TableAdapterManager()

}

private void comboBox1_SelectionChanged(object sender, SelectionChangedEventArgs
{
}

private void comboBox2_SelectionChanged(object sender, SelectionChangedEventArgs
{
/*
MachineOperations_DataDataSet1.TableAdapters.TableAdapterManager TableAdapterManager
new
MachineOperations_DataDataSet1.TableAdapters.TableAdapterManager TableAdapterManager()

ab.TFillBy(nwa, comboBox2.Text);
comboBox2.ItemsSource = nwa;

```

```

    */
}

private void button6_Click(object sender, RoutedEventArgs e)
{
    gears.N = Convert.ToSingle(textBox7.Text);
    gears.PD = Convert.ToSingle(textBox8.Text);
    gears._DP1();
    label23.Content = Convert.ToString(gears.DP) + " Metres";
}

private void button8_Click(object sender, RoutedEventArgs e)
{
    PDB2.Focus();
}

private void button7_Click(object sender, RoutedEventArgs e)
{
    PDB1.Focus();
}

private void button9_Click(object sender, RoutedEventArgs e)
{
    PDB3.Focus();
}

private void button10_Click(object sender, RoutedEventArgs e)
{
    PDB4.Focus();
}

private void a(object sender, RoutedEventArgs e)
{
}

private void PDB4_Loaded(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT WorkpieceMaterial FROM
    SettingsSpeedMetersperMinute";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd5 = new SqlCommand(sql, con5);

    workpieceMaterialComboBox2.ItemsSource = cmd5.ExecuteReader();
}

private void button11_Click(object sender, RoutedEventArgs e)
{
}

```

```

gears.N = Convert.ToSingle(textBox9.Text);
gears.PD = Convert.ToSingle(textBox10.Text);
gears._DP2();
label32.Content = Convert.ToString(gears.DP) + " Metres";
}

private void button12_Click(object sender, RoutedEventArgs e)
{
gears.OD = Convert.ToSingle(textBox11.Text);
gears.DP = Convert.ToSingle(textBox12.Text);
gears._N1();
label35.Content = Convert.ToString(gears.N) + " Metres";
}

private void button13_Click(object sender, RoutedEventArgs e)
{
gears.PD = Convert.ToSingle(textBox13.Text);
gears.DP = Convert.ToSingle(textBox14.Text);
gears._N2();
label38.Content = Convert.ToString(gears.H) + " Metres";
}

private void button14_Click(object sender, RoutedEventArgs e)
{
gears.N = Convert.ToSingle(textBox15.Text);
gears.DP = Convert.ToSingle(textBox16.Text);
gears._PD();
label41.Content = Convert.ToString(gears.PD) + " Metres";
}

private void button15_Click(object sender, RoutedEventArgs e)
{
gears.N = Convert.ToSingle(textBox17.Text);
gears.OD = Convert.ToSingle(textBox18.Text);
gears._PD2();
label44.Content = Convert.ToString(gears.PD) + " Metres";
}

private void button16_Click(object sender, RoutedEventArgs e)
{
gears.N = Convert.ToSingle(textBox19.Text);
gears.DP = Convert.ToSingle(textBox20.Text);
gears._OD();
label47.Content = Convert.ToString(gears.OD) + " Metres";
}

private void button17_Click(object sender, RoutedEventArgs e)
{
gears.DP = Convert.ToSingle(textBox21.Text);
gears._T();
label50.Content = Convert.ToString(gears.T) + " Metres";
}

private void button18_Click(object sender, RoutedEventArgs e)
{
gears.DP = Convert.ToSingle(textBox22.Text);
gears._WD();
label53.Content = Convert.ToString(gears.WD) + " Metres";
}

```

```

private void button19_Click(object sender, RoutedEventArgs e)
{
    gears.DP = Convert.ToSingle(textBox23.Text);
    gears._D();
    label54.Content = Convert.ToString(gears.D) + " Metres";
}

private void workpieceMaterialComboBox2_SelectionChanged(object sender,
SelectionChangedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
"Connect Timeout=30;" +
"User Instance=True;";

    string sql = "SELECT DISTINCT [tool material] FROM
CuttingSpeedMetersperMinute";

    // WHERE WorkpieceMaterial = "" + workpieceMaterialComboBox2.SelectedItem

    SqlConnection con6 = new SqlConnection(cs2);
    con6.Open();

    SqlCommand cmd6 = new SqlCommand(sql, con6);

    tool_materialComboBox.ItemsSource = cmd6.ExecuteReader();
}

private void tool_materialComboBox_SelectionChanged(object sender,
SelectionChangedEventArgs e)
{
}

private void button20_Click(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
"Connect Timeout=30;" +
"User Instance=True;";

    string sql = "SELECT feed1 FROM CuttingSpeedMetersperMinute WHERE
WorkpieceMaterial = '' + workpieceMaterialComboBox2.Text + '' AND [tool material] = '' +
tool_materialComboBox.Text + ''";
    string sql1 = "SELECT feed2 FROM CuttingSpeedMetersperMinute WHERE
WorkpieceMaterial = '' + workpieceMaterialComboBox2.Text + '' AND [tool material] = '' +
tool_materialComboBox.Text + ''";
    string sql2 = "SELECT feed3 FROM CuttingSpeedMetersperMinute WHERE
WorkpieceMaterial = '' + workpieceMaterialComboBox2.Text + '' AND [tool material] = '' +
tool_materialComboBox.Text + ''";
}

```

```

string sql3 = "SELECT feed4 FROM CuttingSpeedMetersperMinute WHERE -
workpieceMaterial = '" + workpieceMaterialComboBox2.Text + "' AND [tool material] = '" +
tool_materialComboBox.Text + "'";
// WHERE WorkpieceMaterial = '" + workpieceMaterialComboBox2.SelectedItem

SqlConnection con6 = new SqlConnection(cs2);
con6.Open();

SqlCommand cmd6 = new SqlCommand(sql, con6);
SqlCommand cmd7 = new SqlCommand(sql1, con6);
SqlCommand cmd8 = new SqlCommand(sql2, con6);
SqlCommand cmd9 = new SqlCommand(sql3, con6);

feed1Label.Content = cmd6.ExecuteScalar().ToString();
feed2Label.Content = cmd7.ExecuteScalar().ToString();
feed3Label.Content = cmd8.ExecuteScalar().ToString();
feed4Label.Content = cmd9.ExecuteScalar().ToString();
}

private void PDB5_loaded(object sender, RoutedEventArgs e)
{
    /*
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
    @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
Security=True;" +
    @"Connect Timeout=30;" +
    @"User Instance=True;";

    string sql = "SELECT WorkPieceMaterial FROM
WorkPieceMaterial LIKE &ReliefAnglesToolLathes";

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();

    SqlCommand cmd5 = new SqlCommand(sql, con5);
    PDB5WorkPieceMatcomboBox4.ItemsSource = cmd5.ExecuteReader();

    */
}

private void PDB6_loaded(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
    @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
Security=True;" +
    @"Connect Timeout=30;" +
    @"User Instance=True;";

    string sql = "SELECT DISTINCT WorkPieceMaterial FROM
ReliefAnglesSinglePointTools";

    SqlConnection con5 = new SqlConnection(cs2);

```

```
con5.Open();
```

```
SqlCommand cmd15 = new SqlCommand(sql, con5);
```

```
workPieceMaterialComboBox3.ItemsSource = cmd15.ExecuteReader();
```

```
// newcomboBox4.Items = .GetString(0);
```

```
private void Window_Loaded_1(object sender, RoutedEventArgs e)
```

```
{  
    string cs = @"Data Source=.\SQLEXPRESS;" +  
    @"DataDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
```

```
Connect Timeout=30;" +
```

```
Server Instance=True;"
```

```
string sql123 = "SELECT DISTINCT WorkPieceMaterial FROM  
table1afieldchipthickness";
```

```
SqlConnection con = new SqlConnection(cs);
```

```
con.Open();
```

```
SqlCommand cmd3 = new SqlCommand(sql123, con);
```

```
workPieceMaterialComboBox4.ItemsSource = cmd3.ExecuteReader();
```

```
WpfApplication3.MachineOperations_DataDataSet machineOperations_DataDataSet =  
WpfApplication3.MachineOperations_DataDataSet(this.FindResource("machineOperations_Dat  
DataSet"));
```

```
// Load data into the table CuttingSpeedMetersperMinute. You can modify this  
code as needed.
```

```
WpfApplication3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedMetersperMinuteTab  
leAdapter machineOperations_DataDataSetCuttingSpeedMetersperMinuteTableAdapter = new
```

```
WpfApplication3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedMetersperMinuteTab  
leAdapter();
```

```
machineOperations_DataDataSetCuttingSpeedMetersperMinuteTableAdapter.Fill(machineOperatio  
n_DataDataSet.CuttingSpeedMetersperMinute);
```

```
System.Windows.Data.CollectionViewSource
```

```
cuttingSpeedMetersperMinuteViewSource =
```

```
(System.Windows.Data.CollectionViewSource)(this.FindResource("cuttingSpeedMetersperMinut  
eViewSource"));
```

```
cuttingSpeedMetersperMinuteViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table Table1afieldchipthickness. You can modify this  
code as needed.
```

```
WpfApplication3.MachineOperations_DataDataSetTableAdapters.Table1afieldchipthicknessTable  
Adapter machineOperations_DataDataSetTable1afieldchipthicknessTableAdapter = new
```

```
WpfApplication3.MachineOperations_DataDataSetTableAdapters.Table1afieldchipthicknessTable  
Adapter();
```

```
machineOperations_DataDataSetTable1afieldchipthicknessTableAdapter.Fill(machineOperations  
_DataSet.Table1afieldchipthickness);
```

```
System.Windows.Data.CollectionViewSource table1afieldchipthicknessViewSource
```

```
(System.Windows.Data.CollectionViewSource)(this.FindResource("table1afieldchipthicknessV  
iewSource"));
```

```

        table1afieldchipthicknessViewSource.View.MoveCurrentToFirst();
        // load data into the table Table2aFacingTurningBoring. You can modify this
        // code as needed.

        Application3.MachineOperations_DataDataSetTableAdapters.Table2aFacingTurningBoringTable
        Adapter machineOperations_DataDataSetTable2aFacingTurningBoringTableAdapter = new
        Application3.MachineOperations_DataDataSetTableAdapters.Table2aFacingTurningBoringTable
        Adapter();

        machineOperations_DataDataSetTable2aFacingTurningBoringTableAdapter.Fill(machineOperation
        _DataDataSet.Table2aFacingTurningBoring);
        System.Windows.Data.CollectionViewSource table2aFacingTurningBoringViewSource =
        (System.Windows.Data.CollectionViewSource)(this.FindResource("table2aFacingTurningBoring
        ViewSource"));
        table2aFacingTurningBoringViewSource.View.MoveCurrentToFirst();
        // load data into the table Table3aLatheFeedsHighSpeedCuttingTool. You can
        // modify this code as needed.

        Application3.MachineOperations_DataDataSetTableAdapters.Table3aLatheFeedsHighSpeedCutt
        ingToolTableAdapter
        machineOperations_DataDataSetTable3aLatheFeedsHighSpeedCuttingToolTableAdapter = new
        Application3.MachineOperations_DataDataSetTableAdapters.Table3aLatheFeedsHighSpeedCutt
        ingToolTableAdapter();

        machineOperations_DataDataSetTable3aLatheFeedsHighSpeedCuttingToolTableAdapter.Fill(machi
        neOperations_DataDataSet.Table3aLatheFeedsHighSpeedCuttingTool);
        System.Windows.Data.CollectionViewSource
        table3aLatheFeedsHighSpeedCuttingToolViewSource =
        (System.Windows.Data.CollectionViewSource)(this.FindResource("table3aLatheFeedsHighSpeed
        CuttingToolViewSource"));
        table3aLatheFeedsHighSpeedCuttingToolViewSource.View.MoveCurrentToFirst();
        // Load data into the table ToolAnglesSinglePointTools. You can modify this
        // code as needed.

        Application3.MachineOperations_DataDataSetTableAdapters.ToolAnglesSinglePointToolsTable
        Adapter machineOperations_DataDataSetToolAnglesSinglePointToolsTableAdapter = new
        Application3.MachineOperations_DataDataSetTableAdapters.ToolAnglesSinglePointToolsTable
        Adapter();

        machineOperations_DataDataSetToolAnglesSinglePointToolsTableAdapter.Fill(machineOperation
        _DataDataSet.ToolAnglesSinglePointTools);
        System.Windows.Data.CollectionViewSource toolAnglesSinglePointToolsViewSource =
        (System.Windows.Data.CollectionViewSource)(this.FindResource("toolAnglesSinglePointTools
        ViewSource"));
        toolAnglesSinglePointToolsViewSource.View.MoveCurrentToFirst();
        // Load data into the table CenterDrillingSizesParameters. You can modify
        // this code as needed.

        Application3.MachineOperations_DataDataSetTableAdapters.CenterDrillingSizesParametersT
        ableAdapter machineOperations_DataDataSetCenterDrillingSizesParametersTableAdapter = new
        Application3.MachineOperations_DataDataSetTableAdapters.CenterDrillingSizesParametersT
        ableAdapter();

        MachineOperations_DataDataSetCenterDrillingSizesParametersTableAdapter.Fill(machineOperat
        _DataDataSet.CenterDrillingSizesParameters);
        System.Windows.Data.CollectionViewSource
        centerDrillingSizesParametersViewSource =

```

```

[System.Windows.Data.CollectionViewSource](this.FindResource("centerDrillingSizesParametersViewSource"));
centerDrillingSizesParametersViewSource.View.MoveCurrentToFirst();
// Load data into the table CuttingAnglesCastAlloySteels. You can modify this
code as needed.

Application3.MachineOperations_DataDataSetTableAdapters.CuttingAnglesCastAlloySteelsTableAdapter machineOperations_DataDataSetCuttingAnglesCastAlloySteelsTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingAnglesCastAlloySteelsTableAdapter();

machineOperations_DataDataSetCuttingAnglesCastAlloySteelsTableAdapter.Fill(machineOperations_DataDataSet.CuttingAnglesCastAlloySteels);
System.Windows.Data.CollectionViewSource
cuttingAnglesCastAlloySteelsViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("cuttingAnglesCastAlloySteelsViewSource"));
cuttingAnglesCastAlloySteelsViewSource.View.MoveCurrentToFirst();
// Load data into the table CuttingFluidVolumeExternalChipRemovalGunDrill.
You can modify this code as needed.

Application3.MachineOperations_DataDataSetTableAdapters.CuttingFluidVolumeExternalChipRemovalGunDrillTableAdapter
machineOperations_DataDataSetCuttingFluidVolumeExternalChipRemovalGunDrillTableAdapter =
new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingFluidVolumeExternalChipRemovalGunDrillTableAdapter();

machineOperations_DataDataSetCuttingFluidVolumeExternalChipRemovalGunDrillTableAdapter.Fill(machineOperations_DataDataSet.CuttingFluidVolumeExternalChipRemovalGunDrill);
System.Windows.Data.CollectionViewSource
cuttingFluidVolumeExternalChipRemovalGunDrillViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("cuttingFluidVolumeExternalChipRemovalGunDrillViewSource"));

cuttingFluidVolumeExternalChipRemovalGunDrillViewSource.View.MoveCurrentToFirst();
// Load data into the table
CuttingFluidVolumePressureInternalChipRemovalGunDrills. You can modify this code as
needed.

Application3.MachineOperations_DataDataSetTableAdapters.CuttingFluidVolumePressureInternalChipRemovalGunDrillsTableAdapter
machineOperations_DataDataSetCuttingFluidVolumePressureInternalChipRemovalGunDrillsTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingFluidVolumePressureInternalChipRemovalGunDrillsTableAdapter();

machineOperations_DataDataSetCuttingFluidVolumePressureInternalChipRemovalGunDrillsTableAdapter.Fill(machineOperations_DataDataSet.CuttingFluidVolumePressureInternalChipRemovalGunDrills);
System.Windows.Data.CollectionViewSource
cuttingFluidVolumePressureInternalChipRemovalGunDrillsViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("cuttingFluidVolumePressureInternalChipRemovalGunDrillsViewSource"));

cuttingFluidVolumePressureInternalChipRemovalGunDrillsViewSource.View.MoveCurrentToFirst();
// Load data into the table CuttingSpeed. You can modify this code as needed.

```

```
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedTableAdapter
machineOperations_DataDataSetCuttingSpeedTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedTableAdapter();

machineOperations_DataDataSetCuttingSpeedTableAdapter.Fill(machineOperations_DataDataSet.
CuttingSpeed);
System.Windows.Data.CollectionViewSource cuttingSpeedViewSource =
((System.Windows.Data.CollectionViewSource)(this.FindResource("cuttingSpeedViewSource")))
cuttingSpeedViewSource.View.MoveCurrentToFirst();
// Load data into the table CuttingSpeedConditionsMilling. You can modify
this code as needed.
```

```
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedConditionsMillingT
ableAdapter machineOperations_DataDataSetCuttingSpeedConditionsMillingTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedConditionsMillingT
ableAdapter();
```

```
machineOperations_DataDataSetCuttingSpeedConditionsMillingTableAdapter.Fill(machineOperat
es_DataDataSet.CuttingSpeedConditionsMilling);
System.Windows.Data.CollectionViewSource
cuttingSpeedConditionsMillingViewSource =
((System.Windows.Data.CollectionViewSource)(this.FindResource("cuttingSpeedConditionsMill
ingViewSource")));
cuttingSpeedConditionsMillingViewSource.View.MoveCurrentToFirst();
// Load data into the table CuttingSpeedsandFeeds. You can modify this code
as needed.
```

```
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedsandFeedsTableAdap
er machineOperations_DataDataSetCuttingSpeedsandFeedsTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedsandFeedsTableAdap
er();
```

```
machineOperations_DataDataSetCuttingSpeedsandFeedsTableAdapter.Fill(machineOperations_Dat
aDataSet.CuttingSpeedsandFeeds);
System.Windows.Data.CollectionViewSource cuttingSpeedsandFeedsViewSource =
((System.Windows.Data.CollectionViewSource)(this.FindResource("cuttingSpeedsandFeedsViewS
ource")));
cuttingSpeedsandFeedsViewSource.View.MoveCurrentToFirst();
// Load data into the table CuttingSpeedsFeedsFaceShoulderMills. You can
modify this code as needed.
```

```
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedsFeedsFaceShoulder
MillsTableAdapter
machineOperations_DataDataSetCuttingSpeedsFeedsFaceShoulderMillsTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedsFeedsFaceShoulder
MillsTableAdapter();
```

```
machineOperations_DataDataSetCuttingSpeedsFeedsFaceShoulderMillsTableAdapter.Fill(machine
Operations_DataDataSet.CuttingSpeedsFeedsFaceShoulderMills);
System.Windows.Data.CollectionViewSource
cuttingSpeedsFeedsFaceShoulderMillsViewSource =
((System.Windows.Data.CollectionViewSource)(this.FindResource("cuttingSpeedsFeedsFaceShou
lderMillsViewSource")));
cuttingSpeedsFeedsFaceShoulderMillsViewSource.View.MoveCurrentToFirst();
// Load data into the table CuttingSpeedsFeedsMillingCutters. You can modify
this code as needed.
```

```
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedsFeedsMillingCutte
rTableAdapter machineOperations_DataDataSetCuttingSpeedsFeedsMillingCutt
erTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.CuttingSpeedsFeedsMillingCutte
rTableAdapter();
```

```
machineOperations_DataDataSetCuttingSpeedsFeedsMillingCutt
erTableAdapter.Fill(machineOperations_DataDataSet.CuttingSpeedsFeedsMillingCutt
er);
System.Windows.Data.CollectionViewSource
cuttingSpeedsFeedsMillingCutt
erCollectionViewSource =
(System.Windows.Data.CollectionViewSource)(this.FindResource("cuttingSpeedsFeedsMillingC
utt
erCollectionViewSource"));
cuttingSpeedsFeedsMillingCutt
erCollectionViewSource.View.MoveCurrentToFirst();
// Load data into the table DrillLipClearanceAtPeriphery. You can modify this
code as needed.
```

```
Application3.MachineOperations_DataDataSetTableAdapters.DrillLipClearanceAtPeripheryTa
bleAdapter machineOperations_DataDataSetDrillLipClearanceAtPeripheryTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.DrillLipClearanceAtPeripheryTa
bleAdapter();
```

```
machineOperations_DataDataSetDrillLipClearanceAtPeripheryTableAdapter.Fill(machineOperati
ons_DataDataSet.DrillLipClearanceAtPeriphery);
System.Windows.Data.CollectionViewSource
drillLipClearanceAtPeripheryCollectionViewSource =
(System.Windows.Data.CollectionViewSource)(this.FindResource("drillLipClearanceAtPeriphe
ryCollectionViewSource"));
drillLipClearanceAtPeripheryCollectionViewSource.View.MoveCurrentToFirst();
// Load data into the table EffectWorkMaterialUltraSonicMachiningRoughing.
You can modify this code as needed.
```

```
Application3.MachineOperations_DataDataSetTableAdapters.EffectWorkMaterialUltraSonicMa
chiningRoughingTableAdapter
machineOperations_DataDataSetEffectWorkMaterialUltraSonicMachiningRoughingTableAdapter =
new
Application3.MachineOperations_DataDataSetTableAdapters.EffectWorkMaterialUltraSonicMa
chiningRoughingTableAdapter();
```

```
machineOperations_DataDataSetEffectWorkMaterialUltraSonicMachiningRoughingTableAdapter.Fi
ll(machineOperations_DataDataSet.EffectWorkMaterialUltraSonicMachiningRoughing);
System.Windows.Data.CollectionViewSource
effectWorkMaterialUltraSonicMachiningRoughingCollectionViewSource =
(System.Windows.Data.CollectionViewSource)(this.FindResource("effectWorkMaterialUltraSon
icMachiningRoughingCollectionViewSource"));
```

```
effectWorkMaterialUltraSonicMachiningRoughingCollectionViewSource.View.MoveCurrentToFirst();
// Load data into the table ElectronBeamMachiningDrilling. You can modify
this code as needed.
```

```
Application3.MachineOperations_DataDataSetTableAdapters.ElectronBeamMachiningDrillingT
ableAdapter machineOperations_DataDataSetElectronBeamMachiningDrillingTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.ElectronBeamMachiningDrillingT
ableAdapter();
```

```
machineOperations_DataDataSetElectronBeamMachiningDrillingTableAdapter.Fill(machineOperat
ions_DataDataSet.ElectronBeamMachiningDrilling);
System.Windows.Data.CollectionViewSource
electronBeamMachiningDrillingCollectionViewSource =
```

```

[System.Windows.Data.CollectionViewSource](this.FindResource("electronBeamMachiningDrill
ingViewSource")));
    electronBeamMachiningDrillingViewSource.View.MoveCurrentToFirst();
    // Load data into the table FeedperTooth. You can modify this code as needed.

Application3.MachineOperations_DataDataSetTableAdapters.FeedperToothTableAdapter
machineOperations_DataDataSetFeedperToothTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.FeedperToothTableAdapter();

machineOperations_DataDataSetFeedperToothTableAdapter.Fill(machineOperations_DataDataSet.
FeedperTooth);
    System.Windows.Data.CollectionViewSource feedperToothViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("feedperToothViewSource"))

    feedperToothViewSource.View.MoveCurrentToFirst();
    // Load data into the table FeedperToothHighSpeedSteelMills. You can modify
this code as needed.

Application3.MachineOperations_DataDataSetTableAdapters.FeedperToothHighSpeedSteelMill
TableAdapter machineOperations_DataDataSetFeedperToothHighSpeedSteelMillsTableAdapter =
Application3.MachineOperations_DataDataSetTableAdapters.FeedperToothHighSpeedSteelMill
TableAdapter();

machineOperations_DataDataSetFeedperToothHighSpeedSteelMillsTableAdapter.Fill(machineOper
ations_DataDataSet.FeedperToothHighSpeedSteelMills);
    System.Windows.Data.CollectionViewSource
FeedperToothHighSpeedSteelMillsViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("feedperToothHighSpeedSteel
MillsViewSource")));
    feedperToothHighSpeedSteelMillsViewSource.View.MoveCurrentToFirst();
    // Load data into the table FeedRates. You can modify this code as needed.

Application3.MachineOperations_DataDataSetTableAdapters.FeedRatesTableAdapter
machineOperations_DataDataSetFeedRatesTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.FeedRatesTableAdapter();

machineOperations_DataDataSetFeedRatesTableAdapter.Fill(machineOperations_DataDataSet.Fee
dRates);
    System.Windows.Data.CollectionViewSource feedRatesViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("feedRatesViewSource")));
    feedRatesViewSource.View.MoveCurrentToFirst();
    // Load data into the table FeedsandParameters. You can modify this code as
needed.

Application3.MachineOperations_DataDataSetTableAdapters.FeedsandParametersTableAdapter
machineOperations_DataDataSetFeedsandParametersTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.FeedsandParametersTableAdapter
();

machineOperations_DataDataSetFeedsandParametersTableAdapter.Fill(machineOperations_DataDa
taDataSet.FeedsandParameters);
    System.Windows.Data.CollectionViewSource feedsandParametersViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("feedsandParametersViewSour
ce"));
    feedsandParametersViewSource.View.MoveCurrentToFirst();
    // Load data into the table FineBoringConditionsCarbideTools. You can modify
this code as needed.

```

```

Application3.MachineOperations_DataDataSetTableAdapters.FineBoringConditionsCarbideToo
TableAdapter machineOperations_DataDataSetFineBoringConditionsCarbideToolsTableAdapter
Application3.MachineOperations_DataDataSetTableAdapters.FineBoringConditionsCarbideToo
TableAdapter();

machineOperations_DataDataSetFineBoringConditionsCarbideToolsTableAdapter.Fill(machineOpe
rations_DataDataSet.FineBoringConditionsCarbideTools);
System.Windows.Data.CollectionViewSource
FineBoringConditionsCarbideToolsViewSource =
(System.Windows.Data.CollectionViewSource)(this.FindResource("fineBoringConditionsCarbid
eToolsViewSource"));
fineBoringConditionsCarbideToolsViewSource.View.MoveCurrentToFirst();
// Load data into the table
FluidPressureVolumeInternalChipRemovalTrepanningHeads. You can modify this code as
needed.

Application3.MachineOperations_DataDataSetTableAdapters.FluidPressureVolumeInternalChi
pRemovalTrepanningHeadsTableAdapter
machineOperations_DataDataSetFluidPressureVolumeInternalChipRemovalTrepanningHeadsTableAd
apter = new
Application3.MachineOperations_DataDataSetTableAdapters.FluidPressureVolumeInternalChi
pRemovalTrepanningHeadsTableAdapter();

machineOperations_DataDataSetFluidPressureVolumeInternalChipRemovalTrepanningHeadsTableAd
apter.Fill(machineOperations_DataDataSet.FluidPressureVolumeInternalChipRemovalTrepanning
Heads);
System.Windows.Data.CollectionViewSource
FluidPressureVolumeInternalChipRemovalTrepanningHeadsViewSource =
(System.Windows.Data.CollectionViewSource)(this.FindResource("fluidPressureVolumeInterna
lChipRemovalTrepanningHeadsViewSource"));
FluidPressureVolumeInternalChipRemovalTrepanningHeadsViewSource.View.MoveCurrentToFirst()

// Load data into the table MachineReamingAllowance. You can modify this code
as needed.

Application3.MachineOperations_DataDataSetTableAdapters.MachineReamingAllowanceTableAd
apter machineOperations_DataDataSetMachineReamingAllowanceTableAdapter = new
Application3.MachineOperations_DataDataSetTableAdapters.MachineReamingAllowanceTableAd
apter();

machineOperations_DataDataSetMachineReamingAllowanceTableAdapter.Fill(machineOperations_D
ataDataSet.MachineReamingAllowance);
System.Windows.Data.CollectionViewSource machineReamingAllowanceViewSource =
(System.Windows.Data.CollectionViewSource)(this.FindResource("machineReamingAllowanceVie
wSource"));
machineReamingAllowanceViewSource.View.MoveCurrentToFirst();
// Load data into the table MachiningConditionsGunDrilling. You can modify
this code as needed.

Application3.MachineOperations_DataDataSetTableAdapters.MachiningConditionsGunDrilling
TableAdapter machineOperations_DataDataSetMachiningConditionsGunDrillingTableAdapter =
Application3.MachineOperations_DataDataSetTableAdapters.MachiningConditionsGunDrilling
TableAdapter();

```

```
machineOperations_DataDataSetMachiningConditionsGunDrillingTableAdapter.Fill(machineOpera  
tions_DataDataSet.MachiningConditionsGunDrilling);  
System.Windows.Data.CollectionViewSource  
MachiningConditionsGunDrillingViewSource =  
(System.Windows.Data.CollectionViewSource)(this.FindResource("machiningConditionsGunDril  
lingViewSource"));  
MachiningConditionsGunDrillingViewSource.View.MoveCurrentToFirst();  
// Load data into the table MillingCuttingSpeeds. You can modify this code as  
needed.  
Application3.MachineOperations_DataDataSetTableAdapters.MillingCuttingSpeedsTableAdapt  
er machineOperations_DataDataSetMillingCuttingSpeedsTableAdapter = new  
Application3.MachineOperations_DataDataSetTableAdapters.MillingCuttingSpeedsTableAdapt  
er();  
machineOperations_DataDataSetMillingCuttingSpeedsTableAdapter.Fill(machineOperations_Data  
DataSet.MillingCuttingSpeeds);  
System.Windows.Data.CollectionViewSource millingCuttingSpeedsViewSource = new  
(System.Windows.Data.CollectionViewSource)(this.FindResource("millingCuttingSpeedsViewSo  
urce"));  
millingCuttingSpeedsViewSource.View.MoveCurrentToFirst();
```



## HELP AND TROUBLESHOOTING SUB-MODULE



```

WpfApplication3.PDBHelpDataSet pDBHelpDataSet =
WpfApplication3.PDBHelpDataSet(this.FindResource("pDBHelpDataSet"));
    // Load data into the table HelpTurning. You can modify this code as needed.
    WpfApplication3.PDBHelpDataSetTableAdapters.HelpTurningTableAdapter
pDBHelpDataSetHelpTurningTableAdapter = new
WpfApplication3.PDBHelpDataSetTableAdapters.HelpTurningTableAdapter();
    pDBHelpDataSetHelpTurningTableAdapter.Fill(pDBHelpDataSet.HelpTurning);
    System.Windows.Data.CollectionViewSource helpTurningViewSource =
((System.Windows.Data.CollectionViewSource)(this.FindResource("helpTurningViewSource")));
    helpTurningViewSource.View.MoveCurrentToFirst();
    // Load data into the table MillingTroubleShooting. You can modify this code
as needed.

WpfApplication3.PDBHelpDataSetTableAdapters.MillingTroubleShootingTableAdapter
pDBHelpDataSetMillingTroubleShootingTableAdapter = new
WpfApplication3.PDBHelpDataSetTableAdapters.MillingTroubleShootingTableAdapter();
pDBHelpDataSetMillingTroubleShootingTableAdapter.Fill(pDBHelpDataSet.MillingTroubleShooting
);
    System.Windows.Data.CollectionViewSource millingTroubleShootingViewSource =
((System.Windows.Data.CollectionViewSource)(this.FindResource("millingTroubleShootingView
Source")));
    millingTroubleShootingViewSource.View.MoveCurrentToFirst();
    // Load data into the table BoringTroubleShooting. You can modify this code
as needed.
    WpfApplication3.PDBHelpDataSetTableAdapters.BoringTroubleShootingTableAdapter
pDBHelpDataSetBoringTroubleShootingTableAdapter = new
WpfApplication3.PDBHelpDataSetTableAdapters.BoringTroubleShootingTableAdapter();
pDBHelpDataSetBoringTroubleShootingTableAdapter.Fill(pDBHelpDataSet.BoringTroubleShooting
);
    System.Windows.Data.CollectionViewSource boringTroubleShootingViewSource =
((System.Windows.Data.CollectionViewSource)(this.FindResource("boringTroubleShootingViews
ource")));
    boringTroubleShootingViewSource.View.MoveCurrentToFirst();
    WpfApplication3.PDBHelpDataSet1 pDBHelpDataSet1 =
(WpfApplication3.PDBHelpDataSet1)(this.FindResource("pDBHelpDataSet1"));
    // Load data into the table HelpTurning. You can modify this code as needed.
    WpfApplication3.PDBHelpDataSet1TableAdapters.HelpTurningTableAdapter
pDBHelpDataSet1HelpTurningTableAdapter = new
WpfApplication3.PDBHelpDataSet1TableAdapters.HelpTurningTableAdapter();
    pDBHelpDataSet1HelpTurningTableAdapter.Fill(pDBHelpDataSet1.HelpTurning);
    System.Windows.Data.CollectionViewSource helpTurningViewSource1 =
((System.Windows.Data.CollectionViewSource)(this.FindResource("helpTurningViewSource1")))

    helpTurningViewSource1.View.MoveCurrentToFirst();
    // Load data into the table MillingWithCarbideTools. You can modify this code
as needed.

WpfApplication3.PDBHelpDataSet1TableAdapters.MillingWithCarbideToolsTableAdapter
pDBHelpDataSet1MillingWithCarbideToolsTableAdapter = new
WpfApplication3.PDBHelpDataSet1TableAdapters.MillingWithCarbideToolsTableAdapter();
pDBHelpDataSet1MillingWithCarbideToolsTableAdapter.Fill(pDBHelpDataSet1.MillingWithCarbid
eTools);
    
```

```

        System.Windows.Data.CollectionViewSource millingWithCarbideToolsViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("millingWithCarbideToolsView
source"));
        millingWithCarbideToolsViewSource.View.MoveCurrentToFirst();
        // Load data into the table GunDrillingTroubleShooting. You can modify this
code as needed.

Application3.PDBHelpDataSet1TableAdapters.GunDrillingTroubleShootingTableAdapter
PDBHelpDataSet1GunDrillingTroubleShootingTableAdapter = new
Application3.PDBHelpDataSet1TableAdapters.GunDrillingTroubleShootingTableAdapter();

PDBHelpDataSet1GunDrillingTroubleShootingTableAdapter.Fill(pDBHelpDataSet1.GunDrillingTro
bleShooting);
        System.Windows.Data.CollectionViewSource gunDrillingTroubleShootingViewSource
[System.Windows.Data.CollectionViewSource](this.FindResource("gunDrillingTroubleShooting
ViewSource"));
        gunDrillingTroubleShootingViewSource.View.MoveCurrentToFirst();
        // Load data into the table TrepanningTroubleShooting. You can modify this
code as needed.

Application3.PDBHelpDataSet1TableAdapters.TrepanningTroubleShootingTableAdapter
PDBHelpDataSet1TrepanningTroubleShootingTableAdapter = new
Application3.PDBHelpDataSet1TableAdapters.TrepanningTroubleShootingTableAdapter();

PDBHelpDataSet1TrepanningTroubleShootingTableAdapter.Fill(pDBHelpDataSet1.TrepanningTroub
leShooting);
        System.Windows.Data.CollectionViewSource trepanningTroubleShootingViewSource
[System.Windows.Data.CollectionViewSource](this.FindResource("trepanningTroubleShootingV
iewSource"));
        trepanningTroubleShootingViewSource.View.MoveCurrentToFirst();
        // Load data into the table BoringTroubleShooting. You can modify this code
as needed.

Application3.PDBHelpDataSet1TableAdapters.BoringTroubleShootingTableAdapter
PDBHelpDataSet1BoringTroubleShootingTableAdapter = new
Application3.PDBHelpDataSet1TableAdapters.BoringTroubleShootingTableAdapter();

PDBHelpDataSet1BoringTroubleShootingTableAdapter.Fill(pDBHelpDataSet1.BoringTroubleShooti
ng);
        System.Windows.Data.CollectionViewSource boringTroubleShootingViewSource1 =
[System.Windows.Data.CollectionViewSource](this.FindResource("boringTroubleShootingViewS
ource1"));
        boringTroubleShootingViewSource1.View.MoveCurrentToFirst();
        // Load data into the table ReamingTroubleShooting. You can modify this code
as needed.

Application3.PDBHelpDataSet1TableAdapters.ReamingTroubleShootingTableAdapter
PDBHelpDataSet1ReamingTroubleShootingTableAdapter = new
Application3.PDBHelpDataSet1TableAdapters.ReamingTroubleShootingTableAdapter();

PDBHelpDataSet1ReamingTroubleShootingTableAdapter.Fill(pDBHelpDataSet1.ReamingTroubleShoo
ting);
        System.Windows.Data.CollectionViewSource reamingTroubleShootingViewSource =
[System.Windows.Data.CollectionViewSource](this.FindResource("reamingTroubleShootingView
Source"));
        reamingTroubleShootingViewSource.View.MoveCurrentToFirst();

```

```
// Load data into the table MillingTroubleShooting. You can modify this code
```

```
as needed.
```

```
Application3.PDBHelpDataSet1TableAdapters.MillingTroubleShootingTableAdapter  
PDBHelpDataSet1MillingTroubleShootingTableAdapter = new  
Application3.PDBHelpDataSet1TableAdapters.MillingTroubleShootingTableAdapter();  
PDBHelpDataSet1MillingTroubleShootingTableAdapter.Fill(pDBHelpDataSet1.MillingTroubleShoo  
ting);
```

```
System.Windows.Data.CollectionViewSource millingTroubleShootingViewSource1 =  
(System.Windows.Data.CollectionViewSource)(this.FindResource("millingTroubleShootingView  
Source1"));
```

```
millingTroubleShootingViewSource1.View.MoveCurrentToFirst();
```

```
// Load data into the table TappingApplications. You can modify this code as
```

```
needed.
```

```
NpfApplication3.PDBHelpDataSet1TableAdapters.TappingApplicationsTableAdapter  
PDBHelpDataSet1TappingApplicationsTableAdapter = new  
Application3.PDBHelpDataSet1TableAdapters.TappingApplicationsTableAdapter();
```

```
PDBHelpDataSet1TappingApplicationsTableAdapter.Fill(pDBHelpDataSet1.TappingApplications);
```

```
System.Windows.Data.CollectionViewSource tappingApplicationsViewSource =  
(System.Windows.Data.CollectionViewSource)(this.FindResource("tappingApplicationsViewSou  
rce"));
```

```
tappingApplicationsViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table GrindingWheelApplications. You can modify this
```

```
code as needed.
```

```
Application3.PDBHelpDataSet1TableAdapters.GrindingWheelApplicationsTableAdapter  
PDBHelpDataSet1GrindingWheelApplicationsTableAdapter = new  
Application3.PDBHelpDataSet1TableAdapters.GrindingWheelApplicationsTableAdapter();
```

```
PDBHelpDataSet1GrindingWheelApplicationsTableAdapter.Fill(pDBHelpDataSet1.GrindingWheelAp  
plications);
```

```
System.Windows.Data.CollectionViewSource grindingWheelApplicationsViewSource  
= (System.Windows.Data.CollectionViewSource)(this.FindResource("grindingWheelApplicationsV  
iewSource"));
```

```
grindingWheelApplicationsViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table CuttingFluidsApplications. You can modify this
```

```
code as needed.
```

```
Application3.PDBHelpDataSet1TableAdapters.CuttingFluidsApplicationsTableAdapter  
PDBHelpDataSet1CuttingFluidsApplicationsTableAdapter = new  
Application3.PDBHelpDataSet1TableAdapters.CuttingFluidsApplicationsTableAdapter();
```

```
PDBHelpDataSet1CuttingFluidsApplicationsTableAdapter.Fill(pDBHelpDataSet1.CuttingFluidsAp  
plications);
```

```
System.Windows.Data.CollectionViewSource cuttingFluidsApplicationsViewSource  
= (System.Windows.Data.CollectionViewSource)(this.FindResource("cuttingFluidsApplicationsV  
iewSource"));
```

```
cuttingFluidsApplicationsViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table ElectrodeMaterialProperties. You can modify this
```

```
code as needed.
```

```
Application3.PDBHelpDataSet1TableAdapters.ElectrodeMaterialPropertiesTableAdapter  
PDBHelpDataSet1ElectrodeMaterialPropertiesTableAdapter = new  
Application3.PDBHelpDataSet1TableAdapters.ElectrodeMaterialPropertiesTableAdapter();
```

```
pDBHelpDataSet1ElectrodeMaterialPropertiesTableAdapter.Fill(pDBHelpDataSet1.ElectrodeMaterialProperties);
```

```
System.Windows.Data.CollectionViewSource
```

```
electrodeMaterialPropertiesViewSource =
```

```
((System.Windows.Data.CollectionViewSource)(this.FindResource("electrodeMaterialPropertiesViewSource")));
```

```
electrodeMaterialPropertiesViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table MaterialsandNonTraditionalMachining. You can
```

```
modify this code as needed.
```

```
Application3.PDBHelpDataSet1TableAdapters.MaterialsandNonTraditionalMachiningTableAdapter
```

```
 = new PDBHelpDataSet1MaterialsandNonTraditionalMachiningTableAdapter (new
```

```
Application3.PDBHelpDataSet1TableAdapters.MaterialsandNonTraditionalMachiningTableAdapter());
```

```
pDBHelpDataSet1MaterialsandNonTraditionalMachiningTableAdapter.Fill(pDBHelpDataSet1.MaterialsandNonTraditionalMachining);
```

```
System.Windows.Data.CollectionViewSource
```

```
materialsandNonTraditionalMachiningViewSource =
```

```
((System.Windows.Data.CollectionViewSource)(this.FindResource("materialsandNonTraditionalMachiningViewSource")));
```

```
materialsandNonTraditionalMachiningViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table ComparisonTraditionalandNonTraditionalMachining.
```

```
You can modify this code as needed.
```

```
Application3.PDBHelpDataSet1TableAdapters.ComparisonTraditionalandNonTraditionalMachiningTableAdapter
```

```
 = new PDBHelpDataSet1ComparisonTraditionalandNonTraditionalMachiningTableAdapter (new
```

```
Application3.PDBHelpDataSet1TableAdapters.ComparisonTraditionalandNonTraditionalMachiningTableAdapter());
```

```
pDBHelpDataSet1ComparisonTraditionalandNonTraditionalMachiningTableAdapter.Fill(pDBHelpDataSet1.ComparisonTraditionalandNonTraditionalMachining);
```

```
System.Windows.Data.CollectionViewSource
```

```
comparisonTraditionalandNonTraditionalMachiningViewSource =
```

```
((System.Windows.Data.CollectionViewSource)(this.FindResource("comparisonTraditionalandNonTraditionalMachiningViewSource")));
```

```
comparisonTraditionalandNonTraditionalMachiningViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table NonTraditionalMachiningSurfaceFinish. You can
```

```
modify this code as needed.
```

```
Application3.PDBHelpDataSet1TableAdapters.NonTraditionalMachiningSurfaceFinishTableAdapter
```

```
 = new PDBHelpDataSet1NonTraditionalMachiningSurfaceFinishTableAdapter (new
```

```
Application3.PDBHelpDataSet1TableAdapters.NonTraditionalMachiningSurfaceFinishTableAdapter());
```

```
pDBHelpDataSet1NonTraditionalMachiningSurfaceFinishTableAdapter.Fill(pDBHelpDataSet1.NonTraditionalMachiningSurfaceFinish);
```

```
System.Windows.Data.CollectionViewSource
```

```
nonTraditionalMachiningSurfaceFinishViewSource =
```

```
((System.Windows.Data.CollectionViewSource)(this.FindResource("nonTraditionalMachiningSurfaceFinishViewSource")));
```

```
nonTraditionalMachiningSurfaceFinishViewSource.View.MoveCurrentToFirst();
```

```
// Load data into the table BroachingApplications. You can modify this code
```

```
as needed.
```

```

        WpfApplication3.PDBHelpDataSetTableAdapters.BroachingApplicationsTableAdapter
        PDBHelpDataSetBroachingApplicationsTableAdapter = new
        WpfApplication3.PDBHelpDataSetTableAdapters.BroachingApplicationsTableAdapter();
        PDBHelpDataSetBroachingApplicationsTableAdapter.Fill(pDBHelpDataSet.BroachingApplications
        System.Windows.Data.CollectionViewSource broachingApplicationsViewSource =
        (System.Windows.Data.CollectionViewSource)(this.FindResource("broachingApplicationsViewS
        ource"));
        broachingApplicationsViewSource.View.MoveCurrentToFirst();
        // Load data into the table BroachingApplications. You can modify this code
        as needed.
        WpfApplication3.PDBHelpDataSet1TableAdapters.BroachingApplicationsTableAdapter
        PDBHelpDataSet1BroachingApplicationsTableAdapter = new
        WpfApplication3.PDBHelpDataSet1TableAdapters.BroachingApplicationsTableAdapter();
        PDBHelpDataSet1BroachingApplicationsTableAdapter.Fill(pDBHelpDataSet1.BroachingApplicatio
        n);
        System.Windows.Data.CollectionViewSource broachingApplicationsViewSource1 =
        (System.Windows.Data.CollectionViewSource)(this.FindResource("broachingApplicationsViewS
        ource1"));
        broachingApplicationsViewSource1.View.MoveCurrentToFirst();
        // Load data into the table ElectrolyteSolutionApplication. You can modify
        this code as needed.
        WpfApplication3.PDBHelpDataSet1TableAdapters.ElectrolyteSolutionApplicationTableAdapter
        PDBHelpDataSet1ElectrolyteSolutionApplicationTableAdapter = new
        WpfApplication3.PDBHelpDataSet1TableAdapters.ElectrolyteSolutionApplicationTableAdapter()
        PDBHelpDataSet1ElectrolyteSolutionApplicationTableAdapter.Fill(pDBHelpDataSet1.Electrolyt
        eSolutionApplication);
        System.Windows.Data.CollectionViewSource
        electrolyteSolutionApplicationViewSource =
        (System.Windows.Data.CollectionViewSource)(this.FindResource("electrolyteSolutionApplica
        tionViewSource"));
        electrolyteSolutionApplicationViewSource.View.MoveCurrentToFirst();
        // Load data into the table ElectrodeMaterialSelection. You can modify this
        code as needed.
        WpfApplication3.PDBHelpDataSet1TableAdapters.ElectrodeMaterialSelectionTableAdapter
        PDBHelpDataSet1ElectrodeMaterialSelectionTableAdapter = new
        WpfApplication3.PDBHelpDataSet1TableAdapters.ElectrodeMaterialSelectionTableAdapter();
        PDBHelpDataSet1ElectrodeMaterialSelectionTableAdapter.Fill(pDBHelpDataSet1.ElectrodeMater
        ialSelection);
        System.Windows.Data.CollectionViewSource electrodeMaterialSelectionViewSource
        (System.Windows.Data.CollectionViewSource)(this.FindResource("electrodeMaterialSelection
        ViewSource"));
        electrodeMaterialSelectionViewSource.View.MoveCurrentToFirst();
    }

    private void comboBox1_DropDownClosed(object sender, EventArgs e)

```

```

    string cs = @"Data Source=.\SQLEXPRESS;" +
    AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
    Security=True;" +
    Connect Timeout=30;" +
    User Instance=True;";
    string sql123 = "SELECT tensilestrength FROM Table1affieldchipthickness WHERE
    PieceMaterial = '" + workPieceMaterialComboBox4.Text + "'";
    SqlConnection con = new SqlConnection(cs);

    con.Open();

    SqlCommand cmd3 = new SqlCommand(sql123, con);
    comboBox2.ItemsSource = cmd3.ExecuteReader();

    comboBox2.IsEnabled = true;
    comboBox3.IsEnabled = false;
}

private void PDB2_Loaded(object sender, RoutedEventArgs e)
{
}

private void workPieceMaterialComboBox3_Closed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
    AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
    Connect Timeout=30;" +
    User Instance=True;";

    string sql = "SELECT DISTINCT WorkPieceMaterialHardnessBHN FROM
    ToolAnglesSinglePointTools WHERE WorkPieceMaterial = '" + workPieceMaterialComboBox3.Text
    ";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    workPieceMaterialHardnessBHNComboBox.ItemsSource = cmd15.ExecuteReader();
}

private void workPieceMaterialHardnessBHNComboBox_Closed(object sender, EventArgs
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
    AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
    Connect Timeout=30;" +
    User Instance=True;";

    string sql = "SELECT DISTINCT ToolMaterial FROM ToolAnglesSinglePointTools
    WorkPieceMaterial = '" + workPieceMaterialComboBox3.Text + "' AND
    PieceMaterialHardnessBHN = '" + workPieceMaterialHardnessBHNComboBox.Text + "'";
}

```

```
SqlConnection con5 = new SqlConnection(cs2);
```

```
con5.Open();
```

```
SqlCommand cmd15 = new SqlCommand(sql, con5);
```

```
comboBox4.ItemsSource = cmd15.ExecuteReader();
```

```
private void button7_Click_1(object sender, RoutedEventArgs e)
```

```
{  
    string cs2 = @"Data Source=.\SQLEXPRESS;" +  
    "AttachDbFilename={DataDirectory}\MachineOperations_Data.mdf;Integrated Security=True;" +  
    "Connect Timeout=30;" +  
    "User Instance=True;";
```

```
    string sql1 = "SELECT BackRakeAngleInDegrees FROM ToolAnglesSinglePointTools  
WHERE WorkPieceMaterial = '" + workPieceMaterialComboBox3.Text + "' AND  
WorkPieceMaterialHardnessBHN = '" + workPieceMaterialHardnessBHNCComboBox.Text + "' AND  
ToolMaterial = '" + comboBox4.Text + "'";
```

```
    string sql2 = "SELECT SideRakeAngleInDegrees FROM ToolAnglesSinglePointTools  
WHERE WorkPieceMaterial = '" + workPieceMaterialComboBox3.Text + "' AND  
WorkPieceMaterialHardnessBHN = '" + workPieceMaterialHardnessBHNCComboBox.Text + "' AND  
ToolMaterial = '" + comboBox4.Text + "'";
```

```
    string sql3 = "SELECT EndClearanceAngleInDegrees FROM  
ToolAnglesSinglePointTools WHERE WorkPieceMaterial = '" + workPieceMaterialComboBox3.Text  
" AND WorkPieceMaterialHardnessBHN = '" + workPieceMaterialHardnessBHNCComboBox.Text +  
" AND ToolMaterial = '" + comboBox4.Text + "'";
```

```
    string sql4 = "SELECT SideClearanceAngleInDegrees FROM  
ToolAnglesSinglePointTools WHERE WorkPieceMaterial = '" + workPieceMaterialComboBox3.Text  
" AND WorkPieceMaterialHardnessBHN = '" + workPieceMaterialHardnessBHNCComboBox.Text +  
" AND ToolMaterial = '" + comboBox4.Text + "'";
```

```
    string sql5 = "SELECT SideAndEndCuttingEdgeInDegrees FROM  
ToolAnglesSinglePointTools WHERE WorkPieceMaterial = '" + workPieceMaterialComboBox3.Text  
" AND WorkPieceMaterialHardnessBHN = '" + workPieceMaterialHardnessBHNCComboBox.Text +  
" AND ToolMaterial = '" + comboBox4.Text + "'";
```

```
SqlConnection con5 = new SqlConnection(cs2);
```

```
con5.Open();
```

```
SqlCommand cmd1 = new SqlCommand(sql1, con5);
```

```
SqlCommand cmd2 = new SqlCommand(sql2, con5);
```

```
SqlCommand cmd3 = new SqlCommand(sql3, con5);
```

```
SqlCommand cmd4 = new SqlCommand(sql4, con5);
```

```
SqlCommand cmd5 = new SqlCommand(sql5, con5);
```

```
label2.Content = cmd1.ExecuteScalar() + " Degrees";
```

```
label3.Content = cmd2.ExecuteScalar() + " Degrees";
```

```
label4.Content = cmd3.ExecuteScalar() + " Degrees";
```

```
label5.Content = cmd4.ExecuteScalar() + " Degrees";
```

```
label7.Content = cmd5.ExecuteScalar() + " Degrees";
```

```
}
```

```

private void t22_Loaded(object sender, RoutedEventArgs e)
{
}

private void comboBox5_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
        "Connect Timeout=30;" +
        "User Instance=True;";

    string sql = "SELECT DISTINCT [depth of hole in millimeters] FROM
        SettingFluidVolumeExternalChipRemovalGunDrill WHERE [size of drill in millimeters] = '" +
        comboBox5.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    comboBox6.ItemsSource = cmd15.ExecuteReader();
}

private void button8_Click_1(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
        "Connect Timeout=30;" +
        "User Instance=True;";

    string sql = "SELECT [fluid flow volume in litre per minute] FROM
        SettingFluidVolumeExternalChipRemovalGunDrill WHERE [size of drill in millimeters] = '" +
        comboBox5.Text + "' AND [depth of hole in millimeters] = '" + comboBox6.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    label11.Content = cmd15.ExecuteScalar();
}

private void tabItem25_Loaded(object sender, RoutedEventArgs e)
{
}

private void comboBox7_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
        "Connect Timeout=30;" +
        "User Instance=True;";
}

```

```

        string sql = "SELECT DISTINCT [tool material] FROM
CuttingSpeedConditionsMilling WHERE [work piece material] = '" + comboBox7.Text + "'";

        SqlConnection con5 = new SqlConnection(cs2);

        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql, con5);

        comboBox8.ItemsSource = cmd15.ExecuteReader();
    }

    private void button9_Click_1(object sender, RoutedEventArgs e)
    {
        string cs2 = @"Data Source=.\SQLEXPRESS;" +
AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
+
Connect Timeout=30;" +
User Instance=True;";

        string sql1 = "SELECT DISTINCT [cutting speed in meters per minute] FROM
CuttingSpeedConditionsMilling WHERE [work piece material] = '" + comboBox7.Text + "' AND
[tool material] = '" + comboBox8.Text + "'";
        string sql2 = "SELECT DISTINCT [cutting feed in millimeters per tooth for
face mills] FROM CuttingSpeedConditionsMilling WHERE [work piece material] = '" +
comboBox7.Text + "' AND [tool material] = '" + comboBox8.Text + "'";
        string sql3 = "SELECT DISTINCT [cutting feed in millimeters per tooth for
slot mills] FROM CuttingSpeedConditionsMilling WHERE [work piece material] = '" +
comboBox7.Text + "' AND [tool material] = '" + comboBox8.Text + "'";
        string sql4 = "SELECT DISTINCT [cutting feed in millimeters per tooth for
slotting and side mill] FROM CuttingSpeedConditionsMilling WHERE [work piece material] =
'" + comboBox7.Text + "' AND [tool material] = '" + comboBox8.Text + "'";
        string sql5 = "SELECT DISTINCT [cutting feed in millimeters per tooth for end
mills] FROM CuttingSpeedConditionsMilling WHERE [work piece material] = '" +
comboBox7.Text + "' AND [tool material] = '" + comboBox8.Text + "'";
        string sql6 = "SELECT DISTINCT [cutting feed in millimeters per tooth for
form cutters] FROM CuttingSpeedConditionsMilling WHERE [work piece material] = '" +
comboBox7.Text + "' AND [tool material] = '" + comboBox8.Text + "'";

        SqlConnection con5 = new SqlConnection(cs2);

        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql1, con5);
        SqlCommand cmd16 = new SqlCommand(sql2, con5);
        SqlCommand cmd17 = new SqlCommand(sql3, con5);
        SqlCommand cmd18 = new SqlCommand(sql4, con5);
        SqlCommand cmd19 = new SqlCommand(sql5, con5);
        SqlCommand cmd20 = new SqlCommand(sql6, con5);

        label14.Content = cmd15.ExecuteScalar();
        label16.Content = cmd16.ExecuteScalar();
        label17.Content = cmd17.ExecuteScalar();
        label18.Content = cmd18.ExecuteScalar();
        label20.Content = cmd19.ExecuteScalar();
        label21.Content = cmd20.ExecuteScalar();
    }
}

```

```
private void tabItem28_Loaded(object sender, RoutedEventArgs e)
{
}
```

```
private void comboBox9_DropDownClosed(object sender, EventArgs e)
{
```

```
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
    @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
    @"Connect Timeout=30;" +
    @"User Instance=True;"
```

```
    string sql = "SELECT DISTINCT [work piece material hardness (brinell hardness)] FROM CuttingSpeedsFeedsFaceShoulderMills WHERE [work piece material] = '" + comboBox9.Text + "'";
```

```
    SqlConnection con5 = new SqlConnection(cs2);
```

```
    con5.Open();
```

```
    SqlCommand cmd15 = new SqlCommand(sql, con5);
```

```
    comboBox10.ItemsSource = cmd15.ExecuteReader();
```

```
private void button10_Click_1(object sender, RoutedEventArgs e)
{
```

```
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
    @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
    @"Connect Timeout=30;" +
    @"User Instance=True;"
```

```
    string sql1 = "SELECT [work piece material tensile strength] FROM CuttingSpeedsFeedsFaceShoulderMills WHERE [work piece material] = '" + comboBox9.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox10.Text + "'";
```

```
    string sql2 = "SELECT [cuttin speed in m/min for SANDVIK COMORANT GRADE S1P(P 10)] FROM CuttingSpeedsFeedsFaceShoulderMills WHERE [work piece material] = '" + comboBox9.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox10.Text + "'";
```

```
    string sql3 = "SELECT [cuttin speed in m/min for SANDVIK COMORANT GRADE S4(P 10)] FROM CuttingSpeedsFeedsFaceShoulderMills WHERE [work piece material] = '" + comboBox9.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox10.Text + "'";
```

```
    string sql4 = "SELECT [cuttin speed in m/min for SANDVIK COMORANT GRADE S6 (P 10)] FROM CuttingSpeedsFeedsFaceShoulderMills WHERE [work piece material] = '" + comboBox9.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox10.Text + "'";
```

```
    string sql5 = "SELECT [feed in millimeters (mm) per tooth] FROM CuttingSpeedsFeedsFaceShoulderMills WHERE [work piece material] = '" + comboBox9.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox10.Text + "'";
```

```
    SqlConnection con5 = new SqlConnection(cs2);
```

```
    con5.Open();
```

```
    SqlCommand cmd15 = new SqlCommand(sql1, con5);
```

```
    SqlCommand cmd16 = new SqlCommand(sql2, con5);
```



```
SqlCommand cmd17 = new SqlCommand(sql3, con5);
SqlCommand cmd18 = new SqlCommand(sql4, con5);
SqlCommand cmd19 = new SqlCommand(sql5, con5);

label24.Content = cmd15.ExecuteScalar();
label25.Content = cmd16.ExecuteScalar();
label26.Content = cmd17.ExecuteScalar();
label27.Content = cmd18.ExecuteScalar();
label28.Content = cmd19.ExecuteScalar();
}

private void comboBox12_Loaded(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT [work piece material] FROM
        MillingSpeedsFeedsMillingCutters";

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);
    comboBox11.ItemsSource = cmd15.ExecuteReader();
}

private void comboBox11_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT [machining operation] FROM
        MillingSpeedsFeedsMillingCutters WHERE [work piece material] = '" + comboBox11.Text +

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);
    comboBox12.ItemsSource = cmd15.ExecuteReader();
}

private void button21_Click(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
```

```

AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
Connect Timeout=30;" +
User Instance=True;";

string sql1 = "SELECT [feed per tooth in millimeters for face and shoulder
mills] FROM CuttingSpeedsFeedsMillingCutters WHERE [work piece material] = '" +
comboBox11.Text + "' AND [machining operation] = '" + comboBox12.Text + "'";
string sql2 = "SELECT [cutting speed in meters per minute for face and
shoulder mills] FROM CuttingSpeedsFeedsMillingCutters WHERE [work piece material] = '" +
comboBox11.Text + "' AND [machining operation] = '" + comboBox12.Text + "'";
string sql3 = "SELECT [feed per tooth in millimeters for side and face
cutters] FROM CuttingSpeedsFeedsMillingCutters WHERE [work piece material] = '" +
comboBox11.Text + "' AND [machining operation] = '" + comboBox12.Text + "'";
string sql4 = "SELECT [cutting speed in meters per minute for side and face
cutters] FROM CuttingSpeedsFeedsMillingCutters WHERE [work piece material] = '" +
comboBox11.Text + "' AND [machining operation] = '" + comboBox12.Text + "'";

SqlConnection con5 = new SqlConnection(cs2);

con5.Open();

SqlCommand cmd15 = new SqlCommand(sql1, con5);
SqlCommand cmd16 = new SqlCommand(sql2, con5);
SqlCommand cmd17 = new SqlCommand(sql3, con5);
SqlCommand cmd18 = new SqlCommand(sql4, con5);

label30.Content = cmd15.ExecuteScalar();
label31.Content = cmd16.ExecuteScalar();
label33.Content = cmd17.ExecuteScalar();
label34.Content = cmd18.ExecuteScalar();

}

private void tabItem32_Loaded(object sender, RoutedEventArgs e)
{

}

private void comboBox13_DropDownClosed(object sender, EventArgs e)
{
string cs2 = @"Data Source=.\SQLEXPRESS;" +
AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
Connect Timeout=30;" +
User Instance=True;";

string sql = "SELECT [work piece thickness in millimeters] FROM
ElectronBeamMachiningDrilling WHERE [work piece material] = '" + comboBox13.Text + "'";

SqlConnection con5 = new SqlConnection(cs2);

con5.Open();

```

```

SqlCommand cmd15 = new SqlCommand(sql, con5);

comboBox14.ItemsSource = cmd15.ExecuteReader();
}

private void button22_Click(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "For Instance=True;";

    string sql1 = "SELECT [hole diameter in millimeters] FROM
        ElectronBeamMachiningDrilling WHERE [work piece material] = '" + comboBox13.Text + "' AND
        [work piece thickness in millimeters] = '" + comboBox14.Text + "'";
    string sql2 = "SELECT [penetration rate in seconds] FROM
        ElectronBeamMachiningDrilling WHERE [work piece material] = '" + comboBox13.Text + "' AND
        [work piece thickness in millimeters] = '" + comboBox14.Text + "'";
    string sql3 = "SELECT [acceleration voltage in kilo-volts] FROM
        ElectronBeamMachiningDrilling WHERE [work piece material] = '" + comboBox13.Text + "' AND
        [work piece thickness in millimeters] = '" + comboBox14.Text + "'";
    string sql4 = "SELECT [average beam current in micro-amperes] FROM
        ElectronBeamMachiningDrilling WHERE [work piece material] = '" + comboBox13.Text + "' AND
        [work piece thickness in millimeters] = '" + comboBox14.Text + "'";
    string sql5 = "SELECT [pulse frequency] FROM ElectronBeamMachiningDrilling
        WHERE [work piece material] = '" + comboBox13.Text + "' AND [work piece thickness in
        millimeters] = '" + comboBox14.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql1, con5);
    SqlCommand cmd16 = new SqlCommand(sql2, con5);
    SqlCommand cmd17 = new SqlCommand(sql3, con5);
    SqlCommand cmd18 = new SqlCommand(sql4, con5);
    SqlCommand cmd19 = new SqlCommand(sql5, con5);

    label137.Content = cmd15.ExecuteScalar();
    label139.Content = cmd16.ExecuteScalar();
    label140.Content = cmd17.ExecuteScalar();
    label142.Content = cmd18.ExecuteScalar();
    label143.Content = cmd19.ExecuteScalar();
}

private void tabItem37_Loaded(object sender, RoutedEventArgs e)
{
}

private void comboBox15_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "For Instance=True;";
}

```

```

        string sql = "SELECT DISTINCT [work piece material strength or hardness] FROM
        RestoringConditionsCarbideTools WHERE [work piece material] ='" + comboBox15.Text +

        SqlConnection con5 = new SqlConnection(cs2);

        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql, con5);

        comboBox16.ItemsSource = cmd15.ExecuteReader();
    }

    private void button23_Click(object sender, RoutedEventArgs e)
    {
        string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
        @"Connect Timeout=30;" +
        @"User Instance=True;";

        string sql1 = "SELECT [depth of cut in millimeters (mm)] FROM
        RestoringConditionsCarbideTools WHERE [work piece material] ='" + comboBox15.Text + "'
        AND [work piece material strength or hardness] = '" + comboBox16.Text + "'";
        string sql2 = "SELECT [radius of tool nose in millimeters (mm)] FROM
        RestoringConditionsCarbideTools WHERE [work piece material] ='" + comboBox15.Text + "'
        AND [work piece material strength or hardness] = '" + comboBox16.Text + "'";
        string sql3 = "SELECT [feed in millimeters per revolution (mm/rev)] FROM
        RestoringConditionsCarbideTools WHERE [work piece material] ='" + comboBox15.Text + "'
        AND [work piece material strength or hardness] = '" + comboBox16.Text + "'";
        string sql4 = "SELECT [speed in meters per minute (m/min)] FROM
        RestoringConditionsCarbideTools WHERE [work piece material] ='" + comboBox15.Text + "'
        AND [work piece material strength or hardness] = '" + comboBox16.Text + "'";
        string sql5 = "SELECT [coolant required] FROM
        RestoringConditionsCarbideTools WHERE [work piece material] ='" + comboBox15.Text + "'
        AND [work piece material strength or hardness] = '" + comboBox16.Text + "'";

        SqlConnection con5 = new SqlConnection(cs2);

        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql1, con5);
        SqlCommand cmd16 = new SqlCommand(sql2, con5);
        SqlCommand cmd17 = new SqlCommand(sql3, con5);
        SqlCommand cmd18 = new SqlCommand(sql4, con5);
        SqlCommand cmd19 = new SqlCommand(sql5, con5);

        label146.Content = cmd15.ExecuteScalar();
        label148.Content = cmd16.ExecuteScalar();
        label149.Content = cmd17.ExecuteScalar();
        label152.Content = cmd18.ExecuteScalar();
        label153.Content = cmd19.ExecuteScalar();
    }

    private void tabItem40_Loaded(object sender, RoutedEventArgs e)

```

```

}

private void comboBox17_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=[DataDirectory]\MachineOperations_Data.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT [work piece material hardness (brinell hardness)] FROM MachiningConditionsGunDrilling WHERE [work piece material] = '" +
        comboBox17.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    comboBox18.ItemsSource = cmd15.ExecuteReader();
}

private void button24_Click(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=[DataDirectory]\MachineOperations_Data.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql1 = "SELECT [tool material] FROM MachiningConditionsGunDrilling WHERE [work piece material] = '" + comboBox17.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox18.Text + "'";
    string sql2 = "SELECT [speed in meters per minute (m/min)] FROM MachiningConditionsGunDrilling WHERE [work piece material] = '" + comboBox17.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox18.Text + "'";
    string sql3 = "SELECT [feed in mm per revolution with tool diameter " + comboBox20.Text + "] FROM MachiningConditionsGunDrilling WHERE [work piece material] = '" + comboBox17.Text + "' AND [work piece material hardness (brinell hardness)] = '" + comboBox18.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql1, con5);
    SqlCommand cmd16 = new SqlCommand(sql2, con5);
    SqlCommand cmd17 = new SqlCommand(sql3, con5);

    label156.Content = cmd15.ExecuteScalar();
    label157.Content = cmd16.ExecuteScalar();
    label158.Content = cmd17.ExecuteScalar();
}

```

```

}

private void button26_Click(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
@"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
@"Connect Timeout=30;" +
@"User Instance=True;";

    string sql = "INSERT INTO [dbo].[MillingCuttingSpeeds] ([work piece
material], [tool material], [feet per minute], [meters per minute]) VALUES ('" +
work_piece_materialComboBox4.Text + "', '" + tool_materialComboBox1.Text + "', '" +
feet_per_minuteTextBox.Text + "', '" + meters_per_minuteTextBox.Text + "')";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    label164.Content = cmd15.ExecuteScalar();
    label163.Content = "Updated";
}

private void image2_MouseDown(object sender, MouseButtonEventArgs e)
{
    Contents.Focus();
}

private void button27_Click(object sender, RoutedEventArgs e)
{
}

private void PDB1_Loaded(object sender, RoutedEventArgs e)
{
}

private void PDB4_loaded(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
@"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
Security=True;" +
@"Connect Timeout=30;" +
@"User Instance=True;";

    string sql = "SELECT DISTINCT WorkpieceMaterial FROM
MillingSpeedMetersperMinute";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd5 = new SqlCommand(sql, con5);
}

```

```

workpieceMaterialComboBox2.ItemsSource = cmd5.ExecuteReader();
tool_materialComboBox.IsEnabled = false;
button20.IsEnabled = false;
}

private void PDB9I(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"Initial Catalog=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT [size of drill in millimeters] FROM
        FluidVolumeExternalChipRemovalGunDrill";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    comboBox5.ItemsSource = cmd15.ExecuteReader();
}

private void PDB8_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"Initial Catalog=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT [work piece material] FROM
        SpeedConditionsMilling";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    comboBox7.ItemsSource = cmd15.ExecuteReader();
}

private void PDBBD_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"Initial Catalog=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT [work piece material] FROM
        SpeedsFeedsFaceShoulderMills";
}

```

```

SqlConnection con5 = new SqlConnection(cs2);
con5.Open();
SqlCommand cmd15 = new SqlCommand(sql, con5);
comboBox9.ItemsSource = cmd15.ExecuteReader();
}

private void PDB18_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "User Instance=True;";

    string sql = "SELECT DISTINCT [work piece material] FROM
        ElectronBeamMachiningDrilling";

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();
    SqlCommand cmd15 = new SqlCommand(sql, con5);
    comboBox13.ItemsSource = cmd15.ExecuteReader();
}

private void tabItem37_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "User Instance=True;";

    string sql = "SELECT DISTINCT [work piece material] FROM
        ReferencingConditionsCarbideTools";

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();
    SqlCommand cmd15 = new SqlCommand(sql, con5);
    comboBox15.ItemsSource = cmd15.ExecuteReader();
}

private void PDB9G_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "User Instance=True;";

```

```

string sql = "SELECT DISTINCT [work piece material] FROM
turningConditionsGunDrilling";

SqlConnection con5 = new SqlConnection(cs2);

con5.Open();

SqlCommand cmd15 = new SqlCommand(sql, con5);

comboBox17.ItemsSource = cmd15.ExecuteReader();
}
}
private void button25_Click(object sender, RoutedEventArgs e)
{
}
private void tabItem20_Initialized(object sender, EventArgs e)
{
string cs2 = @"Data Source=.\SQLEXPRESS;" +
AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
Connect Timeout=30;" +
User Instance=True;";

string sql = "SELECT DISTINCT trouble FROM HelpTurning";

SqlConnection con5 = new SqlConnection(cs2);

con5.Open();

SqlCommand cmd15 = new SqlCommand(sql, con5);

troubleComboBox.ItemsSource = cmd15.ExecuteReader();

comboBox1.IsEnabled = false;
}
private void troubleComboBox_DropDownClosed(object sender, EventArgs e)
{
string cs2 = @"Data Source=.\SQLEXPRESS;" +
AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
Connect Timeout=30;" +
User Instance=True;";

string sql = "SELECT DISTINCT [probable reason] FROM HelpTurning WHERE
trouble = '" + troubleComboBox.Text + "'";

SqlConnection con5 = new SqlConnection(cs2);

con5.Open();

SqlCommand cmd15 = new SqlCommand(sql, con5);

comboBox1.ItemsSource = cmd15.ExecuteReader();

comboBox1.IsEnabled = true;
}
}

```

```
private void listBox1_MouseDown(object sender, MouseButtonEventArgs e)
```

```
{  
}
```

```
private void listBox1_MouseLeftButtonDown(object sender, MouseButtonEventArgs e)
```

```
{  
}
```

```
private void comboBox1_DropDownClosed_1(object sender, EventArgs e)
```

```
{
```

```
    string cs2 = @"Data Source=.\SQLEXPRESS;" +  
    @"AttachDbFilename=[DataDirectory]\PDBHelp.mdf;Integrated Security=True;" +  
    @"Connect Timeout=30;" +  
    @"User Instance=True;"
```

```
    string sql = "SELECT remedy FROM HelpTurning WHERE trouble = '" +  
    troubleComboBox.Text + "' AND [probable reason] = '" + comboBox1.Text + "'";
```

```
    SqlConnection con5 = new SqlConnection(cs2);
```

```
    con5.Open();
```

```
    SqlCommand cmd15 = new SqlCommand(sql, con5);
```

```
    probable_reasonListBox.ItemsSource = cmd15.ExecuteReader();
```

```
}
```

```
private void tabItem25_Initialized(object sender, EventArgs e)
```

```
{
```

```
    string cs2 = @"Data Source=.\SQLEXPRESS;" +  
    @"AttachDbFilename=[DataDirectory]\PDBHelp.mdf;Integrated Security=True;" +  
    @"Connect Timeout=30;" +  
    @"User Instance=True;"
```

```
    string sql = "SELECT DISTINCT problem FROM MillingTroubleshooting";
```

```
    SqlConnection con5 = new SqlConnection(cs2);
```

```
    con5.Open();
```

```
    SqlCommand cmd15 = new SqlCommand(sql, con5);
```

```
    problemComboBox.ItemsSource = cmd15.ExecuteReader();
```

```
}
```

```
private void problemComboBox_DropDownClosed(object sender, EventArgs e)
```

```
{
```

```
    string cs2 = @"Data Source=.\SQLEXPRESS;" +  
    @"AttachDbFilename=[DataDirectory]\PDBHelp.mdf;Integrated Security=True;" +  
    @"Connect Timeout=30;" +  
    @"User Instance=True;"
```

```
    string sql = "SELECT remedy FROM MillingTroubleshooting WHERE problem = '" +  
    problemComboBox.Text + "'";
```

```

SqlConnection con5 = new SqlConnection(cs2);
con5.Open();
SqlCommand cmd15 = new SqlCommand(sql, con5);
listBox1.ItemsSource = cmd15.ExecuteReader();
}

private void tabItem31_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT problem FROM GunDrillingTroubleShooting";
    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();
    SqlCommand cmd15 = new SqlCommand(sql, con5);
    problemComboBox2.ItemsSource = cmd15.ExecuteReader();
}

private void problemComboBox2_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT causes FROM GunDrillingTroubleShooting WHERE problem = " +
        problemComboBox2.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();
    SqlCommand cmd15 = new SqlCommand(sql, con5);
    causesListBox.ItemsSource = cmd15.ExecuteReader();
}

private void tabItem32_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        @"Connect Timeout=30;" +
        @"User Instance=True;";

    string sql = "SELECT DISTINCT problem FROM TrepanningTroubleShooting";
    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();
}

```

```

        SqlCommand cmd15 = new SqlCommand(sql, con5);
        problemComboBox3.ItemsSource = cmd15.ExecuteReader();
    }
    private void problemComboBox3_DropDownClosed(object sender, EventArgs e)
    {
        string cs2 = @"Data Source=.\SQLEXPRESS;" +
            "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
            "Connect Timeout=30;" +
            "User Instance=True;";

        string sql = "SELECT causes FROM TrepanningTroubleShooting WHERE problem = '" +
            problemComboBox3.Text + "'";

        SqlConnection con5 = new SqlConnection(cs2);
        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql, con5);
        causesListBox1.ItemsSource = cmd15.ExecuteReader();
    }
    private void tabItem33_Initialized(object sender, EventArgs e)
    {
        string cs2 = @"Data Source=.\SQLEXPRESS;" +
            "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
            "Connect Timeout=30;" +
            "User Instance=True;";

        string sql = "SELECT DISTINCT problem FROM BoringTroubleShooting";

        SqlConnection con5 = new SqlConnection(cs2);
        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql, con5);
        problemComboBox4.ItemsSource = cmd15.ExecuteReader();
    }
    private void problemComboBox4_DropDownClosed(object sender, EventArgs e)
    {
        string cs2 = @"Data Source=.\SQLEXPRESS;" +
            "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
            "Connect Timeout=30;" +
            "User Instance=True;";

        string sql = "SELECT causes FROM BoringTroubleShooting WHERE problem = '" +
            problemComboBox4.Text + "'";

        SqlConnection con5 = new SqlConnection(cs2);
        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql, con5);
        causesListBox2.ItemsSource = cmd15.ExecuteReader();
    }

```

```

}

private void tabItem35_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "Server Instance=True;";

    string sql = "SELECT problem FROM ReamingTroubleShooting";
    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);
    problemComboBox5.ItemsSource = cmd15.ExecuteReader();
    causesComboBox.IsEnabled = false;
}

private void problemComboBox5_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "Server Instance=True;";

    string sql = "SELECT causes FROM ReamingTroubleShooting WHERE problem = '" +
        problemComboBox5.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);
    causesComboBox.ItemsSource = cmd15.ExecuteReader();
    causesComboBox.IsEnabled = true;
}

private void causesComboBox_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "Server Instance=True;";

    string sql = "SELECT remedy FROM ReamingTroubleShooting WHERE problem = '" +
        problemComboBox5.Text + "' AND causes = '" + causesComboBox.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);
    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);
}

```

```

        remedyListBox.ItemsSource = cmd15.ExecuteReader();
    }

    private void PDB1_Initialized(object sender, EventArgs e)
    {
        comboBox2.IsEnabled = false;
        comboBox3.IsEnabled = false;
    }

    private void comboBox2_DropDownClosed(object sender, EventArgs e)
    {
        comboBox2.IsEnabled = true;
        comboBox3.IsEnabled = true;
    }

    private void workpieceMaterialComboBox2_DropDownClosed(object sender, EventArgs e)
    {
        tool_materialComboBox.IsEnabled = true;
    }

    private void tool_materialComboBox_DropDownClosed(object sender, EventArgs e)
    {
        button20.IsEnabled = true;
    }

    private void tabItem39_Initialized(object sender, EventArgs e)
    {
        string cs2 = @"Data Source=.\SQLEXPRESS;" +
            "AttachDbFilename=[DataDirectory]\PDBHelp.mdf;Integrated Security=True;" +
            "Connect Timeout=30;" +
            "User Instance=True;";

        string sql = "SELECT DISTINCT [work piece material properties] FROM
            MachiningApplications";

        SqlConnection con5 = new SqlConnection(cs2);
        con5.Open();

        SqlCommand cmd15 = new SqlCommand(sql, con5);

        comboBox22.ItemsSource = cmd15.ExecuteReader();

        comboBox23.IsEnabled = false;
        button27.IsEnabled = false;
    }

    private void comboBox22_DropDownClosed(object sender, EventArgs e)
    {
        string cs2 = @"Data Source=.\SQLEXPRESS;" +
            "AttachDbFilename=[DataDirectory]\PDBHelp.mdf;Integrated Security=True;" +
            "Connect Timeout=30;" +
            "User Instance=True;";

        string sql = "SELECT DISTINCT [operation conditions] FROM
            MachiningApplications WHERE [work piece material properties] ='" + comboBox22.Text + "'";
    }

```

```

SqlConnection con5 = new SqlConnection(cs2);

con5.Open();

SqlCommand cmd15 = new SqlCommand(sql, con5);

comboBox23.ItemsSource = cmd15.ExecuteReader();

comboBox23.IsEnabled = true;
button27.IsEnabled = true;
}

private void button27_Click_1(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "User Instance=True;";

    string sql = "SELECT [broaching material recommendations] FROM BroachingApplications WHERE [work piece material properties] ='" + comboBox22.Text + "' AND [operation conditions] ='" + comboBox23.Text + "'";
    string sql2 = "SELECT [comments] FROM BroachingApplications WHERE [work piece material properties] ='" + comboBox22.Text + "' AND [operation conditions] ='" + comboBox23.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);
    SqlCommand cmd16 = new SqlCommand(sql2, con5);

    label141.Content = cmd15.ExecuteScalar();
    label142.Content = cmd16.ExecuteScalar();
}

private void tabItem46_Initialized(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "User Instance=True;";

    string sql = "SELECT DISTINCT [electrolyte base group] FROM ElectrolyteSolutionApplication";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    comboBox24.ItemsSource = cmd15.ExecuteReader();

    comboBox25.IsEnabled = false;
    button28.IsEnabled = false;
}

```

```

}

private void comboBox24_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "MultipleActiveResultSets=True;Instance=True;";

    string sql = "SELECT DISTINCT [electrolyte base] FROM
        ElectrolyteSolutionApplication WHERE [electrolyte base group] = '" + comboBox24.Text +

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    comboBox25.ItemsSource = cmd15.ExecuteReader();

    comboBox25.IsEnabled = true;
    button28.IsEnabled = false;
}

private void comboBox25_DropDownClosed(object sender, EventArgs e)
{
    button28.IsEnabled = true;
}

private void button28_Click(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
        "Connect Timeout=30;" +
        "MultipleActiveResultSets=True;Instance=True;";

    string sql = "SELECT [concentration weight percentage in aqueous solution]
        FROM ElectrolyteSolutionApplication WHERE [electrolyte base group] = '" + comboBox24.Text +
        "' AND [electrolyte base] = '" + comboBox25.Text + "'";
    string sql2 = "SELECT [application] FROM ElectrolyteSolutionApplication WHERE
        [electrolyte base group] = '" + comboBox24.Text + "' AND [electrolyte base] = '" +
        comboBox25.Text + "'";
    string sql3 = "SELECT [comments] FROM ElectrolyteSolutionApplication WHERE
        [electrolyte base group] = '" + comboBox24.Text + "' AND [electrolyte base] = '" +
        comboBox25.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);
    SqlCommand cmd16 = new SqlCommand(sql2, con5);

```

```
SqlCommand cmd17 = new SqlCommand(sql3, con5);
```

```
label144.Content = cmd15.ExecuteScalar();  
textBlock1.Text = cmd16.ExecuteScalar().ToString();  
textBlock2.Text = cmd17.ExecuteScalar().ToString();
```

```
private void tabItem44_Initialized(object sender, EventArgs e)
```

```
{  
    string cs2 = @"Data Source=.\SQLEXPRESS;" +  
@"AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +  
@"Connect Timeout=30;" +  
@"User Instance=True;";
```

```
    string sql = "SELECT DISTINCT [work piece material] FROM  
DuctrodeMaterialSelection";
```

```
SqlConnection con5 = new SqlConnection(cs2);
```

```
con5.Open();
```

```
SqlCommand cmd15 = new SqlCommand(sql, con5);
```

```
comboBox26.ItemsSource = cmd15.ExecuteReader();
```

```
comboBox27.IsEnabled = false;
```

```
comboBox28.IsEnabled = false;
```

```
button29.IsEnabled = false;
```

```
private void comboBox26_DropDownClosed(object sender, EventArgs e)
```

```
{  
    string cs2 = @"Data Source=.\SQLEXPRESS;" +  
@"AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +  
@"Connect Timeout=30;" +  
@"User Instance=True;";
```

```
    string sql = "SELECT DISTINCT [machining operation] FROM  
DuctrodeMaterialSelection WHERE [work piece material] ='" + comboBox26.Text + "'";
```

```
SqlConnection con5 = new SqlConnection(cs2);
```

```
con5.Open();
```

```
SqlCommand cmd15 = new SqlCommand(sql, con5);
```

```
comboBox27.ItemsSource = cmd15.ExecuteReader();
```

```
comboBox27.IsEnabled = true;
```

```
comboBox28.IsEnabled = false;
```

```
button29.IsEnabled = false;
```

```
private void comboBox27_DropDownClosed(object sender, EventArgs e)
```

```
{  
    string cs2 = @"Data Source=.\SQLEXPRESS;" +  
@"AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +  
@"Connect Timeout=30;" +
```

```

User Instance=True;";

    string sql = "SELECT [electrode material] FROM ElectrodeMaterialSelection
WHERE [work piece material] ='" + comboBox26.Text + "' AND [machining operation] ='" +
comboBox27.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    comboBox28.ItemsSource = cmd15.ExecuteReader();

    comboBox28.Enabled = true;
    button29.Enabled = false;
}

private void comboBox28_DropDownClosed(object sender, EventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
AttachDbFilename=|DataDirectory|\POBHelp.mdf;Integrated Security=True;" +
Connect Timeout=30;" +
User Instance=True;";

    string sql = "SELECT [available form of electrode material] FROM
ElectrodeMaterialSelection WHERE [electrode material] ='" + comboBox28.Text + "'";

    SqlConnection con5 = new SqlConnection(cs2);

    con5.Open();

    SqlCommand cmd15 = new SqlCommand(sql, con5);

    label153.Content = "(Available as " + cmd15.ExecuteScalar() + ")";
    button29.Enabled = true;
}

private void button29_Click(object sender, RoutedEventArgs e)
{
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
AttachDbFilename=|DataDirectory|\PDBHelp.mdf;Integrated Security=True;" +
Connect Timeout=30;" +
User Instance=True;";

    string sql1 = "SELECT [performance of electrode material for relaxation type]
FROM ElectrodeMaterialSelection WHERE [work piece material] ='" + comboBox26.Text + "'
[machining operation] ='" + comboBox27.Text + "' AND [electrode material] ='" +
comboBox28.Text + "'";

    string sql2 = "SELECT [performance of electrode material for pulse type] FROM
ElectrodeMaterialSelection WHERE [work piece material] ='" + comboBox26.Text + "' AND
[machining operation] ='" + comboBox27.Text + "' AND [electrode material] ='" +
comboBox28.Text + "'";

    string sql3 = "SELECT [volume wear ratio in roughing] FROM
ElectrodeMaterialSelection WHERE [work piece material] ='" + comboBox26.Text + "' AND
[machining operation] ='" + comboBox27.Text + "' AND [electrode material] ='" +
comboBox28.Text + "'";
}

```

```

string sql4 = "SELECT [corner wear ratio in finishing] FROM
ElectrodeMaterialSelection WHERE [work piece material] ='" + comboBox26.Text + "' AND
[machining operation] ='" + comboBox27.Text + "' AND [electrode material] ='" +
comboBox28.Text + "'";
string sql5 = "SELECT [machinability of electrode material] FROM
ElectrodeMaterialSelection WHERE [work piece material] ='" + comboBox26.Text + "' AND
[machining operation] ='" + comboBox27.Text + "' AND [electrode material] ='" +
comboBox28.Text + "'";
string sql6 = "SELECT [optimum application] FROM ElectrodeMaterialSelection
WHERE [work piece material] ='" + comboBox26.Text + "' AND [machining operation] ='" +
comboBox27.Text + "' AND [electrode material] ='" + comboBox28.Text + "'";
string sql7 = "SELECT [limitations and undesirable uses] FROM
ElectrodeMaterialSelection WHERE [work piece material] ='" + comboBox26.Text + "' AND
[machining operation] ='" + comboBox27.Text + "' AND [electrode material] ='" +
comboBox28.Text + "'";

```

```

SqlConnection con5 = new SqlConnection(cs2);

```

```

con5.Open();

```

```

SqlCommand cmd1 = new SqlCommand(sql1, con5);
SqlCommand cmd2 = new SqlCommand(sql2, con5);
SqlCommand cmd3 = new SqlCommand(sql3, con5);
SqlCommand cmd4 = new SqlCommand(sql4, con5);
SqlCommand cmd5 = new SqlCommand(sql5, con5);
SqlCommand cmd6 = new SqlCommand(sql6, con5);
SqlCommand cmd7 = new SqlCommand(sql7, con5);

```

```

label146.Content = cmd1.ExecuteScalar();
label147.Content = cmd2.ExecuteScalar();
label148.Content = cmd3.ExecuteScalar();
label149.Content = cmd4.ExecuteScalar();
label150.Content = cmd5.ExecuteScalar();
label151.Content = cmd6.ExecuteScalar();
label152.Content = cmd7.ExecuteScalar();

```

```

}
private void comboBox27_SelectionChanged(object sender, SelectionChangedEventArgs

```

```

{
}
private void comboBox28_SelectionChanged(object sender, SelectionChangedEventArgs

```

```

{
}
private void button30_Click(object sender, RoutedEventArgs e)

```

```

{
    RLabel.Content = (Convert.ToInt32(CsTextBox.Text) * 1000) / (3.142 *
    Convert.ToInt32(DTextBox.Text));
}

```

## SOURCE CODES FOR THE MODULE INTERFACE

```

<Window x:Class="WpfApplication3.MainWindow"
    xmlns="http://schemas.microsoft.com/winfx/2006/xaml/presentation"
    xmlns:x="http://schemas.microsoft.com/winfx/2006/xaml"
    Title="Machining Operations Module" Height="702" Width="1009" xmlns:my="clr-
namespace:WpfApplication3" Loaded="Window_Loaded_1" WindowStartupLocation="CenterScreen"
    WindowStyle="ThreeDBorderWindow" Icon="/WpfApplication3;component/Images/process.ico"
    VerticalAlignment="Top">
    <Window.Resources>
        <my:MachineOperations_DataDataSet x:Key="machineOperations_DataDataSet" />
        <CollectionViewSource x:Key="cuttingSpeedMetersperMinuteViewSource"
            Source="{Binding Path=CuttingSpeedMetersperMinute, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="table1afieldchipthicknessViewSource"
            Source="{Binding Path=Table1afieldchipthickness, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="table2aFacingTurningBoringViewSource"
            Source="{Binding Path=Table2aFacingTurningBoring, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="table3aLatheFeedsHighSpeedCuttingToolViewSource"
            Source="{Binding Path=Table3aLatheFeedsHighSpeedCuttingTool, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="toolAnglesSinglePointToolsViewSource"
            Source="{Binding Path=ToolAnglesSinglePointTools, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="centerDrillingSizesParametersViewSource"
            Source="{Binding Path=CenterDrillingSizesParameters, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="cuttingAnglesCastAlloySteelsViewSource"
            Source="{Binding Path=CuttingAnglesCastAlloySteels, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource
            x:Key="cuttingFluidVolumeExternalChipRemovalGunDrillViewSource" Source="{Binding
            Path=CuttingFluidVolumeExternalChipRemovalGunDrill, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource
            x:Key="cuttingFluidVolumePressureInternalChipRemovalGunDrillsViewSource" Source="{Binding
            Path=CuttingFluidVolumePressureInternalChipRemovalGunDrills, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="cuttingSpeedViewSource" Source="{Binding
            Path=CuttingSpeed, Source={StaticResource machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="cuttingSpeedConditionsMillingViewSource"
            Source="{Binding Path=CuttingSpeedConditionsMilling, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="cuttingSpeedsandFeedsViewSource" Source="{Binding
            Path=CuttingSpeedsandFeeds, Source={StaticResource machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="cuttingSpeedsFeedsFaceShoulderMillsViewSource"
            Source="{Binding Path=CuttingSpeedsFeedsFaceShoulderMills, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="cuttingSpeedsFeedsMillingCuttersViewSource"
            Source="{Binding Path=CuttingSpeedsFeedsMillingCutters, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource x:Key="drillLipClearanceAtPeripheryViewSource"
            Source="{Binding Path=DrillLipClearanceAtPeriphery, Source={StaticResource
            machineOperations_DataDataSet}}"/>
        <CollectionViewSource
            x:Key="effectWorkMaterialUltraSonicMachiningRoughingViewSource" Source="{Binding

```

```

EffectWorkMaterialUltraSonicMachiningRoughing, Source={StaticResource
MachineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="electronBeamMachiningDrillingViewSource"
Source="{Binding Path=ElectronBeamMachiningDrilling, Source={StaticResource
MachineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="feedperToothViewSource" Source="{Binding
Path=FeedperTooth, Source={StaticResource machineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="feedperToothHighSpeedSteelMillsViewSource"
Source="{Binding Path=FeedperToothHighSpeedSteelMills, Source={StaticResource
MachineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="feedRatesViewSource" Source="{Binding
Path=FeedRates, Source={StaticResource machineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="feedsandParametersViewSource" Source="{Binding
Path=FeedsandParameters, Source={StaticResource machineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="fineBoringConditionsCarbideToolsViewSource"
Source="{Binding Path=FineBoringConditionsCarbideTools, Source={StaticResource
MachineOperations_DataDataSet}}" />
    <CollectionViewSource
x:Key="FluidPressureVolumeInternalChipRemovalTrepanningHeadsViewSource" Source="{Binding
Path=FluidPressureVolumeInternalChipRemovalTrepanningHeads, Source={StaticResource
MachineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="machineReamingAllowanceViewSource" Source="{Binding
Path=MachineReamingAllowance, Source={StaticResource machineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="machiningConditionsGunDrillingViewSource"
Source="{Binding Path=MachiningConditionsGunDrilling, Source={StaticResource
MachineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="millingCuttingSpeedsViewSource" Source="{Binding
Path=MillingCuttingSpeeds, Source={StaticResource machineOperations_DataDataSet}}" />
    <CollectionViewSource x:Key="pDBHelpDataSet" Source="{Binding
Path=pDBHelpDataSet, Source={StaticResource pDBHelpDataSet}}" />
    <CollectionViewSource x:Key="helpTurningViewSource" Source="{Binding
Path=HelpTurning, Source={StaticResource pDBHelpDataSet}}" />
    <CollectionViewSource x:Key="millingTroubleShootingViewSource" Source="{Binding
Path=MillingTroubleShooting, Source={StaticResource pDBHelpDataSet}}" />

    <Storyboard x:Key="Storyboard1">
        <DoubleAnimationUsingKeyFrames BeginTime="00:00:00"
Storyboard.TargetName="image"
Storyboard.TargetProperty="(UIElement.RenderTransform).(TransformGroup.Children)[2].(Rota
tionTransform.Angle)" RepeatBehavior="Forever">
            <SplineDoubleKeyFrame KeyTime="00:00:00" Value="0"/>
            <SplineDoubleKeyFrame KeyTime="00:00:05" Value="359.896"/>
        </DoubleAnimationUsingKeyFrames>
    </Storyboard>
    <CollectionViewSource x:Key="boringTroubleShootingViewSource" Source="{Binding
Path=BoringTroubleShooting, Source={StaticResource pDBHelpDataSet}}" />
    <CollectionViewSource x:Key="pDBHelpDataSet1" Source="{Binding
Path=pDBHelpDataSet1, Source={StaticResource pDBHelpDataSet1}}" />
    <CollectionViewSource x:Key="helpTurningViewSource1" Source="{Binding
Path=HelpTurning, Source={StaticResource pDBHelpDataSet1}}" />
    <CollectionViewSource x:Key="millingWithCarbideToolsViewSource" Source="{Binding
Path=MillingWithCarbideTools, Source={StaticResource pDBHelpDataSet1}}" />
    <CollectionViewSource x:Key="gunDrillingTroubleShootingViewSource"
Source="{Binding Path=GunDrillingTroubleShooting, Source={StaticResource
pDBHelpDataSet1}}" />
    <CollectionViewSource x:Key="trepanningTroubleShootingViewSource"
Source="{Binding Path=TrepanningTroubleShooting, Source={StaticResource
pDBHelpDataSet1}}" />
    <CollectionViewSource x:Key="boringTroubleShootingViewSource1" Source="{Binding
Path=BoringTroubleShooting, Source={StaticResource pDBHelpDataSet1}}" />

```

```

<CollectionViewSource x:Key="reamingTroubleShootingViewSource" Source="{Binding
reamingTroubleShooting, Source={StaticResource p08HelpDataSet1}}" />
<CollectionViewSource x:Key="millingTroubleShootingViewSource1" Source="{Binding
millingTroubleShooting, Source={StaticResource p08HelpDataSet1}}" />
<CollectionViewSource x:Key="tappingApplicationsViewSource" Source="{Binding
tappingApplications, Source={StaticResource p08HelpDataSet1}}" />
<CollectionViewSource x:Key="grindingWheelApplicationsViewSource"
Source="{Binding Path=GrindingWheelApplications, Source={StaticResource
p08HelpDataSet1}}" />
<CollectionViewSource x:Key="cuttingFluidsApplicationsViewSource"
Source="{Binding Path=CuttingFluidsApplications, Source={StaticResource
p08HelpDataSet1}}" />
<CollectionViewSource x:Key="electrodeMaterialPropertiesViewSource"
Source="{Binding Path=ElectrodeMaterialProperties, Source={StaticResource
p08HelpDataSet1}}" />
<CollectionViewSource x:Key="materialsandNonTraditionalMachiningViewSource"
Source="{Binding Path=MaterialsandNonTraditionalMachining, Source={StaticResource
p08HelpDataSet1}}" />
<CollectionViewSource
Source="{Binding Path=ComparisonTraditionalandNonTraditionalMachiningViewSource" Source="{Binding
ComparisonTraditionalandNonTraditionalMachining, Source={StaticResource
p08HelpDataSet1}}" />
<CollectionViewSource x:Key="nonTraditionalMachiningSurfaceFinishViewSource"
Source="{Binding Path=NonTraditionalMachiningSurfaceFinish, Source={StaticResource
p08HelpDataSet1}}" />
<CollectionViewSource x:Key="broachingApplicationsViewSource" Source="{Binding
broachingApplications, Source={StaticResource p08HelpDataSet1}}" />
<CollectionViewSource x:Key="broachingApplicationsViewSource1" Source="{Binding
broachingApplications, Source={StaticResource p08HelpDataSet1}}" />
<CollectionViewSource x:Key="electrolyteSolutionApplicationViewSource"
Source="{Binding Path=ElectrolyteSolutionApplication, Source={StaticResource
p08HelpDataSet1}}" />
<CollectionViewSource x:Key="electrodeMaterialSelectionViewSource"
Source="{Binding Path=ElectrodeMaterialSelection, Source={StaticResource
p08HelpDataSet1}}" />
</Window.Resources>
<Window.Triggers>
<EventTrigger RoutedEvent="FrameworkElement.Loaded">
<BeginStoryboard x:Name="Storyboard1_BeginStoryboard"
Source="{StaticResource Storyboard1}"/>
</EventTrigger>
</Window.Triggers>
</Window>
<Window_Loaded="Window_Loaded" DataContext="{StaticResource
p08HelpDataSet1}" Height="663">
<Grid.Background>
<LinearGradientBrush EndPoint="1,0.5" StartPoint="0,0.5">
<GradientStop Color="Black" Offset="0.377" />
<GradientStop Color="White" Offset="1" />
</LinearGradientBrush>
</Grid.Background>
<TabControl Height="524" HorizontalAlignment="Left" Margin="12,127,0,0"
Name="TabControl1" VerticalAlignment="Top" Width="963">
<TabItem Header="Machine Operations" Name="tabItem1" AllowDrop="False"
Loaded="Window_Loaded">
<Grid Height="459">
<TabControl Height="427" HorizontalAlignment="Left"
Name="TabControl2" VerticalAlignment="Top" Width="808">

```

```

        <TabItem Header="PDB1" Name="PDB1" FontSize="12"
Name="PDB1_Loaded" Initialized="PDB1_Initialized">
        <Grid Background="White">
        <Grid.ColumnDefinitions>
        <ColumnDefinition Width="89*" />
        <ColumnDefinition Width="709*" />
        </Grid.ColumnDefinitions>
        <Rectangle Height="226" HorizontalAlignment="Left"
Name="B1,82,0,0" Name="rectangle1" Stroke="#FFA7D2FF" VerticalAlignment="Top"
Width="452" StrokeThickness="2" Grid.Column="1">
        <Rectangle.Fill>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
        <GradientStop Color="Black" Offset="0" />
        <GradientStop Color="#FF3688F8" Offset="1" />
        </LinearGradientBrush>
        </Rectangle.Fill>
        </Rectangle>
        <ComboBox Height="30" HorizontalAlignment="Left"
Name="C2,245,154,0,0" Name="comboBox2" VerticalAlignment="Top" Width="260"
ItemsSource="tensilestrength" ItemsSource="{Binding}" FontSize="14" Grid.Column="1"
IsReadOnly="True" DropDownClosed="comboBox2_DropDownClosed" />
        <ComboBox Height="30" HorizontalAlignment="Left"
Name="C3,245,202,0,0" Name="comboBox3" VerticalAlignment="Top" Width="260" FontSize="14"
Grid.Column="1">
        <ComboBoxItem Content="25/1000" />
        <ComboBoxItem Content="50/1000" />
        <ComboBoxItem Content="75/1000" />
        <ComboBoxItem Content="100/1000" />
        <ComboBoxItem Content="150/1000" />
        <ComboBoxItem Content="200/1000" />
        <ComboBoxItem Content="300/1000" />
        <ComboBoxItem Content="500/1000" />
        <ComboBoxItem Content="800/1000" />
        </ComboBox>
        <Button Content="Search" Height="30"
HorizontalAlignment="Left" Margin="395,253,0,0" Name="button5" VerticalAlignment="Top"
Width="110" Click="button5_Click" FontSize="14" Grid.Column="1" />
        <Label Height="Auto" HorizontalAlignment="Left"
Name="L19,553,255,0,0" Name="label19" VerticalAlignment="Top" FontSize="16"
BackgroundBrush="#FF28C0FF" BorderThickness="2" Foreground="White" Grid.Column="1">
        <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
        <GradientStop Color="Black" Offset="0" />
        <GradientStop Color="#FF28A9FF" Offset="1" />
        </LinearGradientBrush>
        </Label.Background>
        </Label>
        <Label Content="Work Piece Material:"
HorizontalAlignment="Left" Margin="102,102,0,240" VerticalAlignment="Center"
FontSize="14" Height="30" Foreground="White" Grid.Column="1" />
        <Label Content="Yensile Strength:"
HorizontalAlignment="Left" Margin="126,154,0,188" VerticalAlignment="Center"
FontSize="14" Height="30" Foreground="White" Grid.Column="1" />
        <Label Content="Unit Power for Turning and Milling With
Cutting Chip Thickness" FontFamily="Maiandra GD" FontSize="18" Height="Auto"
HorizontalAlignment="Left" Margin="42,26,0,0" Name="label65" VerticalAlignment="Top"

```

```

Width="500" Foreground="white" BorderBrush="#FF52CAFF" BorderThickness="2"
ColumnSpan="2">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
            GradientStart="0,0.5">
            <GradientStop Color="Black" Offset="0" />
            <GradientStop Color="#FF347981" Offset="1" />
        </LinearGradientBrush>
    </Label.Background>
</Label>
<Label Content="Chip Thickness" FontSize="14"
    Background="white" Height="30" HorizontalAlignment="Left" Margin="138,202,0,140"
    VerticalAlignment="Center" Grid.Column="1" />
<ComboBox DisplayMemberPath="WorkPieceMaterial"
    Grid.Column="1" Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}"
    Margin="245,102,0,240" Name="workPieceMaterialComboBox4" VerticalAlignment="Center"
    Width="260" DropDownClosed="comboBox1_DropDownClosed" FontSize="14">
    <ComboBox.ItemsPanel>
        <ItemsPanelTemplate>
            <VirtualizingStackPanel />
        </ItemsPanelTemplate>
    </ComboBox.ItemsPanel>
</ComboBox>
</Grid>
</TabItem>
<TabItem Header="PDB2" Name="PDB2" Loaded="PDB2_Loaded">
    <Grid Width="Auto" Background="white">
        <Rectangle Height="226" HorizontalAlignment="Left"
            Margin="155,68,0,0" Name="rectangle2" Stroke="#FFA7D2FF" StrokeThickness="2"
            VerticalAlignment="Top" Width="452">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
                    GradientStart="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid HorizontalAlignment="Left" Margin="182,114,0,0"
            Name="grid1" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="Work Piece Material:" Grid.Column="0"
                Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
                Background="white" />
            <ComboBox DisplayMemberPath="WorkPieceMaterial"
                Grid.Column="1" Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}"
                Margin="3,3,0,1" Name="workPieceMaterialComboBox" VerticalAlignment="Center" Width="260">
                <ComboBox.ItemsPanel>
                    <ItemsPanelTemplate>
                        <VirtualizingStackPanel />
                    </ItemsPanelTemplate>
                </ComboBox>
            </Grid>
        </Grid>
    </TabItem>
</Grid>

```

```

        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="Meters Per Minute:" Grid.Column="0"
Grid.Row="1" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Background="White" />
    <Label Content="{Binding Path=MetersPerMinute}"
Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin="3"
MetersPerMinuteLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="Feets Per Minute:" Grid.Column="0"
Grid.Row="2" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Background="White" />
    <Label Content="{Binding Path=FeetsPerMinute}"
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
FeetsPerMinuteLabel" VerticalAlignment="Center" Foreground="White" />
</Grid>
<Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Lathe Cutting Speeds With High Speed Tool Bit for Facing Turning and Boring"
FontFamily="Maiandra GD" FontSize="18" Foreground="White" Height="Auto"
HorizontalAlignment="Left" Margin="35,26,0,0" Name="label58" VerticalAlignment="Top"
Height="627">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
            <GradientStop Color="Black" Offset="0" />
            <GradientStop Color="#FF3479B1" Offset="1" />
        </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PDB3" Name="PDB3">
    <Grid Background="White">
        <Rectangle Height="226" HorizontalAlignment="Left"
Name="rectangle3" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="452">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF368BF8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
latheFeedsHighSpeedCuttingToolViewSource}" HorizontalAlignment="Left"
Name="grid2" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="Work Piece Material:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Background="White" />

```

```

        <ComboBox DisplayMemberPath="WorkPieceMaterial"
Grid.Column="1" Grid.Row="0" Height="30" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="workPieceMaterialComboBox1"
VerticalAlignment="Center" Width="260">
    <ComboBox.ItemsPanel>
        <ItemsPanelTemplate>
            <VirtualizingStackPanel />
        </ItemsPanelTemplate>
    </ComboBox.ItemsPanel>
</ComboBox>
<Label Content="meter per minute:" Grid.Column="0"
Grid.Row="1" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Background="White" />
<Label Content="{Binding Path=meter per minute}"
Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin="3"
Name="meter_per_minuteLabel" VerticalAlignment="Center" Foreground="White" />
<Label Content="inches per minute:" Grid.Column="0"
Grid.Row="2" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Background="White" />
<Label Content="{Binding Path=inches per minute}"
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
Name="inches_per_minuteLabel" VerticalAlignment="Center" Foreground="White" />
</Grid>
<Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Lathe Feeds With High Speed Cutting Tools" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Name="label69" VerticalAlignment="Top" Width="406">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
Point="0,0.5">
            <GradientStop Color="Black" Offset="0" />
            <GradientStop Color="#FF3479B1" Offset="1" />
        </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PDB4" Name="PDB4" Initialized="PDB4_loaded">
    <Grid>
        <Rectangle Height="256" HorizontalAlignment="Left"
Name="rectangle4" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="565">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
Point="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF368BF8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <ComboBox Height="30" HorizontalAlignment="Left"
Name="workpieceMaterialComboBox2" VerticalAlignment="Top" Width="212"
SelectionChanged="workpieceMaterialComboBox2_SelectionChanged" ItemsSource="{Binding}"
DisplayMemberPath="WorkpieceMaterial"
DropDownClosed="workpieceMaterialComboBox2_DropDownClosed" />
        <ComboBox Height="30" HorizontalAlignment="Left"
Name="tool_materialComboBox" VerticalAlignment="Top" Width="212"
ItemsSource="{Binding}" DisplayMemberPath="tool material" IsEditable="False"
DropDownClosed="tool_materialComboBox_DropDownClosed" />

```

```

        <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="442,137,0,0" Name="button20" VerticalAlignment="Top"
Width="95" Click="button20_Click" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="430,181,0,0" Name="feed1Label" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="430,215,0,0" Name="feed2Label" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="430,249,0,0" Name="feed3Label" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="430,283,0,0" Name="feed4Label" VerticalAlignment="Top" Foreground="White" />
        <Label Content="Cutting Conditions for Turning" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="65,15,0,0"
Name="label70" VerticalAlignment="Top" Width="275">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF347981" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
        <Label Content="Work Piece Material:" FontSize="14"
Foreground="White" Height="30" HorizontalAlignment="Left" Margin="167,63,0,277"
VerticalAlignment="Center" />
        <Label Content="Tool Material:" FontSize="14"
Foreground="White" Height="30" HorizontalAlignment="Left" Margin="209,101,0,239"
VerticalAlignment="Center" />
        <Label Content="feed in mm per rev = 4/10 - 60/10 and
Depth in mm = 5 - 10" Height="28" HorizontalAlignment="Left" Margin="39,181,0,0"
Name="label71" VerticalAlignment="Top" Foreground="White" />
        <Label Content="feed in mm per rev = 25/100 - 5/10 and
Depth in mm = 2 - 5" Foreground="White" Height="28" HorizontalAlignment="Left"
Margin="39,215,0,0" Name="label72" VerticalAlignment="Top" />
        <Label Content="feed in mm per rev = 2/10 - 3/10 and
Depth in mm = 5/10 - 2" Foreground="White" Height="28" HorizontalAlignment="Left"
Margin="39,249,0,0" Name="label73" VerticalAlignment="Top" />
        <Label Content="feed in mm per rev = 5/100 - 2/10 and
Depth in mm = 1/10 - 5/10" Foreground="White" Height="28" HorizontalAlignment="Left"
Margin="5,283,0,0" Name="label74" VerticalAlignment="Top" />
    </Grid>
</TabItem>
<TabItem Header="PDB5" Name="PDB5">
    <Grid />
</TabItem>
<TabItem Header="PDB6" Name="PDB6" Loaded="PDB6_loaded">
    <Grid>
        <Rectangle Height="285" HorizontalAlignment="Left"
Margin="62,43,0,0" Name="rectangle5" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="564">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
    </Grid>

```

```

        <ComboBox Height="30" HorizontalAlignment="Left"
Top="306,50,0,0" Name="workPieceMaterialComboBox3" VerticalAlignment="Top" Width="212"
ItemsSource="{Binding}" DisplayMemberPath="WorkPieceMaterial" Loaded="PDB6_loaded"
DropDownClosed="workPieceMaterialComboBox3_Closed" />
        <ComboBox Height="30" HorizontalAlignment="Left"
Top="306,85,0,0" Name="workPieceMaterialHardnessBHNComboBox" VerticalAlignment="Top"
Width="212" ItemsSource="{Binding}" DisplayMemberPath="WorkPieceMaterialHardnessBHN"
DropDownClosed="workPieceMaterialHardnessBHNComboBox_Closed" />
        <Label Content="Work Piece Material:"
HorizontalAlignment="Left" Margin="152,47,0,250" VerticalAlignment="Center" Height="31"
Background="White" />
        <Label Content="Work Piece Material Hardness BHN:"
HorizontalAlignment="Left" Margin="62,84,0,216" VerticalAlignment="Center" Height="28"
Background="White" />
        <ComboBox DisplayMemberPath="ToolMaterial" Height="30"
HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="306,121,0,0" Name="comboBox4"
VerticalAlignment="Top" Width="212" />
        <Label Content="Tool Material:"
HorizontalAlignment="Left" Margin="194,118,0,177" VerticalAlignment="Center" Height="33"
Background="White" />
        <Label Height="28" HorizontalAlignment="Left"
Top="420,194,0,0" Name="label2" VerticalAlignment="Top" Foreground="White" />
        <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="420,157,0,0" Name="button7" VerticalAlignment="Top"
Width="98" Click="button7_Click_1" />
        <Label Height="28" HorizontalAlignment="Left"
Top="420,219,0,0" Name="label3" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Top="420,244,0,0" Name="label4" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Top="420,269,0,0" Name="label5" VerticalAlignment="Top" Foreground="White" />
        <Label Content="Back Rake Angle:"
HorizontalAlignment="Left" Margin="297,190,0,138" VerticalAlignment="Center"
Background="White" />
        <Label Content="Side Rake Angle:"
HorizontalAlignment="Left" Margin="299,216,0,112" VerticalAlignment="Center"
Background="White" />
        <Label Content="End Clearance Angle:"
HorizontalAlignment="Left" Margin="272,240,0,88" VerticalAlignment="Center"
Background="White" />
        <Label Content="Side Clearance Angle:"
HorizontalAlignment="Left" Margin="269,266,0,62" VerticalAlignment="Center"
Background="White" />
        <Label Content="Side & End Cutting Edge:"
HorizontalAlignment="Left" Margin="246,295,0,33" VerticalAlignment="Center"
Background="White" />
        <Label Height="28" HorizontalAlignment="Left"
Top="420,298,0,0" Name="label7" VerticalAlignment="Top" Foreground="White" />
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Tool Angles for Single Point Cutting Tools" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Top="77,6,0,0" Name="label75" VerticalAlignment="Top" Width="353">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>

```

```

        </Label>
    </Grid>
</TabItem>
<TabItem Header="PDB9E" Name="PDB9E">
    <Grid>
        <Rectangle Height="270" HorizontalAlignment="Left"
Origin="92,75,0,0" Name="rectangle6" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="452">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8FB" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
GrillingSizesParametersViewSource}" HorizontalAlignment="Left" Margin="142,82,0,0"
Name="grid3" VerticalAlignment="Top" Width="388">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="173" />
                <ColumnDefinition Width="20" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="size for regular type:"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
            <ComboBox DisplayMemberPath="size for regular type"
Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="size_for_regular_typeComboBox"
VerticalAlignment="Center" Width="120" Background="White">
                <ComboBox.ItemsPanel>
                    <ItemsPanelTemplate>
                        <VirtualizingStackPanel />
                    </ItemsPanelTemplate>
                </ComboBox.ItemsPanel>
            </ComboBox>
            <Label Content="size for bell type:" Grid.Column="0"
Grid.Row="1" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
            <ComboBox DisplayMemberPath="size for bell type"
Grid.Column="1" Grid.Row="1" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="size_for_bell_typeComboBox"
VerticalAlignment="Center" Width="120" Background="White">
                <ComboBox.ItemsPanel>
                    <ItemsPanelTemplate>
                        <VirtualizingStackPanel />
                    </ItemsPanelTemplate>
                </ComboBox.ItemsPanel>
            </ComboBox>
        </Grid>
    </TabItem>
</Grid>

```

```

        <Label Content="work diameter in inches:"
Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <ComboBox DisplayMemberPath="work diameter in inches"
Grid.Column="1" Grid.Row="2" Height="23" HorizontalAlignment="Left"
DataSource="{Binding}" Margin="3" Name="work_diameter_in_inchesComboBox"
VerticalAlignment="Center" Width="120" Background="White">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="work diameter in millimeters:"
Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <ComboBox DisplayMemberPath="work diameter in
millimeters" Grid.Column="1" Grid.Row="3" Height="23" HorizontalAlignment="Left"
DataSource="{Binding}" Margin="3" Name="work_diameter_in_millimetersComboBox"
VerticalAlignment="Center" Width="120" Background="White">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="diameter of countersink:"
Grid.Column="0" Grid.Row="4" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <ComboBox DisplayMemberPath="diameter of
countersink" Grid.Column="1" Grid.Row="4" Height="23" HorizontalAlignment="Left"
DataSource="{Binding}" Margin="3" Name="diameter_of_countersinkComboBox"
VerticalAlignment="Center" Width="120" Background="White">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="drill piont diameter:"
Grid.Column="0" Grid.Row="5" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <ComboBox DisplayMemberPath="drill piont diameter"
Grid.Column="1" Grid.Row="5" Height="23" HorizontalAlignment="Left"
DataSource="{Binding}" Margin="3" Name="drill_piont_diameterComboBox"
VerticalAlignment="Center" Width="120" Background="White">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="body size:" Grid.Column="0"
Grid.Row="6" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Background="White" />
        <ComboBox DisplayMemberPath="body size"
Grid.Column="1" Grid.Row="6" Height="23" HorizontalAlignment="Left"
DataSource="{Binding}" Margin="3" Name="body_sizeComboBox" VerticalAlignment="Center"
Width="120" Background="White">

```

```

        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
</Grid>
    <Label Content="Centre Drilling Sizes" Height="28"
HorizontalAlignment="Left" Margin="172,51,0,0" Name="label9" VerticalAlignment="Top" />
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Center Drilling Sizes and Corresponding Parameters" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="34,15,0,0" Name="label13" VerticalAlignment="Top" Width="426">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF3479D1" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB7" Name="tabItem21">
    <Grid>
        <Rectangle Height="270" HorizontalAlignment="Left"
Margin="176,55,0,0" Name="rectangle7" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="452">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
CenterAnglesCastAlloySteelsViewSource}" HorizontalAlignment="Left" Margin="201,71,0,0"
Name="grid4" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="work piece material:" Grid.Column="0"
Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
            <ComboBox DisplayMemberPath="work piece material"
Grid.Column="1" Height="26" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,3,0,6" Name="work_piece_materialComboBox" VerticalAlignment="Center"
Width="182">

```

```

        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="back rake angle in degrees:"
        Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
        VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=back rake angle in
degrees}" Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin="3"
        Name="back_rake_angle_in_degreesLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="side rake angle in degrees:"
        Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
        VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=side rake angle in
degrees}" Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
        Name="side_rake_angle_in_degreesLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="side relief angle in degrees:"
        Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
        VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=side relief angle in
degrees}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left" Margin="3"
        Name="side_relief_angle_in_degreesLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="front relief angle in degrees:"
        Grid.Column="0" Grid.Row="4" HorizontalAlignment="Left" Margin="3"
        VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=front relief angle in
degrees}" Grid.Column="1" Grid.Row="4" Height="28" HorizontalAlignment="Left" Margin="3"
        Name="front_relief_angle_in_degreesLabel" VerticalAlignment="Center" Foreground="White"
        />
    <Label Content="side cutting edge angle in degrees:"
        Grid.Column="0" Grid.Row="5" HorizontalAlignment="Left" Margin="3"
        VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=side cutting edge angle
in degrees}" Grid.Column="1" Grid.Row="5" Height="28" HorizontalAlignment="Left"
        Name="side_cutting_edge_angle_in_degreesLabel" VerticalAlignment="Center"
        Foreground="White" />
    <Label Content="end cutting edge angle in degrees:"
        Grid.Column="0" Grid.Row="6" HorizontalAlignment="Left" Margin="3"
        VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=end cutting edge angle
in degrees}" Grid.Column="1" Grid.Row="6" Height="28" HorizontalAlignment="Left"
        Name="end_cutting_edge_angle_in_degreesLabel" VerticalAlignment="Center"
        Foreground="White" />
    </Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
        Content="Cutting Angles Cast Alloy Steels" FontFamily="Maiandra GD" FontSize="18"
        Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="79,12,0,0"
        Name="label76" VerticalAlignment="Top" Width="276">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
                StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>

```

```

</TabItem>
<TabItem Header="PDB9i" Name="tabItem22" Loaded="t22_Loaded"
Serialized="PDB9I">
  <Grid>
    <Rectangle Height="270" HorizontalAlignment="Left"
Origin="149,63,0,0" Name="rectangle9" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="452">
      <Rectangle.Fill>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
          <GradientStop Color="Black" Offset="0" />
          <GradientStop Color="#FF36B8F8" Offset="1" />
        </LinearGradientBrush>
      </Rectangle.Fill>
    </Rectangle>
    <ComboBox DisplayMemberPath="size of drill in
millimeters" Height="30" HorizontalAlignment="Left" Margin="350,137,0,0" Name="comboBox5"
VerticalAlignment="Top" Width="212" ItemsSource="{Binding}"
IsDropDownClosed="comboBox5_DropdownClosed" />
    <ComboBox DisplayMemberPath="depth of hole in
millimeters" Height="30" HorizontalAlignment="Left" IsEditable="False"
ItemsSource="{Binding}" Margin="350,175,0,0" Name="comboBox6" VerticalAlignment="Top"
Width="212" />
    <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="467,227,0,0" Name="button8" VerticalAlignment="Top"
Width="95" Click="button8_Click_1" />
    <Label Height="28" HorizontalAlignment="Left"
Origin="455,269,0,0" Name="label11" VerticalAlignment="Top" Foreground="White" />
    <Label Content="size of drill in millimeters:"
HorizontalAlignment="Left" Margin="178,137,0,202" VerticalAlignment="Center" Height="31"
Background="White" />
    <Label Content="depth of hole in millimeters:"
HorizontalAlignment="Left" Margin="161,174,0,164" VerticalAlignment="Center" Height="32"
Background="White" />
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Fluid Requirements of Pressure and Viscosity in External Chip Removal
Experiments" FontFamily="Maiandra GD" FontSize="18" Foreground="White" Height="Auto"
HorizontalAlignment="Left" Margin="6,16,0,0" Name="label77" VerticalAlignment="Top"
Width="720">
      <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
          <GradientStop Color="Black" Offset="0" />
          <GradientStop Color="#FF347981" Offset="1" />
        </LinearGradientBrush>
      </Label.Background>
    </Label>
  </Grid>
</TabItem>
<TabItem Header="PDB9j" Name="tabItem23">
  <Grid>
    <Rectangle Height="203" HorizontalAlignment="Left"
Origin="134,58,0,0" Name="rectangle8" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="525">
      <Rectangle.Fill>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
          <GradientStop Color="Black" Offset="0" />
          <GradientStop Color="#FF36B8F8" Offset="1" />
        </LinearGradientBrush>
      </Rectangle.Fill>
    </Rectangle>
  </Grid>

```

```

        </LinearGradientBrush>
    </Rectangle.Fill>
</Rectangle>
    <Grid DataContext="{StaticResource
CuttingFluidVolumePressureInternalChipRemovalGunDrillsViewSource}"
HorizontalAlignment="Left" Margin="164,95,0,0" Name="grid5" VerticalAlignment="Top">
    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="hole diameter in millimeters:"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <ComboBox DisplayMemberPath="hole diameter in
millimeters" Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
DataSource="{Binding}" Margin="3" Name="hole_diameter_in_millimetersComboBox"
VerticalAlignment="Center" Width="120">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="fluid flow volume in liters per
(litres/min):" Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=fluid flow volume in
per minute (litres/min)}" Grid.Column="1" Grid.Row="1" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="fluid_flow_volume_in_liters_per_minute_litres_min_Label"
VerticalAlignment="Center" />
    <Label Content="pressure:" Grid.Column="0"
Grid.Row="2" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="{Binding Path=pressure}"
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
Name="pressureLabel" VerticalAlignment="Center" />
</Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Fluid Requirements of Pressure and Viscosity in Internal Chip Removal
Drills" FontFamily="Malandra GD" FontSize="18" Foreground="White" Height="Auto"
HorizontalAlignment="Left" Margin="10,10,0,0" Name="label10" VerticalAlignment="Top"
Width="723">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF3479B1" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB9" Name="tabItem24">

```

```

        <Grid>
            <Rectangle Height="140" HorizontalAlignment="Left"
Name="81,112,0,0" Name="rectangle10" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="543">
                <Rectangle.Fill>
                    <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                        <GradientStop Color="Black" Offset="0" />
                        <GradientStop Color="#FF36BBF8" Offset="1" />
                    </LinearGradientBrush>
                </Rectangle.Fill>
            </Rectangle>
            <Grid DataContext="{StaticResource
CuttingSpeedViewSource}" HorizontalAlignment="Left" Margin="114,119,0,0" Name="grid6"
VerticalAlignment="Top">
                <Grid.ColumnDefinitions>
                    <ColumnDefinition Width="Auto" />
                    <ColumnDefinition Width="Auto" />
                </Grid.ColumnDefinitions>
                <Grid.RowDefinitions>
                    <RowDefinition Height="Auto" />
                    <RowDefinition Height="Auto" />
                    <RowDefinition Height="Auto" />
                </Grid.RowDefinitions>
                <Label Content="work piece material:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Background="White" />
                <ComboBox DisplayMemberPath="work piece material"
Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
DataSource="{Binding}" Margin="3" Name="work_piece_materialComboBox1"
VerticalAlignment="Center" Width="120">
                    <ComboBox.ItemsPanel>
                        <ItemsPanelTemplate>
                            <VirtualizingStackPanel />
                        </ItemsPanelTemplate>
                    </ComboBox.ItemsPanel>
                </ComboBox>
                <Label Content="cutting speed for drilling in meters
per minute (m/min):" Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
                <Label Content="{Binding Path=cutting speed for
drilling in meters per minute (m/min)}" Grid.Column="1" Grid.Row="1" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="_cutting_speed_for_drilling_in_meters_per_minute_m_min_Label"
VerticalAlignment="Center" Foreground="White" />
                <Label Content="cutting speed for reaming in meters
per minute (m/min):" Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
                <Label Content="{Binding Path=cutting speed for
reaming in meters per minute (m/min)}" Grid.Column="1" Grid.Row="2" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="_cutting_speed_for_reaming_in_meters_per_minute_m_min_Label"
VerticalAlignment="Center" Foreground="White" />
            </Grid>
            <Label Content="Cutting Speed" HorizontalAlignment="Left"
Margin="153,72,0,261" VerticalAlignment="Center" />
            <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Conditions in Drilling, Reaming and Tapping" FontFamily="Maiandra GD"

```

```

FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="54,70,0,0" Name="label78" VerticalAlignment="Top" Width="430">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
            <GradientStop Color="Black" Offset="0" />
            <GradientStop Color="#FF3479B1" Offset="1" />
        </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PDB8" Name="PDB8" Loaded="tabItem25_Loaded"
Initialized="PDB8_Initialized">
    <Grid Height="341">
        <Rectangle Height="287" HorizontalAlignment="Left"
Margin="18,42,0,0" Name="rectangle16" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="556">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <ComboBox DisplayMemberPath="work piece material"
Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="294,50,0,0"
Name="comboBox7" VerticalAlignment="Top" Width="212"
DropDownClosed="comboBox7_DropDownClosed" />
        <ComboBox DisplayMemberPath="tool material" Height="30"
HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="294,84,0,0" Name="comboBox8"
VerticalAlignment="Top" Width="212" />
        <Label Content="Work Piece Material:"
HorizontalAlignment="Left" Margin="140,52,0,254" VerticalAlignment="Center" Height="30"
Foreground="White" />
        <Label Content="Tool Material:"
HorizontalAlignment="Left" Margin="182,90,0,220" VerticalAlignment="Center" Height="30"
Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="419,154,0,0" Name="label14" VerticalAlignment="Top" Foreground="White" />
        <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="408,120,0,0" Name="button9" VerticalAlignment="Top"
Width="98" Click="button9_Click_1" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="419,180,0,0" Name="label16" VerticalAlignment="Top" Foreground="White" />
        <Label HorizontalAlignment="Left" Margin="419,204,0,0"
Name="label17" Height="28" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="419,230,0,0" Name="label18" VerticalAlignment="Top" Foreground="White" />
        <Label Content="cutting speed in meters per minute"
HorizontalAlignment="Left" Margin="178,154,0,160" VerticalAlignment="Center" Height="30"
Foreground="White" />
        <Label Content="cutting feed in millimeters per tooth
face mills" HorizontalAlignment="Left" Margin="89,180,0,130" VerticalAlignment="Center"
Height="31" Foreground="White" />
        <Label Content="cutting feed in millimeters per tooth
slab mills" HorizontalAlignment="Left" Margin="91,202,0,109" VerticalAlignment="Center"
Height="30" Foreground="White" />

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```

        <Label Content="cutting feed in millimeters per tooth for
        end and side mill" HorizontalAlignment="Left" Margin="18,230,0,80"
        VerticalAlignment="Center" Height="31" Foreground="White" />
        <Label Content="cutting feed in millimeters per tooth for
        end mills" HorizontalAlignment="Left" Margin="91,260,0,55" VerticalAlignment="Center"
        Height="26" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
        Margin="419,258,0,0" Name="label20" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
        Margin="418,292,0,0" Name="label21" VerticalAlignment="Top" Foreground="White" />
        <Label Content="cutting feed in millimeters per tooth for
        end cutters" HorizontalAlignment="Left" Margin="71,290,0,20" VerticalAlignment="Center"
        Height="30" Foreground="White" />
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
        Content="Cutting Conditions for Milling" FontFamily="Maiandra GD" FontSize="18"
        Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="26,4,0,0"
        Name="label82" VerticalAlignment="Top" Width="281">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
                StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3479B1" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>
</TabItem>
<TabItem Header="PDB8E" Name="PDB8E">
    <Grid>
        <Rectangle Height="270" HorizontalAlignment="Left"
        Margin="84,55,0,0" Name="rectangle19" Stroke="#FFA7D2FF" StrokeThickness="2"
        VerticalAlignment="Top" Width="556">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
                StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
        SpeedsandFeedsViewSource}" HorizontalAlignment="Left" Margin="161,97,0,0"
        Name="grid7" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="work piece material:" Grid.Column="0"
            Margin="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
            Foreground="White" />
            <ComboBox DisplayMemberPath="work piece material"
            Margin="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"

```

```

ItemsSource="{Binding}" Margin="3" Name="work_piece_materialComboBox2"
VerticalAlignment="Center" Width="120">
    <ComboBox.ItemsPanel>
        <ItemsPanelTemplate>
            <VirtualizingStackPanel />
        </ItemsPanelTemplate>
    </ComboBox.ItemsPanel>
</ComboBox>
<Label Content="work piece material hardness (brin
hardness):" Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
<Label Content="{Binding Path=work piece material
hardness (brinell hardness)}" Grid.Column="1" Grid.Row="1" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="_work_piece_material_hardness__brinell_hardness_Label" VerticalAlignment="Center"
Foreground="White" />
<Label Content="work piece material tensile
strength:" Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
<Label Content="{Binding Path=work piece material
tensile strength}" Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left"
Margin="3" Name="work_piece_material_tensile_strengthLabel" VerticalAlignment="Center"
foreground="White" />
<Label Content="cutting speed in metres per minute
(m/min):" Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
<Label Content="{Binding Path=cutting speed in met
per minute (m/min)}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left"
Margin="3" Name="_cutting_speed_in_metres_per_minute_m_min_Label"
VerticalAlignment="Center" Foreground="White" />
<Label Content="feed in millimeters per tooth
(mm/tooth):" Grid.Column="0" Grid.Row="4" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
<Label Content="{Binding Path=feed in millimeters p
tooth (mm/tooth)}" Grid.Column="1" Grid.Row="4" Height="28" HorizontalAlignment="Left"
Margin="3" Name="_feed_in_millimeters_per_tooth_mm_tooth_Label"
VerticalAlignment="Center" Foreground="White" />
</Grid>
<Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Speeds and Feeds for Face and Square Shoulder Mills"
FontFamily="Maiandra GD" FontSize="18" Foreground="White" Height="Auto"
HorizontalAlignment="Left" Margin="18,10,0,0" Name="label29" VerticalAlignment="Top"
Width="582">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
            <GradientStop Color="Black" Offset="0" />
            <GradientStop Color="#FF347981" Offset="1" />
        </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PD88D" Name="PD88D" Loaded="tabItem28_Loaded"
Initialized="PD88D_Initialized">
    <Grid>
        <Rectangle Height="306" HorizontalAlignment="Left"
Margin="35,53,0,0" Name="rectangle18" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="666">

```

```

        <Rectangle.Fill>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF36B8F8" Offset="1" />
            </LinearGradientBrush>
        </Rectangle.Fill>
    </Rectangle>
    </Rectangle>
    <ComboBox DisplayMemberPath="work piece material"
Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="456,61,0,0"
Name="comboBox9" VerticalAlignment="Top" Width="212"
DropDownClosed="comboBox9_DropDownClosed" />
    <ComboBox DisplayMemberPath="work piece material hardness
(brinell hardness)" Height="30" HorizontalAlignment="Left" IsEditable="false"
ItemsSource="{Binding}" Margin="456,94,0,0" Name="comboBox10" VerticalAlignment="Top"
Width="212" />
    <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="573,130,0,0" Name="button10" VerticalAlignment="Top"
Width="95" Click="button10_Click_1" />
    <Label Height="28" Margin="496,177,292,0" Name="label24"
VerticalAlignment="Top" Foreground="White" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="496,211,0,0" Name="label25" VerticalAlignment="Top" Foreground="White" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="496,245,0,0" Name="label26" VerticalAlignment="Top" Foreground="White" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="496,279,0,0" Name="label27" VerticalAlignment="Top" Foreground="White" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="496,312,0,0" Name="label28" VerticalAlignment="Top" Foreground="White" />
    <Label Content="work piece material:"
HorizontalAlignment="Left" Margin="307,63,0,279" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="work piece material hardness (brinell
hardness):" HorizontalAlignment="Left" Margin="138,94,0,247" VerticalAlignment="Center"
Foreground="White" />
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Speeds and Feeds for Face and Shoulder Mills" FontFamily="Maiandra G"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="31,10,0,0" Name="label36" VerticalAlignment="Top" Width="436">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF3479B1" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
    <Label Content="work piece material tensile strength"
Foreground="White" HorizontalAlignment="Left" Margin="242,177,0,164"
VerticalAlignment="Center" />
    <Label Content="cutting speed in m/min for SANDVIL
COMORANT GRADE S1P(P 10)" Foreground="White" HorizontalAlignment="Left"
Margin="52,211,0,130" VerticalAlignment="Center" />
    <Label Content="cutting speed in m/min for SANDVIL
COMORANT GRADE S4(P 30)" Foreground="White" HorizontalAlignment="Left"
Margin="60,245,0,96" VerticalAlignment="Center" />
    <Label Content="cutting speed in m/min for SANDVIL
COMORANT GRADE S6 (P 40)" Foreground="White" HorizontalAlignment="Left"
Margin="56,278,0,62" VerticalAlignment="Center" />

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                                <Label Content="feed in millimeters (mm) per tooth
Foreground="White" HorizontalAlignment="Left" Margin="258,312,0,30"
VerticalAlignment="Center" />
                                </Grid>
                                </TabItem>
                                <TabItem Header="POB80" Name="tabItem29">
                                <Grid>
                                <Rectangle Height="287" HorizontalAlignment="Left"
Margin="14,53,0,0" Name="rectangle17" Stroke="#FFA702FF" StrokeThickness="2"
VerticalAlignment="Top" Width="610">
                                <Rectangle.Fill>
                                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                                <GradientStop Color="Black" Offset="0" />
                                <GradientStop Color="#FF36B8F8" Offset="1" />
                                </LinearGradientBrush>
                                </Rectangle.Fill>
                                </Rectangle>
                                <ComboBox DisplayMemberPath="work piece material"
Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="396,64,0,0"
Name="comboBox11" VerticalAlignment="Top" Width="212"
DropDownClosed="comboBox11_DropDownClosed" />
                                <ComboBox DisplayMemberPath="machining operation"
Height="30" HorizontalAlignment="Left" IsEditable="False" ItemsSource="{Binding}"
Margin="396,97,0,0" Name="comboBox12" VerticalAlignment="Top" Width="212"
Loaded="comboBox12_Loaded" />
                                <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="513,133,0,0" Name="button21" VerticalAlignment="Top"
Width="95" Click="button21_Click" />
                                <Label Height="28" HorizontalAlignment="Left"
Margin="436,180,0,0" Name="label30" VerticalAlignment="Top" Foreground="White" />
                                <Label Height="28" HorizontalAlignment="Left"
Margin="436,214,0,0" Name="label31" VerticalAlignment="Top" Foreground="White" />
                                <Label Height="28" HorizontalAlignment="Left"
Margin="436,0,0,94" Name="label33" VerticalAlignment="Bottom" Foreground="White" />
                                <Label Height="28" HorizontalAlignment="Left"
Margin="436,282,0,0" Name="label34" VerticalAlignment="Top" Foreground="White" />
                                <Label Content="work piece material:"
HorizontalAlignment="Left" Margin="247,64,0,277" VerticalAlignment="Center"
Foreground="White" />
                                <Label Content="work piece material hardness (brinell
hardness):" HorizontalAlignment="Left" Margin="79,98,0,242" VerticalAlignment="Center"
Foreground="White" />
                                <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Speeds and Feeds for Milling Cutters" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="35,14,0,0" Name="label22" VerticalAlignment="Top" Width="369">
                                <Label.Background>
                                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                                <GradientStop Color="Black" Offset="0" />
                                <GradientStop Color="#FF3479B1" Offset="1" />
                                </LinearGradientBrush>
                                </Label.Background>
                                </Label>
                                <Label Content="feed per tooth in millimeters for
and shoulder mills" Foreground="White" HorizontalAlignment="Left" Margin="66,180,0,0"
VerticalAlignment="Center" />

```

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        <Label Content="cutting speed in meters per minute"
        face and shoulder mills" Foreground="White" HorizontalAlignment="Left"
        Margin="25,214,0,127" VerticalAlignment="Center" />
        <Label Content="feed per tooth in millimeters for
        and face cutters" Foreground="White" HorizontalAlignment="Left" Margin="81,248,0,94"
        VerticalAlignment="Center" />
        <Label Content="cutting speed in meters per minute"
        side and face cutters" Foreground="White" HorizontalAlignment="Left" Margin="40,282,0,94"
        VerticalAlignment="Center" />
        </Grid>
    </TabItem>
    <TabItem Header="PDB9F" Name="tabItem30">
        <Grid>
            <Rectangle Height="232" HorizontalAlignment="Left"
            Margin="70,86,0,0" Name="rectangle20" Stroke="#FFA7D2FF" StrokeThickness="2"
            VerticalAlignment="Top" Width="610">
                <Rectangle.Fill>
                    <LinearGradientBrush EndPoint="1,0.5"
                    StartPoint="0,0.5">
                        <GradientStop Color="Black" Offset="0" />
                        <GradientStop Color="#FF368F8" Offset="1" />
                    </LinearGradientBrush>
                </Rectangle.Fill>
            </Rectangle>
            <Grid DataContext="{StaticResource
            drillTipClearanceAtPeripheryViewSource}" HorizontalAlignment="Left" Margin="208,115,0,0"
            Name="grid8" VerticalAlignment="Top">
                <Grid.ColumnDefinitions>
                    <ColumnDefinition Width="Auto" />
                    <ColumnDefinition Width="Auto" />
                </Grid.ColumnDefinitions>
                <Grid.RowDefinitions>
                    <RowDefinition Height="Auto" />
                    <RowDefinition Height="Auto" />
                    <RowDefinition Height="Auto" />
                    <RowDefinition Height="Auto" />
                    <RowDefinition Height="Auto" />
                </Grid.RowDefinitions>
                <Label Content="drill diameter in inches:"
                Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
                VerticalAlignment="Center" Foreground="White" />
                <ComboBox DisplayMemberPath="drill diameter in
                inches" Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
                ItemsSource="{Binding}" Margin="3" Name="drill_diameter_in_inchesComboBox"
                VerticalAlignment="Center" Width="120">
                    <ComboBox.ItemsPanel>
                        <ItemsPanelTemplate>
                            <VirtualizingStackPanel />
                        </ItemsPanelTemplate>
                    </ComboBox.ItemsPanel>
                </ComboBox>
                <Label Content="drill diameter in millimeters:"
                Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
                VerticalAlignment="Center" Foreground="White" />
                <ComboBox DisplayMemberPath="drill diameter in
                millimeters" Grid.Column="1" Grid.Row="1" Height="23" HorizontalAlignment="Left"
                ItemsSource="{Binding}" Margin="3" Name="drill_diameter_in_millimetersComboBox"
                VerticalAlignment="Center" Width="120">
                    <ComboBox.ItemsPanel>

```

```

        <ItemsPanelTemplate>
            <VirtualizingStackPanel />
        </ItemsPanelTemplate>
    </ComboBox.ItemsPanel>
</ComboBox>
    <Label Content="general purposes:" Grid.Column="0"
Grid.Row="2" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="{Binding Path=general purposes}"
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
Name="general_purposesLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="hard and tough materials:"
Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=hard and tough
materials}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left"
Margin="3" Name="hard_and_tough_materialsLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="soft and free machining materials:"
Grid.Column="0" Grid.Row="4" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=soft and free machini
materials}" Grid.Column="1" Grid.Row="4" Height="28" HorizontalAlignment="Left"
Margin="3" Name="soft_and_free_machining_materialsLabel" VerticalAlignment="Center"
Foreground="White" />
</Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Drill Lip Clearance at Periphery and Corresponding Parameters"
FontFamily="Maiandra GD" FontSize="18" Foreground="White" Height="Auto"
HorizontalAlignment="Left" Margin="17,30,0,0" Name="label83" VerticalAlignment="Top"
Width="511">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB17" Name="PDB17">
    <Grid>
        <Rectangle Height="231" HorizontalAlignment="Left"
Margin="48,85,0,0" Name="rectangle21" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="644">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
effectWorkMaterialUltraSonicMachiningRoughingViewSource}" HorizontalAlignment="Left"
Margin="98,121,0,0" Name="grid9" VerticalAlignment="Top" Width="554">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>

```

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        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="6*" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="work material:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <ComboBox DisplayMemberPath="work material"
Grid.Column="1" Height="28" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,6,0,1" Name="work_materialComboBox" VerticalAlignment="Center" Width="166"
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="volume metal removal rate in cubic
millimeters per minute:" Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left"
Margin="3" VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=volume metal removal
rate in cubic millimeters per minute}" Grid.Column="1" Grid.Row="1" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="volume_metal_removal_rate_in_cubic_millimeters_per_minuteLabel"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="penetration in millimeters per
minute:" Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=penetration in
millimeters per minute}" Grid.Column="1" Grid.Row="2" Height="28"
HorizontalAlignment="Left" Margin="3" Name="penetration_in_millimeters_per_minuteLabel"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="maximum practical area of tool in
squared millimeters:" Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=maximum practical area
of tool in squared millimeters}" Grid.Column="1" Grid.Row="3" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="maximum_practical_area_of_tool_in_squared_millimetersLabel"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="wear ratio:" Grid.Column="0"
Grid.Row="4" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="{Binding Path=wear ratio}"
Grid.Column="1" Grid.Row="4" Height="28" HorizontalAlignment="Left" Margin="3"
Name="wear_ratioLabel" VerticalAlignment="Center" Foreground="White" />
    </Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Effect of Work Material Type on Roughing by Ultra Sonic Machining"
Fontfamily="Maiandra GD" FontSize="18" Foreground="White" Height="Auto"
HorizontalAlignment="Left" Margin="10,10,0,0" Name="label84" VerticalAlignment="Top"
Width="511">
        <Label.Background>

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StartPoint="0,0.5">
    <LinearGradientBrush EndPoint="1,0.5"
        <GradientStop Color="Black" Offset="0" />
        <GradientStop Color="#FF3479B1" Offset="1" />
    </LinearGradientBrush>
</Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PDB18" Name="PDB18" Loaded="tabItem32_Loaded"
    Initialized="PDB18_Initialized">
    <Grid>
        <Rectangle Height="304" HorizontalAlignment="Left"
            Margin="67,54,0,0" Name="rectangle25" Stroke="#FFA7D2FF" StrokeThickness="2"
            VerticalAlignment="Top" Width="644">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
                    StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <ComboBox DisplayMemberPath="work piece material"
            Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="368,67,0,0"
            Name="comboBox13" VerticalAlignment="Top" Width="212"
            DropDownClosed="comboBox13_DropDownClosed" />
        <ComboBox DisplayMemberPath="work piece thickness in
            millimeters" Height="30" HorizontalAlignment="Left" IsEditable="False"
            ItemsSource="{Binding}" Margin="368,99,0,0" Name="comboBox14" VerticalAlignment="Top"
            Width="212" />
        <Button Content="Search" Height="31"
            HorizontalAlignment="Left" Margin="485,135,0,0" Name="button22" VerticalAlignment="Top"
            Width="95" Click="button22_Click" />
        <Label Height="28" HorizontalAlignment="Left"
            Margin="368,166,0,0" Name="label37" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
            Margin="368,200,0,0" Name="label39" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
            Margin="368,234,0,0" Name="label40" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
            Margin="368,268,0,0" Name="label42" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
            Margin="368,301,0,0" Name="label43" VerticalAlignment="Top" Foreground="White" />
        <Label Content="work piece material:"
            HorizontalAlignment="Left" Margin="211,67,0,274" VerticalAlignment="Center" Height="28"
            Foreground="White" />
        <Label Content="work piece thickness in millimeters:"
            HorizontalAlignment="Left" Margin="118,100,0,241" VerticalAlignment="Center" Height="28"
            Foreground="White" />
        <Label Content="hole diameter in millimeters:"
            HorizontalAlignment="Left" Margin="159,166,0,175" VerticalAlignment="Center" Height="28"
            Foreground="White" />
        <Label Content="penetration rate in seconds:"
            HorizontalAlignment="Left" Margin="163,200,0,141" VerticalAlignment="Center" Height="28"
            Foreground="White" />
        <Label Content="acceleration voltage in kilo-volts:"
            HorizontalAlignment="Left" Margin="133,234,0,107" VerticalAlignment="Center" Height="28"
            Foreground="White" />
    </Grid>
</TabItem>
</TabControl>
</Page.Content>
</Page>
</Window.Content>
</Window>
</Application>

```

```

        <Label Content="pulse frequency:"
HorizontalAlignment="Left" Margin="234,302,0,39" VerticalAlignment="Center" Height="23"
Foreground="White" />
        <Label Content="average beam current in micro-amperes"
HorizontalAlignment="Left" Margin="84,268,0,73" VerticalAlignment="Center" Height="23"
Foreground="White" />
        <Label BorderBrush="#FF52CAFF" BorderThickness="1"
Content="Electron Beam Machining Requirements for Drilling" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="26,7,0,0" Name="label62" VerticalAlignment="Top" Width="432">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB&G" Name="PDB&G">
    <Grid>
        <Rectangle Height="331" HorizontalAlignment="Left"
Margin="104,31,0,0" Name="rectangle26" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="644">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
feedperToothViewSource}" HorizontalAlignment="Left" Margin="149,44,0,0" Name="grid1"
VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="work piece material:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
            <ComboBox DisplayMemberPath="work piece material"
Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="work_piece_materialComboBox3"
VerticalAlignment="Center" Width="120">
                <ComboBox.ItemsPanel>

```

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        <ItemsPanelTemplate>
            <VirtualizingStackPanel />
        </ItemsPanelTemplate>
    </ComboBox.ItemsPanel>
</ComboBox>
    <Label Content="feed per tooth for side mills in
inches:" Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed per tooth for
mills in inches}" Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left"
Margin="3" Name="feed_per_tooth_for_side_mills_in_inchesLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed per tooth for side mills in
millimeters:" Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed per tooth for
mills in millimeters}" Grid.Column="1" Grid.Row="2" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="feed_per_tooth_for_side_mills_in_millimetersLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed per tooth for end mills in
inches:" Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed per tooth for
mills in inches}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left"
Margin="3" Name="feed_per_tooth_for_end_mills_in_inchesLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed per tooth for end mills in
millimeters:" Grid.Column="0" Grid.Row="4" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed per tooth for
mills in millimeters}" Grid.Column="1" Grid.Row="4" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="feed_per_tooth_for_end_mills_in_millimetersLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed per tooth for plain helical
mills in inches:" Grid.Column="0" Grid.Row="5" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed per tooth for
plain helical mills in inches}" Grid.Column="1" Grid.Row="5" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="feed_per_tooth_for_plain_helical_mills_in_inchesLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed per tooth for plain helical
mills in millimeters:" Grid.Column="0" Grid.Row="6" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed per tooth for
plain helical mills in millimeters}" Grid.Column="1" Grid.Row="6" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="feed_per_tooth_for_plain_helical_mills_in_millimeterLabel"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="feed per tooth for saws in inches
Grid.Column="0" Grid.Row="7" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed per tooth for
in inches}" Grid.Column="1" Grid.Row="7" Height="28" HorizontalAlignment="Left"
Margin="3" Name="feed_per_tooth_for_saws_in_inchesLabel" VerticalAlignment="Center"
Foreground="White" />

```

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millimeters:" Grid.Column="0" Grid.Row="8" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
<Label Content="{Binding Path=feed per tooth for saw
in millimeters}" Grid.Column="1" Grid.Row="8" Height="28" HorizontalAlignment="Left"
Margin="3" Name="feed_per_tooth_for_saws_in_millimeterslabel" VerticalAlignment="Center"
Foreground="White" />
</Grid>
<Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Feeds for High Speed Steel Cutters" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="92,4,0,0" Name="label45" VerticalAlignment="Top" Width="432">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black" Offset="0" />
<GradientStop Color="#FF3479B1" Offset="1" />
</LinearGradientBrush>
</Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PDB8H" Name="TabItem34">
<Grid Height="368">
<Rectangle Height="349" HorizontalAlignment="Left"
Margin="204,19,0,0" Name="rectangle11" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="452">
<Rectangle.Fill>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black" Offset="0" />
<GradientStop Color="#FF368BF8" Offset="1" />
</LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
<Grid DataContext="{StaticResource
feedperToothHighSpeedSteelMillsViewSource}" HorizontalAlignment="Left"
Margin="249,15,0,0" Name="grid13" VerticalAlignment="Top">
<Grid.ColumnDefinitions>
<ColumnDefinition Width="Auto" />
<ColumnDefinition Width="Auto" />
</Grid.ColumnDefinitions>
<Grid.RowDefinitions>
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
<RowDefinition Height="Auto" />
</Grid.RowDefinitions>
<Label Content="cutter diameter in inches:"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />

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        <ComboBox DisplayMemberPath="cutter diameter in
inches" Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="cutter_diameter_in_inchesComboBox"
VerticalAlignment="Center" Width="120">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="cutter diameter in millimeters:"
Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <ComboBox DisplayMemberPath="cutter diameter in
millimeters" Grid.Column="1" Grid.Row="1" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="cutter_diameter_in_millimetersComboBox"
VerticalAlignment="Center" Width="120">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="machine steel in inches:"
Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=machine steel in
inches}" Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
Name="machine_steel_in_inchesLabel" VerticalAlignment="Center" Foreground="White" />
        <Label Content="machine steel in millimeters:"
Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=machine steel in
millimeters}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left"
Margin="3" Name="machine_steel_in_millimetersLabel" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="tool steel in inches:"
Grid.Column="0" Grid.Row="4" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=tool steel in inch
Grid.Column="1" Grid.Row="4" Height="28" HorizontalAlignment="Left" Margin="3"
Name="tool_steel_in_inchLabel" VerticalAlignment="Center" Foreground="White" />
        <Label Content="tool steel in millimeters:"
Grid.Column="0" Grid.Row="5" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=tool steel in
millimeters}" Grid.Column="1" Grid.Row="5" Height="28" HorizontalAlignment="Left"
Margin="3" Name="tool_steel_in_millimetersLabel" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="cast iron in inches:" Grid.Column="
Grid.Row="6" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="{Binding Path=cast iron in inch
Grid.Column="1" Grid.Row="6" Height="28" HorizontalAlignment="Left" Margin="3"
Name="cast_iron_in_inchesLabel" VerticalAlignment="Center" Foreground="White" />
        <Label Content="cast iron in millimeters:"
Grid.Column="0" Grid.Row="7" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />

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        <Label Content="{Binding Path=cast iron in
millimeters}" Grid.Column="1" Grid.Row="7" Height="28" HorizontalAlignment="Left"
Margin="3" Name="cast_iron_in_millimetersLabel" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="bronze in inches:" Grid.Column="1"
Grid.Row="8" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="{Binding Path=bronze in inches}"
Grid.Column="1" Grid.Row="8" Height="28" HorizontalAlignment="Left" Margin="3"
Name="bronze_in_inchesLabel" VerticalAlignment="Center" Foreground="White" />
        <Label Content="bronze in millimeters:"
Grid.Column="0" Grid.Row="9" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=bronze in millimeters}"
Grid.Column="1" Grid.Row="9" Height="28" HorizontalAlignment="Left" Margin="3"
Name="bronze_in_millimetersLabel" VerticalAlignment="Center" Foreground="White" />
        <Label Content="aluminum in inches:" Grid.Column="1"
Grid.Row="10" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" />
        <Label Content="{Binding Path=aluminum in inches}"
Grid.Column="1" Grid.Row="10" Height="28" HorizontalAlignment="Left" Margin="3"
Name="aluminum_in_inchesLabel" VerticalAlignment="Center" />
        <Label Content="aluminum in millimeters:"
Grid.Column="0" Grid.Row="11" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" />
        <Label Content="{Binding Path=aluminum in
millimeters}" Grid.Column="1" Grid.Row="11" Height="28" HorizontalAlignment="Left"
Margin="3" Name="aluminum_in_millimetersLabel" VerticalAlignment="Center" />
    </Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Feed per Tooth for High Speed Mills" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="15,-10,0,0"
Name="label187" VerticalAlignment="Top" Width="432">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
            <GradientStop Color="Black" Offset="0" />
            <GradientStop Color="#FF347981" Offset="1" />
        </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PDB9B" Name="PDB9B">
    <Grid>
        <Rectangle Height="183" HorizontalAlignment="Left"
Margin="161,75,0,0" Name="rectangle12" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="452">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource feedRatesViewSource}"
HorizontalAlignment="Left" Margin="177,101,0,0" Name="grid14" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>

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        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="hole diameter in millimeters (mm)"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <ComboBox DisplayMemberPath="hole diameter in
millimeters (mm)" Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="_hole_diameter_in_millimeters__mm_ComboBox"
VerticalAlignment="Center" Width="120">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="feed in millimeter per revolution for
drilling:" Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed in millimeter per
revolution for drilling}" Grid.Column="1" Grid.Row="1" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="feed_in_millimeter_per_revolution_for_drillingLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed in millimeter per revolution for
reaming:" Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed in millimeter per
revolution for reaming}" Grid.Column="1" Grid.Row="2" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="feed_in_millimeter_per_revolution_for_reamingLabel" VerticalAlignment="Center"
Foreground="White" />
    </Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Cutting Conditions in Drilling and Reaming" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="105,33,0,0" Name="label79" VerticalAlignment="Top" Width="353">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB9D" Name="PDB9B">
    <Grid>
        <Rectangle Height="183" HorizontalAlignment="Left"
Margin="170,74,0,0" Name="rectangle13" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="452">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">

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        <GradientStop Color="Black" Offset="0" />
        <GradientStop Color="#FF3608F8" Offset="1" />
    </LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
</Rectangle>
<Grid DataContext="{StaticResource
feedsandParametersViewSource}" HorizontalAlignment="Left" Margin="222,95,0,0"
Name="grid15" VerticalAlignment="Top">
    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="drill size in inches:"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <ComboBox DisplayMemberPath="drill size in inches"
Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="drill_size_in_inchesComboBox"
VerticalAlignment="Center" Width="120">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="feed in inches per revolution:"
Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed in inches per
revolution}" Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left"
Margin="3" Name="feed_in_inches_per_revolutionLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="drill size in millimeters:"
Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=drill size in
millimeters}" Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left"
Margin="3" Name="drill_size_in_millimeterLabel" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed in millimeters per revolution"
Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=feed in millimeter
revolution}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left"
Margin="3" Name="feed_in_millimeters_per_revolutionLabel" VerticalAlignment="Center"
Foreground="White" />
</Grid>
<Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Drill Feed and Corresponding Parameters" FontFamily="Maiandra GD" FontSize
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="67,24,0,0"
Name="label180" VerticalAlignment="Top" Width="353">
    <Label.Background>

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StartPoint="0,0.5">
    <LinearGradientBrush EndPoint="1,0.5"
    <GradientStop Color="Black" Offset="0"
    <GradientStop Color="#FF347981" Offs
    </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PD811B" Name="tabItem37"
loaded="tabItem37_Loaded" Initialized="tabItem37_Initialized">
    <Grid>
        <Rectangle Height="289" HorizontalAlignment="Left"
Margin="134,38,0,0" Name="rectangle14" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="516">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
                StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0"
                    <GradientStop Color="#FF3688F8" Offsets="0,1"
                    </LinearGradientBrush>
                </Rectangle.Fill>
            </Rectangle>
            <ComboBox DisplayMemberPath="work piece material"
Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="405,45,0,0"
Name="comboBox15" VerticalAlignment="Top" Width="212"
DropDownClosed="comboBox15_DropDownClosed" />
            <ComboBox DisplayMemberPath="work piece material strength
or hardness" Height="30" HorizontalAlignment="Left" IsEditable="False"
ItemsSource="{Binding}" Margin="405,78,0,0" Name="comboBox16" VerticalAlignment="Top"
Width="212" />
            <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="522,114,0,0" Name="button23" VerticalAlignment="Top"
Width="95" Click="button23_Click" />
            <Label Height="28" HorizontalAlignment="Left"
Margin="434,154,0,0" Name="label46" VerticalAlignment="Top" Foreground="White" />
            <Label Height="28" HorizontalAlignment="Left"
Margin="434,188,0,0" Name="label48" VerticalAlignment="Top" Foreground="White" />
            <Label Height="28" HorizontalAlignment="Left"
Margin="434,222,0,0" Name="label49" VerticalAlignment="Top" Foreground="White" />
            <Label Height="28" HorizontalAlignment="Left"
Margin="434,256,0,0" Name="label52" VerticalAlignment="Top" Foreground="White" />
            <Label Height="28" HorizontalAlignment="Left"
Margin="434,289,0,0" Name="label53" VerticalAlignment="Top" Foreground="White" />
            <Label Content="work piece material:" Height="29"
HorizontalAlignment="Left" Margin="265,47,0,294" VerticalAlignment="Center"
Foreground="White" />
            <Label Content="work piece material strength or
hardness:" HorizontalAlignment="Left" Margin="134,80,0,262" VerticalAlignment="Center"
Foreground="White" />
            <Label Content="depth of cut in millimeters (mm):"
HorizontalAlignment="Left" Margin="199,154,0,187" VerticalAlignment="Center"
Foreground="White" />
            <Label Content="radius of tool nose in millimeters
HorizontalAlignment="Left" Margin="159,188,0,153" VerticalAlignment="Center"
Foreground="White" />
            <Label Content="feed in millimeters per revolution
(mm/rev):" HorizontalAlignment="Left" Margin="132,222,0,119" VerticalAlignment="Center"
Foreground="White" />

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        <Label Content="speed in meters per minute (m/min):"
HorizontalAlignment="Left" Margin="175,256,0,85" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="coolant required:"
HorizontalAlignment="Left" Margin="296,289,0,52" VerticalAlignment="Center"
Foreground="White" />
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Fine Boring Requirements With Carbide Tools" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="6,2,0,0" Name="labelB1" VerticalAlignment="Top" Width="485">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF3479B1" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB10" Name="POB10">
    <Grid>
        <Rectangle Height="227" HorizontalAlignment="Left"
Margin="107,71,0,0" Name="rectangle22" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="516">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8FB" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
fluidPressureVolumeInternalChipRemovalTrepanningHeadsViewSource}"
HorizontalAlignment="Left" Margin="182,116,0,0" Name="grid10" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="hole diameter in millimeters (mm)"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
            <ComboBox DisplayMemberPath="hole diameter in
millimeters (mm)" Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="_hole_diameter_in_millimeters__mm_ComboBox"
VerticalAlignment="Center" Width="120">
                <ComboBox.ItemsPanel>
                    <ItemsPanelTemplate>
                        <VirtualizingStackPanel />
                    </ItemsPanelTemplate>
                </ComboBox.ItemsPanel>
            </ComboBox>

```

```

        <Label Content="volume in litre per millimete
(litre/mm):" Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=volume in litre
millimetres (litre/mm)}" Grid.Column="1" Grid.Row="1" Height="28"
HorizontalAlignment="Left" Margin="3"
Name="_volume_in_litre_per_millimetres__litre_mm_Label" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="pressure:" Grid.Column="0"
Grid.Row="2" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="{Binding Path=pressure}"
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
Name="pressureLabel1" VerticalAlignment="Center" Foreground="White" />
    </Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Fluid Pressure and Volume Requirements for Internal Chip Removal in Trepan
Heads" FontFamily="Maiandra GD" FontSize="18" Foreground="White" Height="Auto"
HorizontalAlignment="Left" Margin="17,18,0,0" Name="label85" VerticalAlignment="Top"
Width="717">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0"
                <GradientStop Color="#FF3479B1" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB15B" Name="PDB15B">
    <Grid>
        <Rectangle Height="198" HorizontalAlignment="Left"
Margin="151,67,0,0" Name="rectangle15" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="516">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0"
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
machineReamingAllowanceViewSource}" HorizontalAlignment="Left" Margin="248,91,0,0"
Name="grid11" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="hole diameter in inches:"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />

```

```

        <ComboBox DisplayMemberPath="hole diameter in
Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignaent="Left"
ItemsSource="{Binding}" Margin="3" Name="hole_diameter_in_inchesComboBox"
VerticalAlignment="Center" Width="120">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="hole diameter in millimeters:"
Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <ComboBox DisplayMemberPath="hole diameter in
millimeters" Grid.Column="1" Grid.Row="1" Height="23" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3" Name="hole_diameter_in_millimetersComboBox1"
VerticalAlignment="Center" Width="120">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="allowance in inches:" Grid.Column
Grid.Row="2" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="{Binding Path=allowance in inches
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
Name="allowance_in_inchesLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="allowance in millimeters:"
Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=allowance in
millimeters}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left"
Margin="3" Name="allowance_in_millimetersLabel" VerticalAlignment="Center"
Foreground="White" />
    </Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Machine Reaming Allowance Requirements" fontFamily="Maiandra GD" FontSize="12"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="23,18,0,0"
Name="label55" VerticalAlignment="Top" Width="405">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDB9G" Name="PDB9G" Loaded="tabItem40_Loaded"
Initialized="PDB9G_Initialized">
    <Grid>
        <Rectangle Height="266" HorizontalAlignment="Left"
Margin="107,60,0,0" Name="rectangle23" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="562">
            <Rectangle.Fill>

```

```

StartPoint="0,0.5">
    <LinearGradientBrush EndPoint="1,0.5"
        <GradientStop Color="Black" Offset="0"
        <GradientStop Color="#FF36B8F8" Offse
    </LinearGradientBrush>
    </Rectangle.Fill>
    </Rectangle>
    <ComboBox DisplayMemberPath="work piece material"
Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="438,71,0,0"
Name="comboBox17" VerticalAlignment="Top" Width="212"
DropDownClosed="comboBox17_DropDownClosed" />
    <ComboBox DisplayMemberPath="work piece material ha
(brinell hardness)" Height="30" HorizontalAlignment="Left" IsEditable="False"
ItemsSource="{Binding}" Margin="438,104,0,0" Name="comboBox18" VerticalAlignment="T
Width="212" />
    <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="555,173,0,0" Name="button24" VerticalAlignment="
Width="95" Click="button24_Click" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="475,214,0,0" Name="label56" VerticalAlignment="Top" Foreground="White" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="475,248,0,0" Name="label57" VerticalAlignment="Top" Foreground="White" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="475,282,0,0" Name="label58" VerticalAlignment="Top" Foreground="White" />
    <Label Content="work piece material:" Height="29"
HorizontalAlignment="Left" Margin="294,61,0,257" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="work piece material hardness (brinell
hardness):" HorizontalAlignment="Left" Margin="125,94,0,224" VerticalAlignment="Cent
Foreground="White" />
    <Label Content="Tool Material:"
HorizontalAlignment="Left" Margin="333,214,0,128" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="speed in meters per minute (m/min):"
HorizontalAlignment="Left" Margin="192,248,0,94" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="feed in mm per revolution:"
HorizontalAlignment="Left" Margin="254,282,0,60" VerticalAlignment="Center"
Foreground="White" />
    <ComboBox Height="30" HorizontalAlignment="Left"
Margin="438,137,0,0" Name="comboBox20" VerticalAlignment="Top" Width="212">
    <ComboBoxItem Content="2 - 4 mm" />
    <ComboBoxItem Content="4 - 6 mm" />
    <ComboBoxItem Content="6 - 12 mm" />
    <ComboBoxItem Content="12 - 19 mm" />
    <ComboBoxItem Content="19 - 25 mm" />
    <ComboBoxItem Content="25 - 50 mm" />
    </ComboBox>
    <Label Content="Tool Diameter:"
HorizontalAlignment="Left" Margin="327,128,0,192" VerticalAlignment="Center"
Foreground="White" />
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Machining Conditions in Gun Drilling" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="53,15,0,0"
Name="label186" VerticalAlignment="Top" Width="405">
    <Label.Background>
    <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
        <GradientStop Color="Black" Offset="0" />

```

```

        <GradientStop Color="#FF3479B1" Offset="0" />
    </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="PDB8C" Name="PDB8C">
    <Grid>
        <Rectangle Height="266" HorizontalAlignment="Left"
Margin="108,63,0,0" Name="rectangle24" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="562">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3479B1" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <ComboBox DisplayMemberPath="work piece material"
Height="30" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="380,97,0,0"
Name="comboBox19" VerticalAlignment="Top" Width="212" />
        <ComboBox DisplayMemberPath="work piece material strength
or hardness" Height="30" HorizontalAlignment="Left" IsEditable="False"
ItemsSource="{Binding}" Margin="380,130,0,0" Name="comboBox21" VerticalAlignment="Top"
Width="212" />
        <Button Content="Search" Height="31"
HorizontalAlignment="Left" Margin="497,166,0,0" Name="button25" VerticalAlignment="Top"
Width="95" Click="button25_Click" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="420,213,0,0" Name="label59" VerticalAlignment="Top" Foreground="White" />
        <Label Height="28" HorizontalAlignment="Left"
Margin="420,247,0,0" Name="label60" VerticalAlignment="Top" Foreground="White" />
        <Label Content="work piece material;" Height="29"
HorizontalAlignment="Left" Margin="240,97,0,244" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="work piece material strength or
hardness;" HorizontalAlignment="Left" Margin="109,130,0,212" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="depth of cut in millimeters (mm):"
HorizontalAlignment="Left" Margin="176,213,0,129" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="radius of tool nose in millimeters (mm):"
HorizontalAlignment="Left" Margin="136,247,0,95" VerticalAlignment="Center"
Foreground="White" />
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Milling Cutting Speeds" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="53,18,0,0"
Name="label61" VerticalAlignment="Top" Width="242">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3479B1" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>
</TabItem>

```

```

<TabItem Header="Contents" Name="Contents">
  <Grid>
    <Grid DataContext="{StaticResource
boringTroubleShootingViewSource}" HorizontalAlignment="Left" Margin="280,103,0,0"
Name="grid20" VerticalAlignment="Top">
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
      </Grid.ColumnDefinitions>
      <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
      </Grid.RowDefinitions>
      <Label Content="problem:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" />
      <ComboBox DisplayMemberPath="problem" Grid.Column
Grid.Row="0" Height="23" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="3"
Name="problemComboBox1" VerticalAlignment="Center" Width="120">
        <ComboBox.ItemsPanel>
          <ItemsPanelTemplate>
            <VirtualizingStackPanel />
          </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
      </ComboBox>
      <Label Content="causes:" Grid.Column="0" Grid.Row
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" />
      <Label Content="{Binding Path=causes}"
Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin="3"
Name="causesLabel" VerticalAlignment="Center", />
    </Grid>
  </TabItem>
</TabControl>
<Image Height="Auto" HorizontalAlignment="Left" Margin="50,91,0,0"
Name="image2" Stretch="None" VerticalAlignment="Top" Width="Auto"
MouseDown="image2_MouseDown" />
<Label Content="Contents" FontFamily="Maiandra GD" FontSize="18"
Foreground="#FF3794D8" Height="Auto" HorizontalAlignment="Left" Margin="30,137,0,0"
Name="label66" VerticalAlignment="Top" MouseDown="image2_MouseDown" FontWeight="Bold"
<Label Content="Machining Operations Module" FontFamily="Maiandra GD"
FontSize="24" Foreground="#FF808080" Height="Auto" HorizontalAlignment="Left"
Margin="31,6,0,0" Name="label67" VerticalAlignment="Top" />
<Image Height="49" HorizontalAlignment="Left" Margin="50,91,0,0"
Name="image1" Stretch="None" VerticalAlignment="Top" Width="46"
Source="/WpfApplication3;component/Images/onebit_39.png" />
</Grid>
</TabItem>
<TabItem Header="Help & Troubleshooting" Name="tabItem2" FontSize="14"
<Grid>
  <TabControl Height="489" HorizontalAlignment="Left"
Name="tabControl6" VerticalAlignment="Top" Width="953">
    <TabItem Header="PDBHelp1" Name="tabItem20"
Initialized="tabItem20_Initialized">
      <Grid>
        <Rectangle Height="284" HorizontalAlignment="Left"
Margin="281,103,0,0" Name="rectangle27" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
          <Rectangle.Fill>

```

```

StartPoint="0,0.5">
    <LinearGradientBrush EndPoint="1,0.5"
        <GradientStop Color="Black" Offset="0" />
        <GradientStop Color="#FF3688F8" Offset="1" />
    </LinearGradientBrush>
    </Rectangle.Fill>
</Rectangle>
<Grid DataContext="{StaticResource
helpTurningViewSource}" HorizontalAlignment="Left" Margin="366,144,0,0" Name="grid17"
VerticalAlignment="Top">
    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="trouble:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
    <ComboBox DisplayMemberPath="trouble" Grid.Column="1"
Height="29" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="3,4,0,2"
Name="troubleComboBox" VerticalAlignment="Center" Width="279"
DropDownClosed="troubleComboBox_DropDownClosed">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="probable reason:" Grid.Column="0"
Grid.Row="1" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
    <ComboBox DisplayMemberPath="probable reason"
Height="29" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="3,7,0,-1"
Name="comboBox1" VerticalAlignment="Center" Width="279" Grid.Column="1" Grid.Row="1"
DropDownClosed="comboBox1_DropDownClosed_1" Grid.RowSpan="2">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
</Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Turning Operation" FontFamily="Maiandra GD" FontSize="14"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="152,46,0,0"
Name="label188" VerticalAlignment="Top" Width="331">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF3479B1" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>

```

```

        <Label Content="remedy:" HorizontalAlignment="Left"
Margin="369,230,0,196" VerticalAlignment="Center" Foreground="White" />
        <ListBox DisplayMemberPath="remedy" Height="146"
HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="489,230,0,56"
Name="probable_reasonListBox" VerticalAlignment="Center" Width="279" />
        <Label Content="remedy:" Foreground="White"
HorizontalAlignment="Left" Margin="369,230,0,173" VerticalAlignment="Center" />
    </Grid>
</TabItem>
<TabItem Header="PDBHelp2" Name="tabItem25"
Initialized="tabItem25_Initialized">
    <Grid>
        <Rectangle Height="297" HorizontalAlignment="Left"
Margin="237,128,0,0" Name="rectangle28" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="483">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
millingTroubleShootingViewSource}" HorizontalAlignment="Left" Margin="324,168,0,0"
Name="grid18" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="problem:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
            <ComboBox DisplayMemberPath="problem" Grid.Column="1"
Height="29" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="3,4,0,2"
Name="problemComboBox" VerticalAlignment="Center" Width="233"
DropDownClosed="problemComboBox_DropDownClosed">
                <ComboBox.ItemsPanel>
                    <ItemsPanelTemplate>
                        <VirtualizingStackPanel />
                    </ItemsPanelTemplate>
                </ComboBox.ItemsPanel>
            </ComboBox>
            <Label Content="remedy:" Grid.Column="0" Grid.Row="1"
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" Foreground="White" />
        </Grid>
        <Label BorderBrush="#FF52CAFF" BorderThickness="1"
Content="Trouble Shooting in Milling" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="111,39,0,0"
Name="label189" VerticalAlignment="Top" Width="257">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3479B1" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>
</TabItem>
</TabControl>
</Page.Content>
</Page>
</UserControl>

```

```

        </LinearGradientBrush>
    </Label.Background>
</Label>
    <ListBox Height="178" HorizontalAlignment="Left"
Margin="401,206,0,0" Name="listBox1" VerticalAlignment="Top" Width="230"
DisplayMemberPath="remedy" ItemsSource="{Binding}" />
    </Grid>
</TabItem>
    <TabItem Header="PDBHelp28" Name="tabItem26">
    <Grid>
        <Rectangle Height="371" HorizontalAlignment="Left"
Margin="212,67,0,0" Name="rectangle39" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Milling with Carbide Tools" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="38,25,0,0" Name="label112" VerticalAlignment="Top" Width="395">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3479B1" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
        <Grid DataContext="{StaticResource
millingWithCarbideToolsViewSource}" HorizontalAlignment="Left" Margin="234,77,0,0"
Name="grid21" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="type of operations:" Grid.Column=
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
                <ComboBox DisplayMemberPath="type of operations"
Grid.Column="1" Height="23" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,3,0,3" Name="type_of_operationsComboBox" VerticalAlignment="Center"
Width="238">

```

```

</ComboBox.ItemsPanel>
    <ItemsPanelTemplate>
        <VirtualizingStackPanel />
    </ItemsPanelTemplate>
</ComboBox.ItemsPanel>
</ComboBox>
    <Label Content="soft steel tool material:"
Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=soft steel tool
material}" Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin
Name="soft_steel_tool_materialLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="medium steel tool material:"
Grid.Column="0" Grid.Row="2" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=medium steel tool
material}" Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin
Name="medium_steel_tool_materialLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="hard steel tool material:"
Grid.Column="0" Grid.Row="3" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=hard steel tool
material}" Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left" Margin
Name="hard_steel_tool_materialLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="cast steel tool material:"
Grid.Column="0" Grid.Row="4" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=cast steel tool
material}" Grid.Column="1" Grid.Row="4" Height="28" HorizontalAlignment="Left" Margin
Name="cast_steel_tool_materialLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="stainless steel tool material:"
Grid.Column="0" Grid.Row="5" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=stainless steel tool
material}" Grid.Column="1" Grid.Row="5" Height="28" HorizontalAlignment="Left" Margin
Name="stainless_steel_tool_materialLabel" VerticalAlignment="Center" Foreground="White"
/>
    <Label Content="soft cast iron tool material:"
Grid.Column="0" Grid.Row="6" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=soft cast iron tool
material}" Grid.Column="1" Grid.Row="6" Height="28" HorizontalAlignment="Left" Margin
Name="soft_cast_iron_tool_materialLabel" VerticalAlignment="Center" Foreground="White"
/>
    <Label Content="hard cast iron tool material:"
Grid.Column="0" Grid.Row="7" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=hard cast iron tool
material}" Grid.Column="1" Grid.Row="7" Height="28" HorizontalAlignment="Left" Margin
Name="hard_cast_iron_tool_materialLabel" VerticalAlignment="Center" Foreground="White"
/>
    <Label Content="non ferrous tool material:"
Grid.Column="0" Grid.Row="8" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <Label Content="{Binding Path=non ferrous tool
material}" Grid.Column="1" Grid.Row="8" Height="28" HorizontalAlignment="Left" Margin
Name="non_ferrous_tool_materialLabel" VerticalAlignment="Center" Foreground="White"
/>
    <Label Content="non metallic tool material:"
Grid.Column="0" Grid.Row="9" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />

```

```

        <Label Content="[Binding Path=non metallic tool
material]" Grid.Column="1" Grid.Row="9" Height="28" HorizontalAlignment="Left" Margin=
Name="non_metallic_tool_materialLabel" VerticalAlignment="Center" Foreground="White" /
        </Grid>
    </Grid>
</TabItem>
<TabItem Header="*PDBHelp3" Name="tabItem28">
    <Grid>
        <Rectangle Height="371" HorizontalAlignment="Left"
Margin="184,52,0,0" Name="rectangle40" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF368BF8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Drilling" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="62,10,0,0"
Name="label113" VerticalAlignment="Top" Width="254">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF347981" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>
</TabItem>
<TabItem Header="PDBHelp38" Name="tabItem31"
Initialized="tabItem31_Initialized">
    <Grid>
        <Rectangle Height="284" HorizontalAlignment="Left"
Margin="200,124,0,0" Name="rectangle41" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF368BF8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in GunDrilling" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="48,30,0,0"
Name="label114" VerticalAlignment="Top" Width="277">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF347981" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>
</TabItem>

```

```

        <Grid DataContext="{StaticResource
gunDrillingTroubleShootingViewSource}" HorizontalAlignment="Left" Margin="274,176,
Name="grid22" VerticalAlignment="Top">
        <Grid.ColumnDefinitions>
            <ColumnDefinition Width="Auto" />
            <ColumnDefinition Width="Auto" />
        </Grid.ColumnDefinitions>
        <Grid.RowDefinitions>
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
        </Grid.RowDefinitions>
        <Label Content="problem:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <ComboBox DisplayMemberPath="problem" Grid.Column="1"
Height="29" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="3,6,0,0"
Name="problemComboBox2" VerticalAlignment="Center" Width="227"
DropDownClosed="problemComboBox2_DropDownClosed">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="causes:" Grid.Column="0" Grid.Row="1"
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" Foreground="White" />
        <ListBox DisplayMemberPath="causes" Grid.Column="1"
Grid.Row="1" Height="163" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,3,0,-60" Name="causesListBox" VerticalAlignment="Center" Width="227" />
    </Grid>
</Grid>
</TabItem>
<TabItem Header="PDBHelp4" Name="tabItem32"
Initialized="tabItem32_Initialized">
    <Grid>
        <Rectangle Height="334" HorizontalAlignment="Left"
Margin="195,102,0,0" Name="rectangle42" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Trepanning" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="46,26,0,0"
Name="label115" VerticalAlignment="Top" Width="277">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3479B1" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>

```

```

        <Grid DataContext="{StaticResource
trepanningTroubleShootingViewSource}" HorizontalAlignment="Left" Margin="255,146,0,0"
Name="grid23" VerticalAlignment="Top">
    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="problem:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
    <ComboBox DisplayMemberPath="problem" Grid.Column=
Height="23" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="3,3,0,3"
Name="problemComboBox3" VerticalAlignment="Center" Width="315"
DropDownClosed="problemComboBox3_DropDownClosed">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="causes:" Grid.Column="0" Grid.Row=
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" Foreground="White" />
    <ListBox DisplayMemberPath="causes" Grid.Column="1"
Grid.Row="1" Height="199" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,3,0,-96" Name="causesListBox1" VerticalAlignment="Center" Width="321" />
    </Grid>
</Grid>
</TabItem>
<TabItem Header="PDBHelp5" Name="tabItem33"
Initialized="tabItem33_Initialized">
    <Grid>
        <Rectangle Height="334" HorizontalAlignment="Left"
Margin="205,94,0,0" Name="rectangle43" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting Boring" FontFamily="Malandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="56,37,0,0"
Name="label116" VerticalAlignment="Top" Width="226">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3479B1" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>
</TabItem>

```

```

        <Grid DataContext="{StaticResource
boringTroubleShootingViewSource1}" HorizontalAlignment="Left" Margin="242,152,0,0"
Name="grid24" VerticalAlignment="Top">
    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="problem:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <ComboBox DisplayMemberPath="problem" Grid.Column="1"
Height="23" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="3,3,0,3"
Name="problemComboBox4" VerticalAlignment="Center" Width="315"
DropDownClosed="problemComboBox4_DropDownClosed">
    <ComboBox.ItemsPanel>
        <ItemsPanelTemplate>
            <VirtualizingStackPanel />
        </ItemsPanelTemplate>
    </ComboBox.ItemsPanel>
</ComboBox>
    <Label Content="causes:" Grid.Column="0" Grid.Row="1"
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" Foreground="White" />
    <ListBox DisplayMemberPath="causes" Grid.Column="1"
Grid.Row="1" Height="200" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,3,0,-97" Name="causesListBox2" VerticalAlignment="Center" Width="321" />
</Grid>
</Grid>
</TabItem>
    <TabItem Header="#PDBHelp6" Name="tabItem35"
Initialized="tabItem35_Initialized">
    <Grid>
        <Rectangle Height="310" HorizontalAlignment="Left"
Margin="188,109,0,0" Name="rectangle44" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF3688F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Reaming" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="45,49,0,0"
Name="label117" VerticalAlignment="Top" Width="259">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF347981" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>

```

```

        <Grid DataContext="{StaticResource
remainingTroubleshootingViewSource}" HorizontalAlignment="Left" Margin="305,132,0,0"
Name="grid25" VerticalAlignment="Top">
        <Grid.RowDefinitions>
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
        </Grid.RowDefinitions>
        <Label Content="problem:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <ComboBox DisplayMemberPath="problem" Height="
HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="74,6,0,0"
Name="problemComboBox5" VerticalAlignment="Center" Width="250"
DropDownClosed="problemComboBox5_DropDownClosed">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="causes:" Grid.Column="0" Grid.
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" Foreground="White"
        <ComboBox DisplayMemberPath="causes" Grid.Row=
Height="27" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="74,6,0,2"
Name="causesComboBox" VerticalAlignment="Center" Width="250"
DropDownClosed="causesComboBox_DropDownClosed">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="remedy:" Grid.Column="0" Grid.
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" Foreground="White"
        <ListBox DisplayMemberPath="remedy" Grid.Row=
Height="153" HorizontalAlignment="Left" ItemsSource="{Binding}" Margin="74,3,0,5"
Name="remedyListBox" VerticalAlignment="Center" Width="250" />
        </Grid>
    </Grid>
</TabItem>
<TabItem Header="PDBHelp7" Name="tabItem36">
    <Grid>
        <Rectangle Height="250" HorizontalAlignment="Left"
Margin="225,130,0,0" Name="rectangle45" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="526">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF36B8F8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Grid DataContext="{StaticResource
tappingApplicationsViewSource}" HorizontalAlignment="Left" Margin="290,192,0,0"
Name="grid19" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />

```

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        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
    </Grid.RowDefinitions>
    <Label Content="tapping operation requirement:"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <ComboBox DisplayMemberPath="tapping operation
requirement" Grid.Column="1" Height="29" HorizontalAlignment="Left"
ItemsSource="{Binding}" Margin="3,4,0,2" Name="tapping_operation_requirementComboBox"
VerticalAlignment="Center" Width="215">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
    <Label Content="operation conditions:"
Grid.Column="0" Grid.Row="1" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
        <Label Content="{Binding Path=operation conditions"
Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin="3"
Name="operation_conditionsLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="recommendations:" Grid.Column="0"
Grid.Row="2" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="{Binding Path=recommendations}"
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3"
Name="recommendationsLabel" VerticalAlignment="Center" Foreground="White" />
    <Label Content="comments:" Grid.Column="0"
Grid.Row="3" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="{Binding Path=comments}"
Grid.Column="1" Grid.Row="3" Height="28" HorizontalAlignment="Left" Margin="3"
Name="commentsLabel" VerticalAlignment="Center" foreground="White" />
    </Grid>
    <Label BorderBrush="#FF52CAFF" BorderThickness="1"
Content="Trouble Shooting in Tapping Applications" FontFamily="Maiandra GD" FontSize="18"
Foreground="White" Height="Auto" HorizontalAlignment="Left" Margin="104,35,0,0"
Name="label118" VerticalAlignment="Top" Width="361">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF3479B1" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
</Grid>
</TabItem>
<TabItem Header="PDBHelp8" Name="tabItem39"
Initialized="tabItem39_Initialized">
    <Grid>

```

```

        <Rectangle Height="250" HorizontalAlignment="Left"
Margin="199,121,0,0" Name="rectangle50" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="553">
        <Rectangle.Fill>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF3688F8" Offset="1" />
            </LinearGradientBrush>
        </Rectangle.Fill>
    </Rectangle>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Broaching Applications" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="21,22,0,0" Name="label134" VerticalAlignment="Top" Width="361">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
    <ComboBox Height="28" HorizontalAlignment="Left"
Margin="483,146,0,0" Name="comboBox22" VerticalAlignment="Top" Width="216"
DropDownClosed="comboBox22_DropDownClosed" ItemsSource="{Binding}"
DisplayMemberPath="work piece material properties" />
    <ComboBox Height="28" HorizontalAlignment="Left"
Margin="483,193,0,0" Name="comboBox23" VerticalAlignment="Top" Width="216"
ItemsSource="{Binding}" DisplayMemberPath="operation conditions" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="483,279,0,0" Name="label141" VerticalAlignment="Top" Foreground="White" />
    <Label Height="28" HorizontalAlignment="Left"
Margin="483,313,0,0" Name="label142" VerticalAlignment="Top" Foreground="White" />
    <Button Content="Search" Height="28"
HorizontalAlignment="Left" Margin="603,227,0,0" Name="button27" VerticalAlignment="Top"
Width="96" Click="button27_Click_1" />
    <Label Content="operation conditions:"
HorizontalAlignment="Left" Margin="326,193,0,210" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="work piece material properties:"
HorizontalAlignment="Left" Margin="266,146,0,258" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="broaching material recommendations:"
HorizontalAlignment="Left" Margin="222,279,0,124" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="comments:" HorizontalAlignment="Left"
Margin="389,313,0,91" VerticalAlignment="Center" Foreground="White" />
    </Grid>
</TabItem>
<TabItem Header="FDBHelp9" Name="tabItem40">
    <Grid>
        <Rectangle Height="250" HorizontalAlignment="Left"
Margin="121,125,0,0" Name="rectangle51" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="686">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF347981" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
    </Grid>
</TabItem>

```

```

        <GradientStop Color="#FF36B8F8" Offset="1" />
    </LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Grinding Wheel Applications" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="36,31,0,0" Name="label135" VerticalAlignment="Top" Width="409">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
            <GradientStop Color="Black" Offset="0" />
            <GradientStop Color="#FF3479B1" Offset="1" />
        </LinearGradientBrush>
    </Label.Background>
</Label>
    <Grid DataContext="{StaticResource
grindingWheelApplicationsViewSource}" HorizontalAlignment="Left" Margin="207,182,0,0"
Name="grid26" VerticalAlignment="Top" Height="193">
    <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
    </Grid.ColumnDefinitions>
    <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="66" />
        <RowDefinition Height="34" />
    </Grid.RowDefinitions>
    <Label Content="Grinding wheel type and name"
Grid.Column="0" Grid.Row="0" HorizontalAlignment="Left" Margin="3"
VerticalAlignment="Center" Foreground="White" />
    <ComboBox DisplayMemberPath="Grinding wheel type
name" Grid.Column="1" Height="32" HorizontalAlignment="Left" ItemsSource="{Binding
Path=applications}" Margin="3,0,0,4" Name="grinding_wheel_type_and_nameComboBox" VerticalAlignment="Top"
Width="346">
        <ComboBox.ItemsPanel>
            <ItemsPanelTemplate>
                <VirtualizingStackPanel />
            </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
    </ComboBox>
    <Label Content="applications:" Grid.Column="0"
Grid.Row="1" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
    <TextBlock Grid.Column="1" Grid.Row="1" Height="32"
HorizontalAlignment="Left" Margin="3,3,0,3" Name="applicationsTextBlock" Text="{Binding
Path=applications}" VerticalAlignment="Center" Width="352" TextWrapping="Wrap"
Foreground="White" />
    <Label Content="comments:" Grid.Row="2"
HorizontalAlignment="Left" Margin="3,31,0,6" VerticalAlignment="Center"
Foreground="White" />
    <Label Content="{Binding Path=comments}"
Grid.Column="1" Grid.Row="2" Height="28" HorizontalAlignment="Left" Margin="3,31,0,6"
Name="commentslabel1" VerticalAlignment="Center" Foreground="White" />
    </Grid>
</Grid>
</TabItem>
<TabItem Header="PDSHelp10" Name="tabItem41">
    <Grid>

```

```

        <Rectangle Height="250" HorizontalAlignment="Left"
Margin="123,133,0,0" Name="rectangle52" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="686">
        <Rectangle.Fill>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF368BF8" Offset="1" />
            </LinearGradientBrush>
        </Rectangle.Fill>
    </Rectangle>
    <Label BorderBrush="#FF52CAFF" BorderThickness="2"
Content="Trouble Shooting in Cutting Fluids Application" FontFamily="Maiandra GD"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="38,39,0,0" Name="label136" VerticalAlignment="Top" Width="409">
        <Label.Background>
            <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                <GradientStop Color="Black" Offset="0" />
                <GradientStop Color="#FF347981" Offset="1" />
            </LinearGradientBrush>
        </Label.Background>
    </Label>
    <Grid DataContext="{StaticResource
cuttingFluidsApplicationsViewSource}" HorizontalAlignment="Left" Margin="184,150,0,0"
Name="grid27" VerticalAlignment="Top">
        <Grid.ColumnDefinitions>
            <ColumnDefinition Width="Auto" />
            <ColumnDefinition Width="Auto" />
        </Grid.ColumnDefinitions>
        <Grid.RowDefinitions>
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
            <RowDefinition Height="Auto" />
        </Grid.RowDefinitions>
        <Label Content="work piece material:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <ComboBox DisplayMemberPath="work piece material"
Grid.Column="1" Height="29" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,4,0,2" Name="work_piece_materialComboBox5" VerticalAlignment="Center"
Width="296">
            <ComboBox.ItemsPanel>
                <ItemsPanelTemplate>
                    <VirtualizingStackPanel />
                </ItemsPanelTemplate>
            </ComboBox.ItemsPanel>
        </ComboBox>
        <Label Content="drilling:" Grid.Column="0"
Grid.Row="1" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
        <Label Content="{Binding Path=drilling}"
Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin="3"
Name="drillingLabel" VerticalAlignment="Center" Foreground="White" />
    </Grid>

```

```

        <Rectangle Height="250" HorizontalAlignment="Left"
Margin="123,133,0,0" Name="rectangle52" Stroke="#FFA7D2FF" StrokeThickness="2"
VerticalAlignment="Top" Width="685">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF368BF8" Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <Label BorderBrush="#FF52CAFF" BorderThickness="1"
Content="Trouble Shooting in Cutting Fluids Application" FontFamily="Maiandra G0"
FontSize="18" Foreground="White" Height="Auto" HorizontalAlignment="Left"
Margin="38,39,0,0" Name="label136" VerticalAlignment="Top" Width="409">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
                    <GradientStop Color="Black" Offset="0" />
                    <GradientStop Color="#FF347981" Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
        <Grid DataContext="{StaticResource
cuttingFluidsApplicationsViewSource}" HorizontalAlignment="Left" Margin="184,138,0,0"
Name="grid27" VerticalAlignment="Top">
            <Grid.ColumnDefinitions>
                <ColumnDefinition Width="Auto" />
                <ColumnDefinition Width="Auto" />
            </Grid.ColumnDefinitions>
            <Grid.RowDefinitions>
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
                <RowDefinition Height="Auto" />
            </Grid.RowDefinitions>
            <Label Content="work piece material:" Grid.Column="0"
Grid.Row="0" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
            <ComboBox DisplayMemberPath="work piece material"
Grid.Column="1" Height="29" HorizontalAlignment="Left" ItemsSource="{Binding}"
Margin="3,4,0,2" Name="work_piece_materialComboBox5" VerticalAlignment="Center"
Width="296">
                <ComboBox.ItemsPanel>
                    <ItemsPanelTemplate>
                        <VirtualizingStackPanel />
                    </ItemsPanelTemplate>
                </ComboBox.ItemsPanel>
            </ComboBox>
            <Label Content="drilling:" Grid.Column="0"
Grid.Row="1" HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center"
Foreground="White" />
            <Label Content="{Binding Path=drilling}"
Grid.Column="1" Grid.Row="1" Height="28" HorizontalAlignment="Left" Margin="3"
Name="drillinglabel" VerticalAlignment="Center" Foreground="White" />

```

```

EndPoint="0,0.5">
    Set="0" />
    Set="1" />
    <LinearGradientBrush EndPoint="1,0.5"
        <GradientStop Color="Black"
        <GradientStop Color="#FF1DA6FF"
    </LinearGradientBrush>
    </Label.Background>
</Label>
<Button Content="Calculate" Height="33"
HorizontalAlignment="Left" Margin="336,157,0,0" Name="button2" VerticalAlignment="Top"
Width="97" Click="button2_Click" />
<Label Content="Diametral Pitch" Height="28"
HorizontalAlignment="Left" Margin="210,105,0,0" Name="label94" VerticalAlignment="Top"
Background="White" />
<Label BorderBrush="#FF52CAFF"
BorderThickness="2" Content="Addendum" FontFamily="Maiandra GD" FontSize="18"
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="69,24,0,0"
Name="label95" VerticalAlignment="Top" Width="179">
    <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
            <GradientStop Color="Black"
            <GradientStop Color="#FF3479B1"
        </LinearGradientBrush>
    </Label.Background>
</Label>
</Grid>
</TabItem>
<TabItem Header="Circular Pitch" Name="tabItem7">
    <Grid>
        <Rectangle Height="129"
HorizontalAlignment="Left" Margin="198,101,0,0" Name="rectangle31" Stroke="#FFA7D2FF"
StrokeThickness="2" VerticalAlignment="Top" Width="427">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
                    <GradientStop Color="Black"
                    <GradientStop Color="#FF3688F8"
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <TextBox Height="32"
HorizontalAlignment="Left" Margin="351,125,0,0" Name="textBox5" VerticalAlignment="Top"
Width="185" />
        <Button Content="Calculate" Height="31"
HorizontalAlignment="Left" Margin="435,181,0,0" Name="button3" VerticalAlignment="Top"
Width="101" Click="button3_Click" />
        <Label FontSize="16" Height="31"
HorizontalAlignment="Left" Margin="454,247,0,0" Name="label12" VerticalAlignment="Top"
Background="White" BorderBrush="#FF7CBFFF" BorderThickness="2">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"

```

```
<GradientStop Color="Black"
<GradientStop Color="#FF109FFF"
</LinearGradientBrush>
</Label.Background>
</Label>
<Label BorderBrush="#FF52CAFF"
FontFamily="Malandra GO" FontSize="18"
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="56,28,0,0"
Label196 VerticalAlignment="Top" Width="179">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
<GradientStop Color="#FF3479B1"
</LinearGradientBrush>
</Label.Background>
</Label>
<Label Content="Diametral Pitch"
Background="White" Height="28" HorizontalAlignment="Left" Margin="241,129,0,0"
Label133 VerticalAlignment="Top" />
</Grid>
</TabItem>
<TabItem Header="Clearance" Name="tabItem8">
<Grid>
<Rectangle Height="160"
HorizontalAlignment="Left" Margin="198,79,0,0" Name="rectangle32" Stroke="#FFA7D2FF"
Thickness="2" VerticalAlignment="Top" Width="454">
<Rectangle.Fill>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
<GradientStop Color="#FF36B8F8"
</LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
<TextBox Height="33"
HorizontalAlignment="Left" Margin="386,125,0,0" Name="textBox6" VerticalAlignment="Top"
Width="185" />
<Label Height="33" HorizontalAlignment="Left"
Name="label15" VerticalAlignment="Top" Foreground="White"
BorderBrush="#FF69B5FF" BorderThickness="2">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
<GradientStop Color="#FF108DFF"
</LinearGradientBrush>
</Label.Background>
</Label>
```

```

        <Button Content="Calculate" Height="33"
        Alignment="Left" Margin="474,180,0,0" Name="button4" VerticalAlignment="Top"
        Click="button4_Click" />
        <Label BorderBrush="#FF52CAFF"
        Thickness="2" Content="Clearance" FontFamily="Maiandra GD" FontSize="18"
        Background="White" Height="Auto" HorizontalAlignment="Left" Margin="50,21,0,0"
        VerticalAlignment="Top" Width="179">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
                StartPoint="0,0.5">
                    <GradientStop Color="Black"
                    Offset="0.5" />
                    <GradientStop Color="#FF3479B1"
                    Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
        <Label Content="Diametral Pitch"
        Background="White" Height="23" HorizontalAlignment="Left" Margin="176,130,0,0"
        VerticalAlignment="Top" />
    </Grid>
</TabItem>
<TabItem Header="Diametral Pitch I" Name="tabItem9">
    <Grid>
        <Rectangle Height="171"
        Alignment="left" Margin="216,66,0,0" Name="rectangle33" Stroke="#FFA7D2FF"
        Thickness="2" VerticalAlignment="Top" Width="391">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
                StartPoint="0,0.5">
                    <GradientStop Color="Black"
                    Offset="0.5" />
                    <GradientStop Color="#FF3688F8"
                    Offset="1" />
                </LinearGradientBrush>
            </Rectangle.Fill>
        </Rectangle>
        <TextBox Height="32"
        Alignment="Left" Margin="380,92,0,0" Name="textBox7" VerticalAlignment="Top"
        />
        <TextBox Height="32"
        Alignment="Left" Margin="380,139,0,0" Name="textBox8" VerticalAlignment="Top"
        />
        <Button Content="Calculate" Height="33"
        Alignment="Left" Margin="469,190,0,0" Name="button6" VerticalAlignment="Top"
        Click="button6_Click" />
        <Label FontSize="16" Height="35"
        Alignment="Left" Margin="486,247,0,0" Name="label23" VerticalAlignment="Top"
        Background="White" BorderThickness="2" BorderBrush="#FF79BFFF">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
                StartPoint="0,0.5">
                    <GradientStop Color="Black"
                    Offset="0.5" />
                    <GradientStop Color="#FF249AFF"
                    Offset="1" />
                </LinearGradientBrush>
            </Label.Background>
        </Label>
    </Grid>
</TabItem>

```

```

        <Label BorderBrush="#FF52CAFF"
        Thickness="2" Content="Diametral Pitch I" FontFamily="Maiandra GO" FontSize="18"
        Background="White" Height="Auto" HorizontalAlignment="Left" Margin="56,24,0,0"
        Label198 VerticalAlignment="Top" Width="179">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
                GradientStop Color="Black"
                GradientStop Color="#FF3479B1"
                />
            </Label.Background>
        </Label>
        <Label Content="Number of Teeth"
        Background="White" Height="28" HorizontalAlignment="Left" Margin="247,96,0,0"
        Label130 VerticalAlignment="Top" />
        <Label Content="Outside Diameter"
        Background="White" Height="28" HorizontalAlignment="Left" Margin="244,143,0,0"
        Label131 VerticalAlignment="Top" />
    </Grid>
</TabItem>
<TabItem Header="Diametral Pitch II"
TabItem10">
    <Grid>
        <Rectangle Height="171"
        HorizontalAlignment="Left" Margin="213,78,0,0" Name="rectangle34" Stroke="#FFA7D2FF"
        Thickness="2" VerticalAlignment="Top" Width="416">
            <Rectangle.Fill>
                <LinearGradientBrush EndPoint="1,0.5"
                GradientStop Color="Black"
                GradientStop Color="#FF36B8F8"
                />
            </Rectangle.Fill>
        </Rectangle>
        <TextBox Height="32"
        HorizontalAlignment="Left" Margin="387,103,0,0" Name="textBox9" VerticalAlignment="Top"
        Width="105" />
        <TextBox Height="32"
        HorizontalAlignment="Left" Margin="387,150,0,0" Name="textBox10" VerticalAlignment="Top"
        Width="105" />
        <Label FontSize="16" Height="33"
        HorizontalAlignment="Left" Margin="462,255,0,0" Name="label32" VerticalAlignment="Top"
        Background="White" BorderBrush="#FF6FB8FF" BorderThickness="2">
            <Label.Background>
                <LinearGradientBrush EndPoint="1,0.5"
                GradientStop Color="Black"
                GradientStop Color="#FF38B9FF"
                />
            </Label.Background>
        </Label>
    </Grid>

```

```

HorizontalAlignment="Left" Margin="466,200,0,0" Name="button11" VerticalAlignment="Top"
Width="196" Click="button11_Click" />
<Label BorderBrush="#FF52CAFF"
BorderThickness="2" Content="Diametral Pitch II" FontFamily="Maiandra GD" FontSize="18"
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="54,36,0,0"
Name="label199" VerticalAlignment="Top" Width="179">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5">
<GradientStop Color="Black">
<GradientStop Color="#FF3479B1">
</LinearGradientBrush>
</Label.Background>
</Label>
<Label Content="Number of Teeth"
Background="White" Height="24" HorizontalAlignment="Left" Margin="264,107,0,0"
Name="label128" VerticalAlignment="Top" />
<Label Content="Pitch Diameter"
Background="White" Height="28" HorizontalAlignment="Left" Margin="279,148,0,0"
Name="label129" VerticalAlignment="Top" />
</Grid>
</TabItem>
<TabItem Header="Number of Teeth I" Name="tabItem11">
<Grid>
<Rectangle Height="176"
HorizontalAlignment="Left" Margin="105,66,0,0" Name="rectangle35" Stroke="#FFA7D2FF"
BorderThickness="2" VerticalAlignment="Top" Width="506">
<Rectangle.Fill>
<LinearGradientBrush EndPoint="1,0.5">
<GradientStop Color="Black">
<GradientStop Color="#FF3688F8">
</LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
<TextBox Height="32"
HorizontalAlignment="Left" Margin="240,96,0,0" Name="textBox11" VerticalAlignment="Top"
Width="185" />
<TextBox Height="32"
HorizontalAlignment="Left" Margin="240,143,0,0" Name="textBox12" VerticalAlignment="Top"
Width="185" />
<Label FontSize="16" Height="33"
HorizontalAlignment="Left" Margin="430,246,0,0" Name="label135" VerticalAlignment="Top"
Background="White" BorderBrush="#FF5CDBFF" BorderThickness="2">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5">
<GradientStop Color="Black">
<GradientStop Color="#FF17B4FF">
</LinearGradientBrush>
</Label.Background>
</Label>

```

```

HorizontalAlignment="Left" Margin="319,193,0,0" Name="button12" VerticalAlignment="Top"
Width="106" Click="button11_Click" />
<Label BorderBrush="#FF52CAFF"
BorderThickness="2" Content="Number of Teeth" FontFamily="Maiandra GD" FontSize="18"
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="78,10,0,0"
Name="label100" VerticalAlignment="Top" Width="179">
  <Label.Background>
    <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
      <GradientStop Color="Black"
Offset="0" />
      <GradientStop Color="#FF3479B1"
Offset="1" />
    </LinearGradientBrush>
  </Label.Background>
</Label>
<Label Content="Outside Diameter"
Background="White" Height="28" HorizontalAlignment="Left" Margin="115,96,0,0"
Name="label101" VerticalAlignment="Top" />
<Label Content="Diametral Pitch"
Background="White" Height="28" HorizontalAlignment="Left" Margin="130,143,0,0"
Name="label102" VerticalAlignment="Top" />
</Grid>
</TabItem>
<TabItem Header="Number of Teeth II"
Name="tabItem12">
  <Grid>
    <Rectangle Height="154"
HorizontalAlignment="Left" Margin="114,72,0,0" Name="rectangle36" Stroke="#FFA7D2FF"
StrokeThickness="2" VerticalAlignment="Top" Width="500">
      <Rectangle.Fill>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
          <GradientStop Color="Black"
Offset="0" />
          <GradientStop Color="#FF36B8F8"
Offset="1" />
        </LinearGradientBrush>
      </Rectangle.Fill>
    </Rectangle>
    <TextBox Height="32"
HorizontalAlignment="Left" Margin="294,96,0,0" Name="textBox13" VerticalAlignment="Top"
Width="185" />
    <TextBox Height="32"
HorizontalAlignment="Left" Margin="294,143,0,0" Name="textBox14" VerticalAlignment="Top"
Width="185" />
    <Label FontSize="16" Height="33"
HorizontalAlignment="Left" Margin="476,246,0,0" Name="label38" VerticalAlignment="Top"
Background="White" BorderThickness="2" BorderBrush="#FF2ECBFF">
      <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
          <GradientStop Color="Black"
Offset="0" />
          <GradientStop Color="#FF1D75FF"
Offset="1" />
        </LinearGradientBrush>
      </Label.Background>

```

```

</Label>
<Button Content="Calculate" Height="33"
HorizontalAlignment="Left" Margin="373,186,0,0" Name="button13" VerticalAlignment="Top"
Width="106" Click="button13_Click" />
<Label Content="Pitch Diameter"
Background="White" Height="28" HorizontalAlignment="Left" Margin="162,100,0,0"
Name="label103" VerticalAlignment="Top" />
<Label BorderBrush="#FF52CAFF"
Thickness="2" Content="Number of Teeth II" FontFamily="Maiandra GD" FontSize="18"
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="31,16,0,0"
Name="label104" VerticalAlignment="Top" Width="179">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
Offset="0" />
<GradientStop Color="#FF3479B1"
Offset="1" />
</LinearGradientBrush>
</Label.Background>
</Label>
<Label Content="Diametral Pitch"
Background="White" Height="28" HorizontalAlignment="Left" Margin="159,141,0,0"
Name="label105" VerticalAlignment="Top" />
</Grid>
</TabItem>
<TabItem Header="Pitch Diameter" Name="tabItem13">
<Grid>
<Rectangle Height="154"
HorizontalAlignment="Left" Margin="114,85,0,0" Name="rectangle37" Stroke="#FFA7D2FF"
Thickness="2" VerticalAlignment="Top" Width="500">
<Rectangle.Fill>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
Offset="0" />
<GradientStop Color="#FF36B8F8"
Offset="1" />
</LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
<TextBox Height="32"
HorizontalAlignment="Left" Margin="366,104,0,0" Name="textBox15" VerticalAlignment="Top"
Width="185" />
<TextBox Height="32"
HorizontalAlignment="Left" Margin="360,150,0,0" Name="textBox16" VerticalAlignment="Top"
Width="185" />
<Label FontSize="16" Height="33"
HorizontalAlignment="Left" Margin="436,245,0,0" Name="label41" VerticalAlignment="Top"
Background="White" BorderBrush="#FF4BD3FF" BorderThickness="2">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
Offset="0" />
<GradientStop Color="#FF0085FF"
Offset="1" />
</LinearGradientBrush>
</Label.Background>

```

```
</Label>
<Button Content="Calculate" Height="33"
HorizontalAlignment="Left" Margin="439,194,0,0" Name="button14" VerticalAlignment="Top"
Width="186" Click="button14_Click" />
<Label BorderBrush="#FF52CAFF"
Content="Pitch Diameter" FontFamily="Maiandra GD" FontSize="18"
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="61,43,0,0"
Name="label106" VerticalAlignment="Top" Width="179">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black" />
<GradientStop Color="#FF3479B1" />
</LinearGradientBrush>
</Label.Background>
</Label>
<Label Content="Diametral Pitch"
Background="White" Height="28" HorizontalAlignment="Left" Margin="238,154,0,0"
Name="label107" VerticalAlignment="Top" />
<Label Content="Number of teeth"
Background="White" Height="28" HorizontalAlignment="Left" Margin="225,108,0,0"
Name="label108" VerticalAlignment="Top" />
</Grid>
</TabItem>
<TabItem Header="Pitch Diameter II" Name="tabItem14">
<Grid>
<Rectangle Height="154"
HorizontalAlignment="Left" Margin="116,76,0,0" Name="rectangle38" Stroke="#FFA7D2FF"
StrokeThickness="2" VerticalAlignment="Top" Width="500">
<Rectangle.Fill>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black" />
<GradientStop Color="#FF3688F8" />
</LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
<TextBox Height="32"
HorizontalAlignment="Left" Margin="335,91,0,0" Name="textBox17" VerticalAlignment="Top"
Width="185" />
<TextBox Height="32"
HorizontalAlignment="Left" Margin="335,138,0,0" Name="textBox18" VerticalAlignment="Top"
Width="185" />
<Label FontSize="16" Height="33"
HorizontalAlignment="Left" Margin="489,248,0,0" Name="label144" VerticalAlignment="Top"
Background="White" BorderThickness="2" BorderBrush="#FF3BCFFF">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black" />
<GradientStop Color="#FF00A2FF" />
</LinearGradientBrush>
</Label.Background>
</Grid>
</TabItem>
</TabControl>
</Page>
</Page>
```



```

</Label>
<Button Content="Calculate" Height="33"
HorizontalAlignment="Left" Margin="408,177,0,0" Name="button16" VerticalAlignment="Top"
Width="106" Click="button16_Click" />
<Label BorderBrush="#FF52CAFF"
BorderThickness="2" Content="Outside Diameter" FontFamily="Maiandra GD" FontSize="18"
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="87,15,0,0"
Name="label119" VerticalAlignment="Top" Width="179">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
Offset="0" />
<GradientStop Color="#FF347981"
Offset="1" />
</LinearGradientBrush>
</Label.Background>
</Label>
<Label Content="Number of Teeth"
Background="White" Height="28" HorizontalAlignment="Left" Margin="286,84,0,0"
Name="label120" VerticalAlignment="Top" />
<Label Content="Diametral Pitch"
Background="White" Height="28" HorizontalAlignment="Left" Margin="219,131,0,0"
Name="label121" VerticalAlignment="Top" />
</Grid>
</TabItem>
<TabItem Header="Tooth Thickness" Name="tabItem16">
<Grid>
<Rectangle Height="136"
HorizontalAlignment="Left" Margin="166,84,0,0" Name="rectangle47" Stroke="#FFA7D2FF"
StrokeThickness="2" VerticalAlignment="Top" Width="340">
<Rectangle.Fill>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
Offset="0" />
<GradientStop Color="#FF36B8F8"
Offset="1" />
</LinearGradientBrush>
</Rectangle.Fill>
</Rectangle>
<TextBox Height="32"
HorizontalAlignment="Left" Margin="256,128,0,0" Name="textBox21" VerticalAlignment="Top"
Width="185" />
<Label FontSize="16" Height="33"
HorizontalAlignment="Left" Margin="438,238,0,0" Name="label50" VerticalAlignment="Top"
Background="White" BorderBrush="#FF76DFFF" BorderThickness="2">
<Label.Background>
<LinearGradientBrush EndPoint="1,0.5"
StartPoint="0,0.5">
<GradientStop Color="Black"
Offset="0" />
<GradientStop Color="#FF0897FF"
Offset="1" />
</LinearGradientBrush>
</Label.Background>
</Label>

```



```
Background="White" Height="Auto" HorizontalAlignment="Left" Margin="39,16,0,0"
Name="label124" VerticalAlignment="Top" Width="179">
  <Label.Background>
    <LinearGradientBrush EndPoint="1,0.5"
      StartPoint="0,0.5">
      <GradientStop Color="Black"
        Offset="0" />
      <GradientStop Color="#FF347981"
        Offset="1" />
    </LinearGradientBrush>
  </Label.Background>
</Label>
<Label Content="Diametral Pitch"
  Background="White" Height="28" HorizontalAlignment="Left" Margin="196,102,0,0"
  Name="label125" VerticalAlignment="Top" />
</Grid>
</TabItem>
<TabItem Header="Dedendum" Name="tabItem18">
  <Grid>
    <Rectangle Height="136"
      HorizontalAlignment="Left" Margin="184,86,0,0" Name="rectangle49" Stroke="#FFA7D2FF"
      StrokeThickness="2" VerticalAlignment="Top" Width="340">
      <Rectangle.Fill>
        <LinearGradientBrush EndPoint="1,0.5"
          StartPoint="0,0.5">
          <GradientStop Color="Black"
            Offset="0" />
          <GradientStop Color="#FF368BF8"
            Offset="1" />
        </LinearGradientBrush>
      </Rectangle.Fill>
    </Rectangle>
    <TextBox Height="32"
      HorizontalAlignment="Left" Margin="312,122,0,0" Name="textBox23" VerticalAlignment="Top"
      Width="185" />
    <Label FontSize="16" Height="33"
      HorizontalAlignment="Left" Margin="448,239,0,0" Name="label54" VerticalAlignment="Top"
      BorderBrush="#FF90CFFF" BorderThickness="2">
      <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
          StartPoint="0,0.5">
          <GradientStop Color="Black"
            Offset="0" />
          <GradientStop Color="#FF80A3FF"
            Offset="1" />
        </LinearGradientBrush>
      </Label.Background>
    </Label>
    <Button Content="Calculate" Height="33"
      HorizontalAlignment="Left" Margin="391,178,0,0" Name="button19" VerticalAlignment="Top"
      Width="106" Click="button19_Click" />
    <Label BorderBrush="#FF52CAFF"
      Content="Dedendum" FontFamily="Maiandra GD" FontSize="18"
      Background="White" Height="Auto" HorizontalAlignment="Left" Margin="50,30,0,0"
      Name="label126" VerticalAlignment="Top" Width="179">
      <Label.Background>
        <LinearGradientBrush EndPoint="1,0.5"
          StartPoint="0,0.5">
```



```

<TabItem Header="tabItem42" Name="tabItem42">
  <Grid>
    <Grid DataContext="{StaticResource
CuttingSpeedsViewSource}" HorizontalAlignment="Left" Margin="242,95,0,0"
Grid16" VerticalAlignment="Top">
      <Grid.ColumnDefinitions>
        <ColumnDefinition Width="Auto" />
        <ColumnDefinition Width="Auto" />
      </Grid.ColumnDefinitions>
      <Grid.RowDefinitions>
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
        <RowDefinition Height="Auto" />
      </Grid.RowDefinitions>
      <Label Content="work piece material:" Grid.Column="0"
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" />
      <ComboBox DisplayMemberPath="work piece material"
Grid.Column="1" Grid.Row="0" Height="23" HorizontalAlignment="Left"
Source="{Binding}" Margin="3" Name="work_piece_materialComboBox4"
VerticalAlignment="Center" Width="120" IsEditable="True">
        <ComboBox.ItemsPanel>
          <ItemsPanelTemplate>
            <VirtualizingStackPanel />
          </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
      </ComboBox>
      <Label Content="tool material:" Grid.Column="0"
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" />
      <ComboBox DisplayMemberPath="tool material"
Grid.Column="1" Grid.Row="1" Height="23" HorizontalAlignment="Left"
Source="{Binding}" Margin="3" Name="tool_materialComboBox1"
VerticalAlignment="Center" Width="120" IsEditable="True">
        <ComboBox.ItemsPanel>
          <ItemsPanelTemplate>
            <VirtualizingStackPanel />
          </ItemsPanelTemplate>
        </ComboBox.ItemsPanel>
      </ComboBox>
      <Label Content="feet per minute:" Grid.Column="0"
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" />
      <TextBox Grid.Column="1" Grid.Row="2" Height="23"
HorizontalAlignment="Left" Margin="3" Name="feet_per_minuteTextBox" Text="{Binding
feet per minute, Mode=TwoWay, ValidatesOnExceptions=true,
OnValidationError=true}" VerticalAlignment="Center" Width="120" />
      <Label Content="meters per minute:" Grid.Column="0"
HorizontalAlignment="Left" Margin="3" VerticalAlignment="Center" />
      <TextBox Grid.Column="1" Grid.Row="3" Height="23"
HorizontalAlignment="Left" Margin="3" Name="meters_per_minuteTextBox" Text="{Binding
meters per minute, Mode=TwoWay, ValidatesOnExceptions=true,
OnValidationError=true}" VerticalAlignment="Center" Width="120" />
    </Grid>
    <Label Content="Milling Cutting Speeds"
HorizontalAlignment="Left" Margin="248,36,0,287" VerticalAlignment="Center" />
    <Button Content="Update" Height="23"
HorizontalAlignment="Left" Margin="443,250,0,0" Name="button26" VerticalAlignment="Top"
Width="75" Click="button26_Click" />
    <Label Height="28" HorizontalAlignment="Left"
Width="536,248,0,0" Name="label63" VerticalAlignment="Top" />
  </Grid>
</TabItem>

```

```

        <Label Height="28" HorizontalAlignment="Left"
Margin="536,290,0,0" Name="label64" VerticalAlignment="Top" />
    </Grid>
</TabItem>
<TabItem Header="tabItem43" Name="tabItem43">
    <Grid>
        <DataGrid AutoGenerateColumns="False"
        CanRowVirtualization="True" Height="200" HorizontalAlignment="Left"
        ItemsSource="{Binding Source={StaticResource millingCuttingSpeedsViewSource}}"
Margin="58,50,0,0" Name="millingCuttingSpeedsDataGrid"
        DetailsVisibilityMode="VisibleWhenSelected" VerticalAlignment="Top" Width="545">
            <DataGrid.Columns>
                <DataGridTextColumn
                Name="work_piece_materialColumn" Binding="{Binding Path=work piece material}"
                Header="work piece material" Width="SizeToHeader" />
                <DataGridTextColumn x:Name="tool_materialColumn"
                Binding="{Binding Path=tool material}" Header="tool material" Width="SizeToHeader" />
                <DataGridTextColumn
                Name="feet_per_minuteColumn" Binding="{Binding Path=feet per minute}" Header="feet per
                minute" Width="SizeToHeader" />
                <DataGridTextColumn
                Name="meters_per_minuteColumn" Binding="{Binding Path=meters per minute}"
                Header="meters per minute" Width="SizeToHeader" />
            </DataGrid.Columns>
        </DataGrid>
        <Label Content="Milling Cutting Speeds"
        HorizontalAlignment="Left" Margin="94,6,0,318" VerticalAlignment="Center" />
    </Grid>
</TabItem>
</TabControl>
</Grid>
</TabItem>
</TabControl>
<Image x:Name="image" Height="100" HorizontalAlignment="Left" Margin="12,12,0,0"
Stretch="Fill" VerticalAlignment="Top" Width="100" RenderTransformOrigin="0.5,0.5"
Source="/WpfApplication3;component/Images/process.ico">
    <Image.RenderTransform>
        <TransformGroup>
            <ScaleTransform/>
            <SkewTransform/>
            <RotateTransform />
            <TranslateTransform/>
        </TransformGroup>
    </Image.RenderTransform>
</Image>
<Label Content="Machining Operations Module" Height="57"
        HorizontalAlignment="Left" Margin="126,22,0,0" Name="label1" VerticalAlignment="Top"
        FontSize="36" FontFamily="Maiandra GD" Foreground="#FF83CBFF" />
</Grid>
</Window>

```

## Johnson's Algorithm

```
private void button52_Click(object sender, RoutedEventArgs e)
{
    int m = Convert.ToInt16(machtextBox.Text);
    int n = Convert.ToInt16(partstextBox.Text);
    string css2 = @"Data Source=.\SQLEXPRESS;" +
@"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
Security=True;" +
@"Connect Timeout=30;" +
@"User Instance=True;";
    SqlConnection ncon = new SqlConnection(css2);

    string tab = "SELECT MAX(TableNo) FROM [dbo].[Table]";

    SqlCommand ncmd2 = new SqlCommand(tab, ncon);
    ncon.Open();
    int table1 = Convert.ToInt32(ncmd2.ExecuteScalar()) + 1;
    string ins = "INSERT INTO [dbo].[Table] (TableNo) VALUES ('" + table1 + "')";
    SqlCommand ncmd3 = new SqlCommand(ins, ncon);
    ncmd3.ExecuteScalar();
    textBox70.Clear();
    label249.Content = "Enter the time take for Part 1" + " on the " + m + "
machines";
    label252.Content = "PART " + 1;

    string k = "CREATE TABLE tab" + table1 + "(part char(50),";
    for (var i = 1; i <= m; i++)
    {
        string str = " m" + Convert.ToString(i) + " int,";
        string str2 = " m" + Convert.ToString(i) + " int)";
        if (i != m)
        {
            k = k + str;
        }
        else
        {
            k = k + str2;
        }
    }
    label250.Content = k;

    SqlCommand ncmd = new SqlCommand(k, ncon);
    ncmd.ExecuteScalar();
    textBox70.Visibility = Visibility.Visible;
    button56.Visibility = Visibility.Visible;
    label249.Visibility = Visibility.Visible;
    rectangle77.Visibility = Visibility.Visible;
    label248.Visibility = Visibility.Visible;
}

private void button56_Click(object sender, RoutedEventArgs e)
```

```

{
    string css3 = @"Data Source=.\SQLEXPRESS;" +
@"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
ty=True;" +
@"Connect Timeout=30;" +
@"User Instance=True;";
    SqlConnection ncon2 = new SqlConnection(css3);
    int m1 = 0;
    int m2 = 0;
    int m = Convert.ToInt16(machtextBox.Text);
    int n = Convert.ToInt16(partstextBox.Text);
    int o = 1;
    var g = Convert.ToInt16(label253.Content.ToString());
    if (m > 2)
    {
        string ol02 = textBox70.Text;
        string insert22 = "";
        CharEnumerator ol3 = ol02.GetEnumerator();
        int[] mach2 = new int[m + 1];
        while (ol3.MoveNext())
        {
            if (ol3.Current != Convert.ToChar(","))
            {
                insert22 = insert22 + ol3.Current;
            }
            else
            {
                mach2[o] = Convert.ToInt16(insert22);
                insert22 = "";
                o++;
            }
        }
        mach2[o] = Convert.ToInt16(insert22);
        int on = Convert.ToInt16(0.5 * o);
        for (var ab = 1; ab <= on; ab++)
        {
            m1 = m1 + mach2[ab];
        }
        for (var ac = (on + 1); ac <= m; ac++)
        {
            m2 = m2 + mach2[ac];
        }
        if (g <= n)
        {
            if (g == n)
            {
                displayButton.Visibility = Visibility.Visible;
                textBox70.Visibility = Visibility.Hidden;
                button56.IsEnabled = true;
            }
        }
    }
}

```

```

        label249.Content = "Enter the time take for Part " + (g + 1) + " on
+ m + " machines";
        label252.Content = "PART " + (g + 1);
        string css2 = @"Data Source=.\SQLEXPRESS;" +
        @"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
        @"Connect Timeout=30;" +
        @"Server Instance=True;";
        SqlConnection ncon = new SqlConnection(css2);

        string tab = "SELECT MAX(TableNo) FROM [dbo].[Table]";
        SqlCommand ncmd2 = new SqlCommand(tab, ncon);
        ncon.Open(); int table1 = Convert.ToInt32(ncmd2.ExecuteScalar());

        string insert = "INSERT INTO tab" + table1 + "(part, m1, m2) VALUES
g.ToString() + ", '";

        insert = insert + m1 + ", " + m2 + "'";
        mtu.Content = insert;
        ncon2.Open();
        SqlCommand ncmd = new SqlCommand(insert, ncon2);
        ncmd.ExecuteScalar();
        g++;
        label253.Content = g.ToString();
        textBox70.Clear();
    }
}
else
{
    try
    {
        string ol = textBox70.Text;
        string insert2 = "";
        CharEnumerator ol2 = ol.GetEnumerator();
        int[] mach = new int[(m + 1)];
        while (ol2.MoveNext())
        {
            if (ol2.Current != Convert.ToChar(","))
            {
                insert2 = insert2 + ol2.Current;
            }
            else
            {
                mach[o] = Convert.ToInt16(insert2);
                insert2 = "";
                o++;
            }
        }
        m1 = mach[1];
        m2 = Convert.ToInt16(insert2);

        if (g <= n)
    }
}

```

```

    {
        if (g == n)
        {
            displayButton.Visibility = Visibility.Visible;
            textBox70.Visibility = Visibility.Hidden;
            button56.IsEnabled = true;
        }

        label249.Content = "Enter the time take for Part " + (g + 1) + "
the " + m + " machines";
        label252.Content = "PART " + (g + 1);
        string css2 = @"Data Source=.\SQLEXPRESS;" +
@"AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated
Security=True;" +
@"Connect Timeout=30;" +
@"User Instance=True;";
        SqlConnection ncon = new SqlConnection(css2);

        string tab = "SELECT MAX(TableNo) FROM [dbo].[Table]";
        SqlCommand ncmd2 = new SqlCommand(tab, ncon);
        ncon.Open(); int table1 = Convert.ToInt32(ncmd2.ExecuteScalar());

        string insert = "INSERT INTO tab" + table1 + "(part, m1, m2)
VALUES ('" + g.ToString() + "', '" +
/*
        for (var i = 1; i <= m; i++)
        {
            string st = "m" + Convert.ToString(i) + ", ";
            string st2 = "m" + Convert.ToString(i) + ") VALUES

+ g.ToString() + "', '" +

            if (i != m)
            {
                insert = insert + st;
            }
            else
            {
                insert = insert + st2;
            }
        }

        string ol = textBox70.Text;
        CharEnumerator ol2 = ol.GetEnumerator();
        while (ol2.MoveNext())
        {

            if (ol2.Current != Convert.ToChar(","))
            {
                insert = insert + ol2.Current;
            }
            else
            {
                insert = insert + "', '";
            }
        }
    }

```



```

SqlConnection ncon = new SqlConnection(css2);

string tab = "SELECT MAX(TableNo) FROM
[Table]";

SqlCommand ncmd2 = new SqlCommand(tab, ncon);
ncon.Open(); int table1 =
r.ToInt32(ncmd2.ExecuteScalar());

string sql = "SELECT m" + (f + 1) + " FROM tab" +
+ "WHERE part = '" + (h + 1).ToString() + "'";
string sql2 = "SELECT MIN (m" + (f + 1) + ") FROM
table1;

SqlConnection con5 = new SqlConnection(cs2);

con5.Open();

SqlCommand cmd15 = new SqlCommand(sql, con5);
SqlCommand cmd16 = new SqlCommand(sql2, con5);
int time = Convert.ToInt16(cmd15.ExecuteScalar());
int mtime = Convert.ToInt16(cmd16.ExecuteScalar());

int[] k = new int[n + 1];

k[h] = time;
if (k.ElementAt(h) == mtime)
{
    z[f] = mtime;
    if (z[0] == z[1])
    {
        z[1] = 1000000;
    }
    // DELETE statement goes here
}
}

for (var ta = 0; ta + 1 <= m; ta++)
{
    if (z.ElementAt(ta) == z.Min())
    {
        string cs3 = @"Data Source=.\SQLEXPRESS;" +
chDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"

        @"Connect Timeout=30;" +
        @"User Instance=True;";

        string css2 = @"Data Source=.\SQLEXPRESS;" +
chDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"

        @"Connect Timeout=30;" +
        @"User Instance=True;";

```

```

SqlConnection ncon = new SqlConnection(css2);
string tab = "SELECT MAX(TableNo) FROM
ble]";
SqlCommand ncmd2 = new SqlCommand(tab, ncon);
ncon.Open(); int table1 =
oInt32(ncmd2.ExecuteScalar());

string sql3 = "SELECT part FROM tab" + table1 +
+ (ta + 1) + " = '" + z.Min().ToString() + "'";

string str3 = " WHERE (m" + (ta + 1) + " = '" +
oString() + "'";

string update = "UPDATE tab" + table1 + " SET part =
for (var i = 1; i <= m; i++)
{
string st = "m" + Convert.ToString(i) + " =
string st2 = "m" + Convert.ToString(i) + " =

if (i != m)
{
update = update + st;
}
else
{
update = update + st2;
}
}
string k = update + str3;

SqlConnection con6 = new SqlConnection(cs3);
con6.Open();
SqlCommand cmd16 = new SqlCommand(sql3, con6);
string p1 = Convert.ToString(cmd16.ExecuteScalar());
SqlCommand cmd17 = new SqlCommand(k, con6);

l[ta] = p1.Trim() + l[ta];

cmd17.ExecuteScalar();
}
}

}

string final = "";
CharEnumerator rev = l[0].GetEnumerator();

```

```

for (var ce = 1; ce <= l[0].Length; ce++)
{
    rev.MoveNext();
    l[2] = rev.Current + l[2];
}
final = l[2] + l[1];

textBox70.Clear();
string mfinal = "";
CharEnumerator r2 = final.GetEnumerator();
for (var de = 1; de <= final.Length; de++)
{
    r2.MoveNext();
    mfinal = mfinal + "Part" + r2.Current + " ==>> ";
}
label254.Content = mfinal;
g++;
label253.Content = g.ToString();
textBox70.Clear();

/*
string ccc2 = @"Data Source=.\SQLEXPRESS;" +
@"AttachDbFilename=[DataDirectory]\PDBHelp.mdf;Integrated Security=True;" +
@"Connect Timeout=30;" +
@"User Instance=True;";

string drop = "DROP TABLE table1";

SqlConnection conn5 = new SqlConnection(ccc2);

conn5.Open();

SqlCommand c5 = new SqlCommand(drop, conn5);
c5.ExecuteNonQuery();
*/
}
}
catch
{
    MessageBox.Show("Make sure you have entered the data properly!");
}
}

private void displayButton_Click(object sender, RoutedEventArgs e)
{
    int m = 2;
    int n = Convert.ToInt16(partstextBox.Text);
    // int[] z = new int[m];

```

```

string[] l = new string[] { "" };

for (var c = 1; c <= n; c++)
{
    int[] z = new int[m];
    string cs2 = @"Data Source=.\SQLEXPRESS;" +
        "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
        "Connect Timeout=30;" +
        "User Instance=True;";
    textBox70.Visibility = Visibility.Hidden;
    for (var f = 0; f + 1 <= 2; f++)
    {
        for (var h = 0; h + 1 <= n; h++)
        {
            string css2 = @"Data Source=.\SQLEXPRESS;" +
                "AttachDbFilename=|DataDirectory|\MachineOperations_Data.mdf;Integrated Security=True;"
                "Connect Timeout=30;" +
                "User Instance=True;";
            SqlConnection ncon = new SqlConnection(css2);

            string tab = "SELECT MAX(TableNo) FROM [dbo].[Table]";
            SqlCommand ncmd2 = new SqlCommand(tab, ncon);
            ncon.Open(); int table1 = Convert.ToInt32(ncmd2.ExecuteScalar());

            string sql = "SELECT m" + (f + 1) + " FROM tab" + table1 + "
            E part = "" + (h + 1).ToString() + """;
            string sql2 = "SELECT MIN (m" + (f + 1) + ") FROM tab" + table1;

            SqlConnection con5 = new SqlConnection(cs2);

            con5.Open();

            SqlCommand cmd15 = new SqlCommand(sql, con5);
            SqlCommand cmd16 = new SqlCommand(sql2, con5);
            int time = Convert.ToInt16(cmd15.ExecuteScalar());
            int mtime = Convert.ToInt16(cmd16.ExecuteScalar());

            int[] k = new int[n + 1];

```

```

k[h] = time;
if (k.ElementAt(h) == mtime)
{
    z[f] = mtime;
    if (z[0] == z[1])
    {
        z[1] = 1000000;
    }
    // DELETE statement goes here
}
}
}

for (var ta = 0; ta + 1 <= m; ta++)
{
    if (z.ElementAt(ta) == z.Min())
    {
        string css2 = @"Data Source=.\SQLEXPRESS;" +
achDbFilename=[DataDirectory]\MachineOperations_Data.mdf;Integrated Security=True;"
        @"Connect Timeout=30;" +
        @"User Instance=True;";
        SqlConnection ncon = new SqlConnection(css2);

        string tab = "SELECT MAX(TableNo) FROM [dbo].[Table]";
        SqlCommand ncmd2 = new SqlCommand(tab, ncon);
        ncon.Open(); int table1 = Convert.ToInt32(ncmd2.ExecuteScalar());

        string cs3 = @"Data Source=.\SQLEXPRESS;" +
achDbFilename=[DataDirectory]\MachineOperations_Data.mdf;Integrated Security=True;"
        @"Connect Timeout=30;" +
        @"User Instance=True;";
        string sql3 = "SELECT part FROM tab" + table1 + " WHERE m" + (ta
+ " = '" + z.Min().ToString() + "'";

        SqlConnection con66 = new SqlConnection(cs3);
        con66.Open();
        SqlCommand cmd166 = new SqlCommand(sql3, con66);
        string wh = Convert.ToString(cmd166.ExecuteScalar()).Trim();
        string str3 = " WHERE (m" + (ta + 1) + " = '" +
).ToString() + "' AND part = '" + wh + "'";
        string update = "UPDATE tab" + table1 + " SET part = N'";
        for (var i = 1; i <= m; i++)
        {
            string st = "m" + Convert.ToString(i) + " = N'1000000'";
            string st2 = "m" + Convert.ToString(i) + " = N'1000000'";

            if (i != m)
            {

```

```
        update = update + st;
    }
    else
    {
        update = update + st2;
    }
}
string k = update + str3;
```

```
SqlConnection con6 = new SqlConnection(cs3);
con6.Open();
SqlCommand cmd16 = new SqlCommand(sql3, con6);
string p1 = Convert.ToString(cmd16.ExecuteScalar());
SqlCommand cmd17 = new SqlCommand(k, con6);
```

```
l[ta] = p1.Trim() + l[ta];
cmd17.ExecuteScalar();
```

```
}
```

```
}
```

```
}
```

```
string final = "";
```

```
CharEnumerator rev = l[0].GetEnumerator();
```

```
for (var ce = 1; ce <= l[0].Length; ce++)
```

```
{
    rev.MoveNext();
    l[2] = rev.Current + l[2];
}
```

```
final = l[2] + l[1];
```

```
string mfinal = "";
```

```
CharEnumerator r2 = final.GetEnumerator();
```

```
for (var de = 1; de <= final.Length; de++)
```

```
{
    r2.MoveNext();
    mfinal = mfinal + "Part" + r2.Current + " ==>> ";
}
```

```
label254.Content = mfinal;
```

```
textBox70.Clear();
```

## Machine Depreciation

```
private void button69_Click(object sender, RoutedEventArgs e)
{
    Single N2 = Convert.ToInt16(textBox82.Text);
    Single ESP = Convert.ToSingle(textBox81.Text);
    Single CP = Convert.ToSingle(textBox80.Text);

    int NN2 = 0;
    double TDCN = 0;

    for (var fa = 0; fa <= (N2-1); fa++)
    {
        NN2 = NN2 + (Convert.ToInt16(N2) - fa);
    }
    <double> j = new List<double>();
    <string> k = new List<string>();

    for (var fb = 1; fb <= (N2 - 1); fb++ )
    {
        TDCN = TDCN + (CP - ESP) * ((N2 - (fb + 1)) / NN2);

        j.Add(TDCN);
        k.Add("Year " + (fb+1));
    }
    listView2.ItemsSource = k;
    listView1.ItemsSource = j;
    label393.Content = "Final Value : " + Convert.ToString(TDCN);
}
```

APPENDIX 2

MODULE ONE: MACHINING OPERATION MODULE DATA

Power for Turning and Milling With Corresponding Chip Thickness

Table 1: field chip thickness										
tensile strength	25/1000	50/1000	75/1000	100/1000	150/1000	200/1000	300/1000	500/1000	800/1000	
40	54	45	41	39	35	33	30	26	23	
50	60	50	45	42	39	36	32	29	26	
60	66	55	50	47	42	39	35	31	28	
70	69	59	53	50	45	42	37	33	30	
80	73	63	65	52	48	44	40	35	32	
90	78	65	59	56	50	47	42	38	34	
100	80	69	62	59	53	49	44	39	35	
110	85	72	65	61	56	53	51	44	36	
150	80	71	66	61	57	52	48	44	40	

Table 1a field chip thickness

piece material	tensile strength	25/1000	50/1000	75/1000	100/1000	150/1000	200/1000	300/1000	500/1000	800/1000
steels	160	86	76	72	67	62	58	54	50	46
steels	170	92	82	78	73	68	61	56	52	48
steels	180	99	90	84	80	75	69	62	59	52
steels	190	104	96	91	86	81	78	69	64	58
steels	200	110	101	96	91	88	85	78	71	60
(grey le)	160	30	26	24	22	21	19	18	16	14
(grey le)	170	31	28	25	24	22	20	19	17	15
(grey le)	180	35	30	27	25	23	22	21	19	17
(grey le)	190	36	31	29	27	24	23	21	17	17
(grey le)	200	38	33	30	28	26	24	22	20	18
(grey le)	220	42	36	33	31	29	26	24	22	20
(grey le)	240	46	40	36	34	31	29	27	24	21
(grey le)	260	50	43	39	37	33	31	29	26	23
(grey le)	280	53	46	42	39	36	34	31	28	25
	10	13	11	9	9	8	7	6	6	5
	20	19	16	14	13	12	11	10	8	7
	30	24	20	17	16	14	13	12	10	9
	40	28	23	21	19	17	16	14	12	11
	50	32	26	23	22	19	18	16	14	12
loys	0	25	21	19	17	16	15	13	12	10
n	10	9	7	6	6	5	5	4	4	3
n	15	10	9	8	7	6	6	6	5	4
n	20	12	10	9	8	7	7	6	5	4
n	25	13	11	10	9	8	7	7	6	5
loys	110	59	51	47	45	41	39	36	32	30

Table 1a field chip thickness

piece material	tensile strength	25/1000	50/1000	75/1000	100/1000	150/1000	200/1000	300/1000	500/1000	800/1000
aluminum	0	61	52	48	45	41	38	35	31	28
aluminum alloys	0	67	58	53	50	45	43	39	35	31
aluminum alloys	0	68	59	54	52	47	45	41	37	34
aluminum alloys	0	77	66	60	57	52	49	45	40	36

## Lathe Cutting Speeds With High Speed Tool Bit for Facing Turning and Boring

Table 2a Facing Turning Boring

piece material	meter per minute	feet per minute
steel (rough cutting)	27	90
steel (finish cutting)	30	100
aluminum (rough cutting)	21	70
aluminum (finish cutting)	27	90
brass (rough cutting)	18	60
brass (finish cutting)	24	80
cast iron (rough cutting)	27	90
cast iron (finish cutting)	30	100
nickel (rough cutting)	61	200
nickel (finish cutting)	93	300

## Lathe Feeds With High Speed Cutting Tools

Table 3a Lathe Feeds High Speed Cutting Tool

piece material	meter per minute	inches per minute
steel (finish cutting)	0.13 - 0.25	0.005 - 0.010
steel (rough cutting)	0.40 - 0.75	0.015 - 0.030
aluminum (finish cutting)	0.07 - 0.25	0.003 - 0.010
aluminum (rough cutting)	0.40 - 0.65	0.015 - 0.025
brass (finish cutting)	0.13 - 0.30	0.005 - 0.012
brass (rough cutting)	0.40 - 0.65	0.015 - 0.025
cast iron (finish cutting)	0.07 - 0.25	0.003 - 0.010
cast iron (rough cutting)	0.25 - 0.50	0.010 - 0.020
nickel (finish cutting)	0.07 - 0.25	0.003 - 0.010
nickel (rough cutting)	0.25 - 0.50	0.010 - 0.020

## Cutting Conditions for Turning

Cutting Speed Meters per Minute					
piece material	tool material	feed in mm per rev = 4/10 - 60/10 and depth in mm = 5 - 10	feed in mm per rev = 25/100 - 5/10 and depth in mm = 2 - 5	feed in mm per rev = 2/10 - 3/10 and depth in mm = 5/10 - 2	feed in mm per rev = 5/100 - 2/10 and depth in mm = 1/10 - 5/10
turning	high speed steels (HSS)	20 - 40	40 - 70	40 - 110	50 - 120
turning	Carbide	90 - 150	120 - 180	150 - 250	200 - 500
	high speed steels (HSS)	25 - 35	30 - 50	30 - 60	40 - 80
	Carbide	60 - 120	80 - 150	120 - 200	150 - 450
carbon	high speed steels (HSS)	15 - 25	25 - 45	25 - 50	30 - 70
carbon	Carbide	50 - 110	60 - 120	90 - 150	120 - 300
	high speed steels (HSS)	10 - 15	15 - 25	15 - 35	20 - 45
	Carbide	30 - 65	40 - 80	60 - 100	80 - 180
	high speed steels (HSS)	15 - 20	20 - 25	20 - 30	30 - 60
	Carbide	50 - 110	60 - 120	90 - 150	120 - 300
steels	high speed steels (HSS)	15 - 20	15 - 25	15 - 30	20 - 50
steels	Carbide	40 - 60	40 - 70	50 - 80	50 - 90
grey	high speed steels (HSS)	20 - 25	25 - 30	35 - 45	40 - 60
grey	Carbide	60 - 90	70 - 100	80 - 110	80 - 120
alloys	high speed steels (HSS)	40 - 70	70 - 100	90 - 120	100 - 200
alloys	Carbide	60 - 150	80 - 180	90 - 450	150 - 600
st	high speed steels (HSS)	40 - 60	60 - 100	90 - 120	100 - 200
st	Carbide	50 - 110	60 - 150	90 - 180	120 - 310
	high speed steels (HSS)	40 - 70	70 - 100	90 - 120	100 - 200
	Carbide	60 - 150	80 - 180	90 - 450	150 - 600
ys	high speed steels (HSS)	10 - 15	15 - 30	30 - 50	50 - 90
ys	Carbide	15 - 30	30 - 50	50 - 90	60 - 120

## Rake and Relief Angles for Tool Lathes Operations

PDBSRake&ReliefAnglesToolLathes							
side relief angle with high speed steel	side relief angle with carbide	end relief angle with high speed steel	end relief angle with carbide	side rake angle with high speed steel	side rake angle with carbide	back rake angle with high speed steel	back rake angle with carbide
12	6 - 10	0	6 - 10	15	10 - 20	35	0 - 10
10	6 - 8	0	6 - 8	5 - (-4)	8 - (-5)	0	0 - (-5)

PDBSRake&ReliefAnglesToolLathes

work piece material	side relief angle with high speed steel	side relief angle with carbide	end relief angle with high speed steel	end relief angle with carbide	side rake angle with high speed steel	side rake angle with carbide	back rake angle with high speed steel	back rake angle with carbide
Low Carbon Steels	10	6-8	8	6-8	5-(-4)	8-(-5)	0	0-(-5)
Medium Carbon Steels, Alloy Steels	10	5-8	8	5-8	12	6-(-7)	5	0-(-7)
High Carbon Steels, Alloy Steels	10-12	5-10	8	5-10	12-18	6-(-7)	8-5	0-(-7)
Cast Irons	10	5-8	8	5-8	15-20	6-(-7)	8	0-(-7)
Aluminum	10	5-8	8	5-8	12	6-(-7)	8	0-(-7)

Angles for Single Point Cutting Tools

ToolAnglesSinglePointTools

work piece material	work piece material hardness (BHN)	tool material	back rake angle in degrees	side rake angle in degrees	end clearance angle in degrees	side clearance angle in degrees	side and end cutting edge in degrees
Low Carbon Steels, Medium Carbon Steels, Alloy Steels	85-225	High speed steel	10	12	5	5	15
Medium Carbon Steels, Alloy Steels	85-225	Brazed carbides	0	6	5	5	15
High Carbon Steels, Alloy Steels	85-225	Throwaway carbides	5	-5	5	5	15
Low Carbon Steels, Medium Carbon Steels, Alloy Steels	225-325	High speed steel	8	10	5	5	15
Medium Carbon Steels, Alloy Steels	225-325	Brazed carbides	0	6	5	5	15
High Carbon Steels, Alloy Steels	225-325	Throwaway carbides	-5	-5	5	5	15
Low Carbon Steels, Medium Carbon Steels, Alloy Steels	325-425	High speed steel	0	10	5	5	15
Medium Carbon Steels, Alloy Steels	325-425	Brazed carbides	0	6	5	5	15
High Carbon Steels, Alloy Steels	325-425	Throwaway carbides	-5	-5	5	5	15
Cast Irons	45RC-58RC	High speed steel	0	10	5	5	15

Tool Angles Single Point Tools

work piece material	work piece material hardness (BHN)	tool material	back rake angle in degrees	side rake angle in degrees	end clearance angle in degrees	side clearance angle in degrees	side and end cutting edge in degrees
Steels, Medium Steels, Alloy Tool Steels		steel					
Churning Steels, Steels, Medium Steels, Alloy Tool Steels	45RC - 58 RC	Brazed carbides	-5	-5	5	5	15
Churning Steels, Steels, Medium Steels, Alloy Tool Steels	45RC - 58 RC	Throwaway carbides	-5	-5	5	5	15
Steel	135 - 275	High speed steel	0	10	5	5	15
Steel	135 - 275	Brazed carbides	0	6	5	5	15
Steel	135 - 275	Throwaway carbides	-5	-5	5	5	15
Steel	100 - 200	High speed steel	5	10	5	5	15
Steel	100 - 200	Brazed carbides	0	6	5	5	15
Steel	100 - 200	Throwaway carbides	-5	-5	5	5	15
(grey, ductile, )	200 - 300	High speed steel	5	8	5	5	15
(grey, ductile, )	200 - 300	Brazed carbides	0	6	5	5	15
(grey, ductile, )	200 - 300	Throwaway carbides	-5	-5	5	5	15
(grey, ductile, )	300 - 400	High speed steel	5	5	5	5	15
(grey, ductile, )	300 - 400	Brazed carbides	-5	-5	5	5	15
(grey, ductile, )	300 - 400	Throwaway carbides	-5	-5	5	5	15
Alloys	30 - 150	High speed steel	20	15	12	10	5
Alloys	30 - 150	Brazed carbides	3	15	5	5	15
Alloys	30 - 150	Throwaway carbides	0	5	5	5	15
Alloys	40 - 200	High speed steel	5	10	8	8	5
Alloys	40 - 200	Brazed carbides	0	8	5	5	15
Alloys	40 - 200	Throwaway carbides	0	5	5	5	15
Alloys	40 - 90	High speed steel	20	15	12	10	5
Alloys	40 - 90	Brazed carbides	3	15	5	5	15

Tool Angles Single Point Tools

work piece material	work piece material hardness (BHN)	tool material	back rake angle in degrees	side rake angle in degrees	end clearance angle in degrees	side clearance angle in degrees	side and end cutting edge in degrees
Aluminum Alloys	40 - 90	Throwaway carbides	0	5	5	5	15
Aluminum Alloys	110 - 440	High speed steel	0	5	5	5	15
Aluminum Alloys	110 - 440	Brazed carbides	0	6	5	5	5
Aluminum Alloys	110 - 440	Throwaway carbides	-5	-5	5	5	5

Cutting Angles for Machining Cast Alloy Steels

Cutting Angles Cast Alloy Steels

work piece material	back rake angle in degrees	side rake angle in degrees	side relief angle in degrees	front relief angle in degrees	side cutting edge angle in degrees	end cutting edge angle in degrees
Aluminum	8 - 20	8 - 20	6	6	10	15
Steel	8	8	6	6	10	15
Aluminum	0	4	6	6	10	15
Steel	4	4	6	6	10	10
Cast Steel	8 - 20	8 - 20	6	6	10	15

Cutting Conditions for Milling

Cutting Speed Conditions Milling

work piece material	tool material	cutting speed in meters per minute	cutting feed in millimeters per tooth for face mills	cutting feed in millimeters per tooth for slab mills	cutting feed in millimeters per tooth for slotting and side mill	cutting feed in millimeters per tooth for end mills	cutting feed in millimeters per tooth for form cutters
Aluminum	high speed steel (HSS)	30 - 40	.30	.25	.175	.15	.10
Aluminum	carbide	100 - 200	.30	.25	.175	.15	.10
Steel	high speed steel (HSS)	25 - 40	.25	.20	.15	.125	.10
Steel	carbide	90 - 130	.25	.20	.15	.125	.10
Aluminum	high speed steel (HSS)	20 - 30	.20	.15	.125	.10	.075
Aluminum	carbide	60 - 90	.20	.15	.125	.10	.075
Steel	high speed steel (HSS)	10 - 20	.15	.10	.075	.06	.05
Steel	carbide	40 - 55	.15	.10	.075	.06	.05
Aluminum	high speed steel	15 - 25	.20	.15	.10	.075	.05

Cutting Speed Conditions Milling

piece material	tool material	cutting speed in meters per minute	cutting feed in millimeters per tooth for face mills	cutting feed in millimeters per tooth for slab mills	cutting feed in millimeters per tooth for slotting and side mill	cutting feed in millimeters per tooth for end mills	cutting feed in millimeters per tooth for form cutters
	(HSS)						
steels	carbide	60 - 80	.20	.15	.10	.075	.05
ss	high speed steel (HSS)	15 - 20	.15	.10	.10	.075	.05
ss	carbide	30 - 60	.15	.10	.10	.075	.05
ductile, (e)	high speed steel (HSS)	20 - 30	.35	.30	.20	.175	.10
ductile, (e)	carbide	70 - 100	.35	.30	.20	.175	.10
ss	high speed steel (HSS)	60 - 100	.50	.40	.30	.25	.175
ss	carbide	60 - 80	.50	.40	.30	.25	.175
	high speed steel (HSS)	40 - 75	.30	.25	.20	.175	.15
	carbide	60 - 100	.30	.25	.20	.175	.15
ss	high speed steel (HSS)	60 - 100	.50	.40	.25	.20	.175
ss	carbide	60 - 180	.50	.40	.25	.20	.175
	high speed steel (HSS)	10 - 30	.15	.125	.10	.075	.05
	carbide	30 - 50	.15	.125	.10	.075	.05

Cutting Speeds and Feeds for Milling Cutters

Cutting Speeds Feeds Milling Cutters

piece material	machining operation	feed per tooth in millimeters for face and shoulder mills	cutting speed in meters per minute for face and shoulder mills	feed per tooth in millimeters for side and face cutters	cutting speed in meters per minute for side and face cutters
steel	roughing	0.2 - 0.5	100 - 180	0.1 - 0.5	80 - 160
steel	finishing	0.1 - 0.4	120 - 200	0.1 - 0.4	100 - 200
steel	roughing	0.2 - 0.5	70 - 140	0.2 - 0.5	70 - 140
steel	finishing	0.1 - 0.4	90 - 180	0.1 - 0.4	90 - 180
	roughing	0.2 - 0.4	60 - 120	0.2 - 0.5	60 - 120
	finishing	0.1 - 0.3	70 - 160	0.1 - 0.4	70 - 160

**Cutting Speeds Feeds Milling Cutters**

work piece material	machining operation	feed per tooth in millimeters for face and shoulder mills	cutting speed in meters per minute for face and shoulder mills	feed per tooth in millimeters for side and face cutters	cutting speed in meters per minute for side and face cutters
low tensile steel	roughing	--	--	--	--
low tensile steel	finishing	--	--	--	--
medium tensile steel	roughing	0.2 - 0.4	70 - 140	0.2 - 0.5	80 - 160
medium tensile steel	finishing	0.1 - 0.3	100 - 180	0.15 - 0.35	100 - 180
high tensile steel (medium tensile)	roughing	0.2 - 0.4	60 - 120	0.2 - 0.5	60 - 120
high tensile steel (medium tensile)	finishing	0.1 - 0.3	70 - 140	0.1 - 0.4	70 - 140
low alloy steel (medium tensile)	roughing	0.2 - 0.4	70 - 140	0.2 - 0.5	70 - 140
low alloy steel (medium tensile)	finishing	0.1 - 0.3	80 - 160	0.1 - 0.4	80 - 160
medium alloy steel	roughing	0.2 - 0.4	80 - 140	0.2 - 0.5	70 - 140
medium alloy steel	finishing	0.1 - 0.3	90 - 160	0.15 - 0.35	90 - 180
high alloy steel (medium alloy)	roughing	0.1 - 0.3	500 - 1000	--	--
high alloy steel (medium alloy)	finishing	0.05 - 0.2	800 - 1400	--	--
low alloy steel (non alloyed)	roughing	0.05 - 0.2	300 - 700	0.1 - 0.4	300 - 700
low alloy steel (non alloyed)	finishing	0.05 - 0.2	400 - 900	0.05 - 0.3	400 - 900

**Table 1: Milling Cutting Speeds**

Milling Cutting Speeds			
work piece material	tool material	feet per minute	meters per minute
low tensile steel	high speed cutter	70 - 100	21 - 30
low tensile steel	carbide cutter	150 - 250	45 - 75
medium tensile steel	high speed cutter	60 - 70	18 - 20
medium tensile steel	carbide cutter	125 - 200	40 - 60
low alloy steel	high speed cutter	50 - 80	15 - 25
low alloy steel	carbide cutter	125 - 200	40 - 60
medium alloy steel	high speed cutter	65 - 120	20 - 35
medium alloy steel	carbide cutter	200 - 400	60 - 120
high alloy steel	high speed cutter	500 - 1000	150 - 300
high alloy steel	carbide cutter	1000 - 2000	150 - 300

**Table 2: Cutting Speeds and Feeds for Face and Shoulder Mills**

Cutting Speeds Feeds Face Shoulder Mills						
work piece material	work piece material hardness (brinell hardness)	work piece material tensile strength	cutting speed in m/min for SANDVIK COMORANT GRADE S1P (P 10)	cutting speed in m/min for SANDVIK COMORANT GRADE S4 (P 30)	cutting speed in m/min for SANDVIK COMORANT GRADE S6 (P 40)	feed in millimeters (mm) per tooth

Cutting Speeds/Feeds/Face/Shoulder Mills

work piece material	work piece material hardness (brinell hardness)	work piece material tensile strength	cutting speed in m/min for SANDVIK COMORANT GRADE S1P (P 10)	cutting speed in m/min for SANDVIK COMORANT GRADE S4 (P 30)	cutting speed in m/min for SANDVIK COMORANT GRADE S6 (P 40)	feed in millimeters (mm) per tooth
alloy non steel, realized : non 0.15%	125	45	160 - 200 - 300	140 - 170 - 200	100 - 130 - 160	0.4 - 0.2 - 0.1
alloy non steel, realized : non 0.35%	150	55	125 - 175 - 250	100 - 140 - 175	60 - 75 - 100	0.4 - 0.2 - 0.1
alloy non steel, realized : non 0.70%	250	80	100 - 150 - 180	75 - 90 - 125	50 - 75 - 90	0.4 - 0.2 - 0.1
steel (tempered)	150 - 200	50 - 65	100 - 150 - 180	100 - 130 - 160	60 - 75 - 100	0.4 - 0.2 - 0.1
steel (tempered and hardened)	200 - 275	65 - 90	100 - 175	75 - 90 - 125	50 - 75 - 90	0.4 - 0.2 - 0.1
steel (tempered and hardened)	275 - 325	90 - 110	75 - 125	60 - 80 - 100	40 - 60 - 75	0.4 - 0.2 - 0.1
steel (tempered and hardened)	325 - 450	110 - 150	50 - 90	50 - 60 - 80	--	0.4 - 0.2 - 0.1
stainless steel (austenitic, ferritic)	--	--	125 - 200	100 - 125 - 175	100 - 115 - 140	0.4 - 0.2 - 0.1
stainless steel (ferritic)	--	--	125 - 200	90 - 115 - 150	80 - 110 - 130	0.4 - 0.2 - 0.1
castings (alloy)	0 - 50	0 - 150	130 - 160	70 - 100 - 140	60 - 80 - 120	0.4 - 0.2 - 0.1
castings (alloy)	150 - 250	50 - 80	80 - 120	55 - 75 - 100	40 - 50 - 80	0.4 - 0.2 - 0.1
castings (alloy)	160 - 200	--	--	100 - 115 - 150	80 - 90 - 110	0.4 - 0.2 - 0.1

Cutting Speeds and Feeds for Face and Square Shoulder Mills

Cutting Speeds and Feeds

work piece material	work piece material hardness (brinell hardness)	cutting speed in m/min for H1P (K10 GRADE)	cutting speed in m/min for H13 (K10 GRADE)	cutting speed in m/min for H20 (K20 GRADE)	feed in millimeters (mm) per tooth
steel (austenitic steel 12-14%)	200	25 - 50	15 - 30	10 - 20	0.4 - 0.2 - 0.1
steel (tempered)	HRC 50-65	15 - 25	15 - 20	10 - 15	0.4 - 0.2 - 0.1
cast iron (chipping)	--	100 - 125 - 150	80 - 100 - 120	80 - 100 - 120	0.4 - 0.2 - 0.1
cast iron (chipping)	--	125 - 150 - 175	80 - 100 - 120	80 - 100 - 120	0.4 - 0.2 - 0.1
cast iron (chipping) and grey cast	180	90 - 150 - 175	80 - 130 - 150	60 - 110 - 130	0.4 - 0.2 - 0.1

Cutting Speeds and Feeds

work piece material	work piece material hardness (brinell hardness)	cutting speed in m/min for H1P (K10 GRADE)	cutting speed in m/min for H13 (K10 GRADE)	cutting speed in m/min for H20 (K20 GRADE)	feed in millimeters (mm) per tooth
chillable cast iron (high-tensile grey iron)	250	75 - 100 - 125	70 - 90 - 115	45 - 70 - 90	0.4 - 0.2 - 0.1
nodular-graphite iron (ferritic)	160	90 - 100 - 125	60 - 70 - 90	--	0.4 - 0.2 - 0.1
nodular-graphite iron (pearlitic)	250	80 - 90 - 120	50 - 60 - 85	--	0.4 - 0.2 - 0.1
nodular-graphite iron (chilled cast)	400	15 - 25	--	--	0.4 - 0.2 - 0.1
nodular-graphite iron (chilled cast)	600	10 - 15	--	--	0.4 - 0.2 - 0.1

Table 86: Cutting Speeds and Feeds for Side and Face Cutters

Cutting Speeds and Feeds

work piece material	work piece material hardness (brinell hardness)	work piece material tensile strength	cutting speed in metres per minute (m/min)	feed in millimeters per tooth (mm/tooth)
carbon steel	0 - 150	0 - 50	100 - 160	0.4 - 0.12
carbon steel	150 - 280	50 - 90	80 - 120	0.3 - 0.10
carbon steel	280 - 440	90 - 150	40 - 80	0.25 - 0.08
castings	--	--	30 - 120	0.35 - 0.10
iron	0 - 200	--	60 - 100	0.4 - 0.15
iron	200 - 350	--	50 - 80	0.35 - 0.10
chillable cast	--	--	60 - 100	0.4 - 0.15
aluminum alloys	--	--	280 - 150	0.35 - 0.15
aluminum alloys	--	--	280 - 150	0.35 - 0.15
aluminum alloys	0 - 80	--	200 - 600	0.6 - 0.15
stainless steel	--	--	--	--
castings	--	--	30 - 80	0.4 - 0.15

Table 87: Cutting Feeds for High Speed Steel Cutters

Feed per Tooth

work piece material	feed per tooth for side mills in inches	feed per tooth for side mills in millimeters	feed per tooth for end mills in inches	feed per tooth for end mills in millimeters	feed per tooth for plain helical mills in inches	feed per tooth for plain helical mills in millimeters	feed per tooth for saws in inches	feed per tooth for saws in millimeters
carbon steel	0.007	0.18	0.006	0.015	0.010	0.25	0.002	0.05
carbon steel	0.005	0.13	0.004	0.010	0.007	0.18	0.002	0.05
carbon steel	0.007	0.18	0.007	0.018	0.010	0.18	0.002	0.05

Feed per Tooth

work piece material	feed per tooth for side mills in inches	feed per tooth for side mills in millimeters	feed per tooth for end mills in inches	feed per tooth for end mills in millimeters	feed per tooth for plain helical mills in inches	feed per tooth for plain helical mills in millimeters	feed per tooth for saws in inches	feed per tooth for saws in millimeters
steel	0.008	0.20	0.009	0.23	0.011	0.28	0.003	0.08
aluminum	0.013	0.33	0.011	0.28	0.018	0.46	0.005	0.13

Fig. Feed per Tooth for High Speed Mills

Feed per Tooth High Speed Steel Mills

cutting speed	cutting speed in millimeter/s	machine steel in inches	machine steel in millimeter	tool steel in inches	tool steel in millimeter	cast iron in inches	cast iron in millimeter	bronze in inches	bronze in millimeter	aluminum in inches	aluminum in millimeter	
3.17	0.0005	.01	.0005	.01	.0005	.01	.0005	.01	.0005	.01	.002	.05
6.35	.0010	.02	.0010	.02	.0010	.02	.0010	.02	.0010	.02	.003	.07
9.52	.0020	.05	.0020	.05	.0020	.05	.0020	.05	.0020	.05	.003	.07
12.70	.0030	.07	.0020	.05	.0030	.07	.0030	.07	.0030	.07	.005	.12
19.05	.0040	.10	.0030	.07	.0030	.07	.0030	.07	.0030	.07	.006	.15
25.40	.0050	.12	.0030	.07	.0040	.10	.0040	.10	.0040	.10	.007	.17

Tool Geometry for Milling

Milling Tool Geometry

work piece material	milling operation	tool material	axial rake angle in degrees	radial rake angle in degrees	axial relief angle in degrees	radial relief angle in degrees	corner
(machinability = 100)	face milling	high speed steel (HSS)	10 - 15	10 - 15	5 - 7	3 - 7	
(machinability = 100)	face milling	carbide	0 - (-7)	0 - (-7)	5 - 7	3 - 7	1x45° or radius
(machinability = 100)	end milling	high speed steel (HSS)	30 - 35	10 - 20	3 - 7	radial relief angle for end mills (A)	1x45° or radius
(machinability = 100)	end milling	carbide	15 - 25	3 - 5	3 - 5	4 - 8	1x45° or radius
(machinability = 100)	side or slot milling	high speed steel (HSS)	10 - 15	10 - 15	2 - 4	4 - 8	1x45° or radius
(machinability = 100)	side or slot milling	carbide	0 - (-5)	(-5) - 5	2 - 4	4 - 8	1x45° or radius
(machinability = 100)	face milling	high speed steel (HSS)	20 - 30	-5 - (-10)	4 - 7	4 - 7	1x45° or radius
(machinability = 100)	face milling	carbide	5 - 10	-5 - (-10)	4 - 7	4 - 7	1x45° or radius
(machinability = 100)	end milling	high speed steel (HSS)	30 - 35	12	3 - 7	radial relief angle for end	1x45° or radius

Milling Tool Geometry

work piece material	milling operation	tool material	axial rake angle in degrees	radial rake angle in degrees	axial relief angle in degrees	radial relief angle in degrees	corner
						mills (A)	
aluminum (machinability = 100)	end milling	carbide	---	--	3-7	radial relief angle for end mills (A)	1x45° or radius
aluminum (machinability = 100)	side or slot milling	high speed steel (HSS)	10-12	10-20	2-4	3-7	1x45° or radius
aluminum (machinability = 100)	side or slot milling	carbide	0-(-10)	5-(-10)	3-5	nil	1x45° or radius
low alloy steels	face milling	high speed steel (HSS)	10-15	10-12	8-10	8-10	1x45° or radius
low alloy steels	face milling	carbide	0-10	0-(-10)	3-7	radial relief angle for end mills (A)	1x45° or radius
low alloy steels	end milling	high speed steel (HSS)	30-35	15	3-7	radial relief angle for end mills (A)	1x45° or radius
low alloy steels	end milling	carbide	15-25	0-3	3-7	radial relief angle for end mills (A)	1x45° or radius
low alloy steels	side or slot milling	high speed steel (HSS)	10-12	5-12	3-5	4-8	1x45° or radius
low alloy steels	side or slot milling	carbide	(-5)-5	2-4	2-4	5-8	1x45° or radius
low alloy steels	face milling	high speed steel (HSS)	20-35	20-35	3-5	10-12	1x45° or radius
low alloy steels	face milling	carbide	10-20	10-20	3-5	10-12	1x45° or radius
low alloy steels	end milling	high speed steel (HSS)	30-45	15-20	8-12	radial relief angle for end mills (B)	1x45° or radius
low alloy steels	end milling	carbide	25	5-8	8-12	radial relief angle for end mills (B)	1x45° or radius
low alloy steels	side or slot milling	high speed steel (HSS)	12-25	10-20	5-7	5-11	1x45° or radius
low alloy steels	side or slot milling	carbide	10-20	5-15	5-7	5-11	1x45° or radius

Radial Relief Angles for End Mills Operation

Radial Relief Angles		
in millimeters	A	B
	12°	15°
	11°	13°
	10°	13°
	9°	12°
	8°	10°

### Operating Conditions in Drilling, Reaming and Tapping

Cutting Speed		
Workpiece material	cutting speed for drilling in meters per minute (m/min)	cutting speed for reaming in meters per minute (m/min)
Tool steels	20 - 30	11 - 15
	20 - 23	11 - 14
Carbon steels	14 - 20	9 - 14
	18 - 22	10 - 14
	5 - 8	3 - 5
Aluminum alloys	12 - 15	9 - 25
Aluminum alloys, ductile	20 - 23	12 - 17
Aluminum alloys	35 - 55	25 - 30
Aluminum alloys	30 - 45	20 - 40
Aluminum alloys	60 - 105	30 - 40
Aluminum alloys	12 - 15	9 - 25

### Operating Conditions in Drilling and Reaming

Feed Rates		
Drill diameter in millimeters (mm)	feed in millimeter per revolution for drilling	feed in millimeter per revolution for reaming
	0.04 - 0.06	0.08 - 0.13
	0.05 - 0.10	0.1 - 0.20
	0.05 - 0.13	0.15 - 0.30
	0.10 - 0.18	0.20 - 0.40
	0.12 - 0.20	0.30 - 0.51
	0.15 - 0.25	0.41 - 0.61
	0.18 - 0.28	0.46 - 0.66
	0.20 - 0.30	0.50 - 0.71
	0.23 - 0.33	0.56 - 0.76
	0.25 - 0.36	0.61 - 0.81
	0.28 - 0.41	0.71 - 0.91
	0.30 - 0.41	0.81 - 1.00

### Operating Speeds for High Speed Drills

Spindle Speed in Revolution per Minute												
Drill diameter in inches	steel casting at feed rate of 40 feet per minute	steel casting at feed rate of 12 meters per minute	tool steel at feed rate of 60 feet per minute	tool steel at feed rate of 18 meters per minute	cast iron at feed rate of 80 feet per minute	cast iron at feed rate of 24 meters per minute	machine steel at feed rate of 100 feet per minute	machine steel at feed rate of 30 meters per minute	brass at feed rate of 200 feet per minute	brass at feed rate of 60 meters per minute	aluminum at feed rate of 200 feet per minute	aluminum at feed rate of 60 meters per minute
0.625	2245	1910	3665	2865	4890	3820	6110	4775	12225	9550	12225	9550
0.750	1220	1275	1835	1910	2445	2545	3055	3185	6110	6365	6110	6365
0.875	815	955	1220	1430	1630	1910	2035	2385	4075	4775	4075	4775

**Spindle Speed in Revolution per Minute**

drill diameter in inches	drill diameter in millimeters	steel casting at feed rate of 40 feet per minute	steel casting at feed rate of 12 meters per minute	tool steel at feed rate of 60 feet per minute	tool steel at feed rate of 18 meters per minute	cast iron at feed rate of 80 feet per minute	cast iron at feed rate of 24 meters per minute	machine steel at feed rate of 100 feet per minute	machine steel at feed rate of 30 meters per minute	brass at feed rate of 200 feet per minute	brass at feed rate of 60 meters per minute	aluminum at feed rate of 200 feet per minute	aluminum at feed rate of 60 meters per minute
5	0.2500	610	765	915	1145	1220	1530	1530	1910	3055	3820	3055	3820
6	0.3125	490	635	735	955	980	1275	1220	1590	2445	3180	2445	3180
7	0.3750	405	545	610	820	815	1090	1020	1305	2035	2730	2035	2730
8	0.4375	350	475	525	715	700	955	875	1195	1745	2390	1745	2390
9	0.5000	305	425	460	635	610	850	765	1060	1530	2120	1530	2120
10	0.6250	245	350	365	520	490	695	610	870	1220	1735	1220	1735
15	0.7500	205	255	305	380	405	510	510	635	1020	1275	1020	1275
20	0.8750	175	190	260	285	350	380	435	475	875	955	875	955
25	1.0000	155	150	230	230	305	305	380	380	765	0	765	0

**Drill Feed and Corresponding Parameters**

**Feeds and Parameters**

size in inches	feed in inches per revolution	drill size in millimeters	feed in millimeters per revolution
3 and smaller	0.001 - 0.002	3 and smaller	0.02 - 0.05
0.250	0.002 - 0.004	3 - 6	0.05 - 0.10
0.500	0.004 - 0.007	6 - 12	0.10 - 0.17
1.000	0.007 - 0.015	12 - 25	0.17 - 0.37
1.500	0.015 - 0.025	25 - 38	0.37 - 0.63

**Center Drilling Sizes and Corresponding Parameters**

**Center Drilling Sizes Parameters**

regular type	size for bell type	work diameter in inches	work diameter in millimeters	diameter of countersink	drill point diameter	body size
1	11	0.1875 - 0.3125	3 - 8	0.093750	0.046875	0.1250
2	12	0.3750 - 0.5000	9.5 - 12.5	0.140625	0.078125	0.1875
3	13	0.6250 - 0.7500	15 - 20	0.187500	0.109375	0.2500
4	14	1.0000 - 1.5000	25 - 40	0.234375	0.125000	0.3125
5	15	2.0000 - 3.0000	50 - 75	0.328125	0.187500	0.4375
6	16	3.0000 - 4.0000	75 - 100	0.375000	0.218750	0.5000
7	17	4.0000 - 5.0000	100 - 125	0.468750	0.250000	0.6250
8	18	6.0000 and above	150 and over	0.562500	0.312500	0.7500

**Drill Lip Clearance at Periphery and Corresponding Parameters**

**Drill Lip Clearance At Periphery**

diameter in inches	drill diameter in millimeters	general purposes	hard and tough materials	soft and free machining materials
0.15 - 0.33		28	22	30

Drill Lip Clearance At Periphery

drill diameter in inches	drill diameter in millimeters	general purposes	hard and tough materials	soft and free machining materials
0.1	0.34 - 0.99	24	20	26
0.11	1.00 - 2.45	21	18	24
0.11	2.50 - 3.00	18	16	22
0.125	3.30 - 6.35	16	14	20
0.25	6.50 - 8.37	14	12	18
0.25	8.80 - 12.70	12	10	16
	13.10 - 19.05	10	8	14
and above	19.45 and above	8	7	12

Machining Conditions in Gun Drilling

Machining Conditions Gun Drilling

work piece material	work piece material hardness (brinell hardness)	tool material	speed in meters per minute (m/min)	feed in mm per revolution with tool diameter 2 - 4 mm	feed in mm per revolution with tool diameter 4 - 6 mm	feed in mm per revolution with tool diameter 6 - 12 mm	feed in mm per revolution with tool diameter 12 - 19 mm	feed in mm per revolution with tool diameter 19 - 25 mm	feed in mm per revolution with tool diameter 25 - 50 mm
Carbon	85 - 125	K - 20 Carbide	160	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	125 - 175	K - 20 Carbide	140	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	175 - 225	K - 20 Carbide	125	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	225 - 275	K - 20 Carbide	100	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	125 - 175	K - 20 Carbide	140	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	175 - 225	K - 20 Carbide	125	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	225 - 275	K - 20 Carbide	100	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	275 - 325	K - 20 Carbide	80	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	325 - 375	K - 20 Carbide	65	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	375 - 425	K - 20 Carbide	50	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	175 - 225	K - 20 Carbide	115	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	225 - 275	K - 20 Carbide	90	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
Carbon	275 - 325	K - 20 Carbide	75	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375

Machining Conditions Gun Drilling

work piece material	work piece material hardness (brinell hardness)	tool material	speed in meters per minute (m/min)	feed in mm per revolution with tool diameter 2 - 4 mm	feed in mm per revolution with tool diameter 4 - 6 mm	feed in mm per revolution with tool diameter 6 - 12 mm	feed in mm per revolution with tool diameter 12 - 19 mm	feed in mm per revolution with tool diameter 19 - 25 mm	feed in mm per revolution with tool diameter 25 - 50 mm
	325 - 375	K - 20 Carbide	60	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	375 - 425	K - 20 Carbide	40	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	175 - 225	K - 20 Carbide	115	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	225 - 275	K - 20 Carbide	90	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	275 - 325	K - 20 Carbide	75	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	325 - 375	K - 20 Carbide	60	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	375 - 425	K - 20 Carbide	40	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	200 - 250	K - 20 Carbide	80	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	250 - 275	K - 20 Carbide	60	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	120 - 150 (ferritic iron)	K - 20 Carbide	120	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	160 - 200	K - 20 Carbide	100	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	190 - 220	K - 20 Carbide	80	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	220 - 260	K - 20 Carbide	65	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	250 - 320 (pearlitic)	K - 20 Carbide	50	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	100 - 215	K - 20 Carbide	55	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	120 - 175	K - 20 Carbide	45	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375
	150 - 250	K - 20 Carbide	35	0.003 - 0.006	0.007 - 0.013	0.015	0.02	0.025	0.0375



Table 9.9: Cutting Fluid Requirements of Pressure and Viscosity in External Chip Removal Gun Drills

Cutting Fluid Volume External Chip Removal Gun Drill		
Size of drill in millimeters (mm)	depth of hole in millimeters	fluid flow volume in litre per minute
6	150	10
6	300	15
6	450	15
6	600	15
6	900	15
6	1200	15
10	150	15
10	300	15
10	450	20
10	600	25
10	900	25
10	1200	25
13	150	20
13	300	25
13	450	35
13	600	40
13	900	45
13	1200	45
19	150	30
19	300	35
19	450	40
19	600	55
19	900	70
19	1200	70
25	150	40
25	300	50
25	450	65
25	600	80
25	900	100
25	1200	120
32	150	60
32	300	80
32	450	100
32	600	120
32	900	160
32	1200	160
38	150	70
38	300	100
38	450	120
38	600	160
38	900	200
38	1200	200

9j: Cutting Fluid Requirements of Pressure and Viscosity in Internal Chip Removal Gun Drills

Cutting Fluid Volume Pressure Internal Chip Removal Gun Drills		
diameter in millimeters	fluid flow volume in liters per minute (litres/min)	pressure
10	25 - 35	56 - 63
16	35 - 55	50 - 56
19	55 - 105	45 - 50
25	105 - 160	40 - 48
30	160 - 300	30 - 40
	400	25 - 30
	450	25 - 30
	550	20 - 25

10: Fluid Pressure and Volume Requirements for Internal Chip Removal in Trepanning Heads

Fluid Pressure Volume Internal Chip Removal Trepanning Heads		
diameter in millimeters (mm)	volume in litre per millimeter (litre/mm)	pressure
100	500 - 800	20 - 30
150	800 - 900	15 - 20
200	900 - 1100	10 - 20
300	1100 - 1400	8 - 15
400	1400 - 1700	6 - 10
500	1700 - 2000	6 - 10
600	2000 - 2300	6 - 10

11: Boring Conditions and Corresponding Parameters

Boring Conditions									
work piece material	work piece material strength and hardness	roughing depth of cut in millimeters	roughing feed in revolution per minute	roughing speed in m/min for high speed steel	roughing speed in m/min for carbide	finishing depth of cut in millimeters	finishing feed in revolution per minute	finishing speed in m/min for high speed steel	finishing speed in m/min for carbide
low carbon steel	less than 60	2.5	0.2	30 - 45	100 - 160	0.25	0.13	30 - 50	120 - 200
medium carbon steel	greater than 60	2.5	0.2	15 - 35	60 - 120	0.25	0.13	20 - 40	80 - 150
low alloy steel	less than 80	2.5	0.2	20 - 35	80 - 120	0.25	0.13	20 - 45	100 - 160
high alloy steel	greater than 80	2.5	0.2	10 - 20	30 - 90	0.25	0.13	15 - 30	50 - 150
cast iron	less than 180 brinell hardness	2.5	0.2	20 - 35	90 - 150	0.25	0.13	30 - 40	100 - 180
brass	greater than 180 brinell	2.5	0.2	15 - 25	50 - 100	0.25	0.13	20 - 30	60 - 140

Boring Conditions

work piece material	work piece material strength and hardness	roughing depth of cut in millimeters	roughing feed in revolution per minute	roughing speed in m/min for high speed steel	roughing speed in m/min for carbide	finishing depth of cut in millimeters	finishing feed in revolution per minute	finishing speed in m/min for high speed steel	finishing speed in m/min for carbide
	hardness								
aluminum and alloys	--	2.5	0.2	60 - 300	200 - 300	0.25	0.13	100 - 300	250 - 350
brass	--	2.5	0.2	15 - 30	50 - 140	0.25	0.13	20 - 40	60 - 200
bronz	--	2.5	0.2	15 - 30	50 - 140	0.25	0.13	20 - 40	60 - 200

PB11b: Fine Boring Requirements With Carbide Tools

Fine Boring Conditions Carbide Tools

work piece material	work piece material strength or hardness	depth of cut in millimeters (mm)	radius of tool nose in millimeters (mm)	feed in millimeters per revolution (mm/rev)	speed in meters per minute (m/min)	coolant required
brass	--	0.1 - 0.4	0.4 - 1.5	0.03 - 0.13	300 - 600	soluble oil
bronz	--	0.1 - 0.4	0.4 - 1.5	0.03 - 0.13	300 - 450	soluble oil
low carbon steels and plain carbon steels	less than 60	0.1 - 0.4	0.25 - 0.8	0.08 - 0.18	200 - 250	soluble oil or cutting oil
plain carbon steels	greater than 60	0.1 - 0.4	0.25 - 0.8	0.08 - 0.18	100 - 160	soluble oil or cutting oil
alloy steels	less than 80	0.1 - 0.4	0.25 - 0.8	0.08 - 0.18	120 - 200	cutting oil
alloy steels	greater than 80	0.1 - 0.4	0.25 - 0.5	0.08 - 0.18	70 - 150	cutting oil
cast iron	less than 180 (brinell hardness)	0.1 - 0.4	0.4 - 1.5	0.08 - 0.15	160 - 200	not required
cast iron	greater than 180 (brinell hardness) less than 180 (brinell hardness)	0.1 - 0.4	0.4 - 1.5	0.03 - 0.15	100 - 160	turpentine
aluminum and aluminum alloys	--	0.1 - 0.4	0.4 - 1.5	0.06 - 0.13	300 - 500	paraffin or soluble oil

PB12: Threading Requirements with High Speed Tool Bit

Threading Cutting Speeds High Speed Toolbit

work piece material	threading cutting speed in feet per minute	threading cutting speed in meter per minute
machine steel	35	11
tool steel	30	9
cast iron	25	8
bronz	25	8
aluminum	60	18

**PDB13: Shaping Feeds and Speeds with Corresponding Parameters**

**Shaping Feeds and Speeds**

work piece material	cutting tool material	speed in feet per minute	speed in meters per minute	feed in feet per minute	feed in metres per minute
machine steel	high speed steel	80	24	0.01	0.25
machine steel	carbide	150	46	0.01	0.25
tool steel	high speed steel	50	15	0.015	0.38
tool steel	carbide	150	46	0.012	0.30
cast iron	high speed steel	60	18	0.020	0.51
cast iron	carbide	100	30	0.012	0.30
brass	high speed steel	160	48	0.010	0.25
brass	carbide	300	92	0.015	0.38

**PDB13b Shaping Speeds for Roughing and Finishing**

**Shaping Speeds**

work material	roughing speed in meters per minute (m/min)	finishing speed in meters per minute (m/min)
aluminum	45	60
brass	45	60
bronze	45	60
grey iron	18	12 and 30
mild steel	15	10.5 and 24
tool steel	12	18
heat resisting alloys	3 - 4.5	6 - 9

**PDB13c: Shaping Requirements for Annealed Carbon Steel and Grey Cast Iron**

**Shaping Annealed Carbon Steel Grey Cast Iron**

work piece material	speed in meters per minute (m/min)	feed in millimeters per stroke (mm/stroke)	depth of cut in millimeters (mm)
annealed carbon steel (C45)	13	1.50	4.50
annealed carbon steel (C45)	13	1.90	4.50
annealed carbon steel (C45)	13	1.25	6.25
annealed carbon steel (C45)	10	1.90	6.25
grey cast iron	20	1.00	12.50
grey cast iron	20	1.25	12.50
grey cast iron	20	0.60	19.00
grey cast iron	20	1.00	19.00

**PDB14: Planing Conditions and Corresponding Parameters**

**Planing Conditions**

work piece material	work piece material strength or hardness	roughing depth of cut in millimeters	roughing feed per stroke in millimeter	roughing speed in meters per minute for high speed steel tools	roughing speed in meters per minute for carbide tools	finishing depth of cut in millimeters	finishing feed per stroke in millimeters	finishing speed in meters per minute for high speed steel tools	finishing speed in meters per minute for carbide tools
low and plain carbon steels	less than 60	5 - 10	up to 1.5	20 - 30	15 - 20	0.15	0.6667 square nose finishing	20 - 25	50 - 70
plain carbon steels	greater than 60	5 - 10	up to 1.5	15 - 25	6 - 15	0.15	0.6667 square nose finishing	15 - 20	50 - 60
alloy steel	less than 80	5 - 10	up to 1.5	15 - 25	60 - 100	0.15	0.6667 square nose finishing	15 - 20	50 - 60
alloy steel	greater than 80	5 - 10	up to 1.2	8 - 20	15 - 20	0.15	0.6667 square nose finishing	10 - 15	40 - 50
cast iron	less than 180 brinell hardness	5 - 10	up to 1.5	15 - 20	50 - 80	0.20	0.6667 square nose finishing	15 - 18	50 - 60
cast iron	greater than 180 brinell hardness	5 - 10	up to 1.2	6 - 15	30 - 60	0.15	0.6667 square nose finishing	8 - 12	30 - 40
aluminum and aluminum alloys	--	5 - 10	up to 2.5	60 - 100	50 - 90	0.25	0.6667 square nose finishing	60 - 100	60 - 80

#### PDB15: Reaming Speeds and Corresponding Parameters

work piece material	Reaming Speeds	
	surface feet per minute	surface meters per minute
steel castings	20 - 30	6 - 9
tool steel	35 - 40	10 - 12
cast iron	50 - 70	15 - 21
machine steel	50 - 70	15 - 21
brass	130 - 200	40 - 60
aluminum	140 - 200	43 - 61
bronze	50 - 100	15 - 30
stainless steel	40 - 50	12 - 15
magnesium	170 - 250	52 - 76

#### PDB15h: Machine Reaming Allowance Requirements

hole diameter in inches	Machine Reaming Allowance		
	hole diameter in millimeters	allowance in inches	allowance in millimeters
0.25	6.35	0.010	0.25
0.50	12.70	0.015	0.38
1.00	25.40	0.020	0.50
1.50	38.10	0.025	0.63
2.00	50.80	0.030	0.76

Machine Reaming Allowance

hole diameter in inches	hole diameter in millimeters	allowance in inches	allowance in millimeters
1.00	76.20	0.045	1.14

DB15c: Stock Allowance Requirements in Reaming

Stock Allowances Reaming

hole size in inches	hole size in millimeters	allowance in inches	allowance in millimeters
0.25	6.35	0.010	0.25
0.50	12.7	0.015	0.38
0.75	19.05	0.018	0.46
1.00	25.4	0.020	0.51
1.25	31.75	0.022	0.56
1.50	38.1	0.025	0.63
1.75	44.45	0.030	0.76
2.00	50.8	0.030	0.76
2.25	57.15	0.045	1.14

DB16: Tapping Speeds Requirements with High Speed Taps

Tapping Speeds High Speed Taps

work piece material	surface feet per minute	surface meters per minute
aluminum	90 - 100	27 - 30
brass	90 - 100	27 - 30
bronze	40 - 60	12 - 18
cast iron	70 - 80	21 - 24
cast steel	20 - 30	6 - 9
machinery	40 - 60	12 - 18
nickel	25 - 35	8 - 11
stainless steel	15 - 25	5 - 8
tool steel	25 - 35	8 - 11

DB17: Effect of Work Material Type on Roughing by Ultra Sonic Machining

Effect Work Material Ultra Sonic Machining Roughing

work material	volume metal removal rate in cubic millimeters per minute	penetration in millimeters per minute	maximum practical area of tool in squared millimeters	wear ratio
aluminum	425	3.8	2580	100 : 1
brass	185	1.5	1935	75 : 1
bronze	265	2.9	2260	100 : 1
cast iron	390	3.2	2260	100 : 1
cast steel (glass bonded)	390	3.2	2240	100 : 1
cast steel	250	2.0	1935	100 : 1
cast steel	200	1.7	1935	50 : 1
cast steel	45	0.4	580	2.5 : 1
cast steel	40	0.4	775	1.5 : 1
cast steel	30	0.3	775	1 : 1

DI18: Electron Beam Machining Requirements for Drilling

Electron Beam Machining Drilling						
work piece material	work piece thickness in millimeters	hole diameter in millimeters	penetration rate in seconds	acceleration voltage in kilo-volts	average beam current in micro-amperes	pulse frequency
30 series stainless steel	0.25	0.012	less than 1	130	60	3000
commercial aluminum (side)	0.75	0.030	30	125	60	50
tungsten	0.25	0.025	less than 1	140	50	50
tungsten	0.40	0.075	less than 1	130	100	50
10-10 tantalum tungsten	1.00	0.125	less than 1	140	100	50
10-10 tantalum tungsten	2.00	0.125	10	140	100	50
10-10 tantalum tungsten	2.50	0.125	10	140	100	50
stainless steel	1.00	0.125	less than 1	140	100	50
stainless steel	2.00	0.125	10	140	100	50
stainless steel	2.50	0.125	10	140	100	50
aluminum	2.50	0.125	10	140	100	50
quartz	3.18	0.025	less than 1	140	10	50

DI18b: Electron Beam Machining Requirements in Slot Cutting

Slot Cutting Electron Beam Machining						
work piece material	work piece thickness in millimeters (mm)	slot description in millimeters (mm)	cutting speed in millimeters per minute (mm/min)	acceleration voltage in kilo-volts	average beam current in micro-ampere	pulse frequency
stainless steel	1.60	rectangle of 0.200 x 6.500	5	140	120	50
stainless steel	0.18	0.100 wide	50	130	50	50
stainless steel	0.05	0.050 wide	100	130	20	50
beryllium copper	3.20	rectangle of 0.450 x 1.800	10	140	150	50
brass	0.25	0.100 wide	50	130	50	50
aluminum	0.75	0.100 wide	600	150	200	200
tungsten	0.05	0.025 wide	175	150	30	50

MODULE TWO: HELP AND TROUBLE SHOOTING GUIDE MODULE DATA

DI18 Help1: Trouble Shooting in Turning Operation

Help Turning			
trouble	probable reason	cause	remedy
excessive crater wear	wrong grades of carbide used	change over to P grade preferably lower numbers i.e. having more titanium carbide	
excessive crater wear	chip too tight	increase the chip breaker distance	
excessive crater wear	higher speed	reduce speed	

### Help Turning

trouble	probable reason	remedy
excessive crater wear	higher feeds	reduce feed
edge chipping	wrong grade of carbide	change over to tougher grade
edge chipping	built-up edge	increase the speed
edge chipping	vibration and/or chatter	reduce tool overhang,
edge chipping	vibration and/or chatter	change to rigid shank
edge chipping	vibration and/or chatter	increase feed, reduce depth of cut
edge chipping	vibration and/or chatter	increase or decrease speed
edge chipping	vibration and/or chatter	reduce nose radius
edge chipping	vibration and/or chatter	increase approach angle
edge chipping	vibration and/or chatter	reduce clearance in tool post slide
edge chipping	vibration and/or chatter	check rigidity of work holding device
edge chipping	vibration and/or chatter	reduce the overhang of tailstock spindle
edge chipping	vibration and/or chatter	tighten tailstock centre
edge chipping	vibration and/or chatter	use work rest
edge chipping	wrong geometry	decrease rake angle
edge chipping	wrong geometry	reduce clearance angle
edge chipping	wrong geometry	decrease approach angle
edge chipping	cutting edge too sharp	hone the edges with a diamond lap
edge chipping	grinding damage	use correct grade of wheel
edge chipping	grinding damage	use correct grinding technique
chip breakage	lack of rigidity	reduce overhang
chip breakage	lack of rigidity	use rigid shank
chip breakage	lack of rigidity	use thicker insert
chip breakage	lack of rigidity	increase the nose radius
chip breakage	lack of rigidity	support the work piece
chip breakage	lack of rigidity	change to square insert from triangular insert if possible
chip breakage	shock due to interruptions	use negative rake
chip breakage	shock due to interruptions	change to tougher grade carbide
chip breakage	shock due to interruptions	clean insert pocket in case of tools with indexable insert
chip breakage	shock due to interruptions	remove built-up edge before indexing
chip breakage	shock due to interruptions	tighten the shim
chip breakage	shock due to interruptions	change the damaged shim
chip breakage	shock due to interruptions	avoid chip breaker play
chip breakage	tool holder errors	too much clamping pressure on the insert
chip breakage	tool holder errors	insert seating NOT FLAT
chip breakage	chip crowding	increase chip breaker distance
chip breakage	chip crowding	reduce speed
chip breakage	wrong assembly	use negative rake tips only in negative rake holders
insert breaking at the nose	no support under nose	change shim to suit the insert radius
insert breaking at the nose	no support under nose	use negative shim in negative holders (positive rake will not give sufficient support to negative rake inserts)

### HelpTurning

trouble	probable reason	remedy
tool life too short	rapid wear	change to harder grades of carbides
tool life too short	rapid wear	reduce speed
tool life too short	rapid wear	reduce feed if material is not work hardening type
tool life too short	rapid wear	increase speed if material is work hardening type
tool life too short	rapid wear	decrease approach angle
tool life too short	rapid wear	increase clearance
tool life too short	rapid wear	anneal work piece
poor finish on work piece	incorrect geometry	increase nose geometry
poor finish on work piece	incorrect geometry	use higher grade of carbide
poor finish on work piece	marred by chip	direct chips away from the work piece use angular chip breaker
poor finish on work piece	marred by chip	use positive back rake
poor finish on work piece	in correct cutting conditions	decrease feed
poor finish on work piece	in correct cutting conditions	increase speed
poor finish on work piece	in correct cutting conditions	reduce depth of cut
poor finish on work piece	in correct cutting conditions	check tool centre height
poor finish on work piece	shim radius projecting	use same or larger radius shim as an insert
poor finish on work piece	no relief on cutting edge	use positive rake insert on positive rake holder

### DBHhelp2: Trouble Shooting in Milling

MillingTroubleShooting	
problem	remedy
chipping of cutting edge	use tougher carbide
chipping of cutting edge	increase speed
chipping of cutting edge	hone cutting edge
chipping of cutting edge	reduce feed
chipping of cutting edge	use proper geometry
excessive flank wear	use harder carbides
excessive flank wear	hone cutting edge
excessive flank wear	increase feed
excessive flank wear	reduce speed
excessive flank wear	use proper geometry
excessive crater wear	use harder carbide
excessive crater wear	reduce speed
excessive crater wear	reduce feed
chip logging	reduce number of teeth
chip logging	increase chip pockets
rough finish	increase speed
rough finish	reduce feed

**Milling Trouble Shooting**

problem	remedy
rough finish	check axial run-out of teeth
excessive chatter	increase feed
excessive chatter	check loose arbor
excessive chatter	increase rigidity of the cutter or machine
excessive chatter	use proper geometry
excessive chatter	try unequal pitch cutters
excessive chatter	reduce number of cutting edges
excessive chatter	check if machine stalls
excessive chatter	increase chip pocket
excessive chatter	reduce feed
chill up edge	increase speed
chill up edge	increase feed
chill up edge	select suitable grade of carbide

**Table 20: Trouble Shooting in Milling with Carbide Tools**

**Milling With Carbide Tools**

type of operation	soft steel tool material	medium steel tool material	hard steel tool material	cast steel tool material	stainless steel tool material	soft cast iron tool material	hard cast iron tool material	non ferrous tool material	non-metallic tool material
finishing	good for most applications	fair-successful in many applications	fair-successful in many applications	fair-successful in many applications	poor- not generally recommended	good for most applications	poor- not generally recommended	good for most applications	good for most applications
roughing	good for most applications	good for most applications	good for most applications	good for most applications	fair-successful in many applications	good for most applications	poor- not generally recommended	good for most applications	good for most applications
semi-finishing	good for most applications	good for most applications	good for most applications	good for most applications	fair-successful in many applications	good for most applications	fair-successful in many applications	good for most applications	good for most applications
roughing or finishing	good for most applications	good for most applications	fair-successful in many applications	good for most applications	poor- not generally recommended	good for most applications	fair-successful in many applications	good for most applications	good for most applications
roughing	good for most applications	good for most applications	poor- not generally recommended	fair-successful in many applications	poor- not generally recommended	good for most applications	poor- not generally recommended	good for most applications	good for most applications
finishing	fair-successful in many applications	fair-successful in many applications	poor- not generally recommended	fair-successful in many applications	poor- not generally recommended	good for most applications	fair-successful in many applications	good for most applications	good for most applications

Table 3: Trouble Shooting in Drilling

Drilling Trouble Shooting	
problem	causes
runout of tang	imperfect fit between taper shank and socket, caused by dirt, chips, burrs or badly worn out shanks and sockets
chatter of the drill at the web	insufficient lip clearance
chatter of the drill at the web	excessive feed
chatter of the drill at the web	excessive web-thinning
chatter of the drill at the web	careless ejection of drill from spindle causing the drill to fall on the table
chatter of the drill at the web	striking the drill on the point with hammer (only soft material should be used as hammer)
excessive wear of outer corners	excessive speed
excessive wear of outer corners	hard spots in material
excessive wear of outer corners	no coolant
excessive wear of outer corners	clogging of flutes
chatter or flattening of outer corners of drill run off	spring or backlash in the drill press and fixture work
chatter cutting lips	excessive feed
chatter cutting lips	excessive clearance angle
chatter in cutting lips	overheating or too quick-cooling while sharpening or drilling
chatter of drill	point improperly ground
chatter of drill	heavy feed
chatter of drill	insecure clamping of drill or work
chatter of drill	drill is dull
chatter of drill	flute clogged by chips
chatter of drill	point improperly ground
chatter of drill	no coolant
chatter of drill	heavy feed
chatter of drill	fixture not rigid
chatter of drill	unequal angle or length of the cutting edges or both
chip coming out of one flute, small chip	point improperly ground
chip coming out of one flute, small chip	one lip doing all the cutting

Table 3b: Trouble Shooting in Gun Drilling

Gun Drilling Trouble Shooting	
problem	causes
poor surface finish	improper alignment
poor surface finish	low speed
poor surface finish	low coolant pressure and improper filtration
poor surface finish	chatter
poor surface finish	heavy feed rate
poor surface finish	incorrect grinding of point
poor surface finish	faulty wear pad
poor round hole	improper geometry
poor round hole	misalignment
poor round hole	excessive clamping of job
poor round hole	worn-out bushing

#### GunDrillingTroubleShooting

problem	causes
oversized hole	improper geometry
oversized hole	heavy feed
unsatisfactory chip control	imperfect fluid system
unsatisfactory chip control	improper point geometry
unsatisfactory chip control	high viscosity of coolant
unsatisfactory chip control	heavy feed rate
unsatisfactory chip control	low speed
unsatisfactory chip control	low coolant pressure
faster tool wear	improper point geometry
faster tool wear	insufficient coolant supply
faster tool wear	improper alignment
faster tool wear	elevated cutting conditions
faster tool wear	disproportionate tool overhang
faster tool wear	improper grade of carbide (in case of carbides)

#### PDBHelp4: Trouble Shooting in Trepanning

##### TrepanningTroubleShooting

problem	causes
faster tool wear	high speed
faster tool wear	improper set-up
faster tool wear	insufficient coolant supply
faster tool wear	misalignment
faster tool wear	improper grade of carbide
faster tool wear	vibration
poor surface finish	vibration
poor surface finish	worn out cutter
poor surface finish	incorrect geometry
poor surface finish	low speed
poor surface finish	unfiltered coolant
poor surface finish	faulty wear pads
eccentricity	improper start bushing
eccentricity	misalignment
eccentricity	incorrect geometry
unsatisfactory chip control	improper design of chip
unsatisfactory chip control	breakers
unsatisfactory chip control	low speed
unsatisfactory chip control	uneven and light feed

#### PDBHelp5: Trouble Shooting Boring

##### BoringTroubleShooting

problem	causes
chatter	lack of rigidity of the bar or spindle
chatter	insufficient clearance angle
chatter	too large nose radius
poor finish	worn out tool

### Boring Trouble Shooting

problem	causes
poor finish	low speed
poor finish	nose radius too small
poor finish	very high speed
tool chipping	cutting edge not sufficiently supported
tool chipping	chatter
tool chipping	interrupted cutting
tool chipping	hard spots or inclusions in material
edge cracking	worn out or chipped off cutting edge
edge cracking	improper application of coolant
edge cracking	chatter
edge cracking	low cutting speed
excessive tool wear	feed too low
excessive tool wear	speed too low
excessive tool wear	incorrect geometry
excessive tool wear	poor surface finish on cutting edge
excessive tool wear	excess dwell on cut

### Reaming Trouble Shooting

Reaming Trouble Shooting		
problem	causes	remedy
oversized holes	misalignment	use floating holders
oversized holes	bent shanks, lack of concentricity on the edges owing to improper grinding	proper care to be taken while regrinding
oversized holes	material build up on cutting edges	use heavy lard oil or carbide reamer
oversized holes	material build up on cutting edges	reduce reamer land width and change to helical fluted reamers
reamer mouthed and tapered holes	misalignment	use floating holder
reamer mouthed and tapered holes	misalignment	use double lead angle with 45° bevel lead and 2-3° taper lead
poor surface finish, hole slightly over sized and work material adheres to cutting edge faces	cutting speed too high	reduce speed
poor surface finish, hole slightly over sized and work material adheres to cutting edge faces	insufficient or unsuitable cutting fluid	increase supply of cutting fluid
poor surface finish, hole slightly over sized and work material adheres to cutting edge faces	feed too high	reduce feed
poor surface finish, surface scoured over the hole surface particularly towards the top of the hole	burrs on cutting edges. Burrs on the outer edge of the flute face due to bad handling	care to be taken while regrinding and handling
holes of poor surface finish or isolated score marks in hole	insufficient reaming allowance	maintain correct allowance
holes of poor surface finish or isolated score marks in hole	insufficient reaming allowance	regrind drill carefully to minimize lip height error
poor surface finish towards bottom of hole	insufficient chip clearance beyond the hole	provide greater clearance beyond the hole
poor surface finish while reaming in aluminum	number of flutes too many	use reamer with less number of flute or grind off lands of alternate flutes
reamer tang broken while cutting or when withdrawing reamer from hole	poor fit between reamer shank and machine socket	ensure that fit is good, remove burrs, dirt, etc.

**PDBHelp6b: Trouble Shooting in Reaming Applications**

ReamingApplications			
reaming operation requirement	operation conditions	recommendations	comments
machine reaming	hole finish and accuracy not critical	use rose chucking reamer	none
end cutting	hole finish and accuracy not critical	use rose chucking reamer	none
close tolerance	cost critical	use fluted chucking reamer	several sizes of reamers can be used with one arbor, when reamer is worn or damaged the arbor can be used with new reamer, more economical for reaming large holes
high finish	cost critical	use fluted chucking reamer	several sizes of reamers can be used with one arbor, when reamer is worn or damaged the arbor can be used with new reamer, more economical for reaming large holes
expansion feature	any	use expansion reamer	due to expansion feature this reamer can be expanded or sharpened to its original size
adjustable feature	cost critical	use adjustable chucking reamer	the adjustable blade feature and replaceable blade makes this an economical reamer
highly improved production rates	machining of castings with sand and scale	use carbide tipped reamer	the carbide tipped reamer has improved abrasion resistance, ability to withstand high cutting temperatures and maintain uncompromised cutting edge
reaming of tapered holes	any	use machine taper reamer	none
holes to be finished to high degree of accuracy	any	use solid type hand reamer	none

**PDBHelp7: Trouble Shooting in Tapping Applications**

TappingApplications			
tapping operation requirement	operation conditions	recommendations	comments
easy starting in hole	hole through the work piece	use taper tap or plug tap	none
reaming to base of a blind hole	any	use bottoming tap	none
machine tapping	any	use gun tap	none
hand tapping	any	use gun tap	none
shallow through holes of depth not more than one tap diameter	material is soft and stringy	use stub flute tap	none
edge a key way	material is soft steel or aluminum or magnesium or brass or copper or die cast metal and hole is deep	use spiral fluted tap	none
tap in a hole to be threaded	material is soft steel or aluminum or magnesium or brass or copper or die cast metal and hole is deep	use spiral fluted tap	none

**PDBHelp8: Trouble Shooting in Broaching Applications**

BroachingApplications			
work piece material properties	operation conditions	broaching material recommendations	comments
low tensile strength, high density, non metallic, non ferrous and cast iron	any	use silicon carbide	none

### Broaching Applications

work piece material, properties	operation conditions	broaching material recommendations	comments
high tensile strength, ferrous metal	any	use aluminum oxide	except cast iron
cemented carbides	any	use green silicon carbide	none
hard non ferrous materials	any	use green silicon carbide	none
cast iron	any	use black silicon carbide	none
ceramics	any	use black silicon carbide	none
soft non ferrous materials e. g. aluminum, brass and copper	any	use black silicon carbide	none
any	loose abrasive is required	use boron carbide	none
any	cheap substitute for diamond dust	use boron carbide	none
any	job is precision gauge	use boron carbide	none
any	sand-blast nozzle is being used	use boron carbide	none
any	ultra sonic applications	use boron carbide	none
high speed steel	grinding with ease and accuracy, at temperatures up to 1370°C, in conditions of inorganic salts and organic compounds, with the requirement of close tolerances	use cubic boron nitride	none
ultra hard e.g. tungsten carbide or silicon carbide and highly advanced alloys	any	use RVG diamond	none
cemented carbide, ceramic	grinding is electrolytic	use MBG-II diamond	none
sapphire	grinding is electrolytic	use MBG-II diamond	none
ceramic	grinding is electrolytic	use MBG-II diamond	none
concrete	metal bonded saw is to be used	MBS diamond	none
marble	metal bonded saw is to be used	MBS diamond	none
tile	metal bonded saw is to be used	MBS diamond	none
granite	metal bonded saw is to be used	MBS diamond	none
stone	metal bonded saw is to be used	MBS diamond	none
masonry material	metal bonded saw is to be used	MBS diamond	none

### PDBHelp9: Trouble Shooting in Grinding Wheel Applications

#### Grinding Wheel Applications

Grinding wheel type and name	applications	comments
Type 1 : straight	Cylindrical operations, centerless operations, internal operations, cutter operations, surface operations and offhand grinding operations	none
Type 2 : cylinder	Surface grinding on horizontal and vertical spindle grinders	none
Type 4: tapered (both sides)	Snagging operations	tapered sides lessen chances of the wheel's breaking
Type 5; recessed (one side)	Cylindrical operations, centerless operations, internal operations, surface grinders	recess provides clearance for the mounting of flange
Type 6: straight cup	Cutter and tool grinder and surface grinding on vertical and horizontal spindle machines	none
Type 7 recessed (both sides)	Cylindrical, centerless and surface grinders	recesses provide clearance for mounting flanges
Type 11: flaring cup	Cutter and tool grinder	used mainly for sharpening milling cutters and reamers
Type 12: dish	Cutter and tool grinder	its thin edge permits it to be used in narrow slots
Type 13: saucer	Saw gumming, gashing, milling cutter teeth	none

**Help10: Trouble Shooting in Cutting Fluids Application**

Cutting Fluids Applications					
work piece material	drilling	reaming	threading	turning	milling
aluminum	Soluble oil, kerosene, kerosene & lard oil	Soluble oil, kerosene, mineral oil	Soluble oil, kerosene & lard oil	Soluble oil	Soluble oil, Lard oil, mineral oil-dry
brass	Dry soluble oil, kerosene, lard oil	Dry soluble oil	Soluble oil, lard oil	Soluble oil	Dry soluble oil
bronz	Dry soluble oil, mineral oil, lard oil	Dry soluble oil, mineral oil, lard oil	Soluble oil, lard oil	Soluble oil	Dry soluble oil, mineral oil, lard oil
cast iron	Dry air jet, soluble oil	Dry soluble oil, mineral lard oil	Dry sulphurized oil, mineral lard oil	Dry Soluble oil	Dry soluble oil,
copper	Dry soluble oil, mineral lard oil kerosene,	soluble oil, lard oil	soluble oil, lard oil	Soluble oil	Dry soluble oil,
freeable iron	Dry soda water	Dry soda water	lard oil, soda water	Soluble oil	Dry soda water
tool metal	Soluble oil, lard oil	Soluble oil, lard oil	lard oil	Soluble oil	Soluble oil, mineral lard oil
steel alloys	Soluble oil, sulphurized oil, mineral lard oil	Soluble oil, sulphurized oil, mineral lard oil	sulphurized oil, lard oil	Soluble oil	Soluble oil

**Help11: Trouble Shooting in Electrode Material Selection**

Electrode Material Selection										
work piece material	machining operation	electrode material	available form of electrode material	performance of electrode material for relaxation type	performance of electrode material for pulse type	volume wear ratio in roughing	corner wear ratio in finishing	machinability of electrode material	optimum application	limitations and undesirable uses
cast iron	roughing, finishing	graphite	blocks, rods	poor	excellent	100 : 1	5 : 1	excellent	press tooling, dies,	carbide work piece material
brass	roughing, finishing	brass	bar, tube, wire	fair	excellent	1 : 1	7 : 1	good	holes, slits	close tolerance application and deep slots
brass	semi-finishing, finishing	copper tungsten	short bars, flats, shims, wire, tube	excellent	excellent	8 : 1	3 : 1	fair	machining of carbide, slots and micro machining	large areas
brass	roughing, finishing	copper	bar, tube, wire	excellent	good	2 : 1	1 : 1	good	holes	large areas, deep slots with close tolerance
cast iron	semi-finishing, finishing	tungsten	wire, rod, ribbon	good	good	10 : 1	5 : 1	poor	small slots and holes	irregular holes
cast iron	semi-finishing, finishing	tungsten carbides	sintered rod	good	good	10 : 1	6 : 1	poor	small slots, holes	irregular holes

## Electrode Material Selection

work piece material	machining operation	electrode material	available form of electrode material	performance of electrode material for relaxation type	performance of electrode material for pulse type	volume wear ratio in roughing	corner wear ratio in finishing	machinability of electrode material	optimum application	limitations and undesirable uses
tractor metals										
non ferrous materials	semi-finishing,	steel	rods, ingots, forgings	poor	good	4 : 1	4 : 1	good	through-holes	carbide
steel	roughing, semi-finishing	zinc	cast shapes	poor	fair	2 : 1	7 : 1	good	forging die cavities	through-holes
steel	roughing	aluminum	cast shape, extruded bars	poor	fair	5 : 1	5 : 1	good	forging cavities only	through-holes

## DIIIelp11b: Trouble Shooting in Electrode Material Properties

## Electrode Material Properties

electrode material	merits	demerits
graphite (reverse polarity in grinding)	easily machined, easily attached to punch of holder with conductive adhesives, can be ground together with hardened punch, very good rate of metal removal, best wear ratio	must be machined completely to shape because it cannot be etched, needs very good flow of dielectric fluid, care required in machining carbides to prevent arcing, dielectric fluid soaks up graphite and then it cannot be attached to punches, cannot be machined with surface finish better than 1 micro-meter
super tungsten (reverse polarity machining)	can be attached by brazing, surface finish better than 1 micro-meter achieved	brazing can soften the hardened punch, costs more than graphite, can machine steel only with reverse polarity
steel (reverse polarity)	good for short-run dies	wear ratio is satisfactory only for certain steels, metal removal rate is slow (five times slower than that of graphite)
zinc-based casting alloys	good wear ratio of any zinc alloys, high production rate of electrodes	die making is costly, additional flow holes may be required for the dielectric
zinc-tin alloys	easily coined to accurate dimensions, permits accurate machining of complex shapes, easy to cast because of its low melting temperature, can be remelted and used, costs less than the machined electrodes	high corner wear, will not produce fine details
brass	low cost, easily machined, higher wear ratios than steel, produces extremely smooth finish on work	lower wear than graphite, non-availability of material in various sizes, more expensive than graphite
aluminum alloys (reverse polarity)	high currents can be use permitting large metal removal rate (millimeters squared per minute at 400 amperes)	high melting temperature, high shrinkage (5 to 7 percent), not suitable for use with capacitance type generators
steel	available in small tubing and shim stock, machines almost any material, has good machinability and produces high finish	poor wear ratio (1 -6)
super tungsten	good wear ratio, makes accurate cuts, resists tool edge breakage	initial cost of material is high, difficult to machine

DBHhelp12: Trouble Shooting in Electrolyte Solution Application

Electrolyte Solution Application				
electrolyte base group	electrolyte base	concentration weight percentage in aqueous solution	application	comments
neutral salt	sodium chloride (common salt)	5 - 20	alloyed and unalloyed steel	inexpensive, non poisonous, simple supervision; non-passivating, high stray machining effect, pitting, corrosive
neutral salt	sodium chlorate	20 - 45	steel	high removal rates with low stray machining effects; inflammable
neutral salt	sodium nitrate	10 - 20	alloyed and unalloyed steel, aluminum, copper and zinc alloys	ph value supervision is easy, no skin irritation, low stray machining; passivating with steel
neutral salt	sodium chloride + sodium nitrate	6% sodium chloride + 2% sodium nitrate	titanium alloys	none
neutral salt	sodium nitrite	up to 12	copper alloys	only for special applications; poisonous
neutral salt	sodium sulphate	10	copper alloys	only for special applications
acids	hydrochloric acid	up to 10	for special applications	no hydroxide residue, better
acids	sulphuric acid	up to 10	nickel, chromium, and cobalt alloys	considerable expenses for safety measures because it is corrosive
acids	hydrofluoric acid + hydrochloric acid + nitric acid	10% by volume of each acid	titanium	none
alkalis	sodium hydroxide	up to 10	tungsten and molybdenum	caustic and unpleasant handling

DBHhelp13: Materials' Guide in Non-Traditional Machining

Materials and Non-Traditional Machining								
workpiece material	ultrasonic machining (USM)	abrasive jet machining (AJM)	electrochemical machining (ECM)	chemical machining (CHM)	electrical discharge machining (EDM)	electron beam machining (EBM)	laser beam machining (LBM)	plasma arc machining (PAM)
aluminum	poor	fair	fair	good	fair	fair	fair	good
steel	fair	fair	good	good	good	fair	fair	good
copper alloys	poor	good	good	fair	good	fair	fair	good
titanium	fair	fair	fair	fair	good	fair	fair	fair
inert gases	good	good	fair	poor	good	good	poor	poor
ceramic	good	good	not applicable	poor	not applicable	good	good	not applicable
plastic	fair	fair	not applicable	poor	not applicable	fair	fair	fair
composites	good	good	not applicable	fair	not applicable	fair	fair	not applicable

Table 14: Non-Traditional Machining Relationships with Workpiece Shape

Non Traditional Machining and Workpiece Shape																
Machining process	precision small holes (micro-holes diameter less than 3/100 mm)	precision small holes (micro-holes diameter from 15/100 to 3/100 mm)	deep holes (shall ow of depth and/or diameter less than 20m m)	deep holes (shall ow of depth and/or diameter greater than 20m m)	through cavities (precision)	through cavities (standard)	pocketing (shall ow)	pocketing (standard)	surfacing (double contouring)	surfacing (surface revolution)	through cutting (shall ow)	through cutting (deep)	grinding	honin g	debur ring	threading
ultrasonic machining (USM)	not applicable	not applicable	good	poor	good	good	poor	poor	poor	not applicable	poor	not applicable	poor	fair	good	not applicable
inert gas jet machining (IJM)	not applicable	not applicable	fair	poor	poor	fair	not applicable	not applicable	not applicable	not applicable	good	not applicable	good	not applicable	good	not applicable
chemical machining (ECM)	not applicable	not applicable	good	good	fair	good	good	good	good	fair	good	good	fair	good	good	poor
electrochemical machining (ECM)	not applicable	not applicable	good	good	fair	good	good	good	good	fair	good	good	fair	good	good	poor
chemical machining (CIM)	fair	fair	not applicable	not applicable	poor	fair	good	poor	not applicable	not applicable	good	not applicable	not applicable	not applicable	poor	not applicable
dielectric discharge machining (EDM)	not applicable	fair	good	fair	good	good	good	good	fair	not applicable	poor	not applicable	electrical discharge machining (EDM)	good	not applicable	poor
electron beam machining (EBM)	fair	good	fair	poor	poor	poor	not applicable	poor	not applicable	not applicable	good	fair	not applicable	not applicable	not applicable	not applicable
laser beam machining (LBM)	good	good	fair	poor	poor	poor	not applicable	poor	not applicable	not applicable	good	fair	not applicable	not applicable	not applicable	not applicable
plasma arc machining (PAM)	not applicable	not applicable	fair	not applicable	poor	poor	not applicable	poor	not applicable	poor	good	good	not applicable	not applicable	not applicable	poor

PDBHlp15: Comparing Traditional and Non-Traditional Machining Performance

Comparison of Traditional and Non-Traditional Machining							
machining process	maximum metal removal rate in millimeters cubed per minute	power consumed in kilowatt per centimeters cubed per minute	cutting speed in meters per minute	penetration rate in millimeters per minute	accuracy attainable in millimeters	accuracy at maximum removal rates in millimeters	typical machine input power in kilowatt
conventional turning $\times [10]^3$	3300000	0.045	75	not applicable	0.002	0.100	22
conventional grinding	820000	0.450	1500	not applicable	0.002	0.050	18
ultrasonic machining (USM)	800	9.000	not applicable	0.50	0.005	0.025	11
electrochemical machining (ECM)	16000	7.200	not applicable	12	0.010	0.100	150
chemical machining (CIM)	490000	not applicable	not applicable	0.02	0.010	0.050	not applicable
electrical discharge machining (EDM)	49100	1.800	not applicable	12	0.010	0.100	11
electron beam machining (EBM)	8	450	60	160	0.005	0.025	7.5
laser beam machining (LBM)	5	2700	not applicable	100	0.010	0.010	15
plasma arc machining (PAM)	160000	0.900	15	250	0.250	2.500	150

PDBHlp16: Non-Traditional Machining Surface Finish Characteristics

Non-Traditional Machining Surface Finish		
machining process	surface finish in micro-meter in less frequent applications	surface finish in micro-meter in less average applications
ultrasonic machining (USM)	3.2 - 1.6 and 0.4 - 0.2	1.6 - 0.4
abrasive jet machining (AJM)	1.6 - 0.8 and 0.2 - 0.1	0.8 - 0.2
electrical discharge machining (EDM)- roughing	less than 12 and 3.2 - 0.8	12 - 3.2
electrical discharge machining (EDM)- finishing	6 - 3.2 and 0.8 - 0.05	3.2 - 0.8
electrical discharge grinding (EDG)	3.2 - 1.6 and 0.4 - 0.2	1.6 - 0.4
electron beam machining (EBM)	0.8 - 0.4	6 - 0.8
laser beam machining (LBM)	0.8 - 0.4	6 - 0.8
plasma arc machining (PAM)	less than 12 and 6 - 3.2	12 - 6
electrochemical machining (ECM)- cut	1.6 - 0.8 and 0.4 - 0.05	1.6 - 0.4
electrochemical machining (ECM)- cut	12 - 6 and 1.6 - 0.2	6 - 1.6
electrochemical grinding (ECG)	3.2 - 0.8 and 0.2 - 0.1	0.8 - 0.2

Non Traditional Machining Surface Finish

machining process	surface finish in micro-meter in less frequent applications	surface finish in micro-meter in less average applications
electrochemical deburring (ECD)	1.6 - 0.8 and 0.2 - 0.1	0.8 - 0.2
chemical machining	12 - 6 and 1.6 - 0.2	6 - 1.6