DEVELOPMENT OF COMPUTER – AIDED DESIGN SOFTWARE FOR JIGS AND FIXTURES FOR DRILLING FLANGES

BY

ODUFALE OLATUNDE ABIODUN

(MEE/98/1439)

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A THESIS SUBMITTED TO THE DEPARTMENT OF MECHANICAL ENGINEERING SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE,NIGERIA IN PARTIAL FULFILMENT FOR THE AWARD OF M-ENG. IN MECHANICAL ENGINEERING

CERTIFICATION

We, the undersigned hereby certify that this research thesis has been carried out by ODUFALE, Olatunde Abiodun for partial fulfillment of the requirements for the award of Master of Engineering (M.ENG) in Production Engineering, Federal University of Technology, Akure and that the work has not been submitted elsewhere for the award of a degree.

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25/09/06
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25.09.06
Date

DEDICATION

This project work is dedicated to the loving memory of my parents, who toiled to give me basic and qualitative education but could not wait to reap the fruit of their labour.

May their perfect soul rest in perfect peace (Amen).

ACKNOWLEDGEMENT

Not withstanding the level of man, his mind is continually being stocked with ideas emanating from others, which might awaken some responses and invariably lead to concepts being developed and documented. This fact makes it more or less practically impossible for any individual work to be completely original.

It is with this mind that I wish to express my profound gratitude to my project supervisor Dr. Engr. Pastor Sam Adejuyigbe for his expert criticism, timely correction and suggestions for this research work. I am also indebted to Engr. Akinola, Engr. Oke, Engr. Rahman, Engr . Ogedengbe for their unqualifiable lectures given to me to see me through this programme.

I also appreciate the brotherly advise of Engr, Bello and Engr. Mohammed, who encouraged me to continue to this level.

I will not forget the fatherly advise and critic of this project work by the present Head Of Department Mechanical Engineering Dr.O.P.Fatpetu and the former Head of Department Engr.Prof. A.A Aderoba.

I acknowledge my indebtedness to Engr. Mogaji, Engr. Adeoye, Engr. popoola, Engr. Adebayo (Ajaaraja) Engr Durojaiye, and also my course mates for their relevant assistance and team work towards the conclusion of this programme.

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Above all, I glorify God, the almighty for giving me the zeal and knowledge to complete this programme.

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NOMECLATURE

PCD	-	Pitch Circular Diameter
R	-	Radius
F	-	Force
T	-	Torgue
P	-	Power
Δ	-	Delta
θ	-	Pressure Angle
FT	-	Tangential Force
FR	-	Radial Force
FK	-	SKF Bearing Dynamic Load Factor (Gear)
FD	-	SKF Bearing Dynamic Load Factor (Machine)
MB	-	Bending Moment
MT	-	Torsional Moment
D	-	Diameter
M	-	Module
P	-	Pressure
A	-	Area
σ	-	Stress
λ	-	Lamda
γ	-	Efficiency
W	-	Angular Velocity
μ	-	Viscosity
α	-	Alpha

ABSTRACT

A detailed review of relevant literature was carried out to provide basic information on the construction of jigs design. Also, the documentation of acquired data for the purpose of developing suitable design process using Computer Aided Design (CAD) was carried out.

A computer software that would automatically draw the needed jigs and fixtures from the data of the flange (object) was developed. A description of the design requirements and constraints was obtained by considering the different configurations of the workpiece.

A geometric model of the fixture was developed and analysed for kinematic, force and deformation compatibility. A heuristin algorithm was developed and the program written using JAVA language default package. The program is user-friendly and was written in modules to allow for flexibility and quick responsiveness.

The program was validated with real life sample data from a workpiece.

CHAPTER ONE

INTRODUCTION

1.0 INTRODUCTION

Jigs and fixtures are provided to convert standard machine tools into specialized machine tools. They are usually associated with large-scale production by semi-skilled operation, but they are also used for small-scale production when interchangeability is important, and by skilled operators or machinists when the work piece is difficult to hold without special equipment (Kempster, 1978).

Jigs are machine shop devices that include means of tool guiding, they are only applicable to operations performed on a drilling machine, while fixture are holding devices that do not include means of tool guiding, but they may include means of setting the cutter, Fixtures are used for milling, turning, grinding and similar operations.

1.1 OBJECTIVES OF THE RESEARCH

The specific objectives are to

(a) develop a software for the design of jigs and fixtures for drilling operations and

(b) to draw the jigs and fixtures automatically from Computer Aided Design (CAD) input.

1.2 Expected Contributions of the Research to Knowledge:

The use of computer –aided design is expected to help to:

(i) reduce the time taken in drawing and setting up jigs to the bearest minimum, and

(ii) produce precision drawings needed for the jigs production of jigs and fixtures.

1.3 Research Methodology

A detailed review of relevant literature was carried out to provide basic information on the construction of jigs design. Also, the documentation of acquired data for the purpose of developing suitable design process using CAD was carried out.

A computer software that would automatically draw the needed jigs and fixtures from the data of the flange (object) was developed. A description of the design requirements and constraints was obtained by considering the different configurations of the workpiece.

A geometric model of the fixture was developed and analysed for kinematic force and deformation compatibility. A heuristic algorithm was developed and the program written using JAVA language. The program is user-friendly and was written in modules to allow for flexibility and quick responsiveness.

The program was validated with real life sample data from a workpiece.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 COMPUTER

A computer is a set of electronic equipment that accepts data as input, processes them with the aid of predefined instructions called programme, and produces useful output for management of any other people's use (Kolawole, 1990). The collection of computer equipment is called Hardware while the instructions for processes is called software.

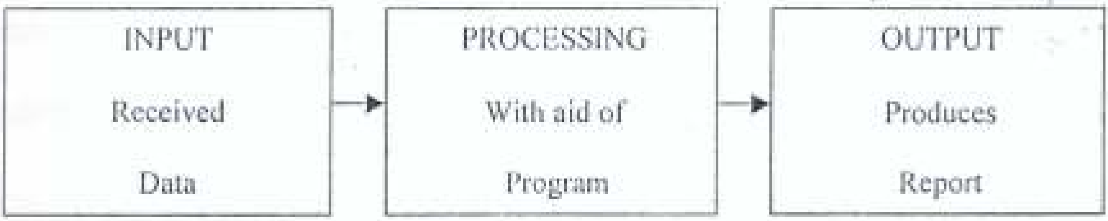


Fig. 2.1 (a) I-P-O Cycle

Computing began development from manual practice to a partially mechanical form as early as the 60's. before the development of computer, humans have been doing computation in less advance methods. Among the early methods is the use of ABACUS (Kolawole, 1990).

2.1.1 EARLY COMPUTER DEVELOPERS

(i) John Napier in 1617 developed a method known as numbering rods called napier's Bones. The rods have numbers printed on them in the order that these numbers would appear in a multiplication table.

(ii) Balsire Pascain 1642 developed the first calculating machine. The machine consisted of wheels for the individual digits in a number. Each wheel contains the number 0 to 9. When particular wheel was rotated from 0 to 0, a mechanism moved the wheel next to it by one digit, thus producing a carrying action.).

(iii) Gollfried Willhem Von Heibnize in 1971 though of the fundamental principles of the first multiplying machine. It was however not practicaly demonstrated until 1694. The basic principles of this machine is that, it perform a multiplication as a series of individuals additions. Digit wheel were used to gether with sliding portion enabling the user to rapidly perform series of additions.

(iii) An English man called Sir Charles Babbage in 1822 built a machine called a Difference Engine. He thought of an analytical Engine capable of performing complicated calculations later. He died before completing the task. His friend called Ada Counters fo Lovelace showed how the analytical engine could be used to do some calculations.

(iv) In 1910, James Power developed some punched accounting equipment used by U.S Census. Unlike that of the Hollerith, it has 90 columns. It was divided into top half of 45 columns and a bottom half of 45 columns

(v) In 1921, 2000 analysis machine was released to the market by NCR in 1922, the first accounting machine that had the subtract features of crossfooter came into existence.

2.1.2 COMPUTER GENERATIONS

The word Computer generations is used to describe the stages of development of computers (Awosanya, 1997);

(i) First generation computers (1954-1958) used Vaccum tubes emphasis on computation ability rather than input and output capability.

(ii) Second generation computers (1958-1964) was by solid-circuiit for greater reliability.

(iii) Third generation computers 1964 this came out 'in 1964 with improved and power and at the same time reduction in cost.

(iv) Fourth generation computers 1971- this involves the introduction of network architecture.

2.1.3 TYPES OF COMPUTER

Lucas (1986) described different types of computer, to include:

(i) **Digital Computer:** Represents its varible in the form of digits, it counts the data that deals within. Whether representing numbers, letters of other symbols are converted into binary form on input to the computer.

(ii) **Analog Computer:** Measure rather than count. This type of computer sets up a models of a system. Common type represents it variable in term of electrical voltage and sets up circuit analogues to the equation connecting the variable (Awosanya, 1997).

(iii) **Hybrid Computer:** In some cases, the user may wish to obtain the output from an analog computer as processed by a digital computer or vice versa. To achieve this, he sets up peripherial of the digital computer (Henry, 1996).

2.1.4 CLASSES OF COMPUTER

Jasper (1981) described different types of computers to include:

(i) **Mainframe computer:** is a large system with the ability to serve a large organization with modern systems (Jasper, 1981.

(ii) **Mini computer:** which is smaller in size and capacity compared with the mainframe having the ability to serve a single unit of an organization (Jasper, 1981).

(iii) **Personal computer:** These are micro computers; it is usually placed on desk and this are of three different types; laptop, Notebook and Palmtop.

2.1.5 COMPONENTS OF A COMPUTER

The components for a computer. can be broadly categorized as Hardware and Software. A Hardware components is physical, tangible object. It can be attached to the computer or be a part of it. Software is a set of instruction given to the hardware to function in a desire manner.

The various hardware components are classified into input and output devices. An input device is the one that accepts information in to the computer. An output displays information generated by the computer. (Robert, 1981).

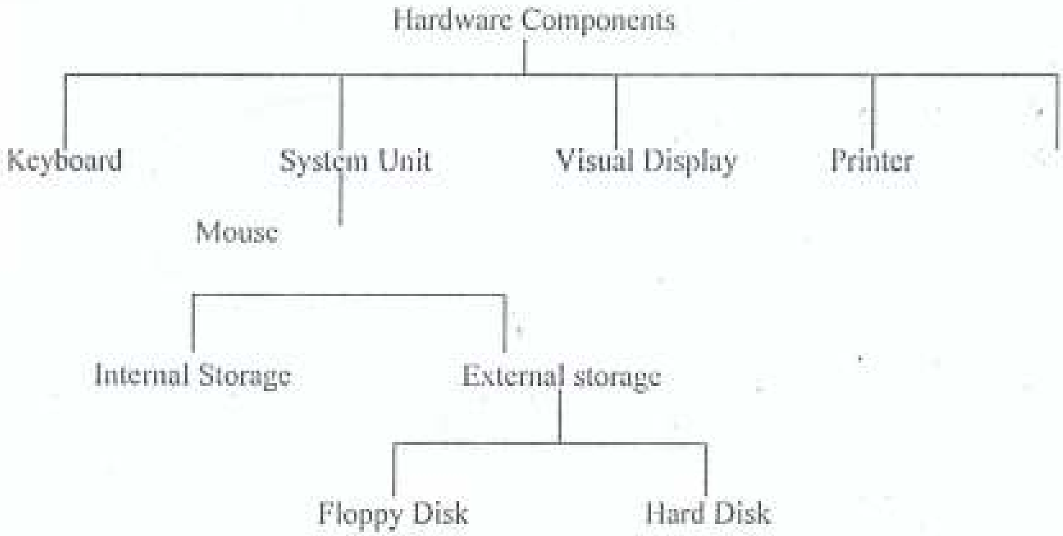


Fig. 2.1.2 (a): Hardware Components Chart
Source: Lucas (1986)

SOFTWARE ALSO ARE DIVIDED INTO THE FOLLOWING CATEGORIES

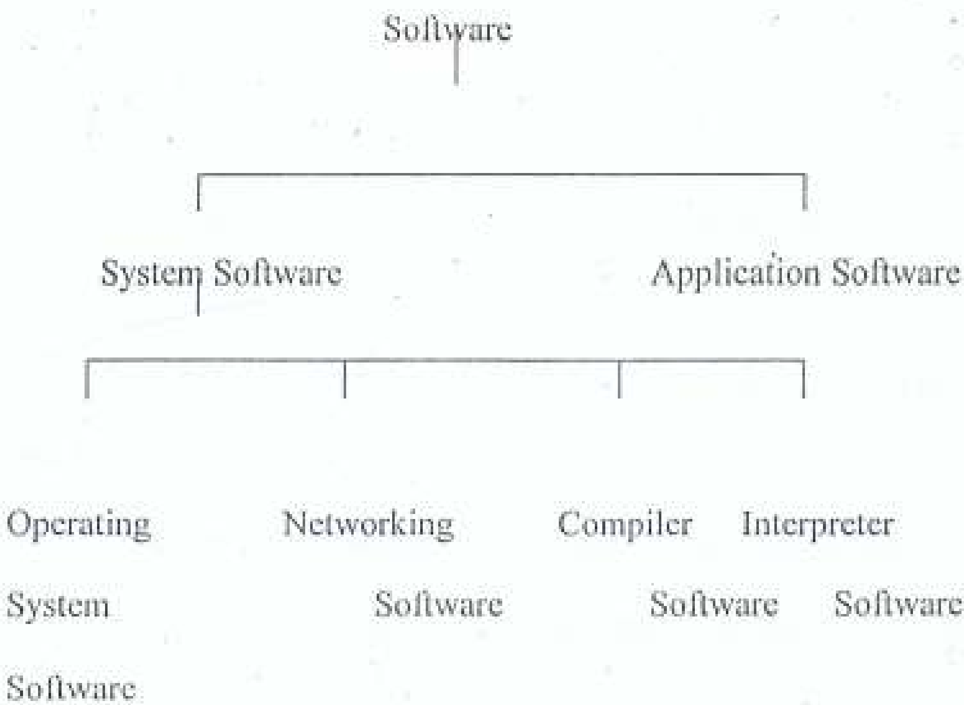


Fig. 2.1.3 (b): Software Chart By: Sam B Adejuyigbe 1999.

Source: Lucas (1986)

2.2 COMPUTER AIDED DESIGN

The aim of Computer – Aided Design (CAD) is to apply computers to both the modelling and communication of design. There have been two different approaches which are often used together (Kenneth, 1992).

(a) At a basic level, to use computers to automatically or assist in such tasks as production of drawing of diagrams and the generation of lists of parts in a design.

(b) At a more advance level, to provide new techniques, which give the designer, enhanced facilities to assist in the design process.

The bulk of the development in commercial CAD system has been in modeling the form of product (i.e. in providing techniques) or in the representation of form using conventional drawing or new modeling techniques) or in systems to assists in the production of diagrams and the subsequent evaluation of designs represented by these diagrams (Bryon, 1992).

The driving force behind the provision of computer assistance for conventional modelling techniques has been the desire to improve the productivity of the designer by the automation of the more repetitive and tedious aspects of design and also to improve the precision of the design models. (Kenneth, 1992) New techniques have been developed in an attempt to overcome perceived limitations in conventional practice-particularly in dealing with complexity, for example in the complexity of form of some design such as automobile bodies or the intricacy or structure of products such as integrated circuits. Computer-aided design should therefore enable the designer to tackle a task more quickly and accurately, or in a way that could be achieved by other means. Computer –Aided should involve the development of a central design description on which all applications in design and manufacture should feed. This implies that computer-based techniques for the analysis and simulation of the design, and for the generation of manufacturing instructions, should be closely integrated with the techniques for modeling the form and structure of the design. In addition, a central design description form an excellent basis for the concurrent development of all aspect throughout the design process, but in practice its impact on the early stages, where very imprecise representations such as sketches are used extensively, has been limited. It must also be stressed that at present CAD does not help the designer in the more creative parts of design, such as the generation of possible design solutions, or in the those aspects that involve complex reasoning about the design – for example in assessing by virtual examination of drawings whether a component may be made or whether it matches the specification. These aspects are, however the subjects of considerable current research.

So far, CAD systems have been described in very general term. More specifically, they can be thought of, as comprising the following (Bryon, 1986).

(a) Hardware: the computer and associated peripheral equipment

(b) Software: the computer program(s) running on the hardware

(c) Data: the data structure created and manipulated by the software

(d) Human knowledge and activities.

CAD systems are no more than computer programs (although often large and complex), perhaps using specialized computing hardware. The software normally comprises a number of different elements or functions that process the stored in the database in different ways:

(a) Model definition: for example to add geometric elements to a model of the form of a compound.

(b) Model manipulation: to move, copy, delete, edit or otherwise modify elements in the design model.

(c) Picture generation to generate images of the design model on a computer screen or on some hard-copy device.

(d) User interaction: to handle commands inputs by the user and to present output to the user about the operation of the system.

(e) Database management: for the management of the files that makes up the database.

(f) Application these elements of the software do not modify the design model, but use it to generate information for evaluation, analysis manufacture.

(g) Utilities: a 'catch-all' term for parts of the software that do not directly affect the design model, but modify the operation of the system in some way (for example, to select the colour to be used for display, or the units to be used for construction of a drawing).

These features may be provided by multiple programs operating on a common database, or by a single program encompassing all the elements.

The Computer Aided Design is used in the following field. (Kenneth, 1992):

(a) Mechanical Engineering

(b) Electrical Engineering

(c) Civil Engineering

(d) Architecture

(e) Electronic Engineering

(f) Marine

(g) Computer

(h) Chemical Engineering etc.

2.2.1 USES OF COMPUTER AIDED DESIGN

Computer Aided Design can be applied in the following areas (Kenneth, 1992):

(a) CAD in conceptual design

(b) Design Automation and optimization

(c) Space and facilities planning and layout

(e) Design and planning for assembly

(f) Geometric methods and applied computational geometry

(g) Aluminium design

(h) Surface and solid modeling

(i) Design and planning for manufacturing, including numerical control, Rapid prototyping and robotics.

2.3 MACHINING OPERATION

Planning the procedures for machining any part, so that it can be machined accurately, and as quickly as possible is very important. Many parts have been defaced because incorrect sequences were followed in the machining process. Although it would be impossible to list the exact sequence of operations that would apply to every type and shape of workpiece, some general rules should be followed in machining operation, (Uara, *et al*, 1969).

The basic machine tools used for the machining of materials are as shown in fig. 2.30, it does not arrange the basic machine tools according to any plan, a good way to classify machine tools is as rotary or reciprocating. The lathe, milling machine and a drill press are all classified as rotary machines while shapes and planers are classified as reciprocating.

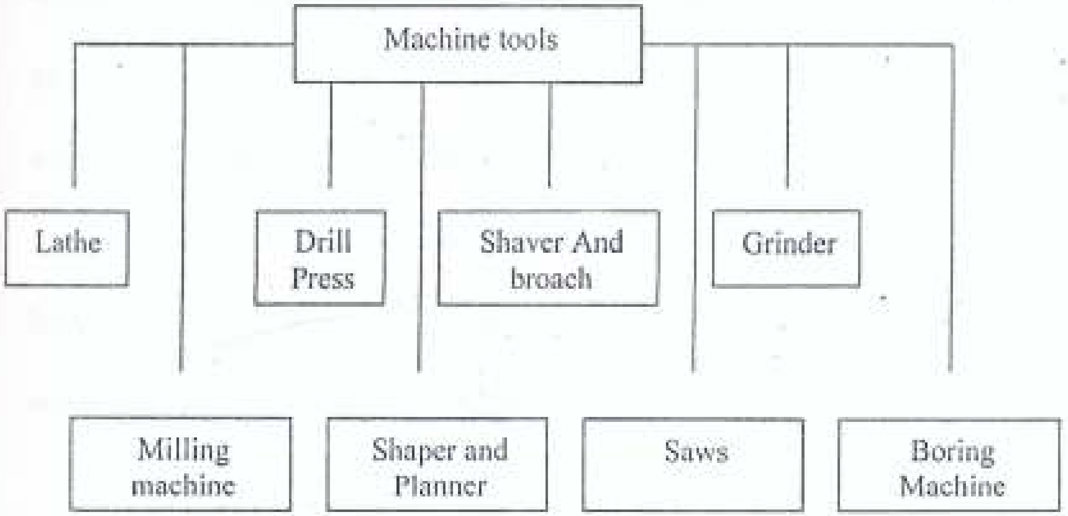


FIG. 2.3.0; Showing basic machine tools

Source: (Adejuyigbe,1999)

For the course of this project, I will limit my study to the lathe, milling, drilling and the grinding machines and their operations.

2.3.1 LATHE MACHINE

Historically, the lathe is the forerunner of all machine tools. The first application of the lathe principles was probably the potter's wheel used in historic times. This machine rotated a mass of clay, which enabled the clay to be formed into a cylindrical shape (Kara, 1969).

The modern lathe operates on the same basic principles. The work is held and rotated on its axis while the cutting tools is advance along the lines of a desired cut. The lathe is one of the most versatile machine tools used in the industry. With suitable attachments, the lathe may be used for turning, tapering, form turning, screw cutting, facing, drilling boring, spinning, grinding and polishing operations. Cutting operations are performed with a cutting told fed either parallel or at high angles to the axis of the work for machining tapers and angles (Uara, et al, 1969).

Modern production has led to the development of many special types of lathes, such as the engines, turret, single and multiple spindle automatic, tracer and numerically controlled lathes.

When many duplicate parts are required, a turret may be used (Uara, et al, 1969). This lathe is equipped with a multi sided tool post called a turret to which several different cutting tools may be mounted. In use, different cutting tools are employed in a given sequence to perform a series of operations on each part. This same sequence may be required on many parts without having to change or reset the cutting tools.

When hundred and thousands of identical small parts are required, they may be produced on single and multiples-spindle automatics lathes.

On these machines, six or eight different operations may be performed on as many parts at the same time. Once the machine is set up it will produce the parts for as long as required.

Tracer lathes are used when a few duplicate parts are required (Uara, et al, 1969). A hydraulically operated cross- slide (and cutting tool) is controlled by a stylus bearing against a round or flat template. tracer attachment are available for converting most engine lathes into tracer lathes.

Numerically controlled lathes have come into widespread use in the past several years. With these machines, the cutting tool movement is controlled by a program, punched tape to perform a sequence of operations automatically on the work piece once the machine has been set up. (Uara, et al, 1969).

A very useful and popular device, which may be added to an engine lathe (or any other machine) is the digital readout system. Engine lathes equipped with these devices can produce duplicate parts to with 0.001m to (0.02m) or less on the diameters and length of a work piece. (Uara, et al, 1969).

Calculation associated with turning lathe machine can be summaised thus:-

(1) cutting speed = $\pi dn/1000$.

where d = diameter of the job in mm.

n = no. of revolution of the job (r.p.m).

2.3.2 MILLING MACHINE

Milling machines are machine tools used to produce one or more machined surfaces accurately on a piece of material, this is done by one or more rotary milling cutters having single or multiple cutting edges. The workpiece is held securely on the workable or the machine or in a holding device clamped to the table. It is then brought into contact with a revolving cutter (Uara, et al, 1969).

The milling machine is a versatile tool, which can handle a variety of machining operations normally performed by other machine tools. It is used not only for milling of flat and irregular shaped surfaces but also for gear and thread cutting, boring, reaming and slotting operations. Its versatility makes it one of the most important machine tools in machine workshop (Uara, et al, 1969).

In order to meet many different industrial requirements milling machines are made in a wide variety of types and sizes. They are classified under the following headings (1) Manufacturing types
(2) Special type (3) Knee and column types.

Manufacturing type milling machines are used primarily for quality production of identical parts. This type of machine may be either semi-automatic or fully and is of simple but sturdy constructions. Fixtures clamped to the table hold the workpiece for a variety of milling operation, depending on the type of cutter and work approach, the rapid movement during the non cutting part of operator is required only to load and unload the machine and start the automatic cycle, controlled by cams and present trip dogs.

Some of the more common manufacturing type milling machine, according to Adejuyigbe (1997) are:

(1) The plain manufacturing type , which has one horizontal spindle and one headstock. This machine is some times equipped with a reciprocating table cycle, which permits feeding and rapid traversing in both directions on this type of machine reciprocal milling is possible. Two identical fixture may be mounted on opposite sides of the table. While work is being machined at one end, a new piece is being loaded into the fixture at the other end.

(2) The duplex manufacturing type is similar to the plain type, except that it has two horizontal spindles mounted in two independently adjustable headstocks. It can be used to perform two identical or two different milling operations on one or more pieces at the same time.

(3) The small plain automatic knee and column type is similar to the plain horizontal mill. It is used for milling small or medium size parts in different quantities. The table is

operated by power and controlled automatically by trip dogs mounted on the front of the table.

(4) The multi type automatic fixed bed milling machine consists of a group of small size manufacturing milling machine units mounted on one base for producing small parts at a high rate of speed.

(5) The small plain automatic fixed bed type has complete automatic cycle control of the table by a selector and trip dogs. The machine may also be equipped with automatic rise and fall of the spindle carrier permitting quick and economical milling of surface on different levels or between obstructions.

(6) The tracer controlled milling machine has a hydraulic or electrical circuit designed to automatically control the relative position of the cutter and the workpiece by a trace stylus riding on a cam, template or model.

(7) This machine is used for efficient, accurate reproduction of curved or irregular surface, if the tracer is disengaged it can be used for standard milling operation.

SPECIAL – TYPE MILLING MACHINE:- these machines are designed for individual milling operations and are used for only one particular job. They may be completely automatic and are used for production purpose when hundreds or thousands of similar pieces are to be machined.

Knee and column type milling machines in the group are categorized into three group (1) plain horizontal milling machine
(2) Universal horizontal milling machine (3) Vertical milling machines. The universal horizontal milling machines is essential for advanced machine shop work, and the difference between this machine and the plain horizontal mill is that it has the addition of a table swivel housing between the table and the saddle. This housing permits the table to be swiveled 45^0 in either direction in a horizontal plan for such operations as the milling of helical grooves in twist drills, milling cutters and gears. The formulae for calculating the revolution per minute (r.p.m.)in milling machine given as:-

$$N = \frac{100 \times CS}{\pi \times D}$$

where n = revolution per minute.

CS = cutting speed in m/min.

D = diameter of bar in mm.

2.3.3 DRILLING MACHINE

One of the first mechanical devices developed prehistorically was a drill to bore holes in various materials (Uara, et al, 1969). A bowstring was wrapped around on arrow and then rapidly sawed back and forth.

This process not only produced fire but it also wore a hole in the wood. The principle of a rotating tool making a hole in various materials is the one on which all drill presses operates, (Uara et al, 1969).

The drilling machine or drill press is essential in any metal working shop, (Uara, et al, 1969). According to Adejuyigbe (1997), a drilling machine consists of a spindle (which tone the drill and which can be advanced into the work, either automatically or by hand) and a work table which holds the workpiece rightly in position as metal. However, operations such as tapping, reaming, counterboring, countersinking boring and spot-facing can also be performed.

A wide variety of drill presses are available, ranging from the simple sensitive drill to the highly complex automatic and numerically controlled machines.

Sensitive drill press is the simplest type of drilling machine. This type of machine has only a hand feed mechanism that enables the operator to "feel" how the drill is cutting and to control the down feed pressure accordingly. Sensitive drill press are generally light, high-speed machine and are manufactured bench and floor models; (Adejuyigbe 1997).

Upright drilling machine is similar to the sensitive – type drill except that it is large and heavier. The basic differences are (1) it is equipped with a gearbox to provide a greater variety of speeds. (2) The spindle may be advanced by three methods, (a) manually with a hand lever (b) Manually with a handwheel (c) automatically by the feed mechanism (3) The table may be raised or lowered by means of a table raising mechanism. (4) Same models are equipped with a reservoir in the base for the storage of coolant, (Uara, et al, 1969).

Gland drills are drilling machines equipped with more than one work or drilling head mounted on a single job. For example, a drill, reamer and tap may be mounted on successive spindle so that the work may be advanced quickly from one operation of the other, (Uara, et al, 1969).

For high-speed production work, a number of spindles may be mounted on a single head. This multi spindle head may incorporate 20 or more spindle on a single head driven by a drilling machine spindle. Several heads equipped with multi spindle attachments may be combined and controlled automatically to drill as many as 100 holes in a single operation, (Uara, et al, 1969).

Radial drilling machine sometimes called a radial arm drill, has been developed primarily for the handling of large workpiece that is possible on upright machines.

The numerically controlled drilling machine is a relatively new advancement in production drilling. The spindle and table movements are controlled electronically by means of a punched tape. A tape reader decodes the information and passes, it on to the machine tool. Here the table and work is positioned as required and the cutting tool needed to perform the operation is indexed, (Uara, et al, 1969).

After the speed and feed of the cutting tool have been set automatically the machine starts and the drill or cutting tool enters the workpiece. When it has cut to the proper depth, the cutting tool will retract and another operation such as tapping or reaming may be performed. When the work cycle is complete another workpiece is positioned under the spindle and the cycle repeated automatically with such precision that the hole positions on every workpiece will be accurate to witching $\pm$ 0.001m, (0.025mm), (Uara, et al, 1969).

Calculation of cutting speed is given as :-

$$CS = \frac{\pi DN}{1000}$$

where

CS = cutting speed (Meters/min)

N = spindle speed (rev/min)

D = diameter.

$$\pi = \frac{22}{7}$$

to calculate machining time for drilling

$$TM = \frac{Lt}{N \times Sm} \text{ mm}, \quad \text{where, r.p.m. is known.}$$

$$TM = \frac{Lt}{SM \times CS \times 1000} \text{ mm, where, r.p.m. is not known.}$$

2.3.4 GRINDING MACHINE

Grinding is an important part of the machine trade. Improved grinding machine construction has permitted the production of parts to extremely fine tolerance with improved surface finish and accuracy.

Because of the dimensional accuracy by grinding, interchangeable manufacture has becomes common place in most industries, grinding has also, in many cases, eliminated the need for conventional machining, with the development of new abrasive and better machines. (Uara, et al, 1969). The rough part is often finished in one grinding operation, thus eliminating the need for other machining processes, (Uara, et al, 1969).

The role of grinding machines has changed over the years, initially they were required on a hardened work and for trying hardened parts which had been distorted by heat-treatment, but today, grinding is applied extensively to the production of unhardened parts where high accuracy and surface finish are required. In many cases modern grinding machines permits the manufacture of intricate parts faster and more accurately then other machining operations.

In a grinding process the workpiece is brought into contact with a revolving grinding wheel. Each small abrasive grain on the periphery of the wheel acts as on individual cutting tool and removed a chip on metal.

As the abrasive grains become dull, the pressure and treatment created the dull face to break away, leaving new sharp cutting edges.

Regardless of the grinding method used, whether it is cylindrical, centralize or surface grinding, the process is the same and certain general rule will apply in all cases. There are different types of grinding machines in use in machining operations (1) Off hard grinding machines under which we have, (a) Bench models (b) Pedestal (or floor) models. (2) Surface grinding machine where we have (a) horizontal spindle type (b) vertical spindle type (3) cylindrical grinding machine (4) Internal-grinding machines. (Adejuyigbe, 1997).

OFF–HAND GRINDING MACHINE: Under this there are two main types.

(a) Bench grinding machines: - This is mounted directly on the bench in the machine shop. It is provided with two grinding wheels. The wheel is clamped between dished steel flange line with soft thick paper washer, which ensure even pressure. The wheels are provided with guards for safety. Rest is provided to allow for tool rest when grinding, thereby promoting correct and even grinding. Bench types grinding machines are used for sharpening small tools (Uara, et al, 1969).

(b) **Pedestal Grinding Machine:-** The pedestal – grinding machine is sometime called floor type grinding machine is like the bench type.

The major difference is in the mounting of the machine. It is provided with a base called pedestal, which enables it to be mounted directly to the floor of the machine shop. It is used for general hand grinding of tools.

(c) **Surface Grinding Machine**:- There are four distinct type of surface grinding machines all of which provide a means of holding the metal and bringing it into contact with the grinding wheel.

(a) The horizontal spindle grinder with a reciprocating table, is probably the most common surface grinder for tool room work. The work is reciprocated under the grinding wheel, which is fed down to provide the desired depth of cut. Feed is obtained by a transverse movement of the table at the end of each stroke.

(b) The horizontal spindle grinder with a rotary table is often found in tool rooms for the grinding of flat circular parts. The surface pattern produces makes it particularly suitable for grinding parts, which must rotate in contact with each other. The work is held on the magnetic chuck of a rotating table and passed under its grinding wheel. Feed is obtained by the transverse movement of the wheel and it is always in contact with the workpiece.

(c) The vertical spindle with a rotary table produces a finished surface by grinding with the face of the wheel rather than the periphery, as in horizontal spindle machines. It is probably the most efficient and accurate form of grinder for the production of flat surface.

(d) The vertical spindle grinder with a reciprocating table grinds on the face of the wheel while the work is moved back and forth under the wheel and the work, this machine is capable of heavy cuts. Materials up to ½ in. (12.7mm) thick may be removed in one pass on larger machines of this type. Provision is made on most of these grinders to tilt the wheel head a few degree from the vertical. This permits greater pressure where the rim of the wheel makes contact with the workpiece and result in faster metal removal. When the wheel head is vertical and grinding is done on the face of the wheel, the surface pattern produced is a series of uniform interesting area. If the wheel head is fitted, it produces a semi-circular pattern.

(3) <u>Cylinder Grinding Machines</u>:- They are used for grinding external cylindrical tapered, end-face or formed surface. The cylindrical grinding machines are plain like the universal grinding machines (Knar, et al, 1969). The universal grinding machine is supplied with various ranges of accessories capable of performing greater job plain type. It can also be adapted for internal grinding.

The two machines have the same fundamental design. The cylindrical grinding machine is specified by the maximum diameters and length of workpiece that can be accommodated. The cylindrical grinding machine is used for mass, lot and piece production automatic cycle. (Knar, et al, 1969).

The plain machine is more robust in construction but it is more restricted in its range of operation, It is capable of taking heavier cut than the universal type without the loss of quality. Due to vibration many operations can be carried out using the two machines such as plain cylindrical grinding taper work and plunge grinding.

The cylindrical centreless grinding machine involves the use of two wheels, turning on almost parallel axis as the name implies, It does not make use of any centre points for it operations. The work is held against the face of the grinding wheel by the combination of the supporting rest, which the work rests upon, and the control wheel.

(4) Internal Grinding Machines: The is the grinding of internal surface or cylindrical or tapered jobs. The faces of the workplace can also be ground to the required standard in these machines. Both the universal, general purpose and special internal grinding can be performed more economically and rapidly on a wide range of hole and sizes. (Knar, et al, 1969).

Internal grinding is mostly used method for finishing holes, the reason can be attributed to its accuracy, satisfactory surface, and economy, reaming has fives way to its accuracy, satisfactory surface, and economy, reaming machines. Each is designed to meet the specific need of individual. According to Knar, et al, (1969), Internal grinding can therefore be classified into these major groups.

(a) The work rotating type:- This type makes use of three or four-jaw chuck, a faceplate, or fixture to hold and turn the work.

(b) The planetary grinder type:- The workpiece is reciprocated to obtain transverse motion, but is not rotated. In this type, the eccentric travel of the wheel spindle generates the correct size holes.

(c) The centreless internal grinding machines. This type uses a set of rollers to hold and turn the work. The work is held by using chuck, faceplate, or fixture in the headstock. The wheelhead is mounted differently on different machines for internal grinding. There is one type that has thew wheelhead mounted on a cross-slide and another on a swinging arm suspended from on overhead crossbar.

It is noteworthy that in any of the designs the wheelhead can be transverse parallel to the way so as to finish the ones used in the external or other conventional grinding machines. The range is from 10-12 inches (or 25mm to 30mm) in diameter. The speed of the internal grinding machine is very high because of the smaller size of the wheel.

Fomulae for calculating the peripheral speed is given as:-

$$PS = \frac{\pi \times d \times n}{1000 \times 60}$$

where,

PS = peripheral speed of the grinding wheel mm/s.

d = diameter of the grinding wheel in mm.

n = revolution per min. of the grinding wheel.

2.4 MACHINE SHOP

The machine tool industry is divided into several different categories such as the general machine shop, the tool room, and the production shop. (Templer, 1978).

A general machine shop contains a number of standard machine tools that are basic to the production of a variety of metal components, operations such as turning, boring, threading, drilling, reaming, sawing, milling, filling etc.

2.5 JIGS AND FIXTURE

In modern engineering, there is no application of jig in mass production It is like looking for needle in a haystack. Dutton (1960) offered justification for the use of jig when he started that "A Craftsman or Student may be prevented from completing piece of creative work merely because some of the necessary operations involved are beyond his skill and that it will be said that it would be desirable if jig can be designed to overcome production obstacle, most especially when the project is in an unfinished state. During the past ten decades many changes have been witnessed in sphere of production engineering. Teachers have become more adventurous in their approach to the work by giving their students the opportunity of constructing such exciting and constructional engineering, casting and foundry work enamellings and etching in metal work to an extent that would have been though impossible to achieve years ago. Now, it's considered that the most important aspect of education through craft is that the work should be develop along creative lines. So that students are able to solve problems of design construction by themselves.

According to Clenister (1955), Jigs are designed to ease certain difficulties in craft operations, they are flexible enough in use to be adapted in a variety of ways to suit the production and are not as substitute for skills. However, some experts in the field of engineering production disapprove the use of Jigs with a view that the use of Jigs underlines the skills of the Production Engineer. It is seen as a substitute for skill and means of institutionalizing laziness on the part of engineers.

They concluded that the uses of Jigs are unprofessional. However, in spite of that sound argument, it is still interesting to learn of the decision of vast majority of Production Engineers who believe that the use of jigs enhances production and does not in any way replace skills which are normally taught in schools. Jigs wide the scope of operation and reduce difficulty of operational skill. It also allow for flexibility and adaptability in various ways. The Institution of Production Engineer Journal (1994) production data memoranda. Jigs and Fixture Design gives a selection of Jigs found in current usage in British industry.

Some of the design covers non-standard and commercially available standard units with emphasis on various clamping techniques employed.

There are different types of drilling Jigs, principal among which are;

(a) Simple built-up jigs

(b) Local jigs with angular base

(c) jig milled from solid

(d) jig for multi-drill

(e) Trunnion jig

(f) Indexing jig

(g) Air operated jig

(h) Box-type jig

(i) Latch-jig

(j) Pot-type jig

2.6 DESCRIPTIONS

(i) **Simple Built-Up:** It is a standard, which provides hand clamping of the component together a fair measure of accuracy of location. In connection with the location on important principle of design is exemplified. The holes in this component are dimensional on the drawing from the outer face of the angles section; therefore this face of the components is clamped against the Jig.

(ii) **Local Jig With Angular Base:**. Location is provided by registering in the Jig a pin locating in a previously drilled hole. The angularity of the hole is obtained by supporting the component on the angular base by two steps pins, which act as a Vee-block.

(iii) **Jig Milled From Solid:** It is for a small component, the Jig may often be milled from solid, it is necessary on this Jig to locate from the inner faces of the component and to this end one of the two clamping screws is inserted at an angle and tends to press the components against both faces of the Jig. The other clamped screw should be tightened after the angular one.

(iv) **Sighting Plate Jig:** A very useful method of locating a component in a Jig by the use of profile or sighting place. The usual arrangement is to have a thin steel plate interposed between the drill plate and the component. The plate is made to the same profile as the component which unable it to be outside the contour of component.

(v) **Pot-Type Jig:** It is more convenient for a small circular component. The jig proper is the bush place, which also provide location spigot and could at a point be used without the pot if a cheap Jig is required. The pot is provided to give accurate support when drilling.

(vi) **Latch Jig:** A latched type for drilling two oil holes diametrically opposite between the teeth of a level gear wheel the Latch is located by means of thumb screw and it may be noted that the clamping in the latch to which the screw locks, is drilled slightly higher than the centre line of the locking screw thereby causing the latch to be forced down on the stop pin.

(vii) **Box Type:** Probably some of the most awkward component as regards drillings are endless variety of small bracket which is encountered in most branches of engineering often required drilling to more planes. It is required to clamp small square components into the angle of the jig to obtain accurate location from two faces. This is achieved by drilling clamp piece.

(viii) **Jig For Multi Drill:** A drill jig with a Multi-drilling machine, the base is bolted to the machine table and carries two spigots to locate the component. Due to the weight of the component and the fact that the hole being drilled are quite small-the components is not clamped, but rests on the base by its own weight.

(ix) **Trunning Jig:** Another methods of handling large components for drilling is by the use of turning types jigs. The jigs proper carries trunnion at its ends, which rotate in cast bearing brackets and the two brackets are mounted on two lengths of standard channel iron.

(x) **Indexing Jig:** This is used for drilling three holes in machine seating on the component also two pairs of bolt holes, each pair at an angle to the centre line and two pairs of blind holes on the sides.

(xi) **Air Operated Jig:** Other way of handing a heavy components such as this is when twenty-four holes have to be drilled inside a component, which is too heavy to be directly into its position in the drill jig. It is necessary therefore to provide arrangement to assist in the handling of this piece.

DRILL JIG TYPES

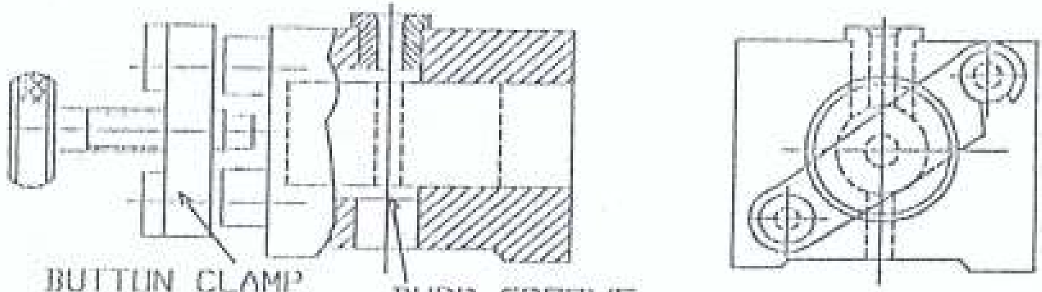


Fig 2.6(A) Solid Jig

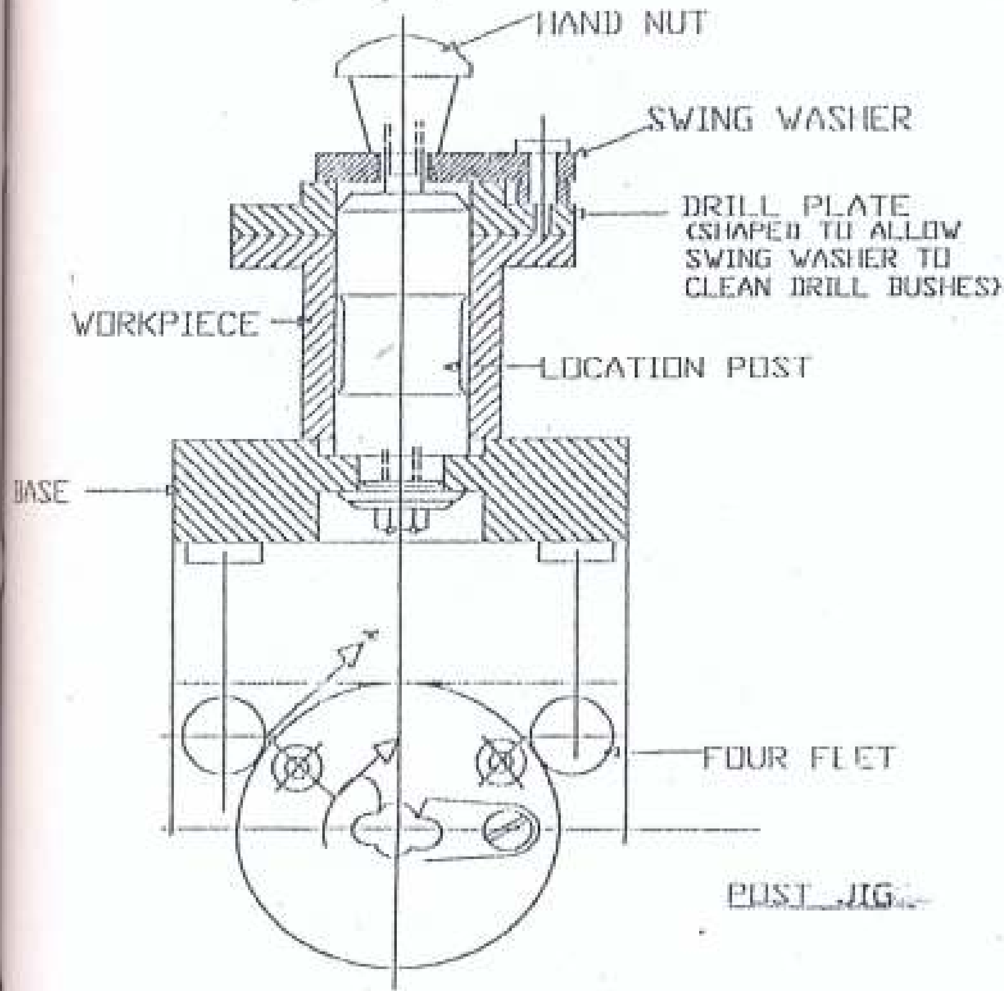


Fig-2.6(B): Post Jig
Source: Kempster (1980)

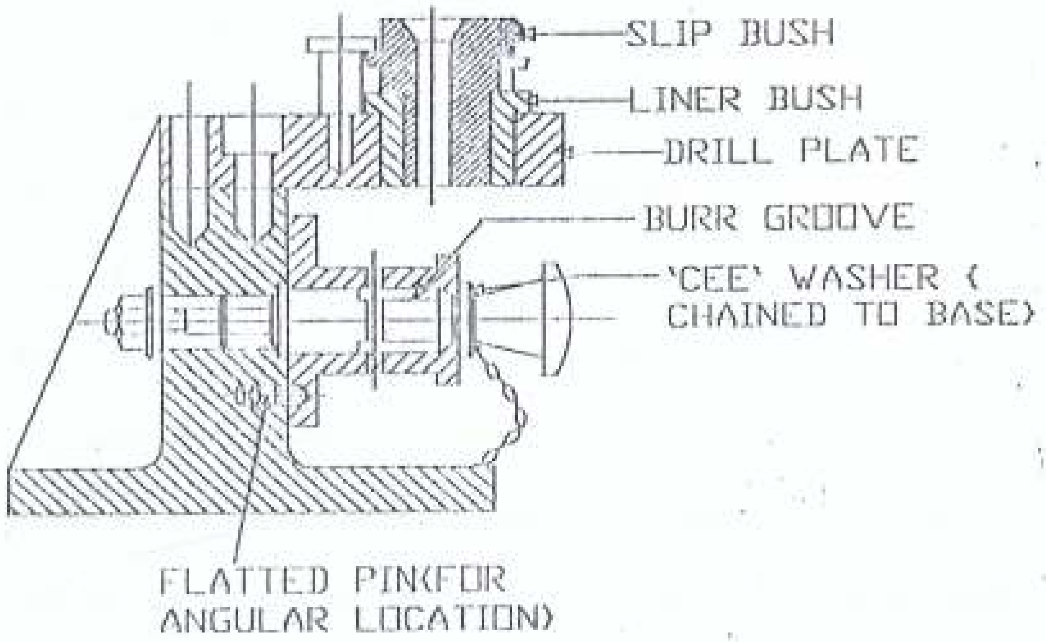


Fig.2.6 (C) Post Jig Side View

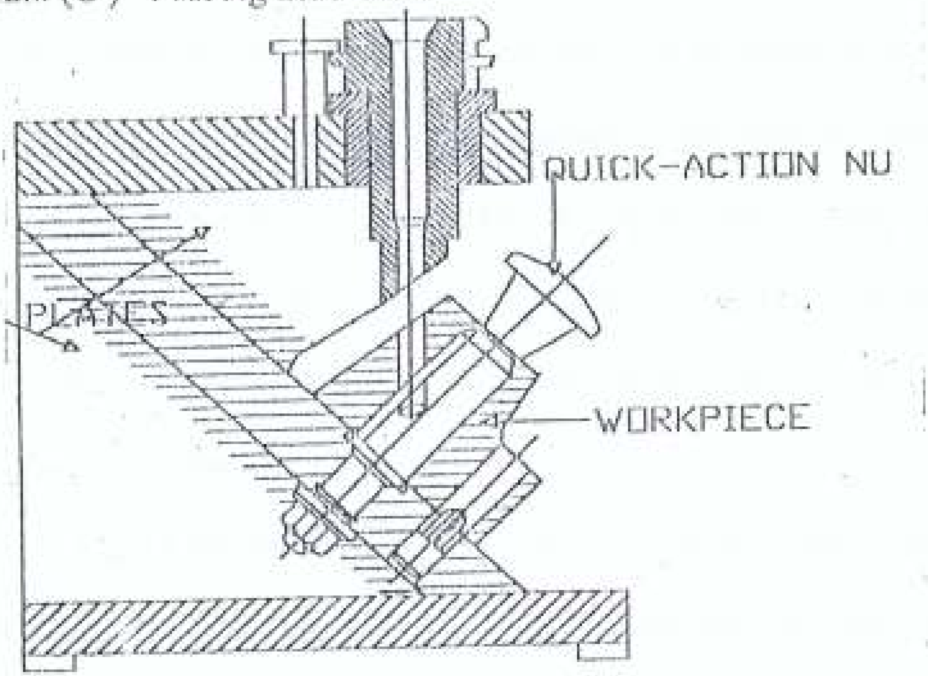


Fig 2.6 (D): Angular Post Jig

Source : Kempster (1980)

2.7 DRILL JIG TYPES

Fig 2.7(a) shows a typical plate jig, which is sighted or located and clamped directly on the work piece and bolted in position. The channel jig shown in fig 2.7 (b) is a slightly more elaborate jig made from channel section. The local jig is a plate jig that is bolted to the face to be machined; the work piece is located and clamped to a base that is suitable for a number of operation.

Fig 2.7 (c) shows a solid jig that is button clamp, and bore groves of steel, in example shown, the work piece is clamped by a button clamp, and burr groves are provided so that work piece can be easily be removed (two grooves are required because one bore will be produced at the point of drill entry and second bore so produce at the point of drill break-through). The post jig shown in fig 2.7 (d) is used to locate the work piece from its bore by means of a post, which is also used to locate the drill plate. The swing washer enables the drill plate to be removed without removing the hand nut.

Fig 2.7 (e) shows an angular post jig of welded construction. The drill bush is extended and shaped to prevent drill run and yet allow removal of the work piece. The clamping nut is of the quick action type because the smallness of the work piece here demands that the nut be removed when the work piece removed.

Fig 2.7 (f) illustrates a point jig in which the work piece is located from its outside in a bush, and a drill bush is located on a post; the work piece is supported at the point of drilling and swarf clearances are provided, the drill plate is located to line up with the swarf clearance grooves.

The pot jig shown in figure 2.7 (g) is a similar type but the work is only placed in the pot to support the flange and the drill plate is located directly from the work piece bore.

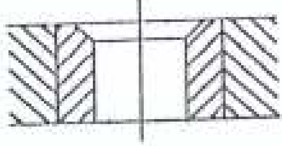
Figure 2.7 (h) show the five detail parts, which together make up a central handle assembly. This consists of a handle (Item 2), which may be moved to either side of its normal vertical position about a pivot stud (Item 3), which passes through the central hole in the body (Item 1). The pivot stud is secured at the back f the body by a collar (Item 4) through which is passed a 2mm pin (Item 5). The handle may be locked in any position by a screw (not shown), which passes through the slot in the body.

The jig is used to hold a special bolt (not shown) during a machining operation in which a square head is milled on the end of the bolt.

The component to be machined is gripped in the covet, which is firmly held in the body of the jig. The body is secured to the base means of the clamping ring but is free to rotate into one of four possible in which it can be locked by a pin (not shown) which engages in mating holes drilled in the body and clamping ring.

This present work, will be limited to a localized special drilling jig-a work-holding device for a drilling T-bracket component, which has to be drilled along two different planes.

Fig. 2.7(a) Fig. 2.7 (b)



HEADLESS DRILL BUSH

Fig. 2.7 (c)

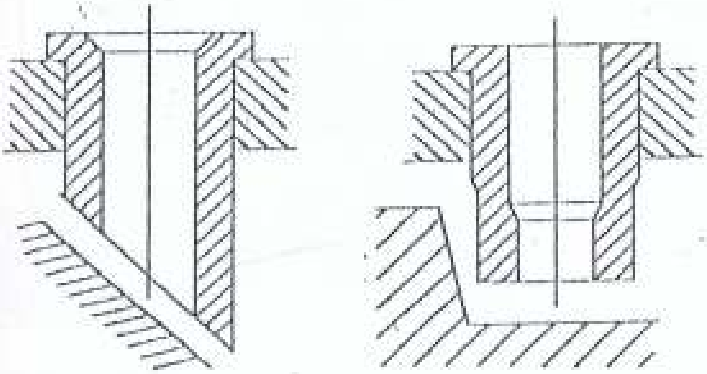


Fig. 2.7 (d): Shaped and Extended Drill Bush

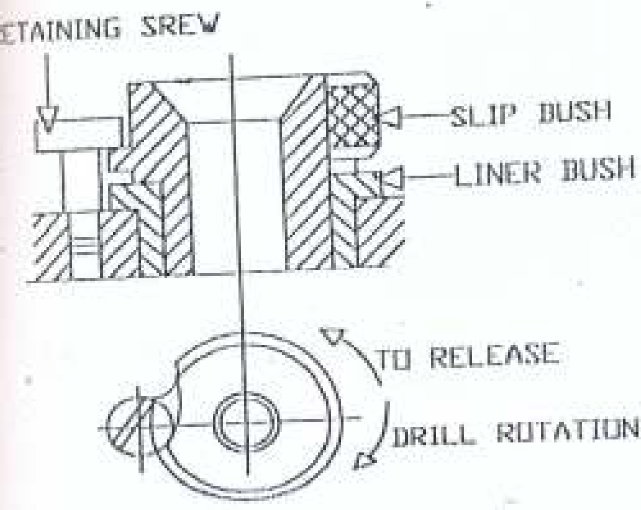


Fig. 2.7 (e) Slip Bush Arrangement

Source: Dutton, S.P (1960)

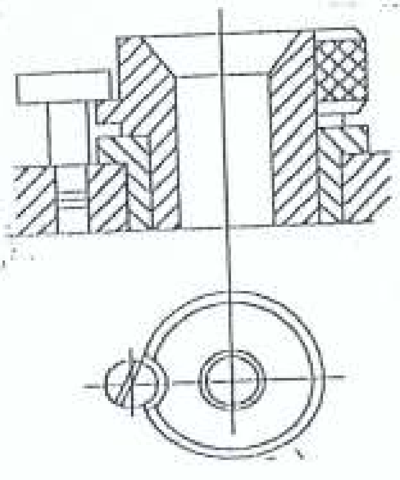


Fig.2.7 (f) Renewable Bush Arrangement

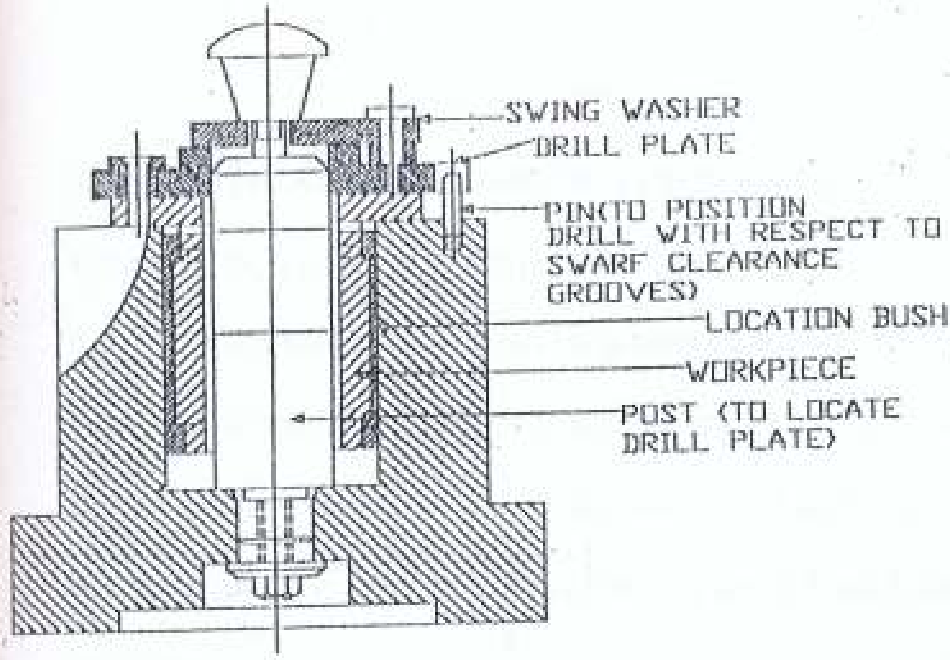


Fig. 2.7 (G): Pot Jig
Source: Dutton, S.P (1960)

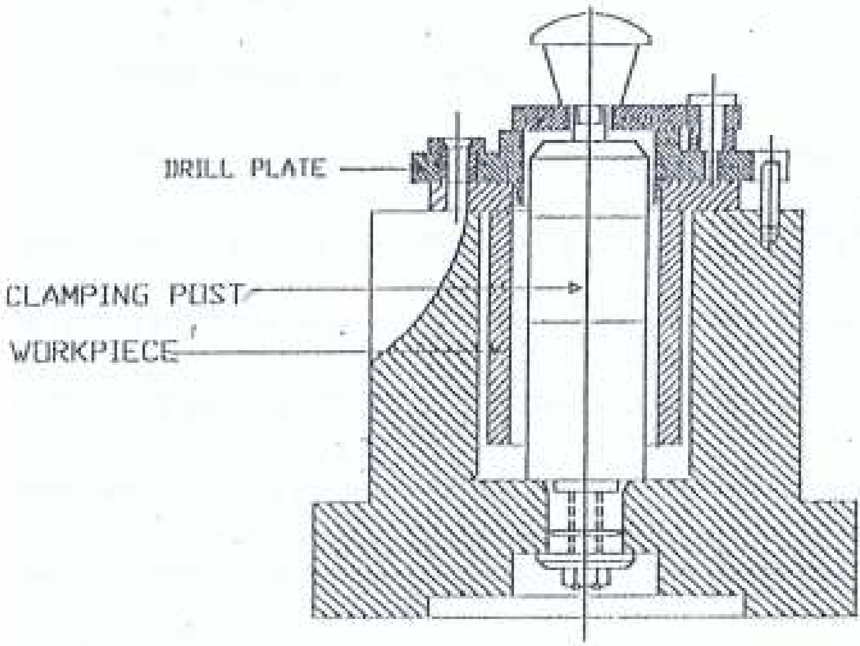


Fig. 2.7(H): General Handle Assembly
Source: Dutton, S.P (1960)

CHAPTER THREE

THEORETICAL BACKGROUND FOR DESIGN AND CONSTRUCTION OF A DRILLING JIG

3.1 PRINCIPLES FOR DESIGN OF A DRILLING JIG

While the jig designer is likely to meet a problem on almost every component he handles, the underling principles of jig design will found to be similar in every branches of engineering and it is advisable that these principles are understood and their values appreciated before work commences on actual design.

3.1.1 REDUCTION OF IDLE TIME

As a machine tool is only making profit, while the tool are actually cutting metal, it is of interest knowing the number of machined installed to put a mark on a piece of paper representing each machine actually cutting. Those who have not already done this will be astonished at the very low percentage of machine actual cutting. Those who have not already done this will be astonished at the very low percentage of machine making chips. It should therefore, be the aim of the jig designer to arrange that loading times are as short as possible.

3.1.2 RIGIDITY

Ensure that jigs are rigid enough. The possibilities on some jobs are never realized through this fault.

3.1.3 CLEARANCE BETWEEN JIG AND COMPONENTS

Remember also to allow adequate clearance between the jig and the component because variations from the dimension in the component drawing may be expected when they commence the works in qualities. Similarly, jig casting may differ from the drawing dimensions.

3.1.4 CLEANING

Quite a large proportion of the jigs which can be seen in any works are so many swarf traps, and it is surprising that the amount of time which has to be wasted by operators in cleaning.

3.1.5 LOCATING POINTS

Make sure that the locating point are clearly defined and are not such that are likely to hold swarf swept from adjacent positions.

3.1.6 EASY LOADING INTO THE JIG

Do not expect operations to be jugglers. Arrange that the component can be easily loaded into the jig. Consider the effort required and design to reduce it.

3.1.7 SIGHTING FACES

In the case of the jig where there are sighting faces against which parts of the components being machined must for location purposes be positioned to give the operator an opportunity of being able to see the faces easily without reckling his neck.

3.1.8 LOCATING PINS

A useful tip on subsequent operations jigs, particularly when machining heavy component is to provide after the component is roughly located in positioning against adjustable screw or by other means.

3.1.9 COOLANT TO THE CUTTING EDGES

Make sure that the adequate arrangements are made for the supply of coolant to the cutting edges, so that at the same time as the cutters are cooled. This swarf is swept clear. This should be watched properly.

3.1.10. DESIGN DRAWINGS

If the design drawing showing the components part in its relative position in an assembled unit is not available. The jig designer should obtain this information in order that the best location points for machining can be determined.

3.1.11 CLEARANCE

Provide clearance of every jig, not only for the burrs thrown up in the previous operations but also for those made by the operation being tooled.

3.1.12_**SPANNERS:** make the jig as self contain as possible, avoid the use of loose spanner, but where this is unavoidable a few size as possible, so that the operator will not have to search for the correct spanner.

1.13 HANDLES OR HOOKS

If part of the jig are to be moved or lifted either during machining at other times provide handle or hook so necessary for this purposes

.14 MAKE SURE THAT COMPONENT WILL ENTER JIG

Hundred of jigs are finished before it is found that component will t enter the jig. This mistake ca easily be made on the drawing board d designer should always be watchful for the trap.

1.15. CLAMPING

Clamping should always be arrange directly above the point pporting the works. If this rule is disregarded it will result in springing the work, causing it to be machined in a distorted position, resulting in ccuracies after the wok is removed from the jig and being released mping strains.

.16. ARMS OF ABUTMENTS

Make your jig as convenience as possible for the operator and ere heavy component have to be accommodated, and the weight luced while the operator gives the whole of his attention to other end of component.

3.1.17. HOW COMPONENT SHOULD BE INJECTED

Wherever possible particularly on heavy component, arrange jig so that when unclamping, the components is either partially or completely ejected, so saving the operator the need for hammering or struggling with the piece.

3.1.18 LOOSE PARTS

For manufacturing purposes, it is necessary to have a loose part holding accurately.

3.1.19 FOOL PROOFING

This means designing a jig or any techniques required for production in such a manner that is impossible for any operator in insert either piece of cutting tools in any position other than correct one.

3.2 DESIGN ANALYSIS, MATERIALS AND METHODS

3.2.1 MACHINE SHOP PROCESS PLANNING

The objective of planning is to determine the most economical method of producing a particular component; the equipment that is available must be taken into account, and so the method selected may need to be a compromise.

Planning is usually carried out before machining commence so that;

(1) The raw materials dimensions can be settled

(2) The machined tool requirement can be assessed

(3) The jigs, fixture, tools and gauges can be designed and manufactured

(4) The labor requirement can be studied

(5) An accurate estimate of the time taken to machine the component can be established.

(6) The machining sequence will depend upon the size of the machine shop, and the class of labor and machine that are available. The amount of detail contained on the process sheet will be only small if the planning is for a tool room or similar machine shop, but if the planning is for a production shop the process will be very detailed. When the planning is for a production shop, drawing are often made showing the machining dimension for each operation; these drawing are used for the intermediate inspection operation and the master drawing only used for the final inspection.

3.2.2 CHOICE OF EQUIPMENT AND METHOD

Centre lathes are associated with small scale production, and with skilled machinists, parts produced on a centre lathe will not need to be finished by grinding unless the tolerance are extremely fine, or if the parts is to be hardened, and will need to be ground after wards to remove distortion due to the quenching will need to be finished by grinding unless the tolerance are coarse.

Universal milling machines are associated with tools room work, horizontal and vertical column and knee machines and fixed bed machines are associated with tool room work and internal and external grinding machines with production work.

Marking out for machining is only used for very small quantity but may be speeded up by the use of template jigs and fixture are used for large scale production.

Table 3.2.2: Showing Choice of Equipment and Method

TOOL ROOM	PRODUCTION SHOP
Casting and forging are marked out	Marking out only used for 'trial materials'
Work located by 'setting up' using a dial indicator.	'Work located in jigs and fixtures'.
Work held in a vice, clamped to machine table, in chuck or on stump by the machinist	Work located and held in special vice jaws in fixture or special collect etc.
Turning done on a centre lathe	Turning done on a capstan lathe or Turret.
Grinding done when tolerance are fine or after heat treatment	Extensive use of grinding because unless tolerance are wide other methods of machining by semi killed machinists will not produce the required accuracy.
Circular table used for many profiling operation.	Profile plates used extensively
Awkward shapes finished by filling	All shapes machines (if not 'as cast')

Although the method adopted for the production shop will be different from that of the tool room, the difference will be mainly be of detail and precise equipment. The fundamental themselves will not be very different, and the method used for production can be regarded as a variation to meet the particular requirement of production.

3.2.3 CLAMPING AND CLAMPING DEVICES

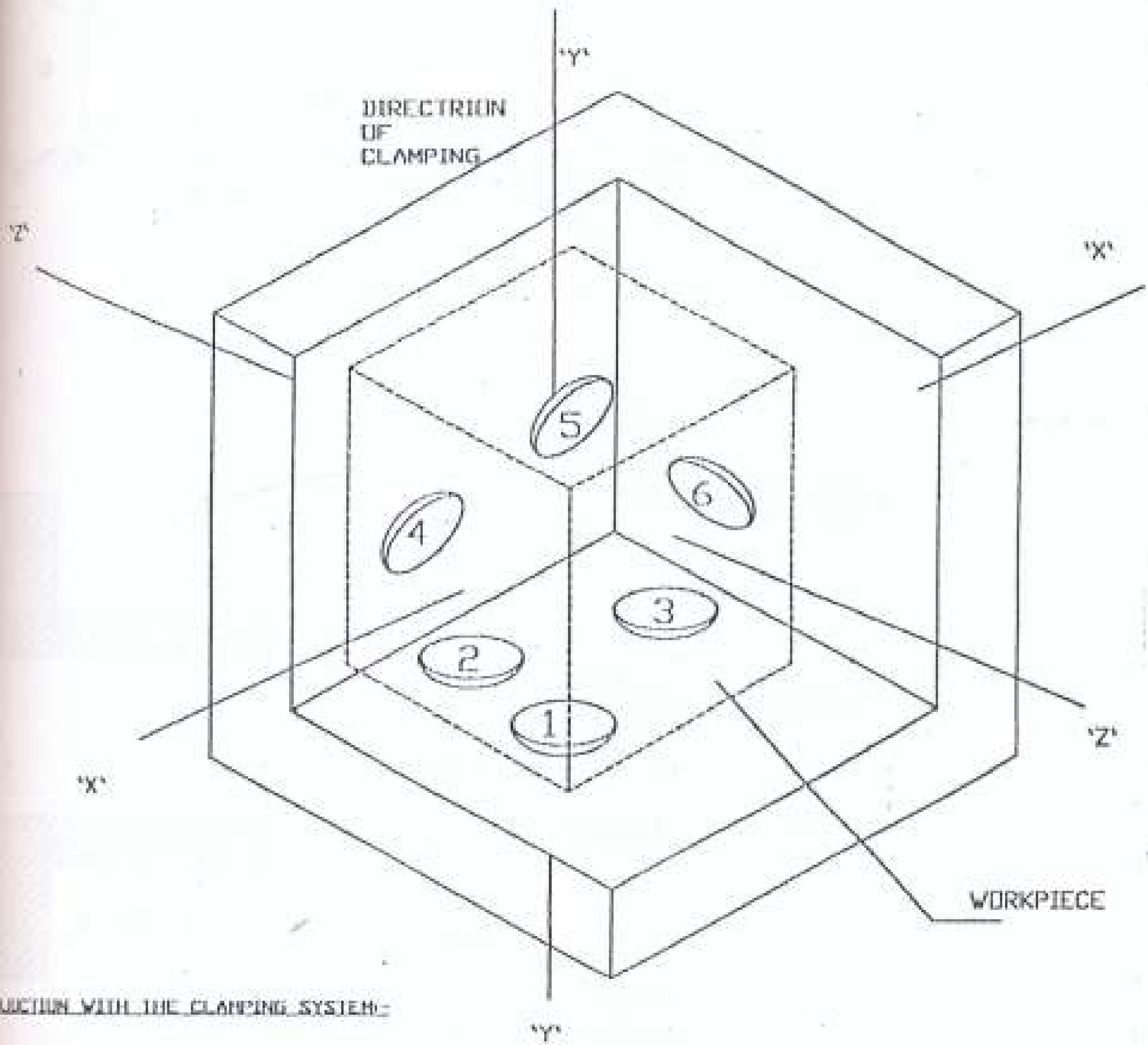
Requirement of the clamping systems: The clamping system must hold the work piece and the cutting forces without causing damage to it. Positions of the clamps: Clamping must be at thick sections of the work piece to avoid piece distortion due to clamping forces, suitable support must be introduced if the work piece is too thin to resist deformation by the clamping forces. The clamps must be positioned so that they can be operated easily and safely by the operator and where they can most effectively prevent movement of the work piece.

3.2.4 DESIGN OF CLAMPS

The clamp and clamping screw must be strong enough not to become distorted clamp, which can cause insecure clamping. The clamping system must produce the required force, this depends upon the operation to be performed. For example, when clamping for turning and milling, hexagonal nuts are usually used to secure the clamp, but hand nuts are usually sufficient when drilling and reaming, this is partly due to the extent of the cutting forces involve, and partly due to the direction and nature of these forces. Hand nuts are more convenient for the operator than hexagonal nuts because a spanner is not used to tighten them, the force that the operator is able to apply can often be controlled by the sized of the nut and so prevent damage to the work piece due to excessive clamping pressure.

3.2.5 CLAMPING DEVICES

The clamping devices illustrated represent the most common types, most of them are suitable for either hexagonal nut or hard not clamping.



DNJUCTION WITH THE CLAMPING SYSTEM:-

PADS 1,2&3 CONSTRAIN WORKPIECE ALONG 'Y-Y'
ABOUT 'Z-Z' AND ABOUT 'X-X'

PADS 4&5 CONSTRAIN WORKPIECE ALONG 'Z-Z'
AND ABOUT 'Y-Y'

PADS 6 CONSTRAIN WORKPIECE ALONG 'X-X'

E WORKPIECE IS THEREFORE FULLY CONSTRAINED

Fig. 3.3.1: Body that is free in space
Source: Dutton, S.P. (1960)

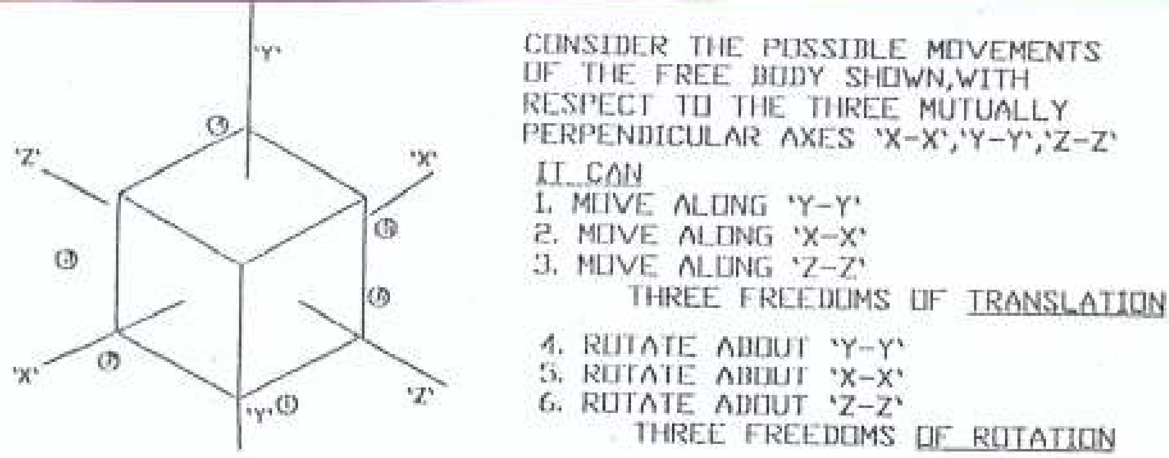


Fig.3.3.2(A) TOTAL:- SIX DEGREES OF FREEDOM

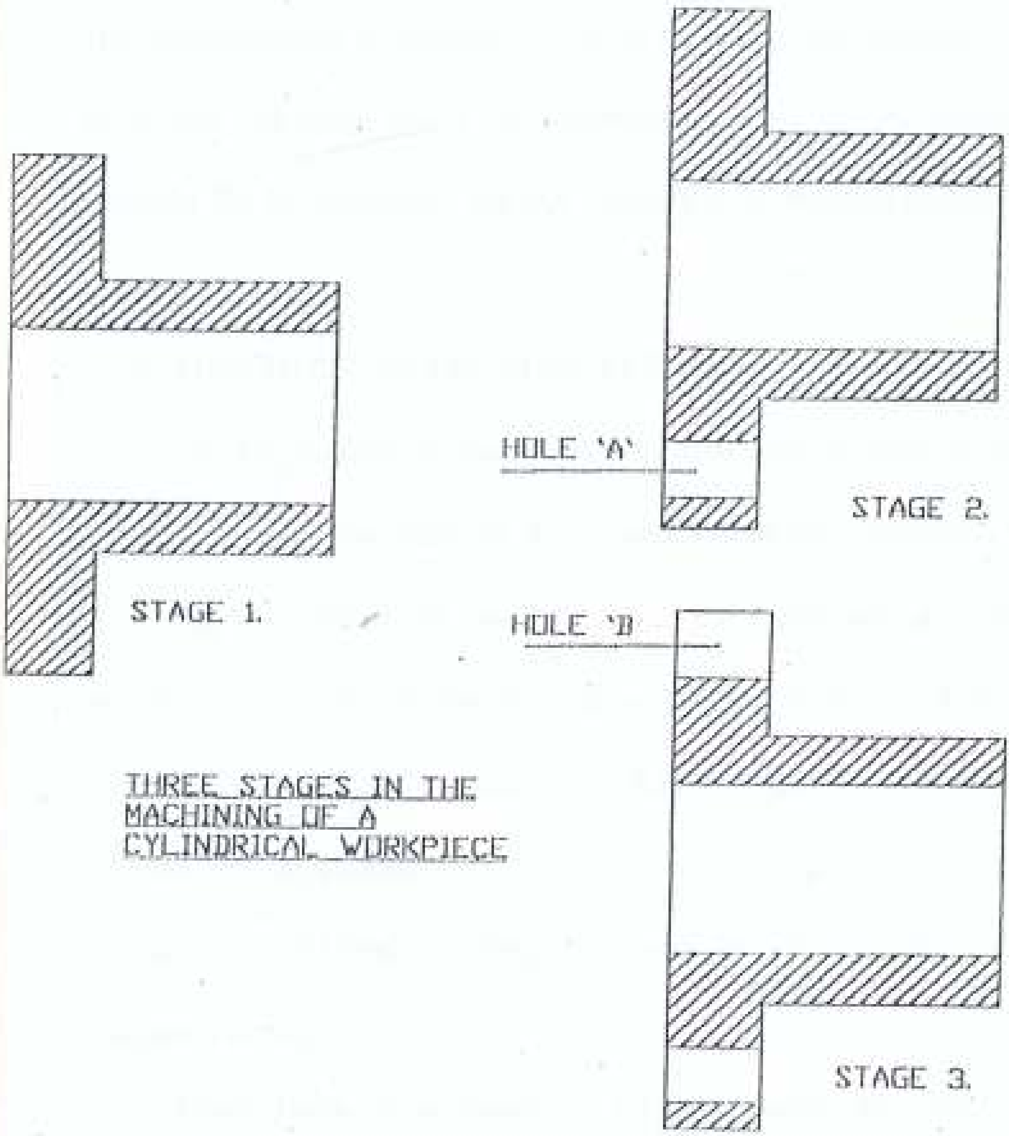


Fig. 3.3.2(B) Three Stages in the Machining of a Cylindrical Workpiece

Source : Kempster (1980)

3.3 LOCATOR AND LOCATION DEVICES

3.3.1 THE SIX DEGREES OF FREEDOM

Fig 3.3.1 illustrates a body that is free in space. A body in this condition has six degrees of freedom: three are freedoms of translation and three are freedom of rotation.

3.3.2 THE DUTY OF THE LOCATION SYSTEM

The location must in conjunction with the clamping system, completely constraint the work piece, or eliminate as many of the six degrees of freedom as is necessary for the operation to be completed with the required accuracy.

3.3.3 THE CHOICE OF LOCATION SYSTEM

The requirement of the location system depend upon the operation being performed and upon the work piece before the operation.

Fig 3.3.2 illustrate, three stages in the machining of a part, when this part is positioned for stage 2 machining it does not need to be controlled about the XX axis because it is symmetrical about that axis but it must be completely constrained when positioned for 3 machining because it is no longer symmetrical about the XX axis after hole '11' is machined at stage 2.

When there is a choice of location points the most effective location system must be selected. The cylinder is the best location shape because a cylinder locator is the least difficult to, produce, an because a single locator of this shape will eliminate five of the six degree of freedom. The ease loading and unloading the work piece must also be considered. This is illustrated in fig. 3.3.2 which shows two methods of machining a work piece, at operation 2 there is a choice between machining hole 'L' and hole 'H' as the work piece must be constrained when it is positioned for operation 3, two locators are necessary. If method 'A' is used, the locators for the operation 3, will be parallel and easily seen during loading, but if needed B is used, the locator that engages hole 'H' will not be easily and must be retractable so that the work pieces can be loaded. Method 'A' is obviously the better method.

3.3.4 REDUNDANT LOCATION

A redundant location is said to exist when two locator are attempting to constraint freedom from two location point, it must be avoided fig. 3.3.4 illustrates a location system in which the work piece is located over two pins, purpose of pin 2 is to prevent rotation about pin 1 but the system such that both pins are attempting to constrain the work piece along XX and so redundant location is introduced. This system is quite impractical because work piece would only be accepted by the location system if the work pieces are located from two concentric cylinders or between two fixed use locations.

3.3.5 THE SIX POINT LOCATION PRINCIPLES

The principles is illustrated in fig. 3.3.1 six pads and clamping system of location and clamping that produces the same effect is necessary to produce complete constraint.

3.4 LOCATORS

Locators are usually made separate from the fixture or jig body, and set are of direct or case hardened steel accurately ground to size (to give a slight clearance fit in the case of cylindrical location) and accurately positioned in the jig or fixture body

Locators may be classified as;

(a) Flat

(b) Cylindrical

(c) Conical

(d) Vee

They may be fixed or adjustable according to the circumstances.

3.4.1 TYPICAL LOCATORS THAT CONTROL THE WORK PIECE FROM FLAT SURFACES OR FROM ITS PROFILE BY MEANS OF PAD OR PINS

Fig. 3.4.1(a) shows simple support pad as used to position or support the work piece from a flat surface, it is an interference fit in the base, and good seating is ensured by chamfering its location hole and under cutting it under the head. If the work piece is to be supported from more that one face in a given plane, adjustment must be provided from the pads and pins at the additional faces fig 3.4.1(b) illustrates a simple adjustable pin, but more elaborate system are used for remote adjustment illustrate pins used for simple location from a profile.

3.4.2 GUIDING THE TOOLS (DRILL BUSHES)

The tools are guided means of holes in the drill plate which is located relative to the work piece. Although the tools may be guided directly that have an interference fit in the drill plate. Some of typical drill plate bushes are shown in figure 3.2.1 headed drill bushes controlled are used when the hole depth must be controlled; good seating of the bush in the hole in the drill plate ensured by chamfering the hole and undercutting the head of the bush. A generous head is provided and in order to prevent the swarf from becoming jammed between the drill plate and the work piece, the bush is either placed close to the work pieces so that the swarf can only escape through between it and the work piece. Headless drill bushes are used where the hole depth is not important special bushes are used for awkward work pieces. When a hole is to be drilled in a face that is some distance form the drill plate. When the drill bush is particularly long, its bore is received so that only the end shear the work piece controls the tool. When two or more tool are to cut on the same axis, as when drilling and the reaming a hole, slip bushes are used, a slip is used for each tool, and is located in a linear bush. The slip bush is prevented from rotating and running up the cutting tool by a retaining screw as shown when a large –diameter cutting tool is also used (as when spot facing the work piece) the tool is usually guided by the linear bush.

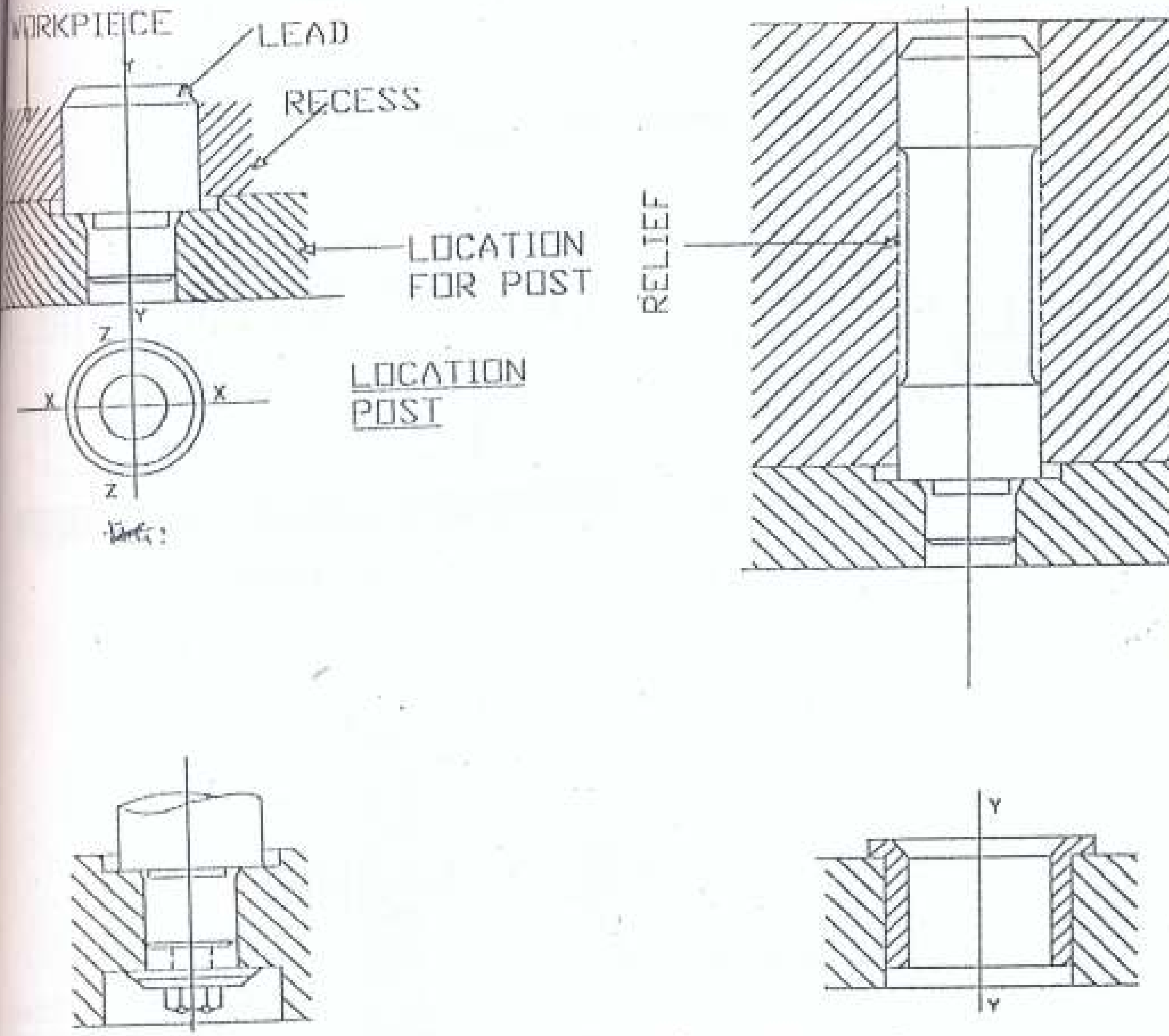


Fig. 3.4.1 (A): Showing simple support Pad

Fig..3.4.1(B): Showing Simple adjustable Pin

Source: Kenneth, P.O. (1992)

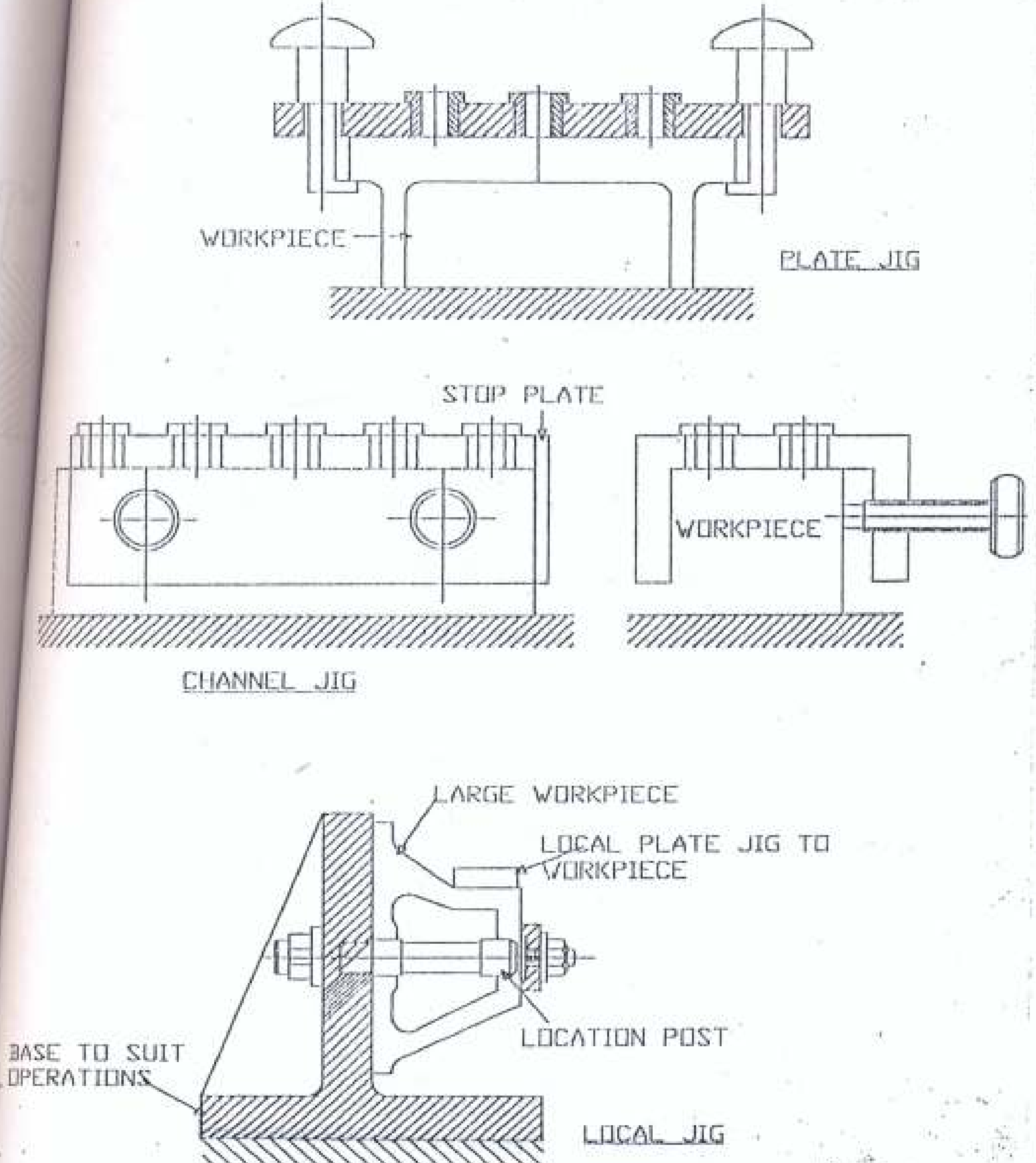


Fig. 3.4.2: Showing various types of Jig. .

Source: Kempster (1980)

3.5 JIGS AND FIXTURES DESIGN

3.5.1 CALCULATIONS ON THE DESIGN OF JIG AND FIXTURE

The calculations and explanations on the design of the drilling jig and fixtures was based on the six principles of jig and fixtures design thus; clamping, clearance, stability and rigidity, handling and other consideration termed general.

The material used for all the components on the jig mild steel (sty 80), since this is the most common available materials in Nigeria.

3.5.2 DETERMINATION ON LOCATION.

- An important aspect of design is concerned with the location of the component. Correct location influences the accuracy of the finished result, and particularly its positional relationship with other surfaces on the component.
- Unless location arrangement are reliable and consistent the jig will not produce uniform components and all the reasons for using the jig will be nolified.
- The principles of location accounts for six degree of freedom, which must be constrained against movement. The location of the job under review is done by the use of a post locator and is about 140mm long and 44mm wide and this is considered not to be a long locator, and it designed in such a way that it will be convenient for the user, and for the purpose of assemblage.

Clamping screw A is provided for this purpose of assemblage. The post locator is solid post, but there is a hole drilled at the middle of dimension shown, to allow the depth of the pre-set drill to be reached. There is another supporting screw B used to support the work during drilling.

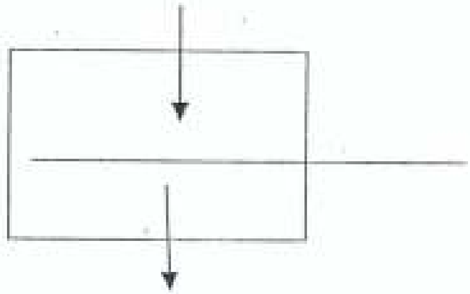
- The tolerance provided on the two locators are 10.01mm.
- The clearance between the job and the post locator is a push, sliding, neutral or transition for where are small amount of clearance or interference can be tolerated given fair ease of assembly and accurate location, it can easily be pushed into positioned or assembled by just hand pressure.
- The positioning of the top clamp which is the cover with the aid of screw A, and the main frame the jig, give a resistance to the cutting force of the drill.
- The clamp was designed in such a way that it is an integral part of the jig body.
- With the tolerance provided, the designs of the clamping use are easy to assembly and natural to use and removed.

3.5.3 CALCULATION ON CLAMPING USING POST LOCATOR, BOLTS, NUTS, AND SCREWS

The calculation for the screw a and supporting screw B and the bolt joint are considered under three cases thus;

Case A: The drill tends to turn the work piece when it is being worked upon.

NORMAL FORCE



Case A: The turning moment (torque) produced by the drill Mn = 981 N cm = 10 Nm.

The minimum torque on the work piece Mn min = 10 Nm.

The maximum torque on the work piece Mn max = 6 Mn min.

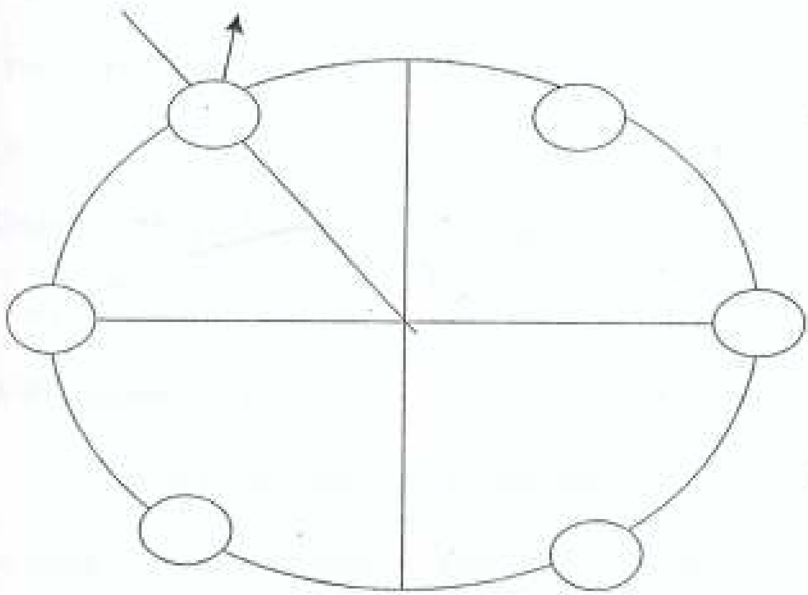
= 6 x 10 = 60 Mn.

That is when six spindles are working on the work piece at the same time.

Mn max = 80 Nm.

CASE B:

The equivalent tangential or shearing force F can be calculated as follows;



F_Q min r = Mn min

Where r = radius = D/2 = 88/2

= 44 mm and D = 88 mm

$\therefore F_Q$ min = Mn = 10 / 0.044 N

F_Q min = 227.3 N

= 227 N

The maximum tangential/shearing force.

F_Q max = 6 x F_R min = 6 x 227

F_Q max 1363.64 =1364 N

The frictional F_Q max $\geq$ F_Q max

$F_Q = F_R$ max =1364 N

The normal force V=Fr/u

Where u is the coefficient of friction.

The initial preload $F_R = F_R / \mu$

From figure 2 $\mu = 0.15$

F_Q 1364 /0.15 = 9093N

Therefore, the preload of the screw F_Q = 9093 N

CASE C:

With regards to Table 2:

A screw of strength class 5.6 and preload of 9093 N will have a diameter of 12 mm. Looking at Table 2 the 12 mm and hole that is drilled under static condition shall require 10 kN which is greater than 9.093 kN. This condition satisfied the condition give above thus;

Friction FQ max $\geq$ FQ max

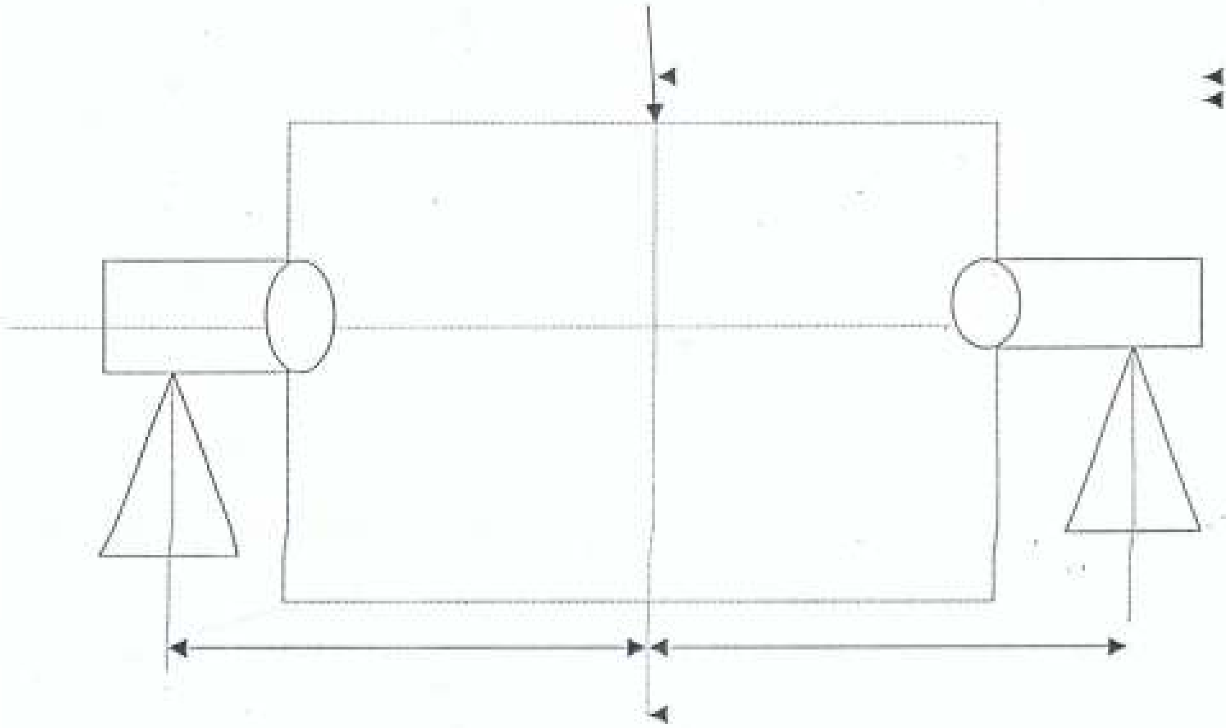
10 KN $\geq$ 9.093 kN

Chosen for this design is screw of diameter d = 16 mm.

In this case the equivalent preload Fr = 16 kN which is far above the required frictional force Fr = 9.093 kN

3.5.4 CALCULATION FOR SIDE DRILLING

The calculation for the side drilling is done considering the bending stress and compares it with allowable stress of the materials



NOT TO SCALE.

To calculate the following bending stress which must be lesser than allowable stress for the materials (mild steel st 60).

(j) Calculation of the forces in the support F_A

$$F_A = \frac{F_Q \times S2}{(S1 + S2)} = \frac{1963 \times 47}{(65 + 47)} = 823.34\ N$$

(ii) Calculation of the forces in the support FQ

$$F_A = \frac{F_Q \times S1}{(S1 + S2)} = \frac{1962 \times 65}{(65 + 47)} = 823.34\ N$$

Where;

FQ = The shear force

V = The normal force

M_{III} = Bending moment at point 1

Fa = Reaction force at point A

Mar – F_A x 1

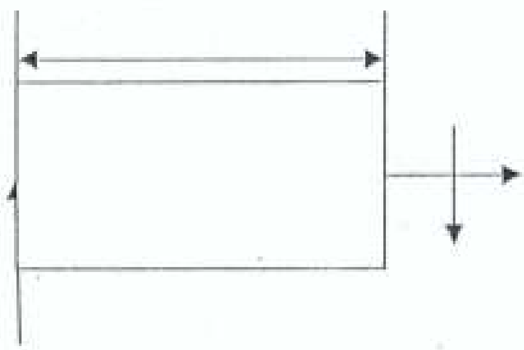
M_{BI} = F_A x 1

Substituting the value gives

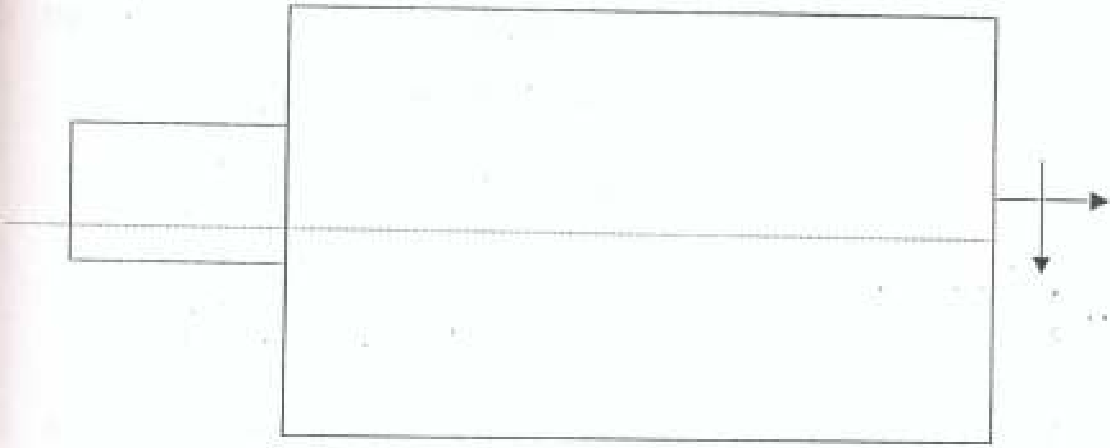
= 823.34 x 15

= 12350.1 Nmm

BENDING MOMENT AT POINT I.



BENDING MOMENT AT POINT II



$M_{BH} + F_Q = FA \times 3 \quad = \quad$ OR $\quad F_B + 1139$

$M_{H} = FA \times 3 - FA \times 3 \qquad M_{BH} = 7 \times 1139 = 7973$ Nm

Substituting the values gives

$= \; M_H = 823.34 \times 105 - 1962 \times 40$

$\therefore M_H = 7970.7$ N mm.

In comparing M_H and M_{BH}. The M_{BH} is greater than M_{BH}, therefore the greater M_{BH} would be applied.

Bending stress $\quad 6b = M_{BI} \leq 6b$ allowable

$6b$ = bending stress

M_{B} = Bending moment

W_{B} = Section modulus = $\pi Da/32 = \pi 16^3 / 32$

= $402.12 mm^3$

6_{bAU} = Allowable bending stress to be taken from the table

$200N \backslash mm^2$

Substituting the values to the equation given;

= 12350.1

= $30.71\ N \backslash mm^2$

= $30.71\ N \backslash mm^2$ which satisfy the condition needed to disallow

bending stress i.e $6b = 6b_{AU}$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

In analyzing the results of this project work, the development of Computer program (Appendix I) using

(i) JAVA language tagged CAD PROG. CODE I for development of Computer – Aided Design software for jigs and fixtures for drilling flanges were used.

(ii) The long hand calculated approach for design of jigs and fixtures for drilling flanges.

4.1. THE COMPUTER AIDED DESIGN SOFTWARE JIGS AND FIXTURES FOR DRILLING FLANGES DEVELOPED

This software automatically analyze the parameters that is supplied and use it to design the jigs and fixtures for drilling flanges (See Fig.4:2 (b).

4.1.1 Hardware Requirements

The software require a multi-media compatible micro-computer with the following hardware configuration for good performance.

i) Intel Pentium 120 MHz processor

ii) 30 MB RAM

iii) 10 MB free hard Disk Drive

iv) 3.5 Floppy Disk Drive

v) 14" VGA Colour Monitor

vi) Standard serial mouse

vii) Laxer Desk Jet Printer

4.1.2 SOFTWARE REQUIREMENT

i) Microsoft Window XP Professional 1995- 2001

ii) Visual Basis Six

iii) JAVA Language

4.2. COMPUTER AIDED DESIGN SOFTWARE FOR JIG AND FIXTURES FOR DRILLING OF FLANGES

Product Result:

The software begins with the welcome screen as the background. The inscription "Click to continue" appear. Clicking the button Fig.4.2 (i).

The "Admin" menu is designed to incorporate the "log on" "design" "log off" and "Exit". Clicking the "log on" menu, display interface where the password is required. Supplying the correct password activate the system. Immediately the system activated, the menu bar change to "Admin" "Input" and "Help" . Fig 4.2(ii). Clicking "Admin" menu display "log on" "Design" "log off" "Exit".

Clicking on the view button display "Jig Design Main Menu" Fig. 4.2 (iii).

Clicking on the "Design Post Locator" display Design post locator Fig. 4.2 (iv).

Clicking on the "Design side plate" display fig. 4.2 (v).

And lastly, clicking on "Show combined design" display Fig.4.2 (ix).

4.3 COMPUTER AIDED DESIGN SOFTWARE FOR JIGS AND FIXTURES FOR DRILLING FLANGES FLOW CHART DEVELOPED

Flowchart of the Design

The design flow chart follows from the basic principle of a design parameter. The start procedure was followed sequentially with the customized design principle.

The input parameters were then simulated to obtain the customized jig design.

This simple process lead to the design of the post locator which the main concern of the design procedure. Design of the plate front and back plate were then considered.

The design of the base metal work piece and the entirety of the jig design were then considered.

The end result of the design were the combined components which form the detailed design.

Flowchart of the Design

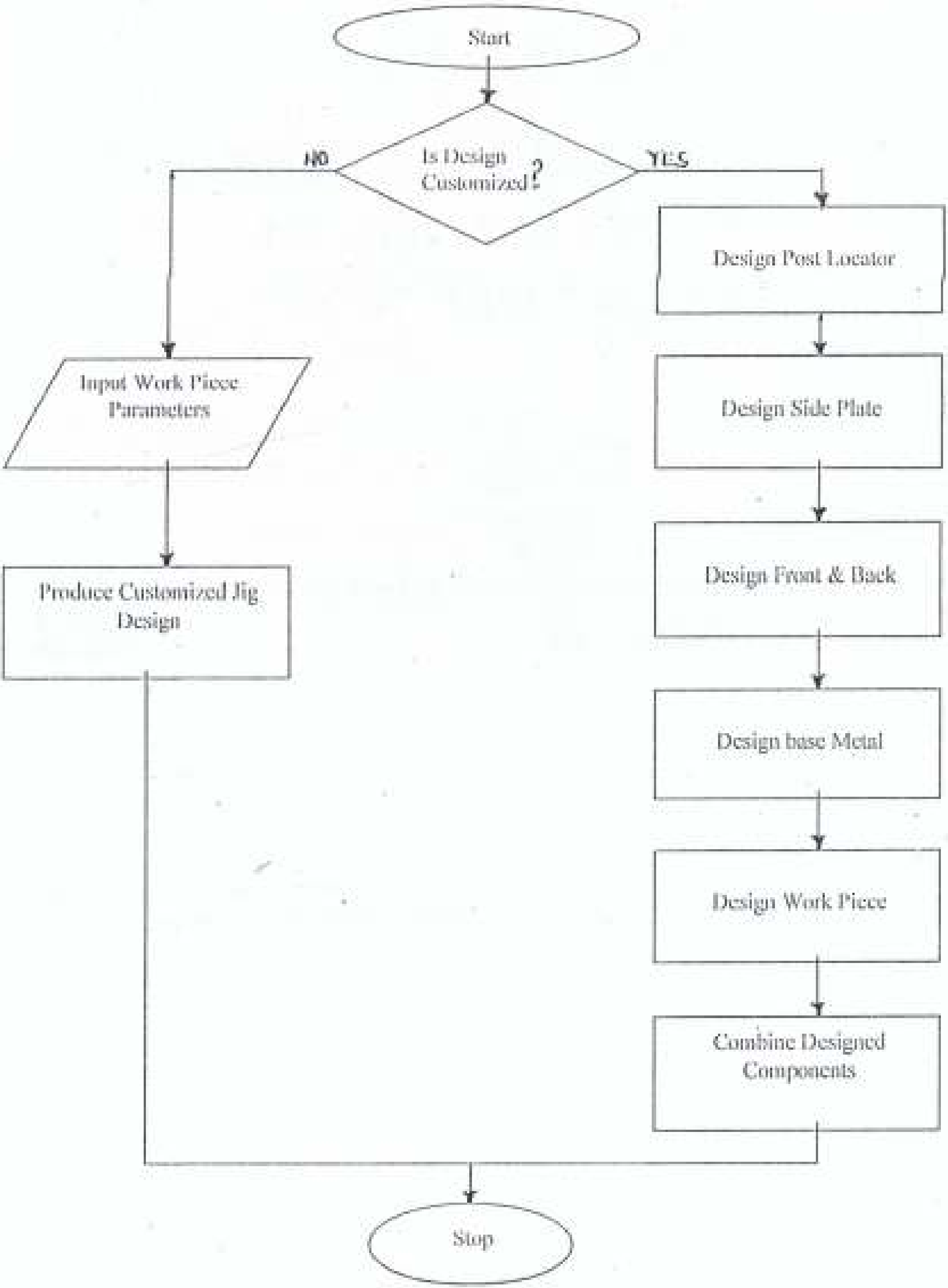


Fig. 4.3: Computer Aided Design Software for Jigs and Fixtures for Drilling Flanges Flow Chart Developed.
Source: Developed by the Author (2006)

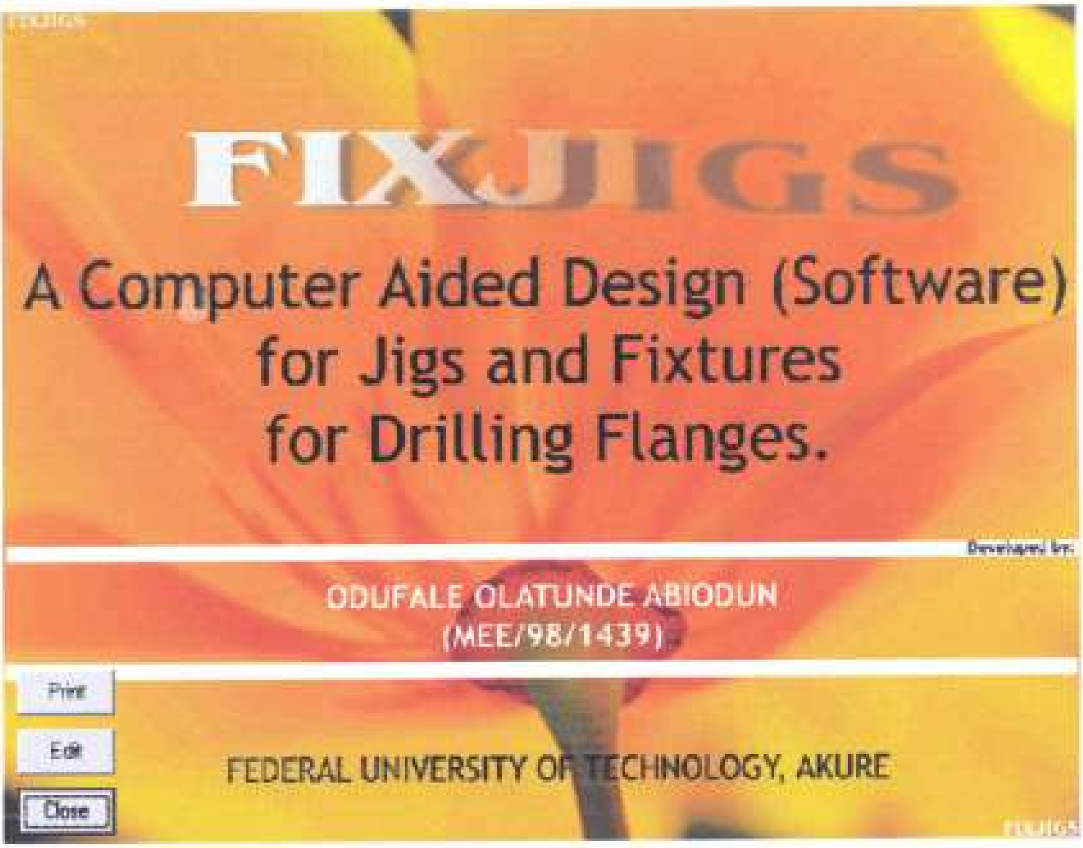


Fig. 4.2 (i): Welcome Screen.
Source: Developed by the Author (2006).

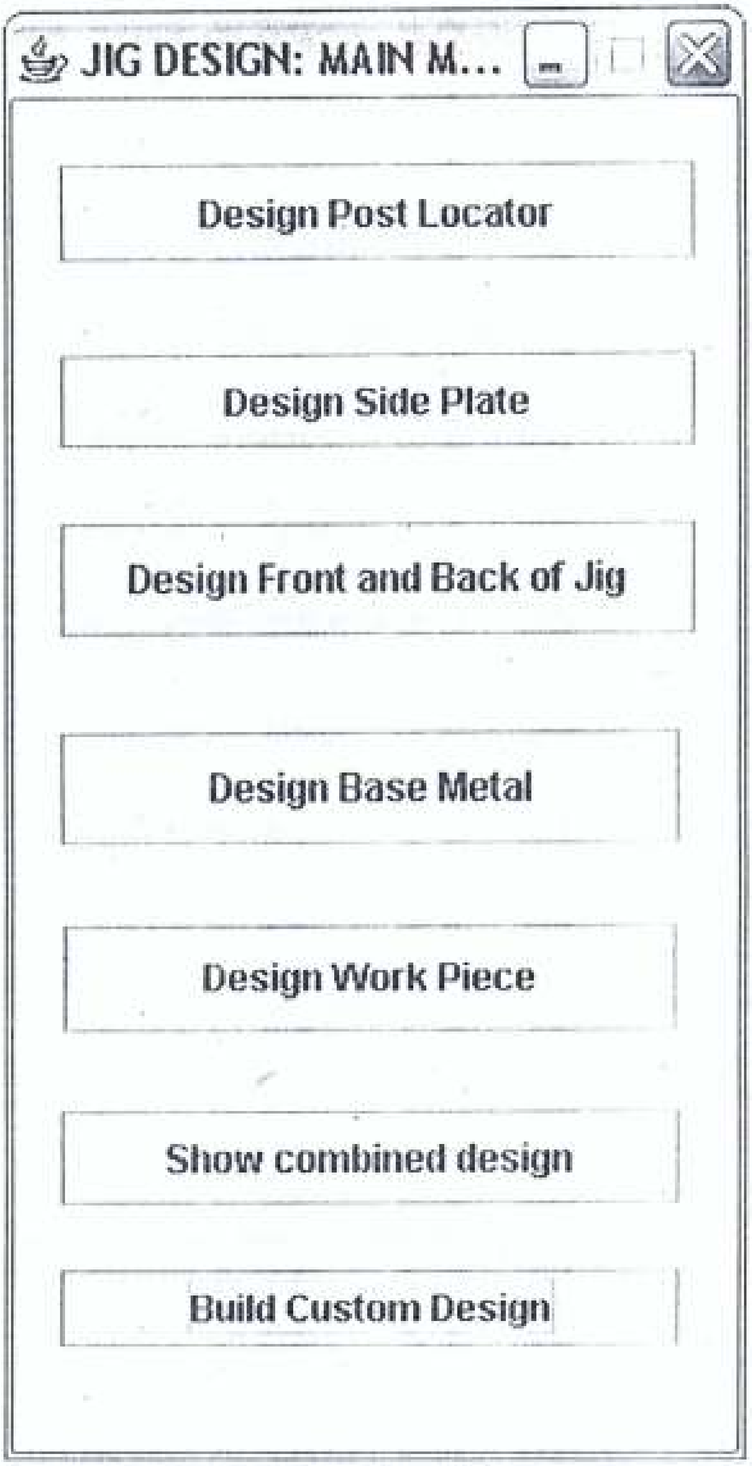


Fig. 4.2 (ii): Jig Main Menu
Source: Developed by the Author (2006).

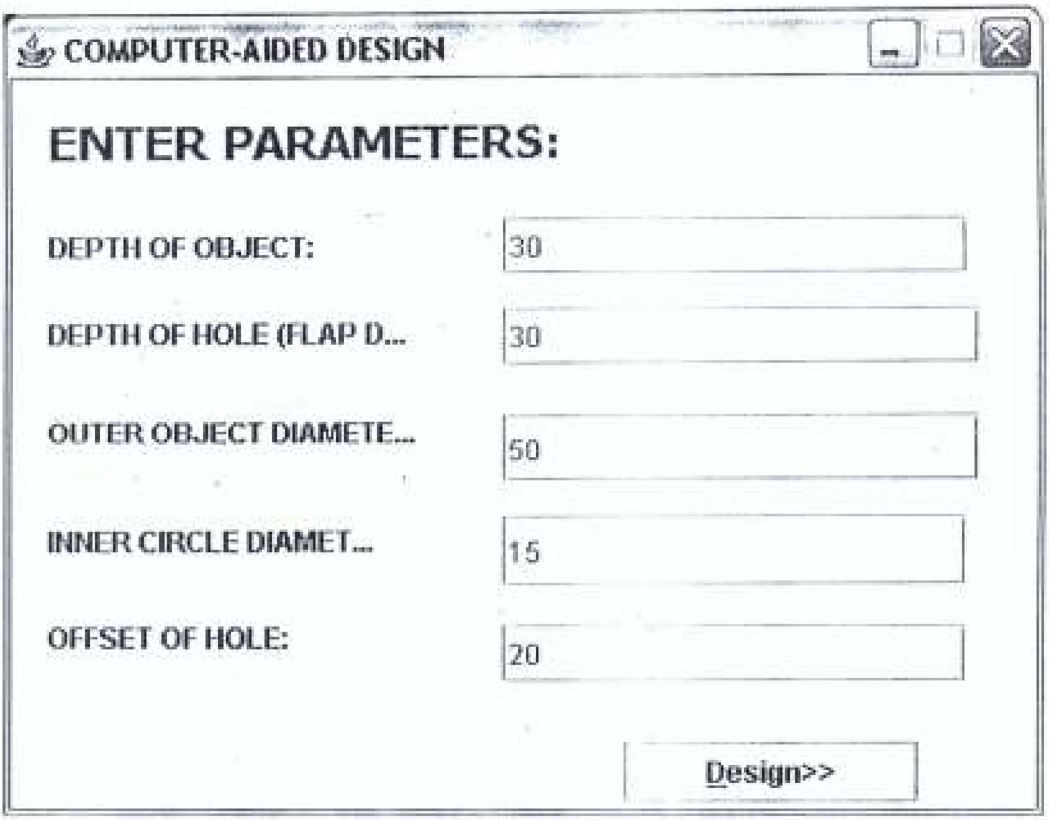


Fig. 4.2 (iii): Data Parameter Interface
Source: Developed by the Author (2006).

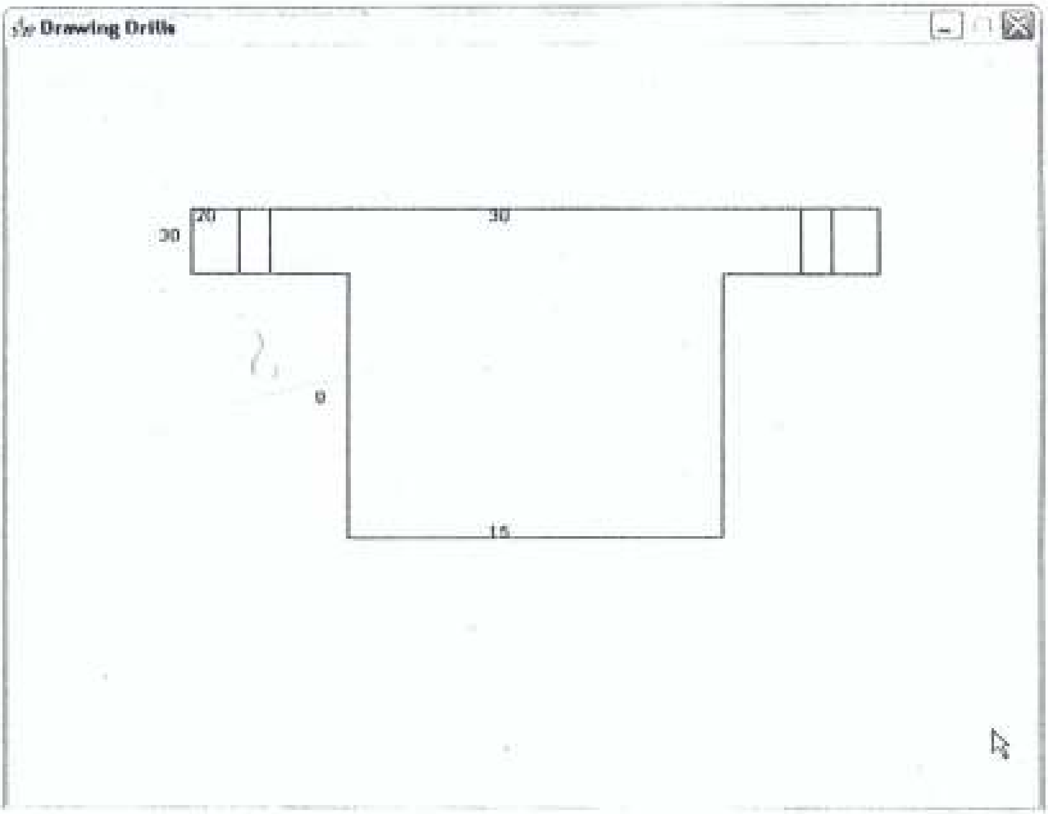
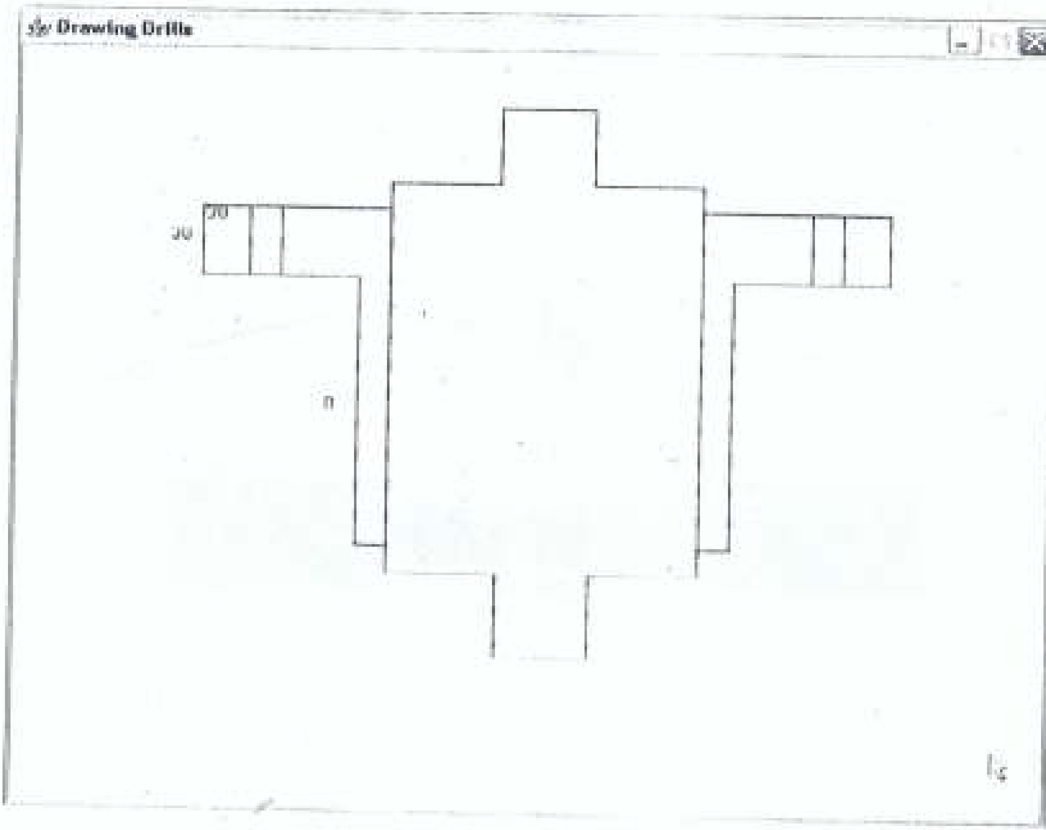


Fig. 4.2 (iv): Design Work piece
Source: Developed by the Author (2006).



[illegible] Work piece with Post Locator
Source: Developed by the Author (2006).

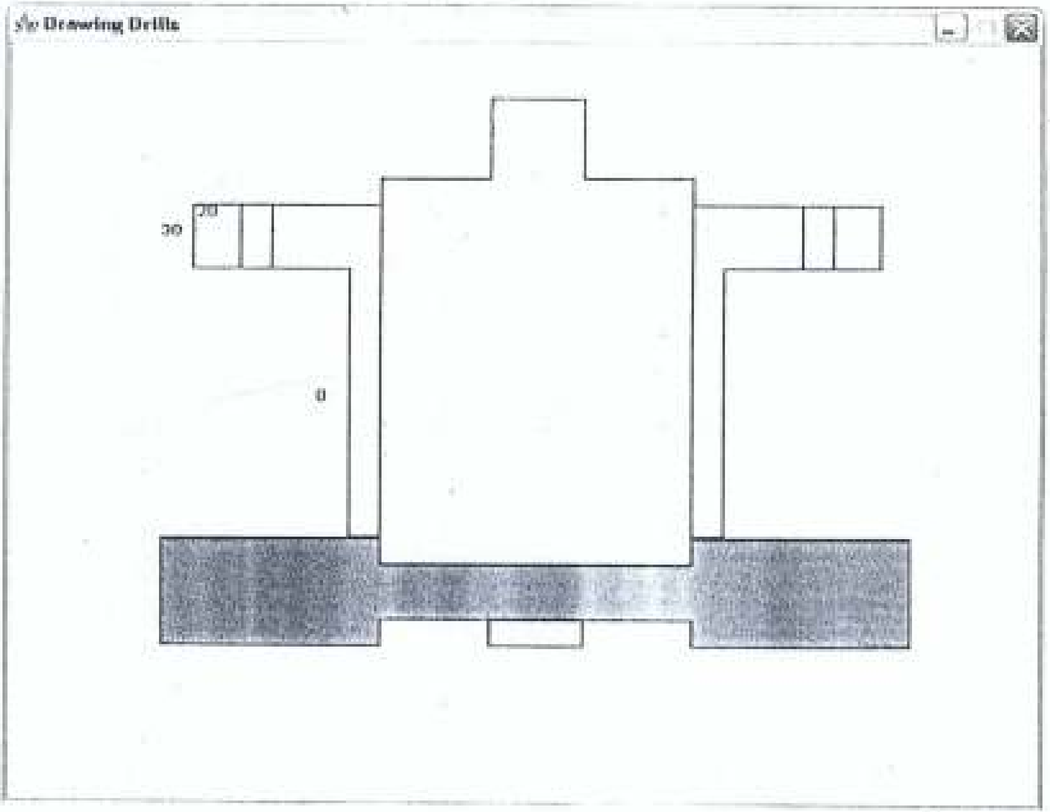


Fig. 4.2 (vi): Combination of work piece, Post Locator and Base Metal
Source: Developed by the Author (2006).

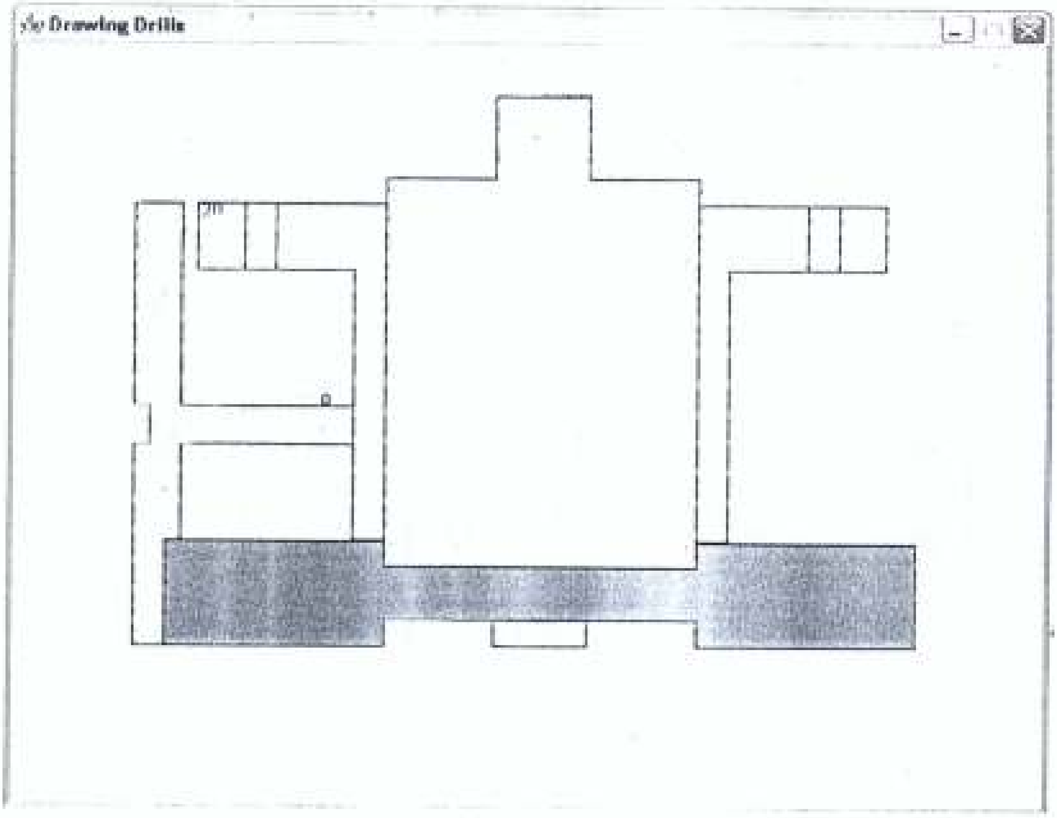


Fig. 4.2 (vii): Combination of Work piece, Post Locator, Base Metal and Side Plate
Source: Developed by the Author (2006).

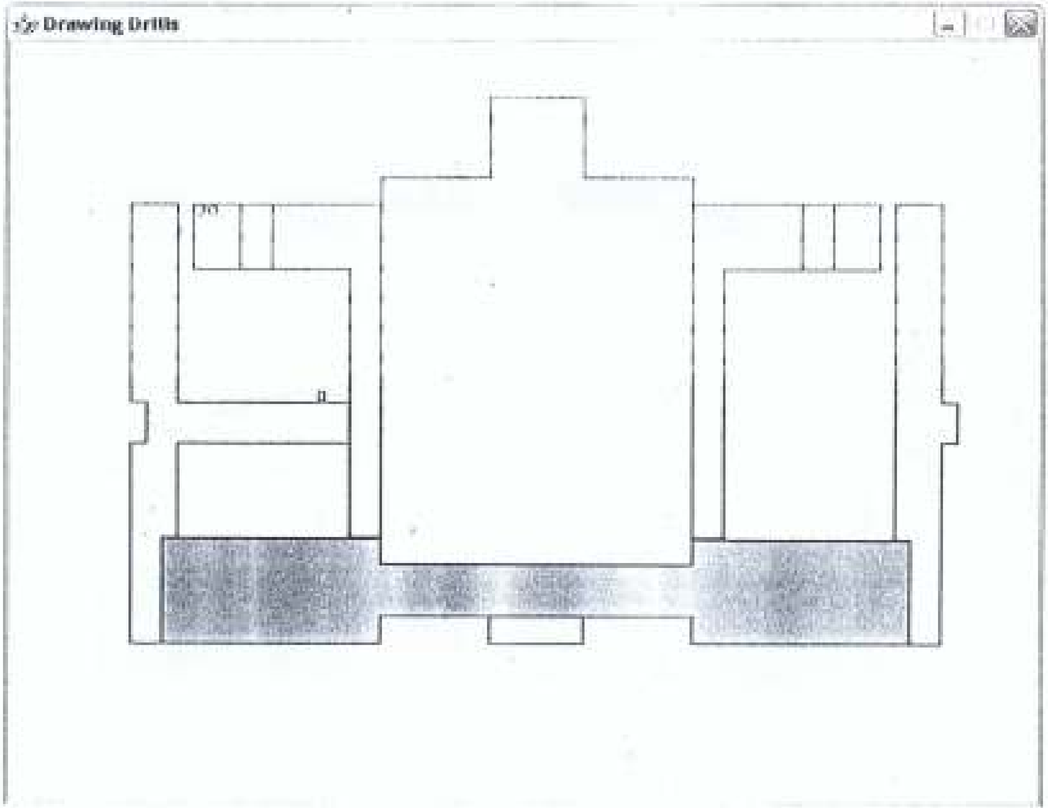


Fig. 4.2 (viii): Combination of Work piece, Post Locator, Base Metal and Both Side Plates
Source: Developed by the Author (2006).

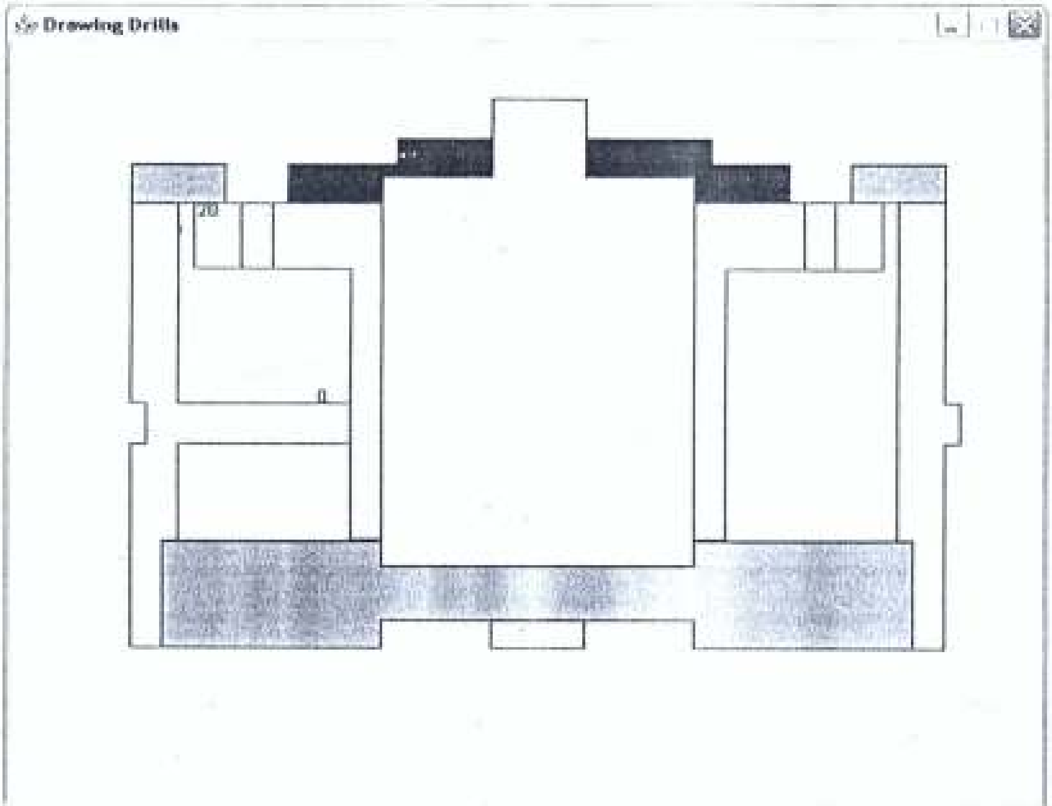


Fig. 4.2 (ix): Complete Jigs and Fixtures Design for drilling the work.
Source: Developed by the Author (2006).

4.4. Table 4.4.1: Showing Computer Aided Design dimensions for Post Locator

S/n	Side	Dimension (mm)
01	A	25
02	B	40
03	C	30

Table 4.4.2: Showing Computer Aided Design dimensions for Side Plate

S/n	Side	Dimension (mm)
01	A	20
02	B	50
03	C	35

Table 4.4.3: Showing Computer Aided Design dimensions for Base Metal

S/n	Side	Dimension (mm)
01	A	35
02	B	30
03	C	35

Table 4.4.4: Showing Computer Aided Design dimensions for Design Workpiece

S/n	Side	Dimension (mm)
01	A	12.0
02	B	70.0
03	C	45

4.5. LONG HAND DESIGN FOR JIGS AND FIXTURES FOR DRILING FLANGES REUSLTS

The use of long hand design approach (manual methods) for design for jigs and fixtures for drilling flanges has been undertaken and analyse in this work.

Table 4.5.1: Showing Manual Design Dimensions for Post Locator

S/n	Side	Dimension (mm)
01	A	25.1
02	B	39.9
03	C	30.1

Table 4.5.2: Showing Manual Design Dimensions for Side Plate

S/n	Side	Dimension (mm)
01	A	20.0
02	B	50.1
03	C	35.0

Table 4.5.3: Showing Manual Design Dimensions for Base Metal

S/n	Side	Dimension (mm)
01	A	35.1
02	B	30.0
03	C	35.1

Table 4.5.4: Showing Manual Design Dimensions for Workpiece

S/n	Side	Dimension (mm)
01	A	12.0
02	B	70.0
03	C	45.0

4.6. COMPARATION AND VALIDATION OF COMPUTER AIDED DESIGN AND MANUAL CALCULATED DIMENSIONS

In comparing and validating of the results, it was discovered that, the side dimensions obtained for the Computer Aided Design for jigs and fixtures for drilling flanges is the same with the manual dimensions obtained for manual design of jigs and fixtures for drilling flanges.

Table 4.6.1: Showing Comparison in Dimensions for Computer Aided and Manual Design for Design of Jigs and Fixtures for Drilling Flanges (Post Locators)

S/N	Side	Computer Aided Dimensions/mm	Manual Dimensions (mm)	Diff.
01	A	25.0	25.1	0.1
02	B	40.0	39.9	0.1
03	C	30.0	30.1	0.1

Table 4.6.2: Showing Side Plate Dimension Comparison

S/N	Side	Computer Aided Dimensions/mm	Manual Dimensions (mm)	Diff.
01	A	20.0	20.0	0.0
02	B	50.0	50.1	0.1
03	C	35.0	35.0	0.0

Table 4.6.3 Showing Base Metal Dimension Comparison

S/N	Side	Computer Aided Dimensions/mm	Manual Dimensions (mm)	Diff.
01	A	35.0	20.0	0.0
02	B	30.0	50.1	0.1
03	C	35.0	35.1	0.1

Table 4.6.4: Showing Workpiece Dimension Comparison

S/N	Side	Computer Aided Dimensions/mm	Manual Dimensions (mm)	Diff.
01	A	12.0	12.0	0.0
02	B	70.0	70.0	0.0
03	C	45.0	45.0	0.0

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

With the design of this computer aided design software, manufacturing of a drilling jig and fixture in large quantity will be very easy.

This software is very reliable consistent and accurate compares to long time hand drawing of a drilling jig and fixture, also the conventional way of producing identical job is time consuming.

The software gives room for change in terms of square, rectangular, round, objects or any shape the occasion might demand.

5.2 RECOMMENDATIONS

1. This research work is restricted to drilling jigs and fixture only.
2. In further studies of this research work intricate parts production can be incorporated.
3. Further work should be done for objects with irregular shape and features.

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APPENDIX I
CAD PROG. CODE 1

```
PACKAGE CAD;
import java.util.TimerTask;

public final class DrawTask extends TimerTask
{
  private DrawDrill myDrill;

  public DrawTask(DrawDrill d)
  {
   super();
   myDrill = d;
  }

  public void run()
  {
   if (myDrill.count <= 7)
   {
    myDrill.repaint();
    myDrill.count++;
   }
   else
   {
    this.cancel();
    //System.exit(0);
   }
  }
}



package CAD;
import java.awt.Dimension;
import java.awt.Graphics;
import java.awt.Polygon;
import javax.swing.JFrame;
```

```
Public class DrawSidePlate extends JFrame

 Private stat  inal int scale = 3;
 Private stat  final int width1 = 35 * scale;
 Pr   e static final int width2 = 30 * scale;
// Private st      final int width3 = 52 * scale;
 Private static final int len1 = 20 * scale;
 Private static final int len2 = 50 * scale;
 Private static final int len3 = 35 * scale;
 //Private static final int width1 = 52;
 Private static final int h1 = 35 * scale;
 Private static final int h2   30 * scale;

 Public DrawSidePlate()

   SetSize(new Dimension(800,640));
   SetResizable(false);
   SetTitle("DESIGNING SIDE PLATE");


    Public void paint(Graphics g)

   int[]    es =
{(100+   h1),(100  idth1+width2),(100+width1+width2),

(100+width1+width2+width1),(100+width1+width2+width1),
                (100+width1+width2),(100+width1+width2),(100+width1),
                (100+width1),100,100,(100+width1),(100+width1)};
   int[] yvalues =
{100,100,100+len1,100+len1,100+len1+len2,100+len1+len2,100+len1+
len2+len3,
```

```
100+len1+len2+len3,100+len1+len2,100+len1+len2,100+len1,100+len1
,100};
   Polygon poly = new Polygon(xvalues,yvalues,13);
   g.drawPolygon(poly);
   g.drawOval(100+width1+(width2/2)-20,100+len1+(len2/2),20,20);


g.drawRect((100+width1+width2+width1)+150,100,20*scale,len1+len2
+len3);

g.drawString(String.valueOf(width1/scale),(100+100+width1)/2,(100+le
n1+len2+len3)+15);

g.drawString(String.valueOf(width2/scale),(100+width1+100+width1+
width2)/2,(100+len1+len2+len3)+15);

g.drawString(String.valueOf(width1/scale),(100+width1+width2+100+(
width1*2)+width2)/2,(100+len1+len2+len3)+15);

   g.drawString(String.valueOf(20),(100+width1+width2+width1)+150
+ (20*scale/2),(100+len1+len2+len3)+15);


g.drawString(String.valueOf(len1/scale),((100+width1+width2+width1)
+35),(100+100+len1)/2);

g.drawString(String.valueOf(len2/scale),((100+width1+width2+width1)
+35),(100+len1+100+len1+len2)/2);

g.drawString(String.valueOf(len3/scale),((100+width1+width2+width1)
+35),(100+len1+len2+100+len1+len2+len3)/2);
```

```
Public static void main(String[] arg)

  New DrawSidePlate().show();

Package CAD;
Import java.awt.Color;
Import java.awt.Dimension;
Import java.awt.Graphics;
Import java.awt.Polygon;
Import javax.swing.JFrame;

Public class DrawPostLocator extends JFrame

 Private static final int scale = 3;
 Private static final int l1 = 25 * scale;
 Private static final int l2 = 15 * scale;
 Private static final int l3 = 95 * scale;
 Private static final int l4 = 15 * scale;
 Private static final int l5 = 13 * scale;
 Private static final int l3_1 = 25 * scale;
 Private static final int l3_2 = 40 * scale;
 Private static final int l3_3 = 30 * scale;
 Private static final int w1 = (14 * scale) + 1;
 Private static final int w2 = 16 * scale;
 Private static final int w3 = (14 * scale) + 1;

 Public DrawPostLocator()

  SetSize(new Dimension(800,640));
  SetResizable(false);
```

```
  g.drawLine(310-w1,70+l1+l2,310+w2+w3-(2*scale),70+l1+l2);
  g.drawLine(310-w1,70+l1+l2+l3,310+w2+w3-
(2*scale),70+l1+l2+l3);
  g.drawString(String.valueOf(w1/scale)+".5",-12+(310+310-
w1)/2,(70+l1+l2+l3+l4+l5)+15);
  g.drawString(String.valueOf(w2/scale),-
12+(310+310+w2)/2,(70+l1+l2+l3+l4+l5)+15);
  g.drawString(String.valueOf(w1/scale)+".5",-
12+(310+w3+w2+310+w2)/2,(70+l1+l2+l3+l4+l5)+15);

  //g.drawString(String.valueOf(20),(100+w1+w2+w1)+150 +
(20*scale/2),(100+len1+len2+len3)+15);


g.drawString(String.valueOf(l3_1/scale),((310+w1+w2+w1)+25),70+(5
2*scale));

g.drawString(String.valueOf(l3_2/scale),((310+w1+w2+w1)+25),70+(8
5*scale));

g.drawString(String.valueOf(l3_3/scale),((310+w1+w2+w1)+25),70+(1
20*scale));

Public static void main(String[] arg)
```

New DrawPostLocator().show();

```
Package CAD;
Import java.awt.event.WindowAdapter;
Import java.awt.event.WindowEvent;
Import java.util.Timer;
Import javax.swing.JFrame;
Import java.awt.Dimension;
Import javax.swing.JLabel;
Import java.awt.Rectangle;
Import java.awt.Font;
Import javax.swing.JButton;
Import javax.swing.JTextField;
Import java.awt.event.ActionListener;
Import java.awt.event.ActionEvent;
```

Public class DrawMain extends JFrame

```
  Private JLabel jLabel1 = new JLabel();
  Private JLabel jLabel2 = new JLabel();
  Private JLabel jLabel3 = new JLabel();
  Private JLabel jLabel4 = new JLabel();
  Private JLabel jLabel5 = new JLabel();
  Private JLabel jLabel6 = new JLabel();
  Private JButton cmdDesign = new JButton();
  Private JTextField txtdepth = new JTextField();
  Private JTextField txtholedepth = new JTextField();
  Private JTextField txtouterdiameter = new JTextField();
  Private JTextField innerdiameter = new JTextField();
  Private JTextField holeoffset = new JTextField();
```

Public DrawMain()

```
  try  jbInit();

  catch(Exception e)

    e.printStackTrace();

/**
 *
 * @param args
 */
public static void main(String[] args)
```

DrawMain drawMain = new DrawMain();

```
 DrawMain.show();
 Private void jbInit() throws Exception

  this.setSize(new Dimension(425, 345));
```

THIS SET Title("COMPUTER-AIDED DESIGN");

```
  this.getContentPane().setLayout(null);
  jLabel1.setText("ENTER PARAMETERS:");
  jLabel1.setBounds(new Rectangle(15, 10, 385, 35));
  jLabel1.setFont(new Font("Tahoma", 1, 19));
  jLabel2.setText("DEPTH OF OBJECT:");
  jLabel2.setBounds(new Rectangle(15, 60, 155, 25));
  jLabel3.setText("DEPTH OF HOLE (FLAP DEPTH)");
  jLabel3.setBounds(new Rectangle(15, 95, 150, 30));
  jLabel4.setText("OUTER OBJECT DIAMETER:");
  jLabel4.setBounds(new Rectangle(15, 135, 150, 35));
  jLabel5.setText("INNER CIRCLE DIAMETER");
  jLabel5.setBounds(new Rectangle(15, 185, 135, 30));
```

```
jLabel6.setText("OFFSET OF HOLE:");
jLabel6.setBounds(new Rectangle(15, 225, 135, 30));
cmdDesign.setText("Design>>");
cmdDesign.setBounds(new Rectangle(250, 285, 120, 25));
cmdDesign.setMnemonic('D');
cmdDesign.addActionListener(new ActionListener()

public void actionPerformed(ActionEvent e)

cmdDesign_actionPerformed(e);
txtdepth.setBounds(new Rectangle(200, 60, 190, 25));
txtholedepth.setBounds(new Rectangle(200, 100, 195, 25));
txtouterdiameter.setBounds(new Rectangle(200, 145, 195, 30));
innerdiameter.setBounds(new Rectangle(200, 190, 190, 30));
holeoffset.setBounds(new Rectangle(200, 235, 190, 25));
setResizable(false);
this.getContentPane().add(holeoffset, null);
this.getContentPane().add(innerdiameter, null);
this.getContentPane().add(txtouterdiameter, null);
this.getContentPane().add(txtholedepth, null);
this.getContentPane().add(txtdepth, null);
this.getContentPane().add(cmdDesign, null);
this.getContentPane().add(jLabel6, null);
this.getContentPane().add(jLabel5, null);
this.getContentPane().add(jLabel4, null);
this.getContentPane().add(jLabel3, null);
this.getContentPane().add(jLabel2, null);
this.getContentPane().add(jLabel1, null);
```

```
this.addWindowListener( new WindowAdapter()

Public void windowClosing(WindowEvent e)

System.exit(0);
    }
   }
 );
}

Private void cmdDesign_actionPerformed(ActionEvent e)

 DrawDrill drawDrill = new DrawDrill();

drawDrill.setDefaultCloseOperation(JFrame.DISPOSE_ON_CLOSE);

 drawDrill.setDepth(Integer.parseInt(txtdepth.getText()));
 drawDrill.setHoleDepth(Integer.parseInt(txtholedepth.getText()));

drawDrill.setOuterDiameter(Integer.parseInt(txtouterdiameter.getText())

drawDrill.setInnerDiameter(Integer.parseInt(innerdiameter.getText()));
 drawDrill.setHoleOffSet(Integer.parseInt(holeoffset.getText()));

 DrawTask task = new DrawTask(drawDrill);
 drawDrill.show();
 new Timer().schedule(task,5000,10000);
 this.dispose();
}
}
```

```
Package CAD;
import java.awt.Dimension;
import java.awt.Graphics;
import javax.swing.JFrame;

public class DrawFrontBack extends JFrame
{
  private static final int scale = 3;
  public DrawFrontBack()
  {
   setSize(new Dimension(800,640));
   setResizable(false);
   setTitle("DESIGNING FRONT AND BACK");
  }

    public void paint(Graphics g)
  {
   int[] xvalues = {120,560,560,460,460,220,220,120,120};
   int[] yvalues = {150,150,200,200,400,400,200,200,150};

   g.drawRect(120,150,194*scale,105*scale);
   g.drawRect(120+(20*scale),150+(10*scale),(194*scale) -
(20*scale*2),
          (105*scale) - (30*scale));
   g.drawLine(120, (150+105*scale+10), 120, (150+105*scale+30));
   g.drawLine(120+(20*scale), (150+105*scale+10), 120+(20*scale),
(150+105*scale+30));
   g.drawLine((120+(20*scale))+((194*scale) - (20*scale*2)),
(150+105*scale+10),
          (120+(20*scale))+((194*scale) - (20*scale*2)),
(150+105*scale+30));
   g.drawLine(120+(194*scale), (150+105*scale+10), 120+(194*scale),
```

```
(150+105*scale+30));

   g.drawLine(124,(150+105*scale+10)+10,120+(20*scale)-
4,(150+105*scale+10)+10);
   g.drawString("20",(124+120+(20*scale)-
4)/2,(150+105*scale+10)+10-2);

   g.drawLine(124+(20*scale),(150+105*scale+10)+10,
      (120+(20*scale))+((194*scale) - (20*scale*2))-
4,(150+105*scale+10)+10);
   g.drawString("154",(124+(20*scale)+(120+(20*scale))+((194*scale)
- (20*scale*2))-4)/2,
            (150+105*scale+10)+10-2);

   g.drawLine(124+(20*scale)+((194*scale) -
(20*scale*2)),(150+105*scale+10)+10,
         120+(194*scale)-4,(150+105*scale+10)+10);
   g.drawString("20",(124+(20*scale)+((194*scale) -
(20*scale*2))+120+(194*scale)-4)/2,(150+105*scale+10)+10-2);

   g.drawLine(90,150,110,150);
   g.drawLine(90,150+(10*scale),110,150+(10*scale));
   g.drawLine(90,(150+(10*scale))+((105*scale) - (30*scale)),110,
         (150+(10*scale))+((105*scale) - (30*scale)));
   g.drawLine(90,150+ (105*scale),110,150+ (105*scale));

   g.drawLine(100,150+3,100,150+(10*scale)-3);
   g.drawString("10",85,((150+3)+(150+(10*scale)-3))/2);

g.drawLine(100,150+(10*scale)+3,100,(150+(10*scale))+((105*scale) -
(30*scale)) -3);

g.drawString("75",85,((150+(10*scale)+3)+((150+(10*scale))+((105*sc
```

```
ale) - (30*scale))-3))/2);
    g.drawLine(100,(150+(10*scale))+((105*scale) -
(30*scale))+3,100,150 + (105*scale) -3);
    g.drawString("20",85,(((150+(10*scale))+((105*scale) -
(30*scale))+3)+(150 + (105*scale)-3))/2);
  }

  public static void main(String[] arg)
   {
     new DrawFrontBack().show();
   }

}

package CAD;
import java.util.Timer;
import javax.swing.JFrame;
import java.awt.*;
import java.awt.event.*;

public final class DrawDrill extends JFrame
{
  private int depth = 250;
  private int outerdiameter = 440;
  private int innerdiameter = 240;
  private int holedepth = 50;
  private int holeoffset = 30;
  public int count;

  public void setDepth(int dep) { depth = dep;}
  public void setOuterDiameter(int diameter) { outerdiameter =
diameter;}
  public void setHoleDepth(int dep) { holedepth = dep;}
```

```
 public void setInnerDiameter(int diameter) { innerdiameter =
diameter;}
 public void setHoleOffSet(int offset) { holeoffset = offset;}

 public DrawDrill()
 {
  super("Drawing Drills");
  this.setBackground(Color.WHITE);
  //show();
  setSize(new Dimension(667,600));
  setResizable(false);
 }

 public void paint(Graphics g)
 {
  int[] xvalues = {120,560,560,460,460,220,220,120,120};
  int[] yvalues = {150,150,200,200,400,400,200,200,150};

  Polygon poly1 = new Polygon(xvalues,yvalues,9);
  g.drawPolygon(poly1);
  g.setColor(Color.WHITE);
  g.fillRect(150,150,20,50);
  g.fillRect(510,150,20,50);

  g.setColor(Color.BLACK);
  g.drawLine(150,150,150,200);
  g.drawLine(170,150,170,200);
  g.drawLine(510,150,510,200);
  g.drawLine(530,150,530,200);
```

```
    g.drawString(String.valueOf(depth - holedepth),199,300);
    g.drawString(String.valueOf(holedepth),99,175);
    g.drawString(String.valueOf(holeoffset),122,160);
    g.drawString(String.valueOf(outerdiameter - holeoffset),310,160);
    //g.setColor);
    g.drawString(String.valueOf(innerdiameter),310,400);

    g.setColor(Color.LIGHT_GRAY);
    int [] xvalues1 =
{310,370,370,440,440,370,370,310,310,240,240,310,310};
    int [] yvalues1 =
{70,70,130,130,420,420,480,480,420,420,130,130,70};
    poly1 = new Polygon(xvalues1,yvalues1,13);
    g.fillPolygon(poly1);

    g.setColor(Color.gray);
    int [] xvalues2 =
{100,240,240,440,440,580,580,440,440,240,240,100,100};
    int [] yvalues2 =
{401,401,420,420,401,401,480,480,460,460,480,480,401};
    poly1 = new Polygon(xvalues2,yvalues2,13);
    g.fillPolygon(poly1);

    g.setColor(Color.LIGHT_GRAY);
    int [] xvalues3 =
{80,80,90,90,80,80,100,100,110,110,220,220,110,110,80};
    int [] yvalues3 =
{150,300,300,330,330,480,480,401,401,330,330,300,300,150,150};
    poly1 = new Polygon(xvalues3,yvalues3,15);
    g.fillPolygon(poly1);
```

```
g.setColor(Color.LIGHT_GRAY);
int [] xvalues4 = {600,600,610,610,600,600,580,580,570,570,600};
int [] yvalues4 = {150,300,300,330,330,480,480,401,401,150,150};
poly1 = new Polygon(xvalues4,yvalues4,11);
g.fillPolygon(poly1);

g.setColor(Color.GRAY);
g.fillRect(80,120,60,30);
g.fillRect(540,120,60,30);

int [] xvalues5 = {180,180,240,240,310,310,250,250,180};
int [] yvalues5 = {120,150,150,130,130,100,100,120,120};
poly1 = new Polygon(xvalues5,yvalues5,9);
g.fillPolygon(poly1);

int [] xvalues6 = {370,370,440,440,500,500,450,450,370};
int [] yvalues6 = {100,130,130,150,150,120,120,100,100};
poly1 = new Polygon(xvalues6,yvalues6,9);
g.fillPolygon(poly1);

g.setColor(Color.LIGHT_GRAY);
setTitle("Design Completed");
g.fillRoundRect(300,55,80,25,10,10);
g.fillRoundRect(300,470,80,25,10,10);
//g.setColor(Color.BLACK);
//g.drawString("I",200,200);
```

```
 /**
  *
  * @param args
  */
 /*public static void main(String[] args)
 {
  DrawDrill drawDrill = new DrawDrill();

drawDrill.setDefaultCloseOperation(JFrame.DISPOSE_ON_CLOSE);
  //DrawTask task = new DrawTask(drawDrill);
  //new Timer().schedule(task,5000,10000);
 }
 */
}

package CAD;
import java.awt.Color;
import java.awt.Graphics;
import java.awt.Polygon;
import java.awt.Window;
import java.awt.event.WindowAdapter;
import java.awt.event.WindowEvent;
import javax.swing.JFrame;
import java.awt.Dimension;
import javax.swing.JPanel;
import java.awt.Rectangle;
import javax.swing.JButton;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
public class DrawComponents extends JFrame

 private JPanel displayPanel = new JPanel();
 private JButton btnOk = new JButton();
 private ComponentPanel comPanel = new ComponentPanel();
```

```
private int depth = 82;
private int outerdiameter = 70;
private int innerdiameter = 45;
private int holedepth = 12;
private int holeoffset = 10;

public DrawComponents()

 tr jbInit();
  setResizable(false);
 // comPanel.setBounds(new Rectangle(0, 0, 550, 370));
 // this.getContentPane().add(comPanel, null);
 // comPanel.repaint();

 catch(Exception e)

  e.printStackTrace();

public void paint(Graphics g)

 setTitle("Designing Jig.");
 int[] xvalues = {120,560,560,460,460,220,220,120,120};
 int[] yvalues = {150,150,200,200,400,400,200,200,150};

 Polygon poly1 = new Polygon(xvalues,yvalues,9);
 g.drawPolygon(poly1);
 g.setColor(Color.WHITE);
 g.fillRect(150,150,20,50);
 g.fillRect(510,150,20,50);

 g.setColor(Color.BLACK);
 g.drawLine(150,150,150,200);
 g.drawLine(170,150,170,200);
 g.drawLine(510,150,510,200);
 g.drawLine(530,150,530,200);
```

```
g.drawString(String.valueOf(depth - holedepth),199,300);
g.drawString(String.valueOf(holedepth),99,175);
//g.drawString(String.valueOf(holeoffset),122,160);
g.drawString(String.valueOf(outerdiameter - holeoffset),310,160);
//g.setColor);
g.drawString(String.valueOf(innerdiameter),310,400);


private void jbInit() throws Exception

this.setSize(new Dimension(860, 640));
this.getContentPane().setLayout(null);
displayPanel.setBounds(new Rectangle(0, 0, 550, 370));
btnOk.setText("Design...");
btnOk.setBounds(new Rectangle(420, 385, 130, 20));
btnOk.setSelected(true);
btnOk.addActionListener(new ActionListener()

 Public void actionPerformed(ActionEvent e)

 btnOk_actionPerformed(e);
//this.getContentPane().add(btnOk, null);
this.addWindowListener(
    new WindowAdapter()
    {
      public void windowClosing(WindowEvent e)
      {
        //System.exit(0);
      }
    }
);
//this.getContentPane().add(displayPanel, null);
}

public static void main(String[] arg)
{
```

```
    new DrawComponents().show();
  }

  private void btnOk_actionPerformed(ActionEvent e)
  {
   // displayPanel.add(new ComponentPanel());
  }
}
```

```
package CAD;
import java.awt.Dimension;
import java.awt.Graphics;
import java.awt.Polygon;
import javax.swing.JFrame;
```

<u>Public class DrawBaseMetal extends *JFrame*</u>

```
  private static final int scale = 3;
  private static final int width1 = 52 * scale;
  private static final int width2 = 50 * scale;
 // private static final int width3 = 52 * scale;
  private static final int len1 = 5 * scale;
  private static final int len2 = 12 * scale;
  private static final int len3 = 3 * scale;
  //private static final int width1 = 52;
  private static final int h1 = 35 * scale;
  private static final int h2 = 30 * scale;

  public DrawBaseMetal()

    setSize(new Dimension(800,640));
    setResizable(false);
```

Set Title("DESIGNING BASE METAL");

```
Public void paint(Graphics g)

 int[] xvalues =
{(100+width1),(100+width1+width2),(100+width1+width2),

(100+width1+width2+width1),(100+width1+width2+width1),
(100+width1+width2),(100+width1+width2),(100+width1),
 (100+width1),100,100,(100+width1),(100+width1)};
   int[] yvalues =
{100,100,100+h1,100+h1,100+h1+h2,100+h1+h2,100+h1+h2+h1,


100+h1+h2+h1,100+h1+h2,100+h1+h2,100+h1,100+h1,100};
 Polygon poly = new Polygon(xvalues,yvalues,13);
g.drawPolygon(poly);
   g.drawOval(100+width1+5,100+h1-20,width2-10,width2-10);

   int [] xvalues2 =
{100,(100+width1),(100+width1),(100+width1)+width2,(100+width1)+
width2,

(100+width1)+width2+width1,(100+width1)+width2+width1,

(100+width1)+width2,(100+width1)+width2,(100+width1),(100+width1
),
                100,100};
   int [] yvalues2 =
{501,501,(501+len1),(501+len1),501,501,(501+len1+len2+len3),
                (501+len1+len2+len3),(501+len1+len2),(501+len1+len2),
                (501+len1+len2+len3),(501+len1+len2+len3),501};
   Polygon poly1 = new Polygon(xvalues2,yvalues2,13);
   g.drawPolygon(poly1);

   g.drawString("52",(100+100+width1)/2,(501+len1+len2+len3)+15);
```

```
g.drawString("50",(100+width1+100+width1+width2)/2,(501+len1+len
2+len3)+15);
   g.drawString("50",(100+width1+100+width1+width2)/2,(100 - 15));

g.drawString("52",(100+width1+width2+100+(width1*2)+width2)/2,(50
1+len1+len2+len3)+15);
   g.drawString("35",(100-35),(100+100+h1)/2);
   g.drawString("30",(100-35),(100+h1+100+h1+h2)/2);
   g.drawString("35",(100-35),(100+h1+h2+100+h1+h2+h1)/2);


 public static void main(String[] arg)

   new DrawBaseMetal().show();



package CAD;
import java.awt.Color;
import java.awt.Graphics;
import java.awt.Polygon;
import javax.swing.JPanel;
import java.awt.Dimension;

public class ComponentPanel extends JPanel
{
 public ComponentPanel()
  {
   try
   {
 jbInit()     //repaint();
System.out.println("ComponentPanel Created");
 setVisible(true)
   catch(Exception e)

    e.printStackTrace();
```

```
Private void jbInit() throws Exception

this.setSize(new Dimension(545, 400));

Public void paint(Graphics g)

  int[] xvalues = {120,560,560,460,460,220,220,120,120};
  int[] yvalues = {150,150,200,200,400,400,200,200,150};

  Polygon poly1 = new Polygon(xvalues,yvalues,9);
  g.drawPolygon(poly1);
  g.setColor(Color.WHITE);
  g.fillRect(150,150,20,50);
  g.fillRect(510,150,20,50);

  g.setColor(Color.BLACK);
  g.drawLine(150,150,150,200);
  g.drawLine(170,150,170,200);
  g.drawLine(510,150,510,200);
  g.drawLine(530,150,530,200);

package CAD;
import java.awt.event.WindowAdapter;
import java.awt.event.WindowEvent;
import java.util.Timer;
import javax.swing.JFrame;
import java.awt.Dimension;
import javax.swing.JButton;
import java.awt.Rectangle;
import java.awt.event.ActionListener;
import java.awt.event.ActionEvent;
public class MainDrill extends JFrame
```

```
private JButton btnPostLocator = new JButton();
private JButton btnSidePlate = new JButton();
private JButton btnFrontBack = new JButton();
private JButton btnBaseMetal = new JButton();
private JButton btnWorkPiece = new JButton();
private JButton btnCombine = new JButton();

public MainDrill()

  try jbInit();
  setResizable(false);
```

SetTitle("JIG DESIGN: MAIN MENU"

```
  setLocation(300,200);
  }
  catch(Exception e)
  {
   e.printStackTrace();

/**
 *
 * @param args
 */
public static void main(String[] args)
{
  MainDrill mainDrill = new MainDrill();
  mainDrill.show();


private void jbInit() throws Exception
```

```
this.setSize(new Dimension(240, 414));
this.getContentPane().setLayout(null);
btnPostLocator.setText("Design Post Locator");
btnPostLocator.setBounds(new Rectangle(15, 50, 205, 30));
btnPostLocator.addActionListener(new ActionListener()

public void actionPerformed(ActionEvent e)

btnPostLocator_actionPerformed(e);

  });
btnSidePlate.setText("Design Side Plate");
btnSidePlate.setBounds(new Rectangle(15, 110, 205, 30));
btnSidePlate.addActionListener(new ActionListener()

    public void actionPerformed(ActionEvent e)

      btnSidePlate_actionPerformed(e);
          +

btnFrontBack.setText("Design Front and Back of Jig");
btnFrontBack.setBounds(new Rectangle(15, 165, 205, 35));
btnFrontBack.addActionListener(new ActionListener()

    public void actionPerformed(ActionEvent e)

      btnFrontBack_actionPerformed(e);

btnBaseMetal.setText("Design Base Metal");
btnBaseMetal.setBounds(new Rectangle(15, 230, 200, 35));
btnBaseMetal.addActionListener(new ActionListener()
```

```
public void actionPerformed(ActionEvent e)

  btnBaseMetal_actionPerformed(e);

btnWorkPiece.setText("Design Work Piece");
btnWorkPiece.setBounds(new Rectangle(15, 290, 200, 35));
btnWorkPiece.addActionListener(new ActionListener()

  public void actionPerformed(ActionEvent e)

    btnWorkPiece_actionPerformed(e);


btnCombine.setText("Show combined design");
btnCombine.setBounds(new Rectangle(15, 350, 200, 30));

btnCombine.addActionListener(new ActionListener()

  public void actionPerformed(ActionEvent e)

    btnCombine_actionPerformed(e);


  this.addWindowListener(
  new WindowAdapter()

    public void windowClosing(WindowEvent e)

      System.exit(0);
```

```
this.getContentPane().add(btnCombine, null);
this.getContentPane().add(btnWorkPiece, null);
this.getContentPane().add(btnBaseMetal, null);
this.getContentPane().add(btnFrontBack, null);
this.getContentPane().add(btnSidePlate, null);
this.getContentPane().add(btnPostLocator, null);


private void btnPostLocator_actionPerformed(ActionEvent e)
 new DrawPostLocator().show();

private void btnSidePlate_actionPerformed(ActionEvent e)

 new DrawSidePlate().show();


private void btnFrontBack_actionPerformed(ActionEvent e)

 new DrawFrontBack().show();

 private void btnBaseMetal_actionPerformed(ActionEvent e)

 new DrawBaseMetal().show();

private void btnWorkPiece_actionPerformed(ActionEvent e)

 new DrawComponents().show();


private void btnCombine_actionPerformed(ActionEvent e)
```

```
 DrawDrill drawDrill = new DrawDrill();

drawDrill.setDefaultCloseOperation(JFrame.DISPOSE_ON_CLOSE);

 DrawTask task = new DrawTask(drawDrill);
 drawDrill.show();
 //  new Timer().schedule(task,5000,10000);
 //  this.dispose();
```

```
package CAD;
import java.util.Timer;
import javax.swing.JFrame;
import java.awt.*;
import java.awt.event.*;

public final class DrawDriller extends JFrame

  private int depth = 250;
  private int outerdiameter = 440;
  private int innerdiameter = 240;
  private int holedepth = 50;
  private int holeoffset = 30;
  public int count;

  public void setDepth(int dep) { depth = dep;}
  public void setOuterDiameter(int diameter) {
outerdiameter = diameter;}
  public void setHoleDepth(int dep) { holedepth = dep;}
  public void setInnerDiameter(int diameter) {
innerdiameter = diameter;}
  public void setHoleOffSet(int offset) { holeoffset =
offset;}
```

```
Public DrawDriller()

super("Drawinq Drills");
this.setBackground(Color.WHITE);
//show();
setSize(new Dimension(667,600));
setResizable(false);


public void paint(Graphics g)


 switch(count)

case 0:
int[] xvalues =
{120,560,560,460,460,220,220,120,120};
int[] yvalues =
{150,150,200,200,400,400,200,200,150};

Polygon poly1 = new Polygon(xvalues,yvalues,9);
g.drawPolygon(poly1);
g.setColor(Color.WHITE);
g.fillRect(150,150,20,50);
g.fillRect(510,150,20,50);
g.setColor(Color.BLACK);
g.drawRect(150,150,20,50);
g.drawRect(510,150,20,50);

g.setColor(Color.BLACK);
g.drawLine(150,150,150,200);
g.drawLine(170,150,170,200);
g.drawLine(510,150,510,200);
g.drawLine(530,150,530,200);
```

```
    g.drawString(String.valueOf(depth -
holedepth),199,300);
    g.drawString(String.valueOf(holedepth),99,175);
    g.drawString(String.valueOf(holeoffset),122,160);
    g.drawString(String.valueOf(outerdiameter -
holeoffset),310,160);
    //g.setColor);

g.drawString(String.valueOf(innerdiameter),310,400);
    break;
    case 1:
    g.setColor(Color.LIGHT_GRAY);
    int [] xvalues1 =
{310,370,370,440,440,370,370,310,310,240,240,310,310};
    int [] yvalues1 =
{70,70,130,130,420,420,480,480,420,420,130,130,70};
    poly1 = new Polygon(xvalues1,yvalues1,13);
    g.fillPolygon(poly1);
    g.setColor(Color.BLACK);
    g.drawPolygon(poly1);
    break;
    case 2:
    g.setColor(Color.gray);
    int [] xvalues2 =
{100,240,240,440,440,580,580,440,440,240,240,100,100};
    int [] yvalues2 =
{401,401,420,420,401,401,480,480,460,460,480,480,401};
    poly1 = new Polygon(xvalues2,yvalues2,13);
    g.fillPolygon(poly1);
     g.setColor(Color.BLACK);
    g.drawPolygon(poly1);
    break;
```

```
    case 3:
    g.setColor(Color.LIGHT_GRAY);
    int [] xvalues3 =
{80,80,90,90,80,80,100,100,110,110,220,220,110,110,80};
    int [] yvalues3 =
{150,300,300,330,330,480,480,401,401,330,330,300,300,15
0,150};
    poly1 = new Polygon(xvalues3,yvalues3,15);
    g.fillPolygon(poly1);
     g.setColor(Color.BLACK);
    g.drawPolygon(poly1);
    break;

    case 4:
    g.setColor(Color.LIGHT_GRAY);
    int [] xvalues4 =
{600,600,610,610,600,600,580,580,570,570,600};
    int [] yvalues4 =
{150,300,300,330,330,480,480,401,401,150,150};
    poly1 = new Polygon(xvalues4,yvalues4,11);
    g.fillPolygon(poly1);
    g.setColor(Color.BLACK);
    g.drawPolygon(poly1);
    break;

    case 5:
    g.setColor(Color.GRAY);
    g.fillRect(80,120,60,30);
    g.fillRect(540,120,60,30);
    g.setColor(Color.BLACK);
    g.drawRect(80,120,60,30);
    g.drawRect(540,120,60,30);
    break;
```

```
    case 6:
    int [] xvalues5 =
{180,180,240,240,310,310,250,250,180};
    int [] yvalues5 =
{120,150,150,130,130,100,100,120,120};
    poly1 = new Polygon(xvalues5,yvalues5,9);
    g.fillPolygon(poly1);
    g.setColor(Color.BLACK);
    g.drawPolygon(poly1);
    break;

    case 7:
    int [] xvalues6 =
{370,370,440,440,500,500,450,450,370};
    int [] yvalues6 =
{100,130,130,150,150,120,120,100,100};
    poly1 = new Polygon(xvalues6,yvalues6,9);
    g.fillPolygon(poly1);
    g.setColor(Color.BLACK);
    g.drawPolygon(poly1);
    break;

    case 8:
    g.setColor(Color.LIGHT_GRAY);
    setTitle("Design Completed");
    g.fillRoundRect(300,55,80,25,10,10);
    g.fillRoundRect(300,470,80,25,10,10);
    g.setColor(Color.BLACK);
    g.drawRoundRect(300,55,80,25,10,10);
    g.drawRoundRect(300,470,80,25,10,10);
    //g.setColor(Color.BLACK);
    //g.drawString("1",200,200);
```

```
    /**
     *
     * @param args
     */
    /*public static void main(String[] args)

      //DrawDriller drawDrill = new DrawDriller();

//drawDrill.setDefaultCloseOperation(JFrame.DISPOSE_ON_
CLOSE);
      //DrawTask task = new DrawTask(drawDrill);
      //new Timer().schedule(task,5000,10000);

    */
```