APPLICATION OF VISUAL BASIC PROGRAMMING AND AUTO CAD IN DESIGN OF OXYGEN CONVERTERS

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CERTIFICATION

I certify that this research project was carried out by SANNI, OLUWATOYIN ADENIKE at the Department of Metallurgical and Materials Engineering Federal University of Technology Akure, under our supervision and it has not been submitted elsewhere for the award of a degree.

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DEDICATION

This project is dedicated to the Lord God Almighty, my maker and the lifter of my head.

ABSTRACT

The oxygen converter steel making process has undergone various improvements since its introduction and is now a mainstream steel making process in the steel industry. This work is an attempt to design oxygen converters of different capacities using the physico chemical process and the blowing regime during melting to derive equations for the calculation of converter inner profiles, computer algorithms for design equations using visual basic programming language was developed. The programm was validated by using Auto Cad to draw the various shapes of the oxygen converter, the higher the tonnes, the higher the height and the wider the diameter, the bulkier the oxygen converter. Visual basic programming language and computer aided design will improve the design of oxygen converters. The recent trend in the equipment technology of oxygen converters is described from the point of view of equipment design.

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CHAPTER ONE

1.1 Background Of The Study

The design of a converter has been considered more of an art than a science but the accumulation of experience and the improvement of mathematical as well as computational techniques helped in better understanding and designing such structures (Wallner 2002). At present over 750 millions of crude steel are produced each year world wide due to its versatile use and relayed ability with no downgrading to a lower quality (International, Iron and steel Institute 1999).

The modern high performance BOF converter is the product of continues improvements over the past 50 years, ever since Voest –Alpine commissioned the first converter in lines, Australia, 1952. Today roughly 600 oxygen converters are in operation worldwide annually producing approximately 450 million tones of steel. This amount for roughly 60% of the total steel produced worldwide (Staudinger, 2004)

The pressure on steel producers regarding cost and quality is ever increasing and is combined with high demands on flexibility in production, shorter delivery times and adherence to time schedules. From the inception of oxygen steel making the converter was the focus at continued improvement with respect to increasing its life and charging weights and decreasing its maintenance requirements (Hollies, 2002).

Visual Basic is the latest and greatest incarnation of the old Basic language that gives a complete windows application development system in one package, it allows writing, editing and testing of window applications. According to Samarasca, 1991, Keith Brimacombe was on of the first to envision the potential power of the new element methods that have been originally developed for the aerospace industry and were starting to expand into other areas. He realized that the powerful flexibility of these methods would unleash the process engineer and mathematician from the inherent limitation of analytical solutions and create new opportunities, for the analysis and understanding of process. Early modeling pioneers had shown how to develop mathematical models to tackle a wide range of phenomenon with more return and accuracy than ever. (Brain, 2002).

This research is an attempt to use the behaviour of physio –chemical Processes and the blowing regime during melting to derive equations for the calculation of converter inner profiles. It also considers the metal current, intensity of slagging, S_i0_2 content in slag, oxygen blowing intensity and the rate of decarbonisation. The calculations derived are especially useful in designing large capacity converters in Ajaokuta steel project Visual basic programme is developed from the given equations. Auto CAD is used for the converter design drawings useful for future reconstruction or expansion of the steel plant.

This work therefore is an attempt to use physico-chemical data to profer analytical solutions by developing mathematical modeling to tackle oxygen converter design problems.

1.2 Objectives of the study

The objectives are to:

1. Develop the process calculations from manual to computer aided processes and blowing regime to developed design equations.
2. Develop computer algorithm for design equations using visual basic programming in design of oxygen converters.
3. Validate the programme using CAD to bring out the various shapes of the oxygen converters.

1.3 Contributions of Research to knowledge. The developed programme will assist indigenous engineers to design oxygen converter.

1.4 Scope of the study.

These study deals with the development of process calculations from manual to computer aided program and also write the appropriate program for the calculations of the dates using visual Basic Programme. Auto card was used to draw the various shapes of the oxygen converters.

1.5 Justification for the study.

There has not been much work on the design of oxygen converter in the whole world. There are almost 600 oxygen converters in operations in the world. In Nigeria there is need to study and understand the steel making process routes since there is an improvement in the technology at the world and manual calculations and drawing are phasing out due to the computer jet age.

There is need to develop computer algorithm for design equations and validating the programme using auto cad to bring out the various shapes of the oxygen converters

CHAPTER TWO

LITERATURE REVIEW

2.1 HISTORY OF STEEL MAKING PROCESSES

In the early days steel was manufactured by packing bars of wrought iron into cast-iron boxes with certain amounts of carbonaceous materials and heating them in a furnace at about 1000^0 C for a week. In these circumstances, carbon was absorbed gradually into the surface of the iron, and when the bars were ultimately forged into whatever shape was required, the carbon became more or less evenly distributed throughout the structure. This process, called the Cementation process, persisted until 1742, when Benjamin Huntsman, a watchmaker, decided that many of his watch springs were breaking because of a lack of homogeneity in the steel. He therefore melted the bars of "blister" steel (the product of the Cementation Process) in a crucible and, after casting and rolling, produced high-grade steel, since most of the slag, present in the original bars of wrought iron and consequently in the blister steel, was lost during melting. High-quality steel is still made by a somewhat modified Huntsman process and continues to be known as "cast steel". In the broad sense all steel is now "cast" in so far as it is poured into ingot moulds and allowed to solidify prior to subsequent forming processes. The term "cast" used in this context is meant to indicate "crucible cast" as distinct from mass-produced steel made by the open-hearth, Bessemer or "oxygen" processes.

Until little more than a hundred years ago steel was an expensive material, produced in only small quantities for such articles as swords and watch springs, while structural work was carried out in cast iron or wrought iron. The first metal bridge in Europe was built over the River Seven (at Ironbridge) in 1779, and contains 400 tonnes of cast iron; whilst the erection of the Eiffel Tower involved the use of some 7000 tonnes of wrought-iron girders. The ill-fated Tay Bridge consisted of 84 spans, each 60 m long, built entirely of wrought iron. It collapsed on one stormy December night in 1879 when a train was passing over, with the loss of over a hundred lives. This disaster was not so much due to the low strength of wrought iron as to bad engineering design. Adequate allowances had not been made for the stress of wind and waves.

The cementation and crucible methods were responsible for all the steel-manufactured until the year 1856, when Henry Bessemer introduced the steel-making process which bears his name. This was the first process for the mass-production of steel. It was followed about ten years later by the open-hearth process, and until 1952 these two processes were responsible for the manufacture of the bulk of the world's steel. To day the newly developed "oxygen process" are again changing the pattern of steel production both in Britain and else-where.

Steel-making processes are said to be either "acid" or "basic", these terms referring to the chemical natures of the slag and furnace linings. Until the researches of Thomas and Gilchrist made it possible to utilize phosphoric pig irons, only low-sulphur, low-phosphorus pigs could be used, and because these were usually rich in silicon, an acid slag, charged with silica, was produced. Since the slag was acid, it was necessary to line the furnace with a similar acid refractory (silica bricks) in order to prevent any reaction from taking place between the slag and the furnace lining.

The work of Thomas and Gilchrist enable phosphoric pig irons to be used. In their processes an excess of lime is added to the slag in order to facilitate the removal of phosphorus. But lime is a basic substance which would quickly react with the ordinary silica-brick furnace lining, leading to its liquefaction in a similar way to that of the siliceous gangue when fluxed by the lime in the blast furnace. Hence in the basic steel-making processes it is necessary to line the furnace with a basic refractory, such as burnt dolomite (CaO.MgO) or burnt magnesite (MaO). These are expensive reefractories, but their use enables the large quantities of phosphoric ore to be turned into high-grade steel. Formerly basic steel was regarded as being inferior to acid steel, but of late, this traditional ideas has been largely dispelled by the improved quality of basic steel which has resulted from technical improvements in the method of production."

2.2 A BASIC OXYGEN CONVERTER

Molten iron and steel scrap are first charged into the converter. An oxygen lance is lowered to within a few feet of the charge and the oxygen is turned on. A violent outburst of smoke and gases issues from the mouth of the converter as the oxygen refines the iron into steel.

In addition the new method can be used to produce steel on a small scale.

The process is thus well suited to smaller nations with little capital producing steel for the first time which accounts for the eager adoption of the process by many such countries.

A basic oxygen converter closely resemble a Bessemer converter, but without the holes in the bottom for the admission of an air blast. Instead of air, pure oxygen is employed to refine the steel. It is fed into the mouth of the converter like the Bessemer converter. The basic oxygen converter is tilted on its side to receive the charges which consist of about seventy five percent molten iron and 25 percent scrap. The vessel is then moved to an upright position and a water-cooled lance is lowered to within a few feet of the charge. The lance is connected to a tank containing oxygen kept under pressure (Higgins, 1983). The oxygen is turned on and flows through the lance to the charge. As the oxygen hits the molten iron the reaction is instantaneous and violent flames and dense clorid of smoke and gas empty from the open mouth of the converter with a loud roaring noise. The gas and smoke are collected in a close – fitting shielded and passed through cleaning - equipment so that nothing escapes into the atmosphere.

The oxygen is dissolved in the mouth bath and quickly oxidizes the silicon, magnesium, phosphorous and carbon monoxide gas which produces a vigorous slicing action of the entire charge. But all the carbon is not allows to be oxidized. A very small amount must be retained to convert the iron and steel. The point at which the carbon reaches extremely low level is easily recognized.

The boiling action stops and the flames at the mouth of the converter die down. The oxygen is turned off, the lance is withdrawn and the vessel is tilted on its side to permit skimming off the slag. The converter is tilted over further so that the molten steel can be poured into a ladle. The entire operation takes about thirty –eight minutes.

About half of the basic oxygen steel produced is used for sheets, plates, and structural steel of welding quality. The other half is used for rimming steel (explained later). From which deep-drawn parts are made, such as automobile body parts.

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The (BOS) vessel holds about 280 tonnes of steel. It is lined with special bricks called refractories that tolerate very hot temperatures. The BOS vessel is one-fifth filled with steel scrap. Molten iron is added until the vessel is full. Filling the furnace with the ingredients is called charging The vessel is then stood upright and a lance is lowered down into it. The lance blows 99 percent pure oxygen onto the steel and iron, causing the temperature to rise to about 1700°C. This melts the scrap, lowers the carbon content of the molten iron and helps remove unwanted elements, Fluxes (burnt lime or dolomite) are fed into the vessel to form slag which absorbs impurities of the steelmaking process. Near the end of the blowing cycle, which takes about 20 minutes, a temperature reading and samples are taken. The samples are tested and a computer analysis of the steel given within six minutes. The BOS vessel is tilted again and the steel is poured into a giant ladle. This process is called tapping the steel. In the ladle furnace, the steel is further refined by adding alloying materials which give the steel special properties required by the customer. Sometimes argon or nitrogen gas is bubbled into the ladle to make sure the alloys mix correctly. The steel now contains 0.1-1 percent carbon. The more carbon in the steel, the harder it is, but it is also more brittle and less flexible

• 2.4 ELECTRIC ARC FURNACE STEELMAKING

An Electric Arc Furnace (EAF) is used to produce new steel from scrap metal. If scrap steel is readily available, this method is lower cost than the traditional blast furnace method of making steel, and it conserves raw materials like iron ore, coke and fluxes. Iron from other sources can also be used as feed for the EAF. The procedure followed in making electric furnace steel depends upon the product being made. If the steel is to contain an appreciable percentage of easily oxidized alloying elements, such as chromium, tungdten, and molybdenum, two slag covers are used during a heat. An oxidizing slag promotes oxidizing and fluxing of carbon, phosphorus, and silicon. The oxidizing slag is then removed and replaced by a reducing slag in which CaO and CaC_2 are important ingredients. This slag blanket helps removal of sulphur and oxides impurities and affords protection against oxidation of alloy element additions. In making steel for ordinary castings the second slag is not needed, since the easily oxidized elements found in stainless and tool steels are not present.

2.5 The Rotor Process

It was developed about the same time as the Kaldo process it differs from other oxygen processes in that the oxygen is admitted in two stages this results in the complete combustion of carbon to carbon dioxide before it leaves the converter and so gives a much higher thermal efficiency than is the case when partial oxidation to carbon monoxide takes place, the latter then burning in the mouth of the converter and away from the metal bath. Slag –metal reactions follow the same general pattern of other oxygen process.

The Rotor process was developed to use molten pig iron along with high-purity Swedish ore as the coolant, though ore can be replaced by scrap for this purpose if suitable feeding arrangements are provided.

2.6 Spray Steel-making.

It was a continuous process originated by the British Iron and Steel Research Association. A stream of molten pig iron is allowed to fall into the reaction chamber where it meets cross-fire from a number of oxygen jets situated in a ring in the roof of the chamber. Lime and flux are blown into the stream as shown.

The refining reactions, which are similar chemically to those in other oxygen processes, take place almost instantaneously so that continuous operation can be achieved. Combustion of carbon to carbon dioxide is almost complete. This leads to a high thermal efficiency so that up to 40% scrap can be used. Moreover, the equipment is relatively simple and low cost, whilst wear on the refractory should be much less than in other oxygen processes because the reactions occur away from the walls of the reaction chamber. Such a unit, working in conjunction with a blast furnace would lend itself well to continuous casting processes.

Despite such obvious advantages, work on the project has been suspended. Technically because of difficulties of control.

2.7 Computer – Aided Design

Computer – Aided Design (CAD) is concerned with the application of digital computers and computer based technique to the design of engineering systems. The use of digital computers to assist in the engineering design process is not novel, in fact the numerical solution of design equations was one of the earliest applications of computer.

Thus the term CAD was used initially to describe the application of computers to any design calculations. It has now taken active system where the designer and computer are working together in an intimate partnership (Lewin, 1977).

Computer is being used at an increasing rate for both engineering design and drawing purposes. There are many computer aided design which are being continually developed and refined, basically a CAD system consist of a central processing unit (CPU) and a work station,

The work station is a set of hardware equipment and soft ware, which is a collection of instructions by which any computer operates. The work station is connected locally or remotely to the central processing unit of the computer and it consists of input devices display devices, output devices and the supporting software. The included soft ware consist of programs which are list of instructions written in a computer language needed for producing drawings, images etc.

2.8 Advantages of using AutoCAD

(a) Constant quality drawing.

(b) Creation of database which is the collection of useful information that may be retrieved by draughtsmen and accessed by other producers.

(c) Creation of library of commonly used electrical hydraulic welding etc, symbol standard components such as bolts, nuts screws bearings etc. projection symbols, parts of drawings etc can be stored in the memory and recalled when needed.

(d) Use of layers: the drawings may be drawn on any one of a number of available layers which may be considered as a stack of transparent sheets.

(e) Saving on repetition: Repetitive work on similar features on drawings and the resulting tiredness and boredom is replaced by automatic redrawing hence attention and interests are maintained with consequent make interest in speed and productivity.

(f) Greater Accuracy: due to computer mathematical accuracy a high level of dimensional control is a obtained with reduction in the number of mistakes resulting in accurate materials and cost estimates.

Editing functions: the powerful editing functions of correcting mistakes deleting and inserting new features, copying, moving, translating and rotating features, scaling etc is only made possible with the use of computers. (Ostrowsky, 1989)

2.9 Design Automation Systems

Design Automation is primarily concerned with reducing the cost and development time normally required in engineering complete digital systems, design automation is restricted to those aspects of design which are involved with translating the initial systems specification into a viable logic design, complete with packaging and fabrication details (IEEE, 1972).

There are many advantages in using a design automation system.

a. Allows formal design algorithm to be adopted without replacing tedious hand computation, and in many cases expert theoretical knowledge.

b. Fast and error free (providing the initial specification is correctly formulated) design of large variable systems.

c. Alternative design may be evaluated by restating the problems, or by changing implementation parameters such as minimization criteria, logic modules, board sizes, layout e.t.c.

d. Modification and editing of design is easily accomplished without the risk of introducing errors.

e. Simulation packages allow logic desiring to be evaluated and errors corrected before proceedings to the final implementation.

f. Automatic generation of fault test schedules manual generation using simulation techniques can be provided.

The inclusion of synthesis packages (in conjunction with suitable method of system specification and evaluation) in the design automation scheme vastly increases its usefulness, particularly when coupled with interactive techniques, such a system, for example would allow the designer to specify and evaluate a system proposal and then proceed directly to engineering design. The main advantages of a "front-end" of this types is the reduced costs and time involved in producing reliable design and the facility to perform system evaluation and optimization. Moreover the creative ability of the designer continually increases as he learns through man-machine interaction (HEATH, 1972).

An algorithm is generally defined as a finite set of rules which gives a sequence of operations for solving a specific class of problem. An algorithm must of course always terminate after a finite number of steps but the number of steps involved is a critical parameter which determines the efficacy of the algorithm for computer usage many problems can be solved algorithmically. A practical algorithm must have a reasonable number of finite steps which are executed in a realistic time (Knuth, 1972).

CHAPTER THREE

MATERIAL AND METHODS

3.0 Selection Criteria for Design of Oxygen Converter

When designing oxygen converters of a large capacity, the parameters are selected empirically since a modern BOF converter consist of a top cone with lip ring, a barrel section and a lower cone with a distant bottom. (www. Aistech.org). Which ensures the best conditions for pouring in pig iron and charging scrap. The shell of the throat is sometimes made of pig iron with cast in pipes for water cooling the life of the throat thus increases and in addition it clears well from metal and slag skulls.

3.1 THE SHAPE

The shape of modern converters is selected depending on their capacity and the specified rate of oxygen supply for a melt, for a given distance, from the end of the lance to the surface of the quiet bath, and a given pressure and flow rate of oxygen. The diameter of the cone of the oxygen jet at the point of striking the metal surface can be determined. A normal course of melt without much splashing is possible if the minimal allowable inner volume of the vessel has been chosen correctly (Oiks, 1977). There are several criteria for the optimum design of a converter vessel. One of the most important characteristics is the inner volume enclosed by the refractory. This volume should be maximized within the available space so at to have maximum reaction volume to achieve an optimum metallurgical process. A typical BOf converter has a ratio of approximately 1. 0m^3/tonne (Prenaar, 1998)

The engineering of such equipment, which is exposed to extreme temperature mechanical impact and thermal stress conditions, is a formidable challenge. Dramatic improvements have been made with respect to the lifetime of the vessel, increasing charging weight and decreasing maintenance requirements. In converter design, the conditions that occur during the steel making process make it almost impossible to observe directly what is happening inside the converter. There is no mathematical model that can fully describe the coupled thermo- metallurgical/fluid dynamic process that takes place. The metallurgical reactions are most widely understood as they have been investigated and improved from the inception of converter steel making (Standinger, 1998). The suspension system is of particularly high importance for achieving a long converter life for the production of high quality steel grades and to improve the process economics components, which as sub lance, slag stoppers, bottom stirring and automation system were developed. The continuous improvements, standardization of process technology and application of these components together with investigations in plant logistics and metallurgical and cost optimization are effective tools for steel producers (AISE, 1996).

3.2 The Lining of converters

The life of the lining of converters depends on the resistance of its material to the eroding action of metal, slag and dust on its thermal shock or spalling resistance. The material commonly used for lining oxygen convert ers are tar-bonded ,unburnt dolomite and magnesite.

Magnesite is a high refractory material which resists well the eroding action of slag but has a low spalling resistance. Dolomite especially when burnt at a low temperature (approx 1,000^{0}C) is susceptible to erosion by slag and metal and to hydration.

Magnesite – chromites and chrome – magnesite bricks are also employed for lining converters magnesite – chromites bricks has the following composition 68 – 71 % MgO, 9 – 15% Cr_20_3, 6 – 8 % fe_20_3, 1-3 % Ca0, 4-5 % S_10_2, 2 – 4 % Al_20_3 and 2 – 3 percent calcinations loss. Its stability is very high, mechanical strength within 490 – 55 kgf (cm^2 porosity 15 – 17 percent and softening point 1600 – 1,630^{0}C (oiks, 1977). Magnesite bricks prepared under pressure from a mixture of burnt magnesite powder and molasses are burnt at a temperature of 1550 – 16500C. The content of Mg0 in magnesite bricks must be at least 91 percent, that of S_10_2, 3 – 3.5 percent, and that of Ca0 not more than 3 percent.

Dolomite brick is formed from burnt dolomite powder with the addition of tar at 560kgf $1cm^2$ and burnt at 1550 – 1600°C slag – stable burnt dolomite bride is made by pressing drying and burning a mixture of dolomite stabilized by the addition of magnesium silicate and silica, dolomite clinker, and magnesite clinkers. Bricks (45 – 65 percent Mg0, 22 – 29 percent Ca0 and 10 percent S_10_2) are characterized by a high spalling resistance and high resistance to the eroding action of slag.

The lining of oxygen converters is usually made up of three layers of brick. First, the inner layer of magnesite, magnesite chromites or burnt dolomite brick is made gaps between bricks and the shell being filled with tar dolomite ramming prepared from used tar dolomite bricks. The same ramming composition is used for making up the second intermediates layer. The upper working layer is made of non burnt tar dolomite brick. The same ramming composition is used for making up the second, intermediate layer. The upper working layer is made of non burnt tar dolomite or dolomite – magnesite brick. The working layer determines the life of the whole lining of the vessel. The conical throat position is lined in the same manner.

The converter bottom also has at least three layers of lining, first a layer of fire day or burnt magnesite brick is laid on to the metallic bottom, then a layer of magnesite brick and finally, the working layer of tar dolomite or dolomite magnesite brick. The later may sometimes be tar dolomite rammed.

3.3 CHARGE MATERIALS FOR THE OXYGEN CONVERTER PROCESS.

The charge for an oxygen converter melt is composed of pig iron, scrap, iron ore, lime, fluorspar, limestone, mill scale e.t.c.

3.3.1 Pig iron:

The proportion of pig iron is 70 to 100 percent of the metallic charge. The process is suitable for treating pig irons of any composition. High silicon pig iron increases the amount of fluxes to be used, the bulk of slag and the loss of iron with slag impair the life of the lining and complicates dephosphorization and desulphurization in the case of one –slag operation. Too low a concentration of silicon in pig iron is also in admissible, since it may result in a protracted period of lime dissolution i.e. a longer period of vessel operation with almost no slag. This in turn causes rapid wear of the lining at the slag belt, skulling of the lance and power desulphurization of the metal. A recommended composition of pig iron for the process is 0.7 – 0.8 %, silica is 0.7 -0.9 % manganese 0.03 % sulphur and not more than 0.2 % phosphorus (Oiks, 1977).

3.3.2 Steel Scrap

Steel scrap is used to chill the converter metal. The proportion of scrap in oxygen converters charges has been gradually increasing and now reaches 30 percent of the metallic charge. Larger proportions of scrap are preferable since scrap is cheaper than iron. The density of scrap should not be less than $2.5 t/m^3$. Light weight scrap and chips are unsuitable for the oxygen converter process as much time is required for their charging. Briquetting of light weight scrap to a density of $2.5\ t/m^3$ is advisable. The whole mass of the scrap may be charged from the scrap into the vessel at one go.

3.3.3 Iron Ore

Iron ore to be charged to the converter should have at least 8 – 10 percent S_10_2 and not more than 5 percent fines of the total amount. (Oiks, 1977).

3.3.4 Slag forming additives

Lime and fluorspar are most often used to form slag. The most suitable slag former for oxygen converter melting is white low – burnt lime produced by calcining in rotary furnaces at a moderate temperature with more than 90 percent Ca0, less than 0.5 percent S, less than 3 percent S_10_2 and with lump size 10 – 25 mm, porosity at least 48 – 50 percent (Aftanasye; 1957). A high porosity of lime, promotes filter reacting of ferrous oxide (owing to a greater area of reaction surface), quicker slag formation and deeper dephosphurization and desulphurization of the metal. Lime may be replaced with limestone, but this slow down the formation of slag, increase the blow time, makes the slag foamy, increases splashing and the amount of waste gases and reduces the steel yield. According to Ajaokuta steel complex handbook, the lime shop is designed for making 91, 000t/y of converter lime, it has two rotary kilns, 3.6 m in diameter 75m long as well as drum coolers, 2.5m in diameter, 38m long.

3.3.5 Mill scale

Mill scale must be dry and clean and is usually charged in small amounts, Ore agglomerates is sometimes used as coolants. It should contain not more than 8 percent S_10_2 and not more than 5 percent times of the total amount. (Oiks, 1977).

3.4 Basic programming languages.

Throughout the years, the computer industries have seen some radical improvements in soft ware developments tools in the early days of computers, when a computer took up an entire room programme flipped switches to make the computer perform simple additions, these complex machine were the cutting edge in technology. These could add two numbers as technology pfogress, punch cards which were then fed into a reader that would interprets the tools and create programming code on mainframes. The next generations of programming tools were text based editors and were used to write machine language, assembly language and Beginners All-purpose symbolic Instructional code (BASIC), once considered a toy,the Basic language evolved into one of the most easy to use and powerful programming language. (www. Ingestion connection).

3.4.1 Visual Basic Programming language.

Visual Basic provides a graphical environment in which you visually design the forms and controls that become the building blocks of your application, visual basic support many useful tools that will help you to be more productive. These include, but are not limited to projects, forms, class, objectives, templates customer, useful adding and database managers. You can use these tools together to create complete application in months, weeks or even days, producing an application using another language can take much longer (Brown, 1998).

3.4.2 Visual Basic language is chosen because

1. It is graphical programming language.
2. It is easier than all other programming language.
3. It is a window based programming language
4. It is user friendly and an interactive program.

3.4.3 The Standard set of steps to follow when creating visual basic programme are:

1. Decide what your application is to do by creating an overall design.
2. Create the visual portion of your application.
3. Add visual basic programming language code to tie the visual elements together and to automate the programme.
4. Test your application and distribute the compiled application to your users.

The most important steps in writing a programme is understanding the problem in need of solution and in defining the objectives that must be reached. The better you understand the problem and the objectives the better your solution will be (wortman et al 1984).

3.5. CALCULATIONS OF CONVERTER INNER PROFILES.

The various parameters for analysis were calculated manually and using visual basic programme, Data were obtained.

The parameters of the working surface in the design of oxygen converter are

1. The diameter of the converter mouth d_1
2. The inner diameter d_2
3. The diameter of the spherical bottom d_3.
4. The height of the upper conical segment h_1.

5. The height of the cylindrical part h_2.

6. The depth of the metallic bath.

7. The height of the lower conical segment h_3.

8. The height of the spherical segment h_4.

3.5.1 The diameter of the converter.

The diameter of the converter mouth d_1 is always designed in such a way as to be big enough to permit changing of scrap contained in a single scrap box without destroying the lining further more of reduce splashing and slopping and at the same time satisfy the need for higher rate of material charging, the optimal value of the diameter of the converter mouth d_1 must be between 0.4 – 0.6 of the internal diameter. Angle of inclination of the wall θ must ensure possible stable lining without its disturb in practice. It was discovered that when the normal scrap ratio in the charge is 25%, the value at d_1 could be determined by the equation.

$d_1 \geq 0.22T^{1/2}$ 3.1

However, the mouth diameter must be chosen from the point of view that the refractory lining is continuously wary away by the waste gases and also reductive in metal deposition at the neck. Hence the mouth must satisfy the following condition.

$d_1 \geq 0.12\, QO_2^{1/2}$ 3.2

The average value between the two could be chosen.

The diameter of the cylindrical segment,

$d_2 = 2d_1$ 3.3

The diameter of sphere is taken to be

$d_3 = 0.855d_2$ 3.4

3.5.2 Height of the converter

In the process of blowing, the converter bath level is greatly increased it is necessary to note that metal movement at the bath surface has a complex way characteristics accompanied by excessive periodic splashing during which metal – slag –gas suspension overflow it, forming what is generally known as slopping. The intensity of slopping depends greatly on tendency of slag to foam and it were add with the silica (S_1O_2) content of slag, and especially when some solid unassimilated lumps of lime, which are capable of stabilizing the foam are present in the slag. This apart from loss of metal also occurs as a result of splashing. If parameter for construction of the oxygen converter is correctly chosen, loss of metal to splashing is not as significant as compared to loss of metal to slopping.

Calculations of the converter are done with the assumption that the average level of converter bath at the period of decarburization is at the top of the cylinder parts. A more recent method of calculating the bath height considers the need to eliminate stagnant zones usually formerly in the bath around the perimeter of the bottom wall. The height of the converter is the calculated sum of height of separate segment of the converter (Adewuyi B.O, 1983)

$H = h_1 + h_2 + h_3 + h_4$ 3.5

Height of the upper conical segment

$H_1 = 0.5d_2\tan\alpha/2$ 3.6

Height of the cylindrical segment

$h_2 = 4V_2 / \pi d_2^2$ 3.7

Height of lower conical segment

$H_3 = T^1 / 4.7d_2^2$... .... 3.8

$T^1 = T/0.89$

Height of the spherical segment

$h_4 = R - \sqrt{R_2 - d_2^2/4}$ 3.9

Where d_2 = diameter of the cylinder segment M^3

α = angle of inclination of the neck $\alpha = 57^0 - 60^0$

V_2 = volume of the cylindrical segment, M^3

R = Radius of the spherical segment

$R = 1.75\ d_2$

θ = Angle of inclination to the vertical

Varies from 20 to $40 - 45^0$

Height of the spherical segment is normally taken to be 1/6 – 1/9 d_2

For this research, α is taken to be 57^0

3.5.3 Volume of the converter

It is often assumed that for better circulation of slag – meter emulsion, the lower part of the converter is usually designed in form of two integrated rotating bodies i.e. the spherical segment with volume Vsp and the conical segment with volume Vcs.

Volume of the upper conical segment V_1 from Equation 3.3, $d_1 = 0.5\ d_2$.

Hence

$V_1 = h_1/12\ (d_2^{\ 2} + 0.5\ d_2^{\ 2} + (0.5d_2)^2$ ……………………..3.9

Volume of cylindrical segment V_2

As earlier said, the volume of the foaming bath, when decarburization is maximum is proportional to the blowing intensity $i0_2$, hence it was established that

$V_2 + V_3 = (0.75i0_2 + 1)\ V_3$……………………..3.10

Where V_3 = volume of the metallic bath

$V_3 = T^{1/p}$ ………………………………………..3.11

Where T^1 = weight of liquid metal in the bath = T/0.89

P = metal density = 7

3.5.4 Volume of the metallic bath

The metallic bath is made up of the conical and spherical segment from equation 3. 4

$d_3 = 0.855d_2$

Hence, volume of the lower conical segment, Vcs.

$Vcs = \pi h_3/12 \quad (d_3 + 0.855 d_2^2 + 0.855d_2)^2$ ………………3.12

And volume of the spherical segment VSP

$VSP = \pi h_4^2 (R-h_4)^3)$ …………………3.13

3.5.5 Converter shell and Refractory lining

Construction of the converter lining is determined by the melting technology, quality of the refractory material blowing, regime and dimension of the working surface.

Presently converter lining are done with different refractory metals in two or three layers. The outer layer is to protect the metallic outer shell of the converter. The thickness of this layer varies from 115 – 230 mm while the intermediate layer's thickness varies from 50 – 100mm.

The refractory thickness r_2 in the cylindrical part is calculated by the following equation.

$r_2 = 0.1423 \sqrt{T}$……………………..3.14

Where T = converter capacity, t

Thickness of the upper conical segment, t

$r_1 = r_2 - 0.15$ 3.15

Thickness of the bottom r_3

$r_3 = r_2 + 0.125$ 3.16

The converter shell thickness is determined by

$\delta = 0.015\ {}^3\sqrt{T^1}$ 3.17

External diameter of the converter

$Ds = d_2 + 2r_2 + 2\ \delta$............................3.18

Area of the bath surface SB

$S.B = \frac{\pi\ d_2^2}{4}$......................................3.19

Diameter tapping hole is given as $do = 0.1 + 0.00033T^1$

3.6 COMPUTER MODELS DEVELOPMENT

The computer models were obtained using various equations

$d_1 = 0.22T^{1/2}$ or $0.12\ Q_O^{1/2}$

$d_2 = 2d_1$

$d_3 = 0.855d_2$

$h_1 = 0.5\ d_2 \tan \alpha/2 \qquad \alpha = 57^0$

$h_2 = (4V_2/\pi\ D_2^2)$

$h_3 = T^1/4.7d_2^2$

$h_4 = R - \sqrt{R2 - D_2^2/4}$

$d_o = 0.1 + 0.00033\, T$

$r_2 = 0.142 * {}^3\sqrt{T}$

$r_1 = r2 + 0.125$

$SB = \pi d_2^2 /4$

$\delta = 0.015\, {}^3\sqrt{T}$

$H = h_1 + h_2 + h_3 + h_4$

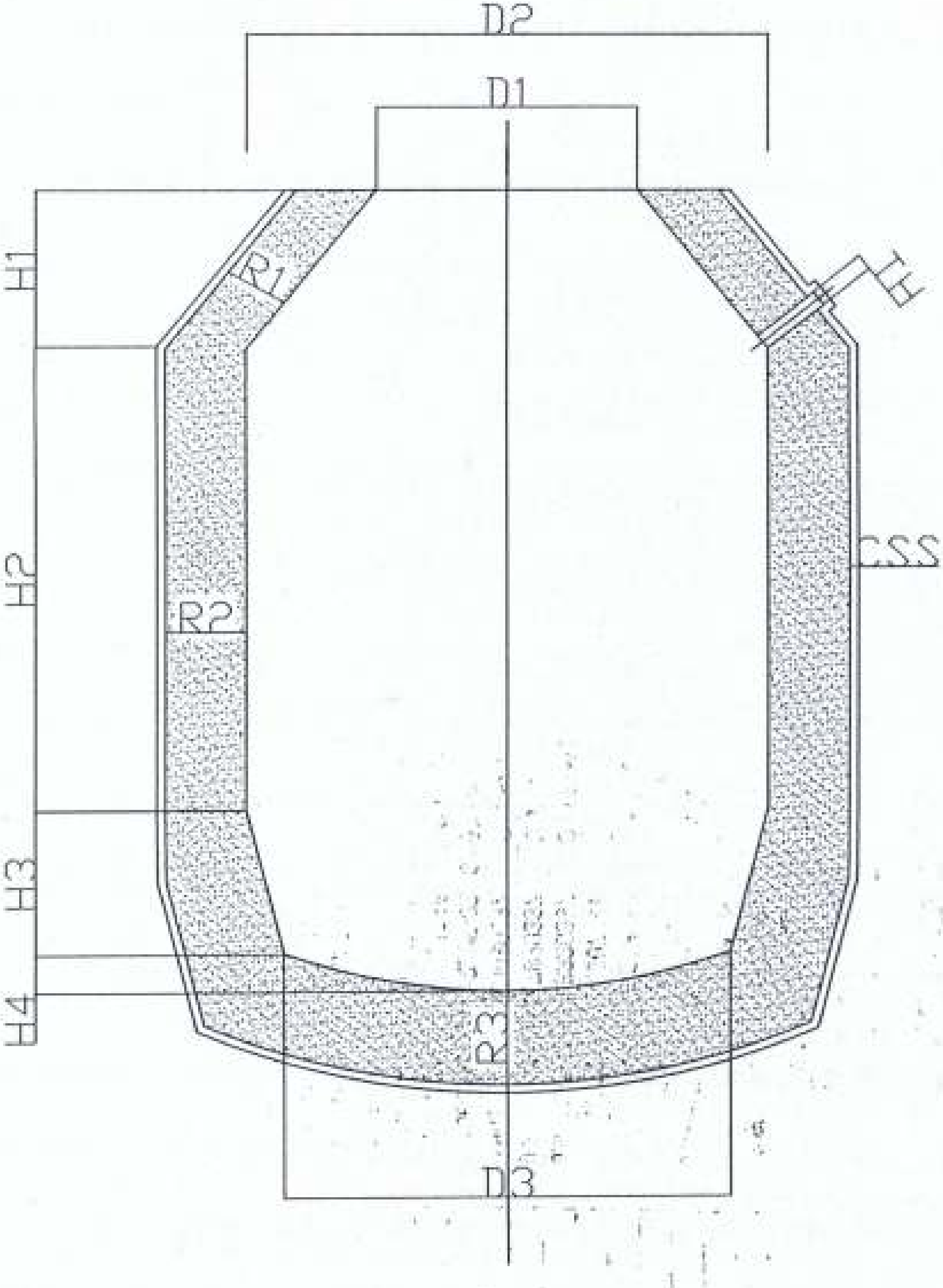
3.7 PROGRAM DEVELOPMENT

In using computer to solve a problem the solution must first be reduced to a series of specifics steps or instructions.

These instructions must be extremely detailed they must also be expressed in a language the computer can understand. The names and locations of files must be designated and the logic and calculations to be used must be spelled out once the solution is defined and reduced to specific steps, the computer can be used with all its capabilities to execute the steps to process the input and produce appropriate output (Mandell, 1979).

A visual basic programmed was written for the various equations, with the visual basic programme any other capacities can be calculated. The flow chart for the visual Basic programme was developed.

In writing the programme, a thorough understanding of the problems are required. The Visual Basic programmed are written in sub routine, the dimension (Dim) is used in creating a location to store values as in Dim H_{11}, H_{21} and H_{31} in the program



Fig, 1: Oxygen Converter in mm.

CHAPTER FOUR

RESULTS AND DISCUSSION

The results for such different capacities of oxygen converters are shown on tables 1 - 17.

4.1. The height of the upper conical segments of the converter h_1

Table 1: The height of the upper conical segments of the converter h_1

Converter Capacity,T	Height of conical segment (m)
100	1.37302
150	1.681599
200	1.541744
250	2.170935
300	2.37814
350	2.568685
400	2.74604

The height h_1 increases as the converter capacities increases for various converter capacity the corresponding height are shown in Table 1 above, from the table it was deduced that this ensures minimum metal loss during melting as the shapes are able to accommodate the increase in bath volume it prevents slopping and splashing in the converter during blowing.

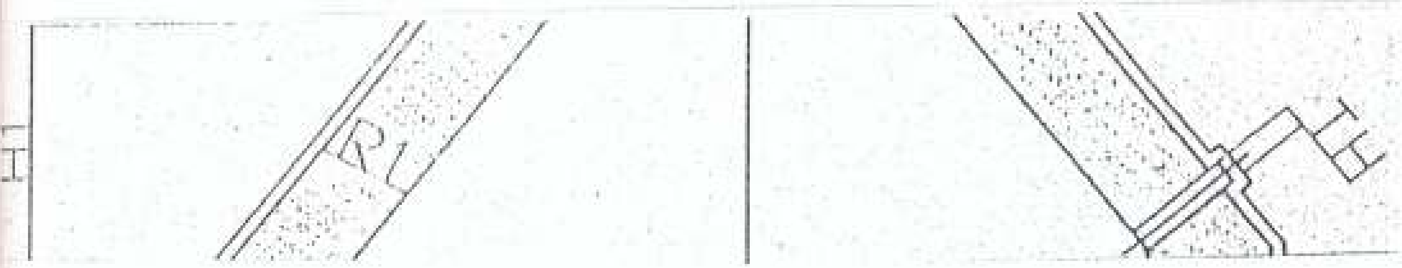


Fig 2: Upper conical segment.

4.2 Height of the cylindrical segment, h_2

Table 2: Height of the cylindrical segment, h_2

Converter Capacity (T)	Height of the cylindrical segment (m)
100	3.957064
150	3.957063
200	3.957064
250	3.957065
300	3.957064
350	3.957064
400	3.957064

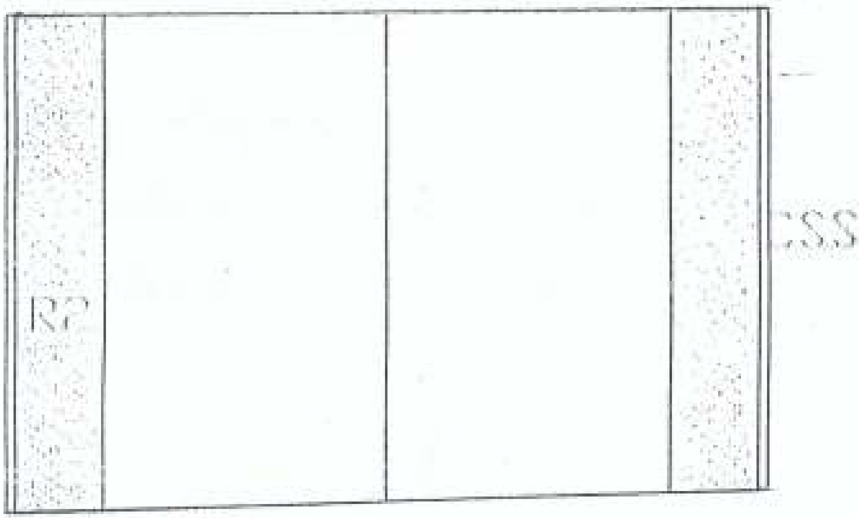


Fig 3: Schematic drawing of height of the cylindrical segment h_2.

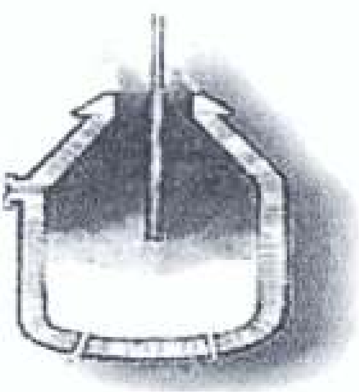


Fig 4: Reaction in the oxygen converter

The height of the cylindrical segment h_2 is approximately the same for the various oxygen converters capacities.

From Figure 4 it can be deduced that this zone accommodates the violent reactions between the gases and flames before the escape form the mouth of the converter this gas and smoke are collected in a close fitting shield and passes through cleaning equipment so that nothing escapes into the atmosphere.

4.3. Height of the lower conical segment h_3.

Table 3: Height of the lower conical segment h_3.

Converter Capacities T	Corresponding height of the lower conical segment (m)
100	1.234829
150	1.234829
200	1.234829
250	1.234829
350	1.234829
400	1.234829

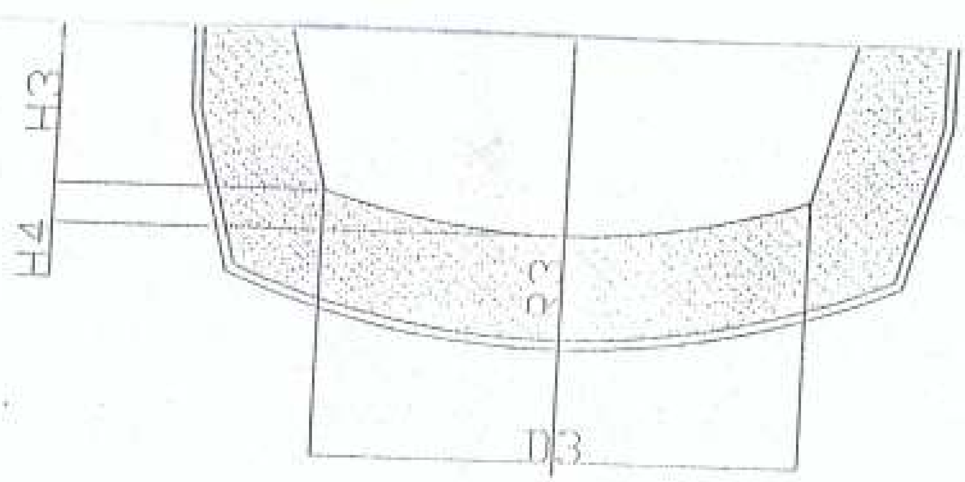


Fig5: Schematic drawing of the lower conical segment

The height of the lower conical segment h_3 has the same value for the various oxygen converter capacities. This is the zone where the oxygen is supplied to the charge using a lance, immediately the oxygen hits charge the reaction is instantaneous and violent this is shown in the Figure 3 above, the height helps to accommodate the reactions.

4.4 Height of the Spherical segment h_4

Table 4: Height of the Spherical segment h_4

Converter Capacity (T)	Corresponding height of the spherical segment h_4
100	0.3209757
150	0.3931133
200	0.4539282
250	0.507507
300	0.5559462
355	0.6004905
400	0.641513

From the table it was observed that the height of the spherical segment H_4, increases as converter capacities increases. These deduced that the volume for the various converters differs and it increases as the converter capacities increases. This is the part where the charge reacts with the oxygen.

4.5 Diameter of the converter.

Table 5: Diameter of the converter.

Converter Capacity (T)	Corresponding diameter (m)
100	2.2
150	2.694439
200	3.11127
250	3.478505
300	3.810512
350	4.115823
400	4.4

The diameter of the mouth of the converter increases from 2.2m in 100 tones converter capacity to 4.4m in 400tonnes converter capacity. The converter mouth is designed in such a way that there will be minimum heat loss through the mouth, if the diameter d_1 is too large there will be section of atmospheric air into the vessel which can increases the nitrogen of the final steel which causes brittleness

From the result it was observed that the converter mouth d_1 increases the capacity of the converter increases and the more scrap is to be charge during the more time specified and therefore the wider the charging scrap must be, and therefore the wider must be the diameter of the converter mouth so that the refractory lining of the mouth is not destroyed.

4.6 The diameter of the cylindrical segment d_2

Table 6: The diameter of the cylindrical segment d_2

Converter Capacity (T)	Corresponding diameter of the cylindrical (m)
100	4.4
150	5.388878
200	6.22254
250	6.95701
300	7.621024
350	8.231646
400	8.8

The diameter of the cylindrical segment is twice the diameter of the mouth.

4.7 The diameter of the spherical segment D_3.

Table7: The diameter of the spherical segment D_3.

Converter Capacity (T)	Diameter of the spherical segment (m)
100	3.762
150	4.607491
200	5.320271
250	5.948244
300	6.515975
350	7.038057
400	7.524

4.8 Refractory thickness

Table 8: Refractory thickness

Converter Capacity (T)	Corresponding refractory thickness of the upper (m)
100	0.5341354
150	0.6330337
200	0.7117575
250	0.778231
300	0.8363327
350	0.888285
400	0. 935495

The life of the lining of converters depends on the resistance materials to the eroding action of metal, slag and dust; the lining of oxygen converter is usually made up of three layers of brick, first the inner layer of magnesite

Comparing the refractory thickness r_1, r_2 and r_3 for the same converter r_3,is thicker than r_2,the lining r_3 at the charging are.

The refractory thickness of the cylindrical part r_2 increases as the capacity increases also

Table 9: Refractory thickness of the cylinder part R_2

Converter Capacity (T)	Refractory thickness of the cylinder part R_2 (m)
100	0.6841354
150	0.7830337
200	0.8617575
250	0.928231
300	0.9863327
350	1.038285
400	1.085495m

The refractory thickness of the bottom R_3 increases as the capacity increases.

Table 10: Refractory thickness of the bottom R_3

Converter Capacity	Refractory thickness of the bottom R_3 (m)
100	0.8091354
150	0.9080337
200	0.9867575
250	1.053231
300	1.111333
350	1.163285
400	1.210495

Comparing the refractory thickness r_1, r_2 and r_3 for the same converter, r_3 is thicker than r_2. The lining, r_3 at the charging same is thicker because of the reactions that takes place at the zone The refractory thickness increases as the capacity increases and this help in minimizing Heat loss due to radiation. The refractory thickness at the bottom is more than the refractory thickness of the upper conical segment r, and the cylindrical segment because it is at these section that the reaction is higher hence the need for thicker refractory lining

4.9 Converters steel shell.

The converter shell increases as the tonnage increases; this is due to the increases in the stresses of the converters as the tonnage increases.

Table 11: . Shell Thickness

Converter Capacity T	Shell Thickness δ mm
100	0.007125136
150	0.008145228
200	0.008956391
250	0.009640805
300	0.1023866
350	0.1077297
400	0.112583

4.10 External Diameter Ds

Table 12 : External Diameter Ds

Converter Capacity T	Total Converter Diameter (m)
150	7.11785
200	8.125183
250	9.006281
300	9.798463
350	10.52367
400	11.19616

The external diameter is calculated as $Ds = d_2 + 2r_2 + 2\delta s$ this is the total diameter of the converter ideally this increases as the tonnage increases since the refractory thickness and the diameter of the cylindrical segment increase as the tonnage increases.

4.11 Diameter of the tapping hole, Do.

Table 13: Diameter of the tapping hole, Do

Converter Capacity (T)	Total Converter Diameter(m)
100	0.1370787
150	0.155618
200	0.1741573
250	0.1926966
300	0.211236
350	0.2297753
400	0.2483146

Do increases as the tonnage increases to give room for easier tapping of the steel the tapping hole is shown in the diagram below in fig 7

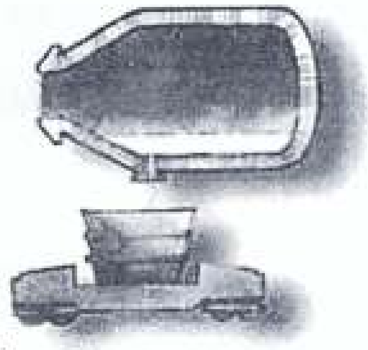


Fig. 6. Tapping of the steel

I. Total Height of the Converter, H

Table 14: Total Height of the Converter, H

Converter Capacity (T)	Total Height (m)
100	6.885889
150	7.26660
200	7.587565
250	7.870336
300	8.125979
350	8.361069
400	8.579885

The Height H increases as the tonnage increases.

From the drawing we can see that the higher the tonnage, the higher the height, the wider the diameter and the bulkier the oxygen converters.

4.12 Area of the bath surface SB

Table 15: Area of the bath surface SB

Converter Capacity (T)	Area (m^2)
100	15.21143
150	22.81715
200	30.42286
250	38.02856
300	45.63429
350	53.24
400	60.84571

The area of the bath surface increases as the tonnage increases.

It ensures easy and smooth circulation of slag metal emulsion

The visual Basic Programming language is easy and a window base programming language, it has made the data generation to be easier. is When comparing the two results table i.e. the manually generated table and the visual basic generated table, it was discovered that the data from the visual basics result table are more accurate and precise than the manuals generated table ,for example considering the height of the converters for manually generate table.

Table 16: Height of the upper conical segment, $h_{1\,(M)}$

Converter Capacity (T)	Height of the upper conical segment, h_1 (m)
100	1.6939
150	2.0711
200	2.39449
250	2.6794
300	2.9338
350	3.1688
400	3.38770

While for visual basic generated result, the table is as shown.

Table 17: Height of the upper conical segment $h_{1\ (M)}$

Capacity (T)	Height of the upper conical segment $h_{1\ (M)}$
100	1.37302
150	1.681599
200	1.941744
250	2.170935
300	2.37814
350	2.56885
400	2.74604

We can see that the visual basic generated results are more accurate.

The Result can be obtained under 10minutes when using visual basic programmed for all the oxygen converters capacities. The data generated were used to draw the different shapes of oxygen converters using Automatic computer aided design (Auto CAD)

CHAPTER FIVE

CONCLUSION

The oxygen converter is a facility of great design interest. The process calculations from manual to computer aided design were developed. Computer algorithms for design equations using visual basic programming language were developed for design of oxygen converter.

The result from the programme was used to draw various shapes of the oxygen converters using auto cad.

The adoption of visual Basic programming language and computer aided design will go a long way to improve the design of oxygen converters. Most especially in our steel complex and this will go a long way to enhance our National Development.

In the future the oxygen converter equipment will undergo ever increasing severity of operating conditions as the steel production technologies progress. All this calls for constant improvement and functional enhancement in production equipment.

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Appendix I

COMPUTER PROGRAMS

A.1.1 Computer Program for calculating parameters for Design of Oxygen converters.

A.1.1.1 A short program written in visual basic (the complete listing is giving below) is used for computing the parameters required for the drawing of oxygen converters for different tonnes

A.1.1.2 Input of Data

The data is input by means of a control

D_1 = 0.22 *T^ 0.5

D_2 = 2* d1

D_3 = 0.855*d2

H_1 = 0.5*d2* (tan (alpha)\2

α = 570

h_2 = 4* (0.75*1+1) * T\71.1236 T* 1.1236\7

(pie *d2^2)

h_3 =T10.84 \4.7*d_2^2

R = 1.75*d_2

H_4 = R – (R^2 – (d_2^2\4) ^ 0.5

Do = 0.1+0.00033* T0.89

R_+ = 0.142 *(T*1.1236) ^0.33

$R_1 = r_2 - 0.15$

$R_3 = r2 + 0.125$

SB = PIE * d2^2\4

δ = 0.015* (T*1.1236) ^0.33

H = h1+h2+h3+h4

Ds = d2+2*r2+2*delta

Ves = (h3\12) * (d2^2) + (0.855*(d2^2)+0.855*d2^2

Vsp = PIE h4^2*(R-H4\3

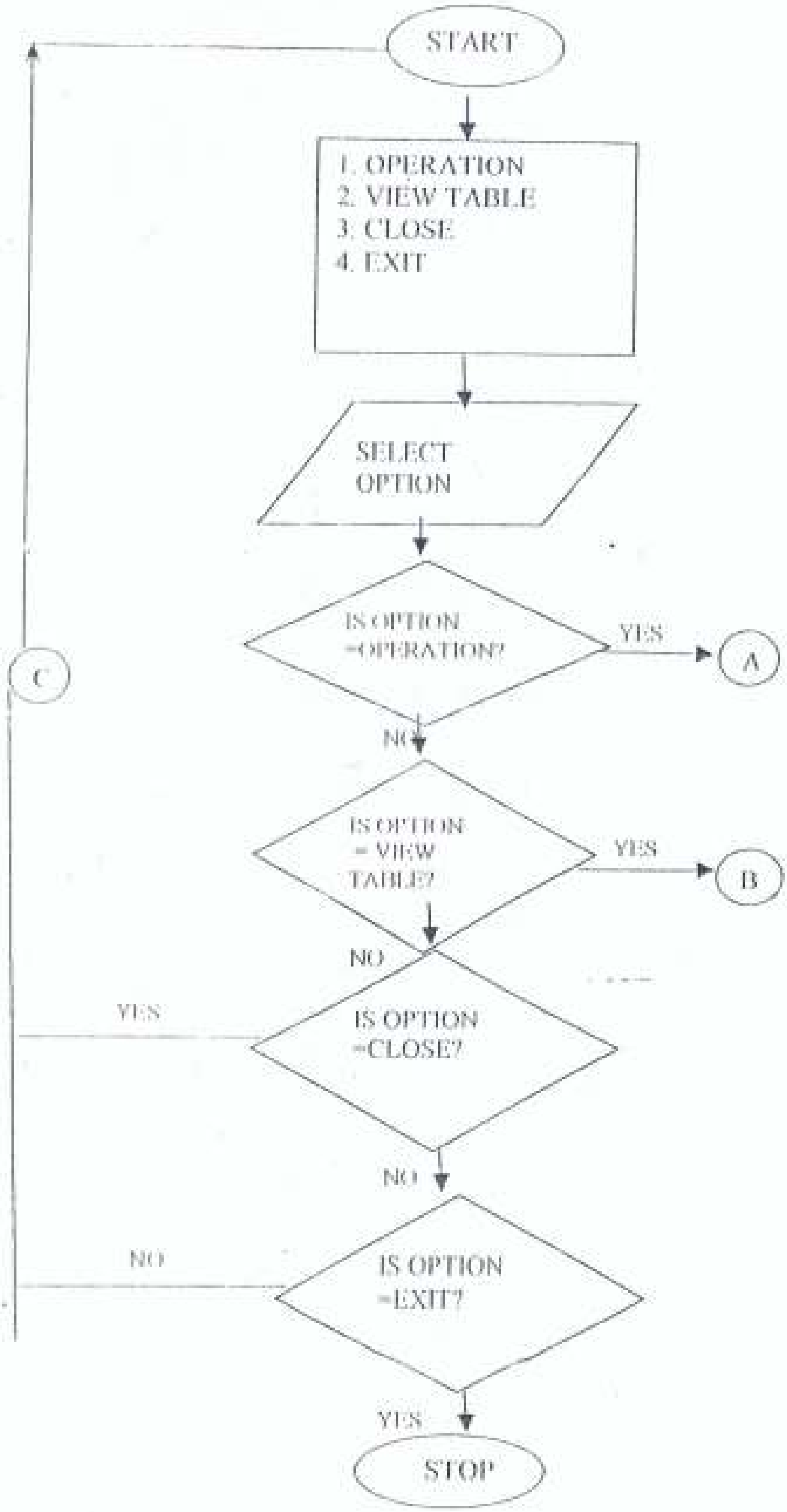
Ratio = H\D

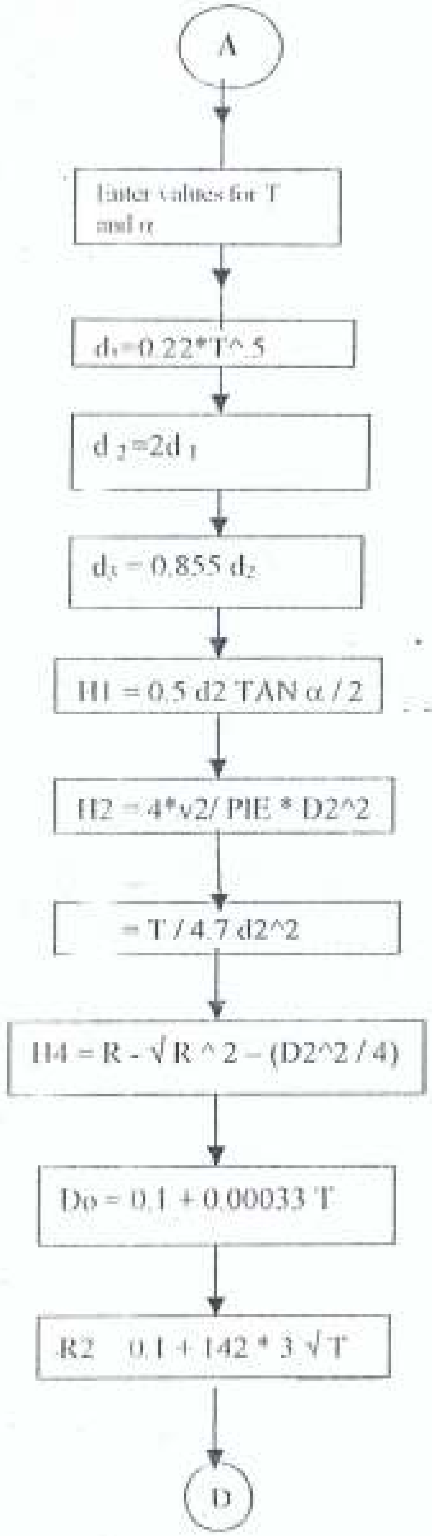
The processing box contains four different option operation, view table, close and Exit.

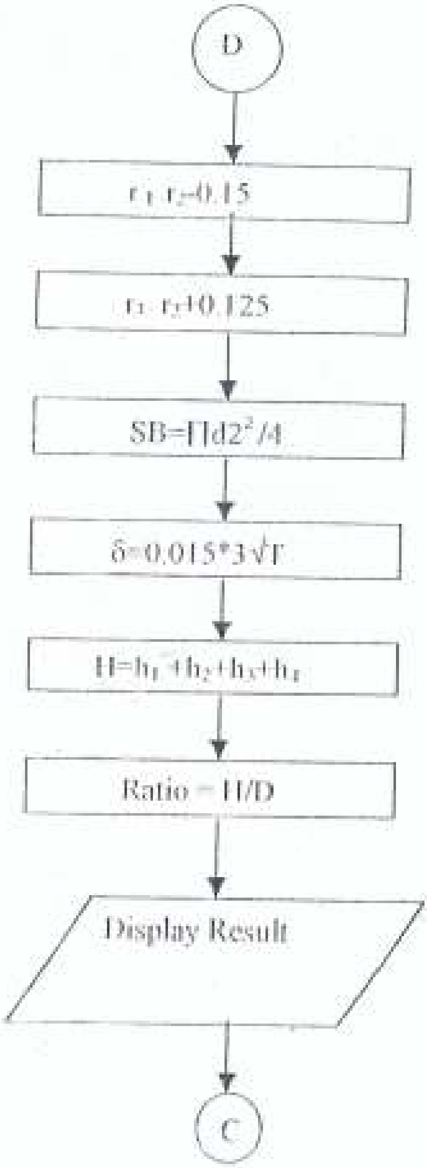
In your input box the option to be used is selected. If option operation is chosen then you move to A, in A, the value for T and option α is entered, T varies for different to es, where α is 57^0 for all. The data are calculated in processing boxes, the results are display in the output.

If option is not operation, then if it is view table that is the operation performed earlier is to be viewed then you move to the connector B, In the decision box it asked whether the operations were performed if no we move to the connector C to reperform the operation. If yes the results are displayed at the storage medium and from their it is connected back to C, If option is close, then the processing for the particular tones is finished then another value for T will be picked. And it goes through the cycle.

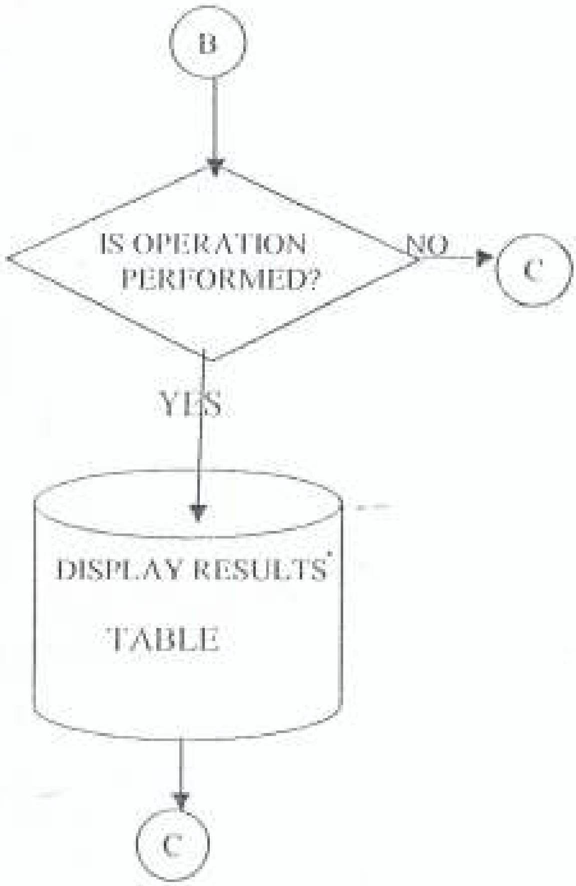
If option is Exit, then the whole program is terminated. The flow sheets show the sequence of operation of the whole program.


START
1. OPERATION
2. VIEW TABLE
3. CLOSE
4. EXIT
SELECT OPTION
IS OPTION =OPERATION?
YES
A
NO
IS OPTION = VIEW TABLE?
YES
B
NO
C
YES
IS OPTION =CLOSE?
NO
NO
IS OPTION =EXIT?
YES
STOP


A
Enter values for T and α
d1=0.22*T^.5
d 2 =2d 1
d3 = 0.855 d2
H1 = 0.5 d2 TAN α / 2
H2 = 4*v2/ PIE * D2^2
= T / 4.7 d2^2
H4 = R - √R ^ 2 – (D2^2 / 4)
Do = 0.1 + 0.00033 T
R2 0.1 + 142 * 3 √T
D



D
r1 r2-0.15
r1 r2+0.125
SB=∏d2²/4
δ=0.015*3√T
H=h1+h2+h3+h4
Ratio = H/D
Display Result
C


B
IS OPERATION PERFORMED?
NO
C
YES
DISPLAY RESULTS TABLE
C

APPENDIX. A.1.2 LISTING OF PROGRAMS

```
ub Command1_Click()
 As Integer
11, H21, H31, H41 As Single
: I As Byte

 22 / 7
Int(TXTTAN.Text)
xt = CStr(CSng(0.22 * T ^ 0.5))
xt = CStr(CSng(2 * D1))
xt = CStr(CSng(0.855 * D2))
xt = CStr(CSng(0.5 * D2 * (1.2482 / 2)))
xt = CStr(CSng((4 * (0.75 * 4 + 1) * (T / 0.89) / 7 - T * 1.1236 / 7) / (PIE * D2 ^ 2

xt = CStr(CSng((T / 0.89) / (4.7 * D2 ^ 2)))
.75 * D2
xt = CStr(CSng(R - (R ^ 2 - (D2 ^ 2 / 4)) ^ 0.5))
xt = CStr(CSng(0.1 + 0.00033 * T / 0.89))
xt = CStr(CSng(0.142 * (T * 1.1236) ^ 0.333))
xt = CStr(CSng(R2 - 0.15))
xt = CStr(CSng(R2 + 0.125))
xt = CSng((PIE * (D2 ^ 2 / 4)))
.Text = CStr(CSng(0.015 * (T * 1.1236) ^ 0.33))
 CSng(H1.Text)
 CSng(H2.Text)
 CSng(H3.Text)
 CSng(H4.Text)
t = CStr(H11 + H21 + H31 + H41)
xt = CStr(CSng(D2 + 2 * R2 + 2 * DELTA))
 (H3 / 12) * (D2 ^ 2) + (0.855 * D2 ^ 2) + 0.855 * D2 ^ 2
 PIE * H4 ^ 2 * (R - H4 / 3)
.Text = CStr(CStr(H.Text) / CStr(DS.Text))

= 1
orm2.MSFlexGrid1
Col = 1
Row = 0
Text = TXTTAN.Text
Row = 1
Text = H1.Text
Row = 2
Text = H2.Text
Row = 3
Text = H3.Text
Row = 4
Text = H4.Text
Row = 5
Text = D1.Text
Row = 6
Text = D2.Text
Row = 7
Text = D3.Text
Row = 8
Text = R1.Text
Row = 9
Text = R2.Text
.Row = 10
.Text = R3.Text
.Row = 11
.Text = DELTA.Text
.Row = 12
.Text = DS.Text
.Row = 13
.Text = D0.Text
.Row = 14
```

```
  .Text = H.Text
  .Row = 15
  .Text = RATIO.Text
  .Row = 16
  .Text = SB.Text

nd With



ub


e Sub Command2_Click()

b

e Sub Form_Load()
H.Text = "100"
.Hide
Form2.MSFlexGrid1
 .Col = 0
 .Row = 0
 .Text = "PARAMETER"
 .Row = 1
 .Text = "HEIGHT H1"
 .Row = 2
 .Text = "HEIGHT H2"
 .Row = 3
 .Text = "HEIGHT H3"
 .Row = 4
 .Text = "HEIGHT H4"
 .Row = 5
 .Text = "DIAMETER D1"
 .Row = 6
 .Text = "DIAMETER D2"
 .Row = 7
 .Text = "DIAMETER D3"
 .Row = 8
 .Text = "REF.THICK R1"
 .Row = 9
 .Text = "REF.THICK R2"
 .Row = 10
 .Text = "REF.THICK R3"
 .Row = 11
 .Text = "CONV. STEEL SHELL"
 .Row = 12
 .Text = "EXT. DIAMETER (DS)"
 .Row = 13
 .Text = "DIAMETER OF TAPP. HOLE DO"
 .Row = 14
 .Text = "TOTAL HEIGHT H"
 .Row = 15
 .Text = "RATIO"
 .Row = 16
 .Text = "AREA BATH SURFACE SB"

With
```

```
te Sub MNUCLOSE_Click()
eForm.Hide
ub

te Sub MNUEXIT_Click()

ub

te Sub MNUOPERATION_Click()
l.Show
ub

te Sub MNUTABLE_Click()
l.Show
ub
```

A.1.3. Output of Result

There are tables showing the different tonnages parameters that were calculated manually and with visual basic program the calculated parameters as listed below were shown on the table.

Height H_1

Height H_2

Height H_3

Height H_4

Diameter D_1

Diameter D_2

Diameter D_3

Refracting thicken R_1

Refractory thicken R_2

Refractory thicken R_3

Converter steel shell δ

Diameter of Tapping hole Do.

Total height, H

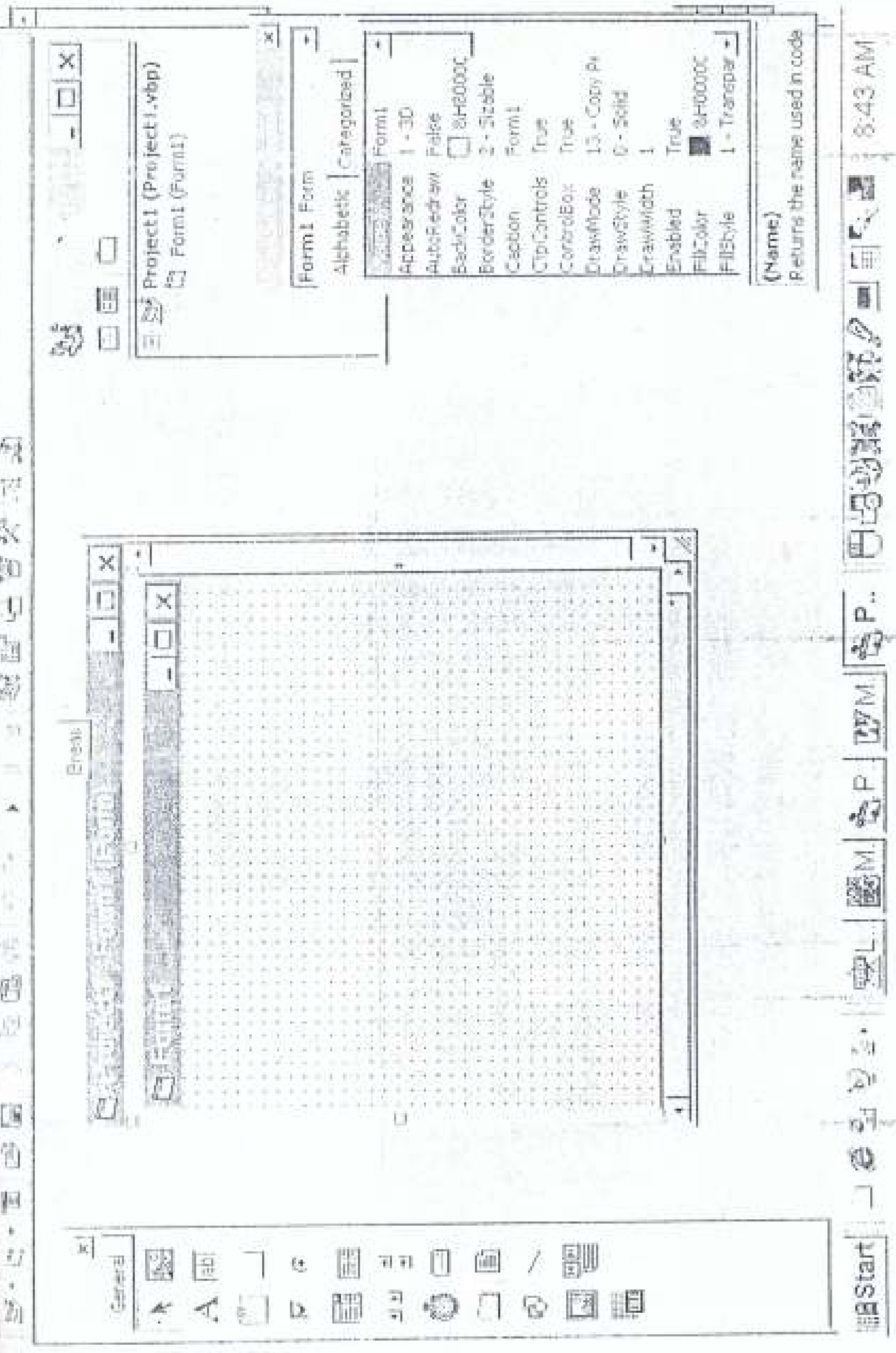
Ratio, "

Area bath surface, SB.

The result tables were shown below

TABLE 18: MANUALLY GENERATED TABLE

Converter Capacities (T)	100	150	200	250	300	350	400
Height of the upper conical segment H_1 (m)	1.6939	2.0711	2.6794	2.39449	2.9338	3.1688	3.38770
Height of the cylindrical segment H_2 (m)	3.1669	3.1	3.1685	3.1643	3.166939	3.166974	3.166953
Height of the lower conical segment H_3 (m)	12348	1.2389	1.2358	1.2338	1.2348	1.23484	1.234833
Height of the spherical segment H_4 (m)	0.36	0.3925	0.4508	0.5077	0.5559	0.6005	0.642
Diameter of the converter mouth D_1 (m)	2.2m	2.69m	3.11m	3.48m	3.811	4.116	4.4
Diameter of the converter segment D_2 (m)	4.4	5.38	6.22	6.96	7.621	8.2316	8.8
Diameter of the sphere D_3 (m)	3.762	4.5999	5.3118	5.9508	6.560	7.0380	7.524
Refractory thickness at the upper conical segment r_1 (m)	0.5352	0.6344	0.7133	0.7800	0.988	1.0404	1.0877
Refractory thickness at the cylindrical segment r_2 (m)	0.6852	0.7844	0.8633	0.930	1.1133	1.1654	1.2127
Refractory thickness at the bottom r_3 (m)	0.8102	0.9093	0.9883	1.055	1.1133	1.1654	1.2127
Converter steel shell δ (m)	0.0724	0.0829	0.0911	0.0982	0.1044	0.1099	0.1149s
External diameter of the converter D (m)	5.915	7.155	8.129	9.016	9.806	10.532	11.205
Diameter of tapping hole d_r (m)	0.137	0.156	0.174	0.193	0.211	0.230	0.248
Total height of the converter H (m)	6.256	6.527	7.251	7.5851	7.8915	8.1712	8.4314
Ratio H/D	1.122	1.213	1.166	1.090	1.036	0.993	0.958
Area of bath surface, SB (m2)	15.205	22.733	30.386	38.0459	45.6156	53.218	60.8212


Project1 (Project1.vbp)
Form1 (Form1)
Form1 Form
Alphabetic
Categorized
Appearance
AutoRedraw
BackColor
BorderStyle
Caption
ClipControls
ControlBox
DrawMode
DrawStyle
DrawWidth
Enabled
FillColor
FillStyle
(Name)
Returns the name used in code
General
Start
8:43 AM

ACTION

PARAMETER	100	150	200	250	300	350	400
HEIGHT H1	1.37302	1.681599	1.941744	2.170935	2.37814	2.568685	2.74604
HEIGHT H2	3.957064	3.957063	3.957064	3.957065	3.957064	3.957064	3.957064
HEIGHT H3	1.234829	1.234829	1.234829	1.234829	1.234829	1.234829	1.234829
HEIGHT H4	0.3209757	0.3931133	0.4539292	0.507507	0.5559462	0.6004305	0.6419513
DIAMETER D1	2.2	2.694439	3.11127	3.478505	3.810512	4.115823	4.4
DIAMETER D2	4.4	5.388878	6.22254	6.95701	7.621024	8.231646	8.8
DIAMETER D3	3.762	4.607491	5.320271	5.948244	6.515975	7.038057	7.524
REF.THICK R1	0.5341354	0.6330337	0.7117575	0.776231	0.8363327	0.888285	0.935495
REF.THICK R2	0.6841354	0.7830337	0.8617575	0.929231	0.9863327	1.038285	1.085495
REF.THICK R3	0.9091354	0.9080337	0.9867575	1.053231	1.111333	1.163295	1.210495
CONV. STEEL SHELL	7.125136E-02	8.145228E-02	8.956391E-02	9.640605E-02	0.1023666	0.1077297	0.112583
EXT. DIAMETER (DS)	5.910774	7.11765	8.125183	9.006289	9.798463	10.52367	11.19616
DIAMETER OF TAPP. HOLE DO	0.1370787	0.155618	0.1741573	0.1926966	0.211236	0.2297753	0.2483146
TOTAL HEIGHT H	6.885869	7.266604	7.587565	7.870336	8.125979	8.361069	8.579865
RATIO	1.164972	1.020899	0.9338331	0.8738712	0.8293117	0.7945012	0.7663239
AREA BATH SURFACE SB	15.21143	22.81715	30.42286	38.02856	45.63429	53.24	60.84571

A.1.1.4 Time.

The time taken to run such a program on a modern fast computer using visual basic 6.0 is very short.

The compilation time for the program is about five seconds. Therefore this type of program is suitable for use in engineering firm.

Appendix 2.

COMPUTER AIDED DESIGN

The parameters for the drawings were gotten from the results obtained from the visual basic program.

The drawings are shown in Figures 6-12, all dimension are in millimetre .

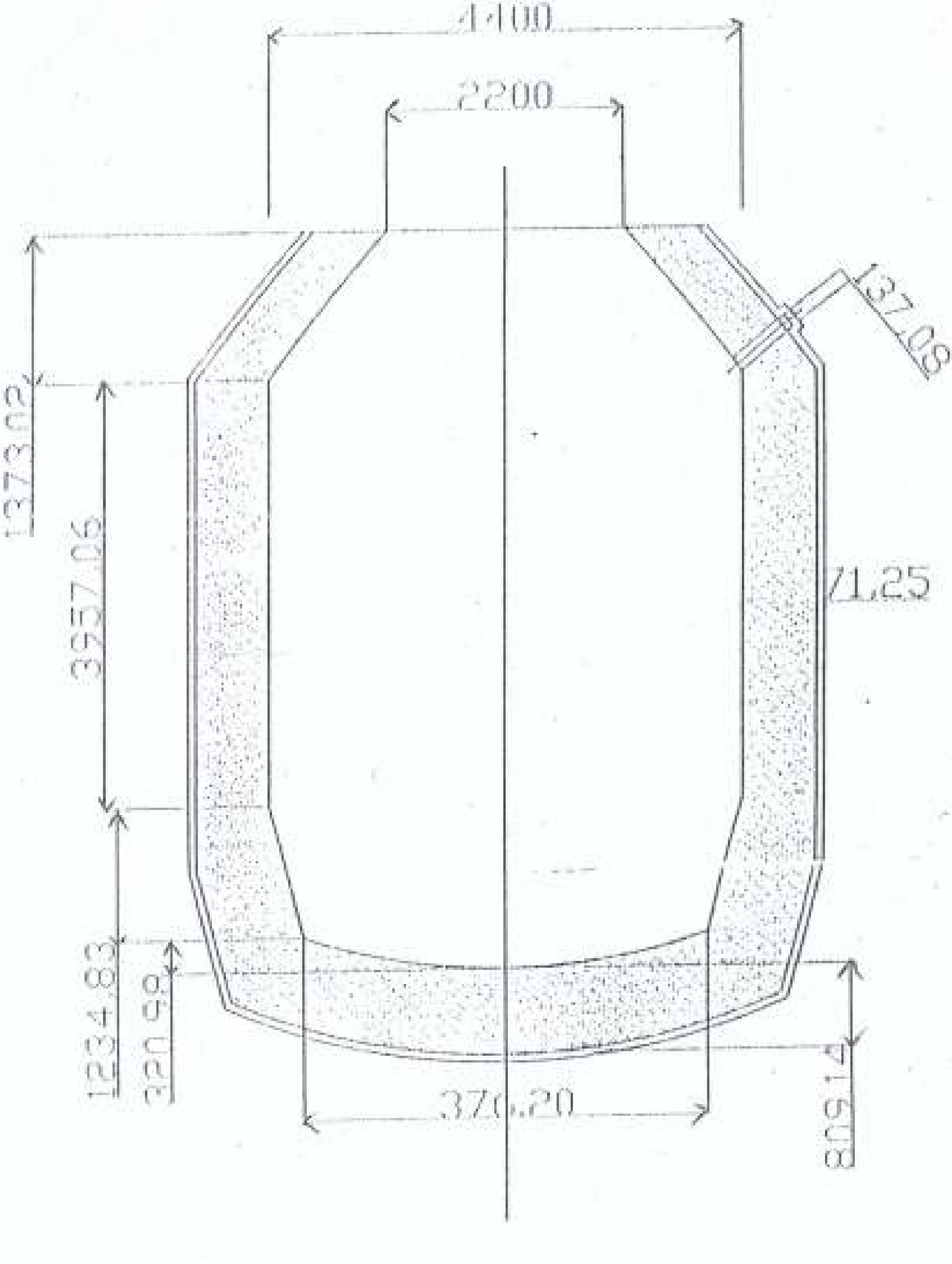
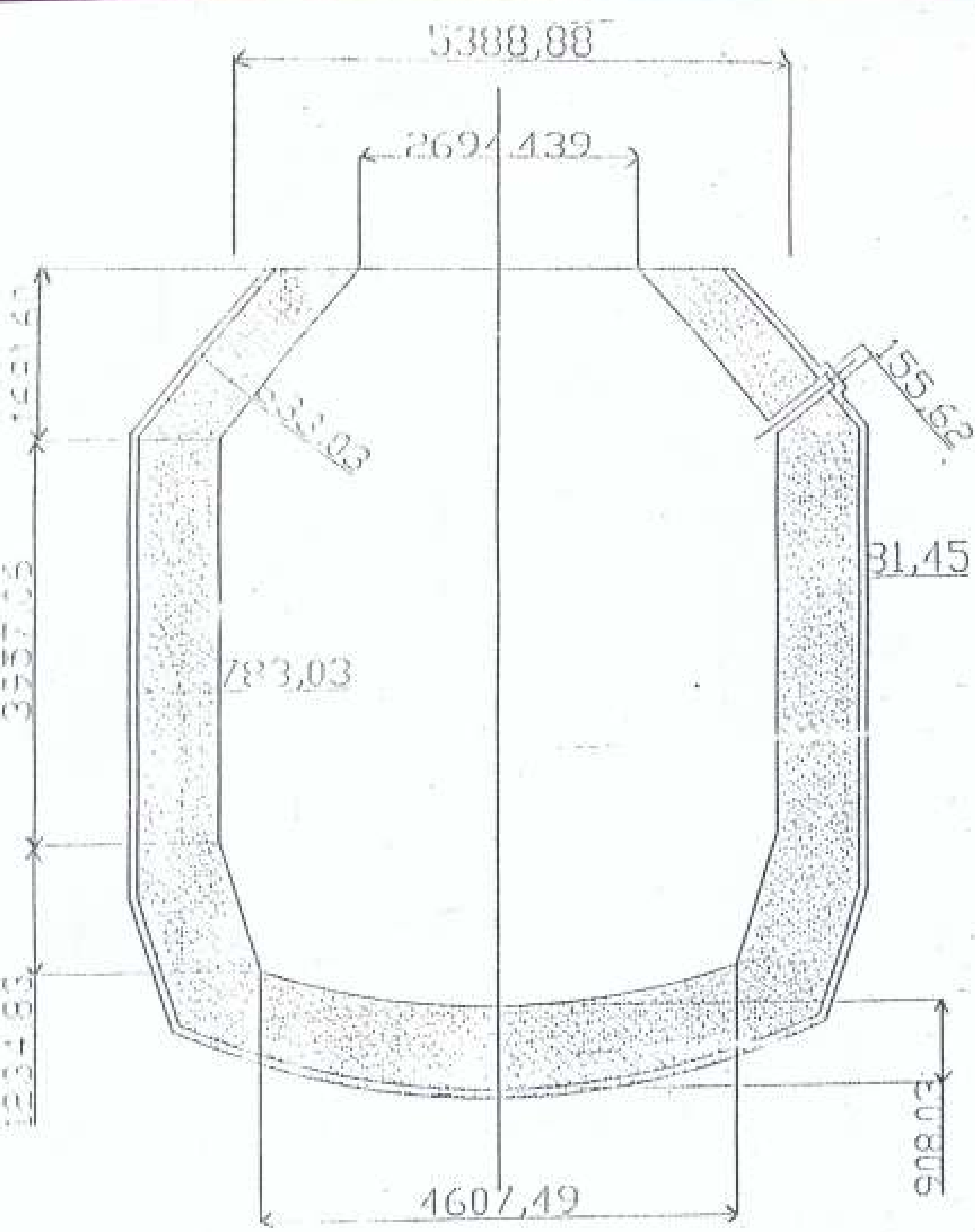
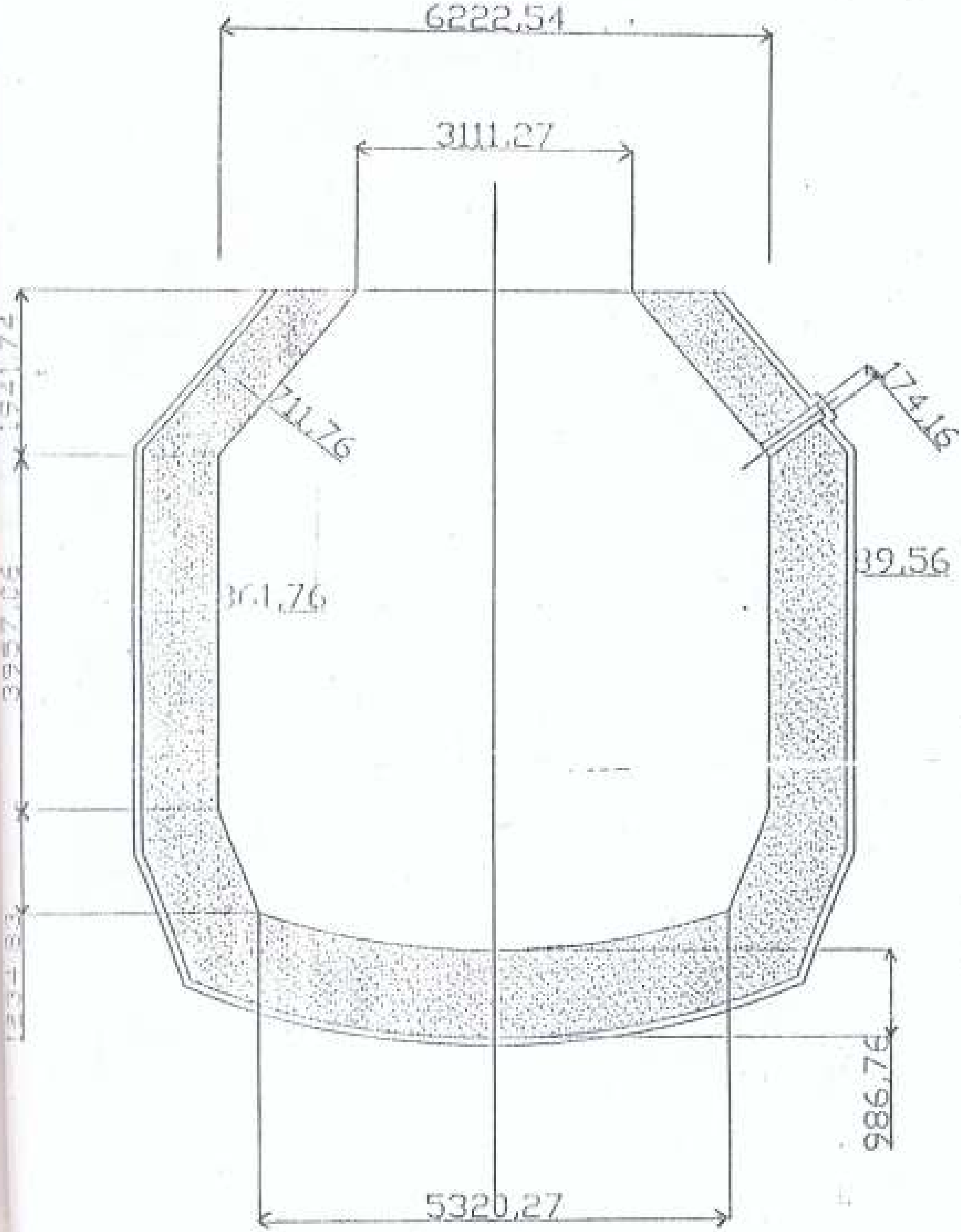


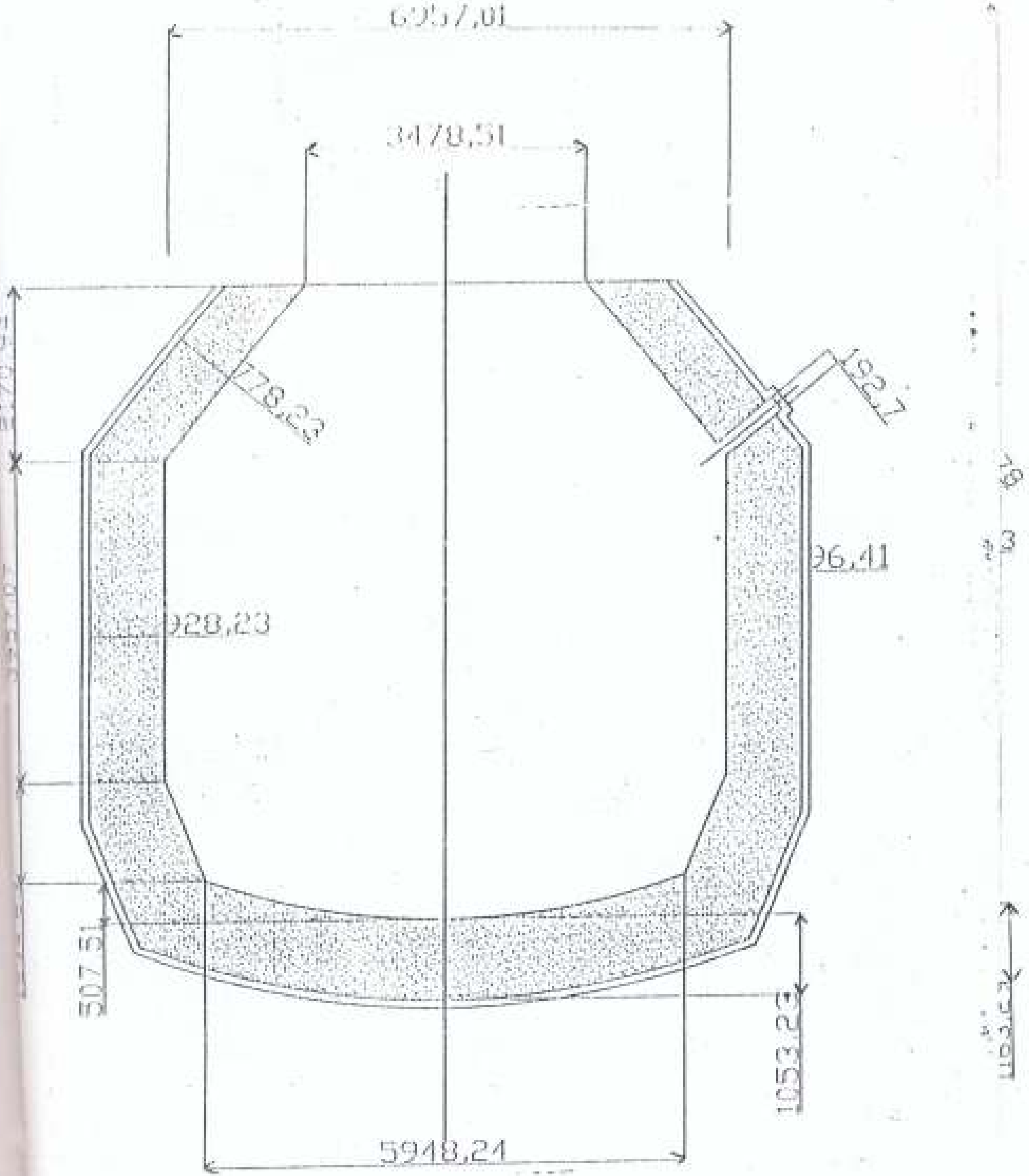
Fig. 6: 100Tons Capacity Oxygen Converter



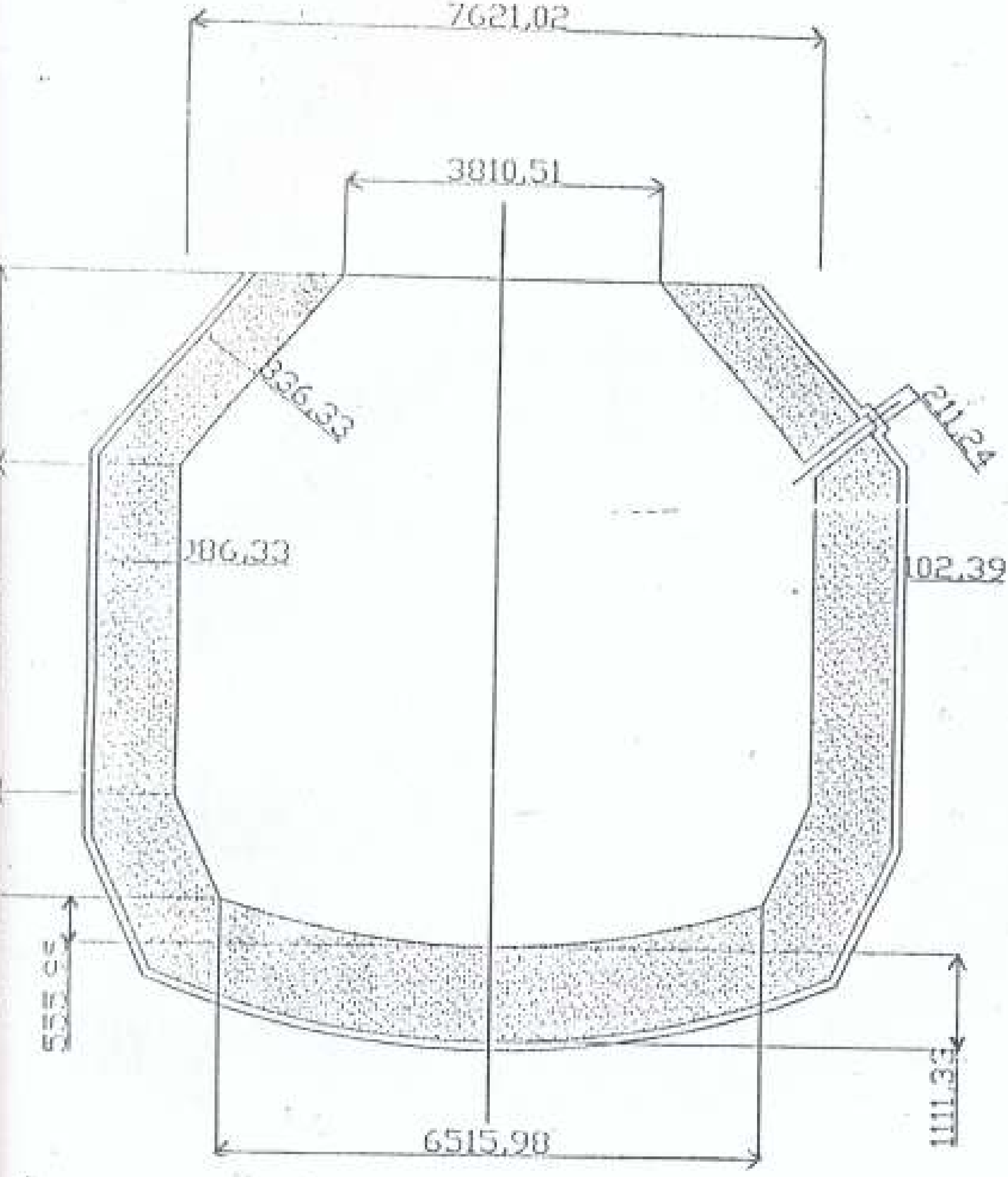
. 150Tons Capacity Oxygen Converter



200Tons Capacity Oxygen Converter



?0Tons Capacity Oxygen Converter



0: 300Tons Capacity Oxygen Converter

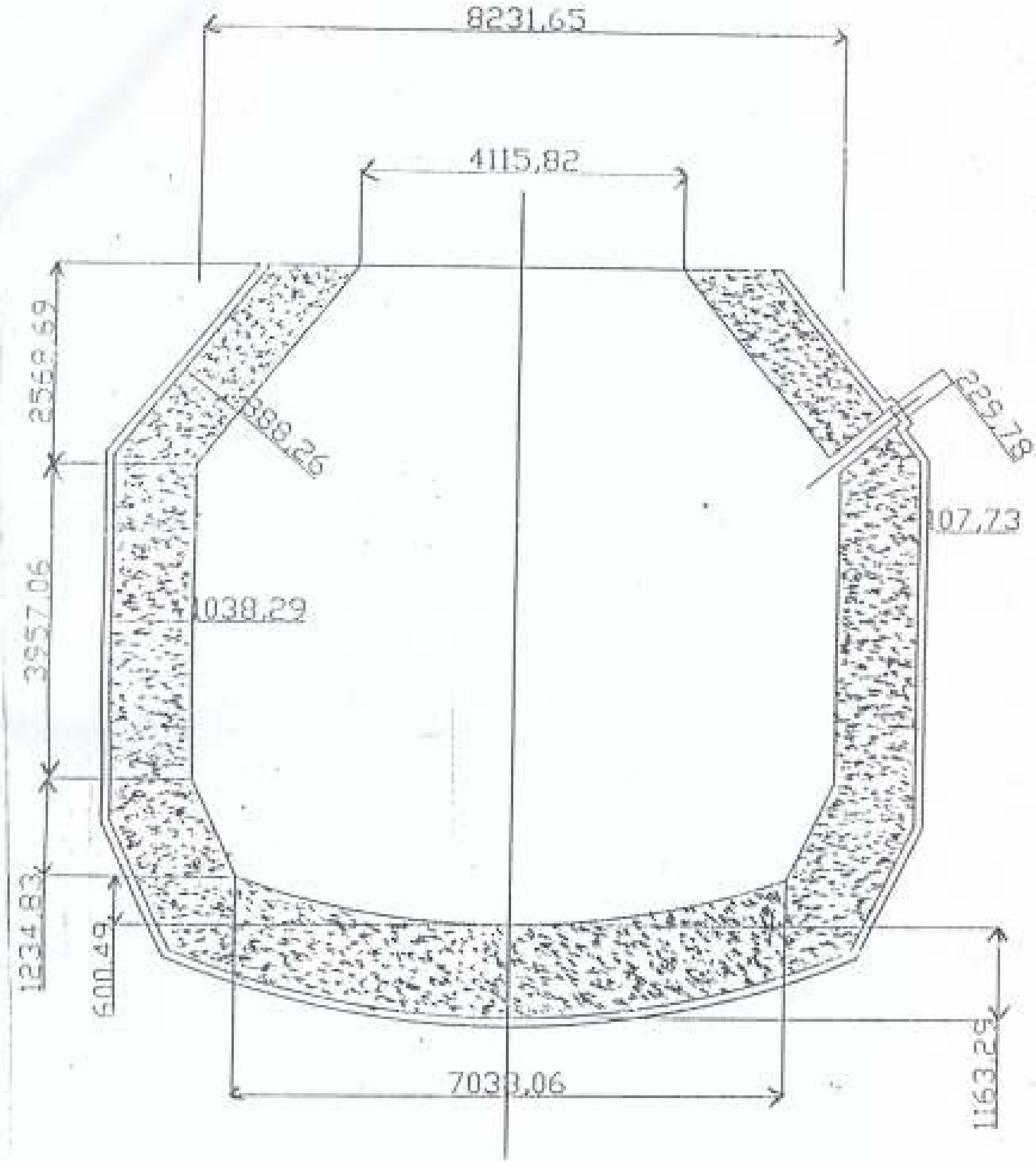


Fig. 11: 350Tons Capacity Oxygen Converter