RECONDITIONING WORN OUT PART OF MACHINE USING CASTING METHOD

BY

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BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) AGRICULTRUAL ENGINEERING.

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DEDICATION

This project work is dedicated to God Almighty Allah for helping me to this stage of life.

CERTIFICATION

This is to certify that this project was carried out by Abdulmalik Mohammed Kudu in the Department of Agricultural Engineering, Federal University of Technology, Minna.

-- 01 · 03 · 001

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-- 28/01/01

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HEAD OF DEPARTMENT.

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ABSTRACT

The Reconditioning worn-out components of machine using casting method have been carried out. The casting of cast iron was conducted at Bacita Sugar Company in Kwara state, while that of aluminum casting in Minna. The specimens were visually examined and maching operations were carried out on each of them. Suggestion on possible treatment necessary for some metals are included, so as to ensure the casting can be produced to withstand specific type and level of service stresses. For practical purpose, a temperature range of 700 to 750°C is recommended for aluminum alloy casting at a pouring speed of 2 to 5 cm/s. while for the metal casting, a temperature range of 1630°C to 1660°C is recommended.

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CHAPTER ONE

1.0. INTRODUCTION

1.1 HISTORICAL GENESIS OF CASTING.

Metal casting is one the oldest of all industries dating back to the ancient and medieval periods. Casting in the pre-Christian world developed to a point it which elaborate bronze statury could be produced in two pieces and come moulds. By the end of the medieval period, decorated bronze and power castings has begun to be used in European Church and domestic life, whilst cast iron made a more sotre appearance in the shape of cannon short and grave slabs.

In the 16^{th} century, Brinquccio wrote a details account on metal casting, giving an impression of the founding men then. Moulding boxes and sand were in use by this time.

Among the earliest, scientists, the work of Reaumur (1683 – 1775) is of outstanding interest to founders. In the course of wide ranging activities he become interested in cast iron, not only did he produce malleable iron but he should a clear perception of the range of cast irons structures of the factors influencing the production of white gray and Molted irons. The wide spread adoption of cast irons as an engineering material awaited the success of Abraham Derby in 1709 in smelting in the coke blast furnace, this paved the way to the massive use of cast irons in construction during the years following the industrial revolution in Europe. This position changed only when bulk supplies of cheap steel became available after Bassemers development of the converter in 1856.

Despite the interest of a few early scientists, metal casting was looked upon as an art and this view persisted unit well into the present century. Many foundries sprang up after the industrial revolution. The organized industry grew around the skills of the mouller and the pattern makers. The skill enables complex form to be produced but the enhancement of metallurgical quality and soundness awaited latter scientific understanding. The lack of quality control in the early stages of casting led to the collapse of important structure, such as Tay bridge in 1879 in which the cast iron used was found to be very porous.

In modern metal casting, the responsibility of selecting the appropriate casting techniques is now vested in the hands of specialists. The pre- engineering of casting methods is accompanied by metallurgical control based on modern laboratory facilities for the determination of metal composition, metallographic structure and properties. Scientific control can be applied at all stages from raw materials to finish products. Hence modern metal casting is now solidly based on technology, proper engineering design, adequate and appropriate testing techniques for quality and selection of most appropriate casting techniques to achieve the desired objectives.

Casting are produced by pouring the super – heated molten metal of the specified composition into a mould whose internal spaces (impression) reproduces the configuration and dimensions of the future cast metal article with maximum accuracy. On cooling, the metal solidifies and acquires the configuration of the mould. Most of metal working processes involves a stage of producing cast articles (or ingot). This shows that casting is an efficient methods of making articles of desired shapes and dimensions and of specified properties directly from molten, with low expenditure of energy, materials, and labor.

Metals casting find wide application as it enable casting of mass from a few grams to hundred tonnes and with dimensions up to tens of matter to be manufactured from alloys of practically any composition, including those which are difficult to shape by plastic working.

The theory and practice of metals casting the modern stage permit the manufacture of articles with high working properties. This is evidenced by reliable operation of casting in jet engines, nuclear power planes, and other critical machine and installations. The main tendency of progress in metal casting consist in improving the quality and dimensional accuracy of casting and reducing metal consumption.

Some other advantaged of casting process are:-

(I) Most intricate of shapes both external and internal may be casted. As a result many other operations such as forging or welding may be eliminated or minimized.

(ii) Because of the metallurgical nature, some metals can only be casted e.g cast iron.

(iii) Object may be cast in a single piece which would otherwise require production in several pieces, and subsequent assembly if mode by other processes.

(iv) Highly adapted for most production.

(v) Extremely large and heavy metals objects can be cast which would be otherwise difficult or economically impossible to produce by other methods.

(vi) Uniform properties are obtained. There is no directionally.

Casting also gives some desirable metallurgical advantage which are:-

(i) Fibrous structure:- The inclusion, of non-metallic impurities are more or less randomly distributed during the solidification process.

(ii) Grain size:- although mechanical working or wrought metals causes breaking up of coarse grains and promoter fine gain size, many casting have grain sizes not very different from those of the former.

(iii) Density:- The density of the cast alloys is usually identical and heat treatment when both are fully sound.

Casting process can be realized in various ways. The sequences of making metals casting in expandable sand moulds is shown in fig.1. The casting manufacture cycle include a number of main and auxiliary operations which are carried put simultaneously or successively in various departments of the foundry shop. pattern, core boxes and other appliances are made, as a rule, in pattern making shop. Moulds are prepare in the moulding unit arrange for pouring.melting is then carried out in the furnace and the molten metal collected and transported to pouring unit.

Casting which is the process of producing a metal object of a desired shaped by pouring molten metal into a mould and allowing the metal to cool and solidify; man has been making cast metals object for artistic or practical purpose since very early times. when the first casting probably were made of gold or copper formed in as tone or clay mold. The earliest axes and other useful metals objects were cast in open mold of stone or baked clay. Early art objects were made of cast gold. silver, copper, or bronze; one existing life sized portrait head in cast bronze Mesopotamia deter from about 2250B.C.

The shaping of metals in the liquid state has been in development for centuries. With the growth of industrial societies, the need for metal castings has become very great. In the United state alone the industry produces more than 16million tons of casting annually, using iron, steel, copper, aluminum, zinc,alloys, and magnesium alloys.

Metals casting are vital components of most modern machines and transportation vehicles. Cast metal parts account for more than 50% of the total weight of a tractor and for more than 80% of an automobile engine. High precision castings are used as turbine vanes and blades

I n an aircraft jet engine. The reason for the wide spread use of casting is that any desired shaped or size can be produced economically.

Casting are made by hand-molding operation or by molding machine. Methods for making cast metals parts can be classed in three group☹1) Molding processes that uses a permanent pattern of the part and an expandable mold;(2) molding processes that use an expandable pattern and an expandable mold; and (3) molding processes that use a permanent mold. An expandable mold or pattern is one that is used only once.

During reconditiong casting process has a number of distinct technological advantages. It can also have metallurgical advantages, particularly in the case of metals and stainless steel. The quantity of molten metal appearing during the casting (Reconditing worn out part) operation depends upon numerous geometrical and technological factors. When Reconditing, filler metals are used to support the liquid metals. The following fundamental characteristics are therefore always found in casting operation:-

-Rapid and load heating of the metal

_Appearance of molten metal, at least some of which result from a partial fusion of pieces to be assembled.

-Formation of a single molten pool.

-rapid cooling of the whole.

All the metallurgical consequences of the operation are derived from this characteristic.

Heating during reconditiong or operation leads to an expansion of the pieces been filled. Ss areas unaffected by heat cannot generally move freely, the edge of the worn out component approach each other, so that the liquid metal occupied a smaller volume than that existing at rron temperature. During cooling the assembly try to regain its original size and this contraction, together with shrinkage of the molten metal during solidification.

In conclusion, it is apparent that the mechanical and structural state of a cast is quit different from the initial state of the base metal. The ability of the cast to withstand shrinkage stresses without failure, and to satisfy services requirements, depends upon the metal which is to recondition and the constituents produced by the casting thermal cycle.

1.2 OBJECTIVES OF THE PROJECT

The objectives of the project work is aimed to reduce worn out component machine in our communities. And to allow mass production of the machine part

1.3 SCOPE AND LIMITATION OF THE PROJECT

This project work is based on the principles of reconditiong worn out component by casting.

Virtually the work will limit itself to the following

(i) Surface preparation

(ii) Reconditioning of worn out component

(iii) Aluminum casting which involve the following steps:-

(a) Pattern making

(b) Moulding

(c) Melting

(d) Pouring

(e) Cleaning & Felting

(f) Inspection of cast products

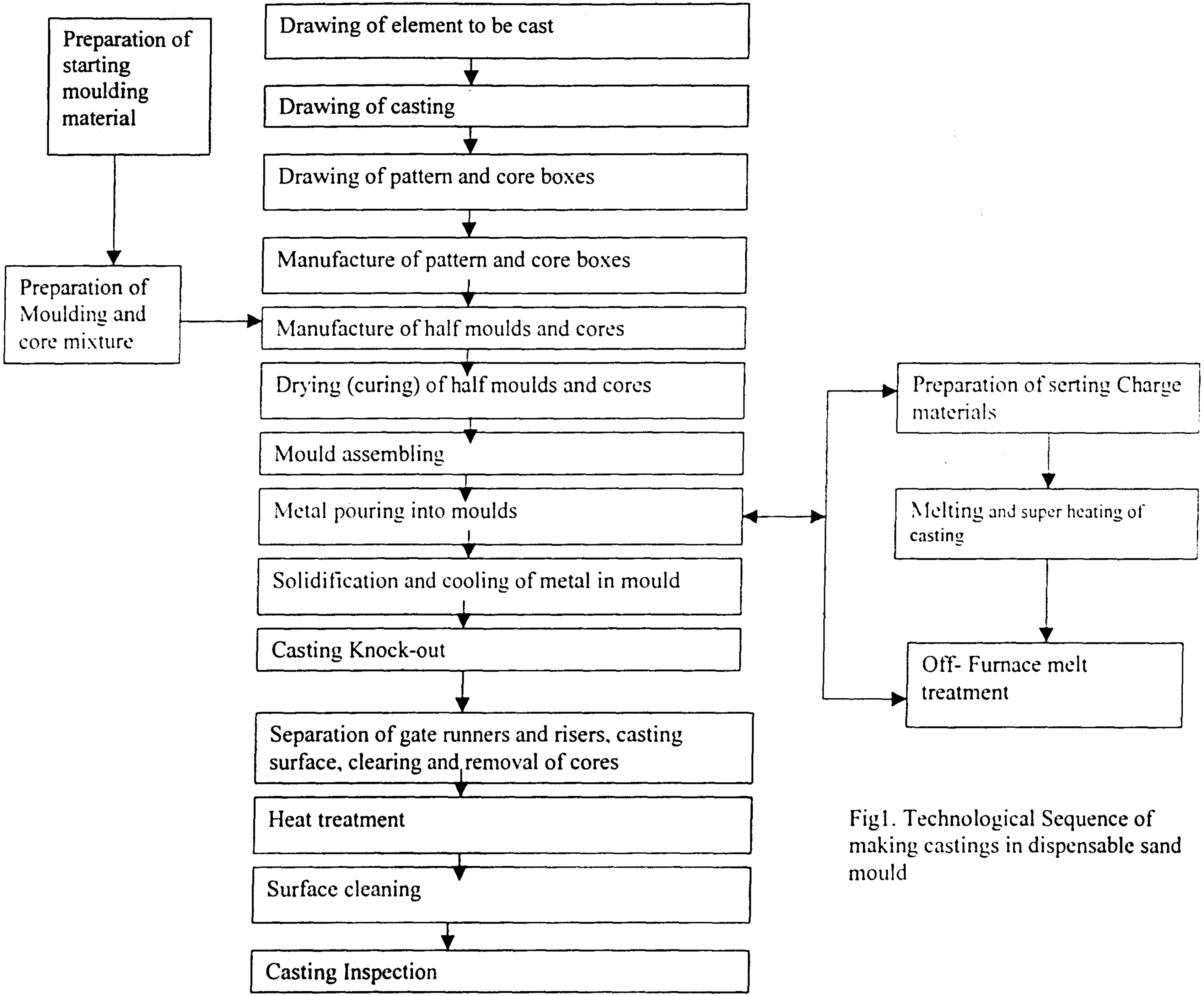

Fig1. Technological Sequence of making castings in dispensable sand mould

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1. Casting Technology and Materials.

This invention concern the field of foundries and, to be more exact, an apparatus for casting of metals and in particular but not only, steel and the formation of ingots, whether they be round or oval or have a square section analogous section.

The casting to which this invention can be applied may have its casting and axis vertical and straight, vertical and round or horizontal or almost.

The problem involved in the process of Reconditing or casting of a part is well known and concern mainly the system to cool the ingot produced and many have an unfavorable effect on the quality of metals obtained.

In the present state of the art these problem have still not been over come satisfactorily even where a downstream mould is employed in prolongation of main mold itself and is cooled with water for the passage and thermal conditioning of the ingot.

In general, when the cast metal passes into the main mould an mould and downstream mould, it undergoes a speedy removal of heat in its zone of contact with the wall of the moulds and is thus solidified quickly.

The solidification takes places in the form of crystals, which grow perpendicularly to the walls of the main mould and downstream mould.

As solidification proceeds, the ingot tends at a given moment to become detached from the guiding walls, with a resulting variation in the condition of transmission of the heat and therefore of the cooling.

At this point, within the still molten metal of the core of the ingot the laws of crystallization vary and the nuclei of the crystallization grow in all fire actions, thus leading to a fused structure. The resulting materials therefore, comprises outer, intermediate, and water zones consisting of different crystals.

In practice the progress of the solidification leads to a heterogeneous structure, which may be the cause of a great number of short comings, such as the fragility of the ingot, the formation of cracks due to inner tension, the presence of central zone of scanty cohesion, etc, which have an unfavorable effect on the employment and subsequent processing of the ingot.

In any event the casting techniques employed so far cannot remedy these shortcomings fully. The employment of the water- cooled downstream mould in its present from does not enable the outcome of the casting to be improved.

In this connection, down stream moulds are in fact known which from ingots with a square section and down stream mould are also known which form ingots with a round section; the former downstream moulds consist of four or more element or plates, positioned according to the sides of a square and distanced at their corners of convergence's, whereas the latter downstream mould consist of shall elements arranged along a circumferences.

In both cased the adjacent sides of the element forming the downstream mould, are parallel to the direction of sliding of the metal and define clefts which extended along the ingot.

These clefts, obviously leave the metals , passing into the downstream mould, exposed to direct contact with the cooling fluid and therefore determine preferred continuos length wise strips of solidification of the metals.

In fact, the metal solidifies along these strips more quickly than in the neighboring zones and enhances the conditions that contribute to the variation of the structure and impairing the homogenous formation of the material.

US 2,698, 467 (DE1;252,371 – fig 3) shows in figure 11, a downstream mould portion having helicoidal groves in its periphery, but this potent does not teach how to adapt the dimensions of the downstream mould to the actual dimension of the ingot so that it does not prevent separation of the downstream mould from the ingot; nor does it teach how to obtained the required pressure on the ingot so as to ensure its peripheral and dimensional continuity.

Moreover, the elements forming the known downstream moulds are normally kept in that working arrangement by means of springs, but the springs, when at work, do make possible the variation and adjustment of the lateral thrust on the ingot during its formation nor the correct self adaptation of the containing elements to the movement and shrinkage of the metal

Lastly, the elements which the traditional downstream moulds consist do not enable the starter bar that draws the ingot to be readily inserted, and these element are hard to open.

The present invention aims, instead, to eliminate or at least to limit appreciably the above problems and short comings of the continuos casting of steel by means of improvements to the downstream mould itself and to the means which support move and thrust the elements forming the down stream mould.

The invention has also been designed for application to any mould already in operation.

For this purpose the invention concern an apparatus for the continuos casting of steel according to the main claim, while the dependents claims describe variants of the idea of the embodiments.

The invention is applied preferably and advantageously to downstream moulds for the casting of ingots, having a round section but can be applied also to downstream moulds for the casting of ingots having a square section.

Moreover, either case the invention is applied to straight as well as to covered downstream moulds for the continuos casting of any type of steel metal in general

The special feature of this invention are therefore the provision of a mould immediately downstream of the main mould and consisting of movable, independent shall elements, the contiguous sides of which are not positioned parallel to the direction of movement of the metal, and consisting also of fluid type actuator to operate the shall elements. The actuator can be of a pneumatic or oleodynamic type.

Thus the clefts, which must not be eliminated and which exit between adjacent shall elements, have a disposition which is not parallel to , or else is like a spiral in relation to, the axis and surface of the ingot.

It follows that the metal moving according to the axis of the downstream mould is exposed to direct cooling only in the gone along the segment, and for the time required, to cross the clefts and therefore to a substantially unimportant extent relation to the length of the downstream mould and the time needed to pass through it.

This arrangement therefore makes it possible to eliminate any preferred strip of surface solidification, to contain and regulate better and to make more uniform the cooling and solidification of the metallic mass, to make the crystallization homogeneous and to reduce the physical, structural and mechanical shortcomings cited above.

Next, the employment of pneumatic actuators, on the other hand, to control the individual shall elements forming the downstream mould permits these elements to be positioned better and also make is possible to very, regulate and make uniform the lateral containment thrust applied to the metallic mass at anytime, ever when the apparatus is working, to enable the shall elements forming the downstream mould to oscillate and, not lastly, to control the opening of the downstream mould for insertion of the starter bar.

The individual shall elements are also enabled to stay always in contact with the ingot passing through

(European patent application 1989)

2.2. **CASTING PROCESS:-**

The pouring of molten metal into a prepared sand moulds of desired shape and allowing it to solidify is known as SAND CASTING. The molten metal passes through the 4 stage. (liquid, musty, plastic, and solid) till solidification takes place.

This is an important and vital part of founding work. This process is very suitable for producing casting of very high melting point metals such as cast iron and steel. Because of the basic simplicity of the casting process, almost any metal or metal alloy can be cast.

In general, there two (2) basic groups of material which are used in the founding work. They are metallic scarps (charge in furnace to produce molten metal) and sand (for producing mould cavities into which the molten metal is poured). The founding units consist of three section namely: pattern, moulding and melting and pouring.

Each of the above processes has an important bearing on the accuracy and quality of the finished casting "as the pattern goes, so goes the casting" is a typical founding phrase, and only those activity engaged in casting of molten metal appreciate the truth of this.

2.3. **PATTERNS:-** Patterns are founding man's mould forming tool. They are not made to standard measurement, but with special rules called contraction rule: or shrink rules. The rules are made to suit the contraction of various metal or alloys as shown in table (2.1) appendix 2.

Pattern making consist of that done within foundries and these often have pattern department. Most pattern department in foundries are more concerned with modifying it for moulding than with producing new patterns. The vast majority of pattern are made in pattern shops which can be independed of the foundry and operate as a separate industry.

To enable a pattern to be removed from a sand mould without tearing the sand, a certain amount of taper is necessary. This is referred to as draw. Round pattern with center joints will leave the mould quite freely, while shallow patterns required only a small amount of draw. In large, deep patterns, a considerable amount of draw is essential or the mould will break away on with drawing the pattern. No standard can be laid down as in many cases. It would not be practicable to leave an extra thickness on all faces of the casting. A general bases for the amount of draw where the thickness can be allowed is approximately 1/8 in to 1ft (3.2mm to 30.48cm). parts of casting to be machined must also have an extra thickness for the machine and it varies according to the type of metal.

The pattern set must satisfy the following requirement:-

i. Secure the desired shape and size of the casting.

ii. Have high strength and long life in order to make it many mould and cores are required.

iii. Be simple in design for ease of manufacture.

iv. Light in mass and convenient to handle, cheap and readily repairs.

v. Retain its dimensions and rigidity during the definite service period.

The required accuracy, strength, and life of a pattern set depend on the production quota involved. For short production, runs, wood pattern find most extensive application. In the large scale and mass production, metal pattern are preferably since they are durable than wood, although costlier. In batch production, use is often made of patterns manufactured from plastics, for example epoxy resins.

2.4 Pattern Allowances:-

Although the pattern is used to produced a casting of the desired dimension, it is not dimensionally identical with the casting. For metallurgical and mechanical reason, a number of allowance must be made on the pattern, if the casting is to be dimensionally correct. These are discussed under the followings:-

(a)Shrinkage allowance:-This is a correction for solidification shrinkage of the metal and its contractions during cooling to room temperature. The total contraction is volumetric, but the correction for it is usually expressed linearly. Pattern shrinkage allowance is the amount the pattern must be made larger than the casting to compensate for total contraction. Hence if the actual object itself were used for the pattern, the resulting casting would be slightly smaller than desired. To provide for this possibility, a shrinkage rule is used in laying out measurement for the pattern.

(b) Machining- finish allowance:- The amount of dimension on casting are made to be oversized to provide stock for machining. The allowance is influenced by the type of metal used, casting design and method of casting and cleaning.

In general, machine finish allowance may be a minimum, if the surface to be machine are entirely in the drag half of the mould since dimensional variation and other defect are usually least prevalent there.

©Draft allowance:-The surface of the pattern is given a slight taper in a direction parallel to which it is being with drawn. The tapering of the side of the pattern, known as draft, is done to provide a slight clearance for the pattern as it is lifted up. The amount of draft on exterior surface is smaller than those of interior. Holes.

(d) Distortion Allowance:- This allowance applies only to those castings of irregular shapes which are distorted in the process of cooling, as a result of metal shrinkage.

(e) Shrinkage allowance:- When a pattern is rapped in the mould before it is withdrawn, the cavity in the mould is slightly increased. In an average sized casting, this increased in size can be ignored.

2.5 Materials used for patterns:-

Most pattern are made of wood because of its cheapness and ability to be worked on easily. Where durability and strength are required, pattern are made from metal. For mass production steel or cast iron may be preferred.

(a) Wood:- The most commonly used material is white price because it is straight grained, light, easy to work on and has little tendency to weep. Lime is also used oftenly because it is soft, readily machineable, has low strength, high hydroscopicity, and increased shrinkage on the drying. It is used for small and medium size pattern. Others includes; mahogany, cherry, beech, basswood, abora, etc.

(b) Metal:-Many of pattern, used in production works are made of metal, because of its ability to withstand hard use. Furthermore, metal pattern do not change their shape when subjected to most conditions and required minimum. Aluminum is the best of all metals, because it is easy to work on, light in weight and resistive to corrosion.

(c) Plastic:- Some plastic materials are also used producing pattern e.g polystyrene plastic pattern are highly resistance to corrosion, lighter and stoner than wooden patterns. Besides, moulding sand stick less to plastic than to wood.

2.6 Moulding sand:-

The principal material used in the foundry shop for moulding is the sand . this is because it posses the properties vital for foundry purposes.

2.6.1. Sources:- All sand are formed by the breaking up of rocks due to the action of natural forces such as frost, wind, rain, heat and water currents. Rocks, however, are very complex in their composition, and sands contains most of the element of the rocks of which they are fragments. For this reasons moulding sands in different parts of the world vary considerably. Today sand is obtained from places which probably once were bottoms and bank of river and sand dunes.

2.6.2 Principal Ingredients:- The principal ingredient of moulding sand are: (1) Silica sand grains; (2)Clay, (3) Moisture and (4) Miscellaneous materials.

Silica in the form of granular quartz. Itself a sand, is the chief constitutes of moulding sand. Silica sand contains from 80 to 90 percent silica dioxide and is characteristic by a high softening temperature and thermal stability. However resistively and permeability to the sand. They are specified according to their average size and shape.

Clay is defined as those particles of sand (under 20 Micros in diameter) that fail to settle at rate of 25mm per minute, when suspended in water. Clay consist of two ingredients: fine silt and true clay. Fine silt is a sort of foreign matter or mineral deposit and has no bounding power. It is the true clay which imparts the necessary bonding strength to the mould sand, so that the mould does not lose its shape after ramming. Most moulding sands for different grades of work contain 5 to 20 percent clay.

Moisture, in requisite amount, furnishes the bonding action of clay. When water is added to clay, it penetrates the mixture and form a microfilm which coats the surface of flake shaped clay particles. The bombing quality of clay depend on the maximum thickness of water film it can maintain.

The bonding action is considered best if the water added is the exact quantity required to form the film . on the other hand the bonding action is reduced and the mould gets weakened if the water is in excess. The water should be between 2 and 8 percent.

Miscellaneous material that are found, in addition to silica and clay, in moulding sand are oxide of iron, limestone, magnesia, soda and potash. The impurities, should be below 2 percent.

2.6.3 Classification:- Moulding sands may be classified generally into three different type;

1. Natural moulding sands
2. Synthetic or high silica sands and
3. Special sands

Natural moulding sands, called green sands are taken from river beds or are dug from pits. They posses an appreciable amount of clay which act as a bond between the sands grains and are used received with water added. The quantity and type of clay mineral present affect the strength, toughness and refractoriness of the sand.

Natural moulding sands are also obtained by crushing and milling soft yellow sandstone, carboniferous rock, etc. During the milling operation, clay aggregates breakdown and clay particles get uniformly distributed over the sand grains. The grains shape of these sands is required to be subangular to round.

Due to their ease of availability, low cost, and high flexibility of operation natural moulding sands are used for most of ferrous and non- ferrous light castings. The requirement sands are satisfied by IS:3343-1965, which has classified them into three grades A,B,and C, according to their clay content and sintering temperature. This is listed in Appendix 2. Table2.3

Synthetic sands are basically high silica sand containing little (less than 2 percent) or no binder (clay) in natural form. They are made in foundry by first crushing quartzite sandstone and than washing and grinding these to yield a sand grade of requisite shape and grain distribution. The desired strength and bonding properties of these sands are developed by separate additions such as bentonite, water and other materials. This allows greater flexibility in the content of properties such as green and dry strength, permeability, and others that can be easily varied at well. Synthetic sands, therefore, are more expensive than natural sands.

IS:1987 –1974 covers the requirement of high silica sands for use in foundries and classifies into three grades according to silica contents. This is listed in Appendix 2 table 2.4.

Special sands, are ideal in getting special characteristic, which are not ordinarily obtained in other sands. Zircon, Olivine, Chamotte, Chromite, and Chrone-magnesite are often used as special sands. They are also suitable for facing materials in mold for steel castings

2.6.4 Properties of Moulding sand

Proper moulding sands must posses six properties. It must have porosity, flowability, collapsisbitlity, adhensiveness, cohesiveness or strength, and refractoriness. The properties are determined, not only by the chemical composition, but by the amount of clayed matter in the sand, its moisture content, and lastly by the shape and size of the silica sand grains.

Porosity:- Molten metal contains a certain amount of dissolved gasses, which are evolved when the metals freetes. If these gasses evolved by the moulding sand do not find opportunity to escape completely through the mould they will form gas holes and pores in the casting.

The sand must, therefore be sufficiently porous to allow the gasses generated within the moulds to be removed freely when the mould are poured. This property of sand is called porosity or permeability.

Flowability: Flowability of moulding sand refers to its ability to behave like a fluid, so that when rammed, it will flow to all portions of the mould and pack all round the pattern and take up the required shape. This property increase as clay and water content increases.

Collapsibility: After the molten metal in the mould gets solidifies, the sand mould must be collapsible so that free contraction of metal occurs, and this would naturally avoid tearing or cracking of the contracting metal.

Adhensiveness: The sand particles must be capable of adhering to another body, I.e. they should cling to the sides of the moulding boxes. It is due to this property that the sand mass can be successfully held in moulding box and it does not fall out of the box when it is removed.

Cohesiveness: This is the ability of sand particles to stick together. Insufficient strength may lead to collapse in the mould or its partial distruction during conveying, turning over or closing.

Refractoriness:- The sand must be capable of withstanding the high temperature of the molten metal without fusing, moulding sands with a poor refractoriness may burn on to the casting.

2.6.5 Grain shape and size of sand

The shape and size of sand grains have substantial effect on the processing properties of moulding sands. The shape of the grains and number of similar grains in the sand determine the possibility of its application in various types of foundry practice.

There are three distinct sizes of sand grain fine, medium and coarse. For small and intricate casting the use of a sand is desirable, so that all the details of the mould will be brought outsharply. Medium, sand is used in bench work and light floor work such as making machinery casting having from 1 to 15mm section. As the size of the casting increases, the sand particles likewise would be coarser to permit the ready escape of gasses that are generated in the mould. Grain size is determined by passing the sand through screens or sieves with certain operating sizes which are measured in microns.

2.6.6. Sand Additives

Additives are the materials generally added to the sand mixture to develop special properties in the mould and consequently in the casting.

Facing materials: The aim of using facing materials is to provides a smooth surface on the casting the mineral forms a thin, smooth coating on the mould.

Different forms of carbon are used for facing purpose because carbon will grow and gives off gasses, but will not melt. Other substances that are used included charcoal, gas carbon, coke dust, black lead, and graphite. These material are either applied to or mixed with the moulding sand that comes incontact with the molten metal.

Miscellaneous Moulding Materials: These are the moulding material, besides those already mentioned. They are used in foundry procedures. They included fiercely, claywash, parting material and core binders.

2.7 Liquid metals flow

Such problems as gas contamination, inclusion of dross or slag and aspiration of gas are factors that must be put into cognizance when pouring liquid metals through the gating systems into the mould(s). these problems are connected with the major problems of having the metal enter the mould in quit and uniform manner. In other words, these are problems concerned with fluid flow, and the law governing fluids can be studied profitably to improve any design.

First of all, it should be recognized that liquid flow either in a streamlined laminar fashion or in a turbulent manner. Weather smooth or turbulent flow result depends upon the velocity of the liquid, the cross section of the flow channel, and the viscosity of the liquid. The relationship is expressed as the Rynolds number.

$$Rn = \frac{\text{Mean velocity of flow x diameter of tube x density of fluid}}{\text{Kinematics viscosity of liquid.}}$$

When the Rynolds number reaches a certain critical value, turbulent flow prevails. Apparently, most metals reach turbulent flow condition quite easily. Investigations shows that steel flow under turbulent conditions (Rn.3500). turbulent flow creates such problems as inclusion of dross or slag, aspiration of and into the metal, erosion of the mold wall, and roughening of the casting surface.

The flow of a liquid metal in a mold is also governed by a number of other variables, best summed up in terms of Bernoulis theorem, which states that the sum of the potential energy, the velocity energy, the pressure energy and the friction energy of a flowing liquid is equal to constant. This problem can be expressed in the following equation:

$WZ = WP = WV^2/2g = WF = K$

Where w = total weight of fluid flowing, kg

Z = height of liquid, m

P = static pressure in liquid, kg/m^2

V = specific volume of the liquid, m3/kg

G = acceleration due to gravity, 9.81m/sec

V = velocity, m/sec.

F = friction losses, m

K = constant.

If the equation is divided by w, all the terms have the dimension of length and may be considered, respectively to represent:-

1. Potential head (Z)
2. Pressure head (PV)
3. Velocity head ($V^2/2g$)
4. Frictional loss of head (F)

Bernoullis theorem, which is based on the first law of thermodynamics, can be usefully applied to a proper understanding of the flow of metal in a mould (5). The potential energy of the metal can be considered a maximum as the metal enters the pouring basin. This form of energy is then rapidly changed to the kinetic or velocity energy and pressure energy as the metal passes through the mould system. Once flow is established and the potential and frictional heads are virtually constant, there velocity is high when the pressure is low and vise versa.

While metal is flowing, there is a constant loss of energy in the form of fluid friction between the metal and mould wall. There is also a heat loss which is not represented in Bernoulli's theorem, but which eventually leads to solidification of the metal.

It will be impossible to consider all the implication of this theorem and its application to the design of gating system.

2.8 Factors involved in Gating Design:

Improper design of a gating system can cause one or more of the following defects in the casting:

1. Sand, slag, dross or other impurities.
2. Rough surface
3. Entrapped gasses
4. Excessively oxidized metal
5. Localished shrinkage (pipe shrinkage, or micro shrinkage).
6. Dispersed porosity, or micro porosity
7. Incomplete fusion of liquid metal where two stream meet (cold shut)
8. Unfilled mould
9. Entrapped globules of presolidification metal (cold shuts)
10. Metal penetration into the sand mould and the worn out components.

The gating system must therefore be designed to accomplished the following objectives:-

1. Fill the mould rapidly, without laps or requiring excessively high pouring temperature.

2. Reduce or prevent agitation or turbulence and the formation of dross in the mould
3. Prevent slag, scum, dross and eroded sand from entering the casting by way of gating system.
4. Prevent aspiration of air or mould gases into the metal stream.
5. Avoid erosion of the moulds and scores.
6. Aid in obtaining suitable thermal gradients to attain directional solidification and minimize distortion in the casting.
7. Obtain a maximum casting yield and minimum grinding cost.
8. Provide for ease of pouring, utilizing available ladle and crane equipemnts.

It is evident that not all these requirement are compatible, and comprises may have to be made to get as close as possible to the desired goal.

2.9: Pouring speed:-

A slight trickle of molten metal poured TOO COLD is undesirable because the metal would freeze TOO FSAT to fill out the mould or would develop cold shuts. Very rapid filling of the mould also present such problems as having an inadequate gating system to handle a large volume of metal in a short time, erosion of the mould will, rough surface; excessive shrinkage and other possible defects. There is therefore as optimum pouring speed range for most casting that must be established.

Some metals like cast- iron are not so sensitive to pouring speed as others. Yet even for cast iron an optimum pouring speed which is a function of casting size and shape is advocated. A metal like steel must be necessily be poured fast to avoid premature freezing because it has high freezing range compared with most other casting alloys. Metals like aluminum or magnesium alloys can be pored more slowly, and here the problem is one of avoiding turbulent, drossing and gas pick-up.

Some data for pouring time are available for cast iron and steel

1.Gray- iron castings ,450kg

Pouring time, t sec. = $k\,(0.95 + T/0.853)\,\sqrt{W}$

Where:

K = Fluidity factor and is affected by iron composition and pouring temperature

W = Weight of the casting in Kg

T= Average thickness in cm

1. Gray iron casting >450kg

   Pouring time t, sec = $k\,(0.95 + T/0.853)\,\sqrt[3]{W}$

2. Steel castings;

   Pouring time, t sec. $K\sqrt{W}$

Where k varies from about 1.2 for 45kg castings to about 0.4 for 45,000kg castings.

With the optimum pouring speed established by whatever means are available, the next step is to proportion the gating system properly to achieve the desired speed while complying as closely as possible with the other desired charatericstic of gating system previously enumerated.

2.10 Pouring Temperature

For metals, change in chemical reaction occur over pouring temperature range. The wide working temperature range of most metals permits ease of manipulation in the foundry, reladling and adequate time for pouring. High temperatures encourages the entrance of gases into the metal, especially if the time at temperature is prolonged.

For cast iron actual pouring range from about 1260to1530C depending on the casting requirements. As temperature increase, oxidation reaction progress more rapidly, although this concept is strictly true only for reaction involving carbon

The tendency of oxidation of silicon and manganese by oxygen decreases with temperature increase. Carbon on the other hand, oxidizes more readily with increasing temperature.

Further more, reduction of oxides of silicon and manganese by carbon occur more readily as temperature increases.

As a result of this relationship silicon and manganese are lost primarily at low temperatures. During melting, under 2600oF (1427oC), and carbon is lost at higher temperatures. Again in silicon, silicon pickup, in the iron occurs at higher temperature because of the ability of carbon to reduce silica.

The solibility of oxygen and hydrogen in molten alloys increases rapidly with temperature. Hydrogen and oxygen pick up by molten metal comes from the furnaces atmosphere moisture, or oils on the furnaces charge, ladles and moulding and core sands. It effects in the metal are harmful since it can cause gas holes and micro-porosity. Dissolved hydrogen can add the difficulties of dispersed shrinkage since the gas will readily diffuse to cavities, precipitate a molecular hydrogen and oxygen gas bubbles, and prevent the cavities from being fed from riser or adjacent areas of the casting.

Gas evolution during freezing normal identification shrinkage from showing up in the vises. In place of pipe, the vises top may small or extrude.

Pouring temperature affects the fluidity and feeding characteristics of the alloy. The higher the temperature, the greater the supper heat the better the feeding characteristic. For long freezing range alloy, a high degree of superheat is needed for proper feeding. Stuttman (1992)

2.11 Defect in casting

Several types of defects may occur during casting, considerably reducing the total output of casting besides increasing the cost of their production. It is therefore essential to understand the cause behind these defects so that they may be suitably eliminated.

Casting defects may be defined as those characteristic that create a deficiency or imperfection contrary to the quality specifications imposed by the design and the service requirements.

2.11.1 Classification of casting defects.

Defect in casting may be of three basic types:

1. Major defects which cannot be rectified, resulting in rejection of the casting total loss;
2. Defects that can be remedied but whose cost of repair may not justify the salvage attempts;
3. Minor defects, which clearly allow the castings to be economically salvaged and thereby leave a reasonable margin for profit.

The defects most commonly occur in castings are further classified under four groups;

1. Surface defects; which are visible imperfections on the surface of castings such as incorrect shape and mass laps, flashes and so on
2. Internal defect and discontinuities of material such as hot and cold cracks, blowholes and others

3. Incorrect chemical composition and defective structure of casting may arise from an incorrect proportioning of charge materials, blending of various kinds of metals and poor melting practice.it is only possible to remedy the condition by properly checking the quality of casting material, striking observing the sequences of weighing and charging the material; and exercising strict control over furnaces run.

4. Unsatisfactory mechanical properties of casting commonly arise from an inadequate chemical composition and structural of the metal being poured.

2.11.2 Types and causes of defects and preventive measure.

Shifts: This is an external defects in a casting due to core misplacement or mismatching of top and bottom parts of the casting usually at parting line. Mis-alignment of flasks is another likely causes of shift.

The defect can be prevented by ensuring proper alignment of the pattern or die part, moulding boxes, correct mounting of patterns or pattern plates, and checking of flakes, locating pins etc. before use.

Warpage: Warpage is unintentional and undesirable deformation in a casting that occur during or after solidification . Due to different rates of solidification in different sections of a casting, stress are set up in adjoins walls resulting in Warpage in these area large or flat section or interacting section such as ribs are particularly prone to Warpage.

The remedy is to produce large areas with wavy corrugated construction to provides equal cooling rates in all areas proper casting design can go along way in reducing the Warpage of the casting.

2.12.3. **Segregation**: Segregation is the non-uniform distribution of alloying components, in-clusions and impurities in a casting, which arise during freezing. The cause of this phenomenon leis in a difference between the solubilities of individual components of an alloy in its solid and liquid phases. The larger this difference the more non uniform is the distribution of an impurity over the cross-section of the casting, and hence the higher the degree impurity segregation.

It is possible to over come the effect of inter dendritic segregation by subjecting the casting of annealing which balances out the content of impurities in individual dendrities.

Harka(1982)

2.13. Construction of Mold

The first step in making a mold is to place the pattern on a molding board which fits the flask being used. Next, the drag is placed on the board with the placed on fig 2.1 A. molding sand is then riddled in to cover the pattern with the fingers and the drag completely filled. For small molds the sand is firmly packed in the drag by a hand rammer. Mechanical ramming is used for large molds and in high production molding. The amount of rammed, it will not hold together when handled or when the molten iron strikes it. on the other hand, if it is rammed too hard, it will not permit the stream and gas to escape when molten metal enters the mold.

After the ramming has been completed, the excess sand is leveled off with a straight bar called a strike rod. to insure the escape of gases when the casting is poured, small vent holes are made through the sand to within several Millimetries of the pattern.

The lower half of the mold is then turned over so that the cope may be placed in position and the mold finished. Before turning, a little sand is sprinkled over the mold and a bottom bard placed on top. This board should be removed back and forth several times to insures an even bearing over the mold. The drag is then rolled over the pattern. The surface of the sand is smoothed over with a trowel and covered with a fine coating of dry parting sand. Parting sand is a fine-grained, dry silica sand with no strength. It prevents the longing of sand in the cope with that in the drag.

Next, the cope is placed on the drag, as shown in figure 2.1 B; the pin is on either side holding it in proper position. To provide a place for the iron to enter the mold; a tapered pin known as a sprue pin is placed approximately 25mm to one side of the pattern. The operations of filling, ramming, and venting the cope proceed in the same manner as in the drag.

At this point the mold is complete except for the removal of the pattern and the sprue pin. The sprue pin is first withdrawn, and a funnel – shaped opening is scooped out at the top so that there will be a fairly large opening in which to pour the metal. The cope half of the flask is then carefully lifted off and set to one side. Before the pattern is withdrawn, the sand round the edge, of the pattern is usually moistened with a swab so that the edges of the mold hold firmly together when the pattern is withdrawn. To loosen the pattern, a draw spike is driven into it and rapped lightly in all directions. The pattern can then be withdrawn by lifting the draw spike.

Before the mold is closed small passage known as a gate must be cut between the cavity made by the pattern and the sprue opening. This passage is shallowest at the mold, so that after the iron has been poured, the metal in the gate may be broken off close to the casting. To allow for metal shrinkage, a hollow is some times cut into the cope which provides a supply of hot metal as the casting cools; this opening is called a riser. The mold surfaces may be prepared coatings often contain silica flour and graphite, but their composition varies considerably depending on the kind of material being cast. A mold coating improve the surface finish of the casting and reduces. Possible surface defects. The completed mold is shown in figure2.1 C. Before the mold is poured, a weight should be put on float the cope and allowing metal to run out of the mold at the parting line.

2.14. HOW CASTING IS DONE:

The process used for making a casting depends on the quantity to be produced, the metal to be cast, and the intricacy of the port. All metals can be cast in sand moulds and there is no restriction as to size.

Casting can be realized in various ways. The sequence of making metal castings in expendable sand moulds is shown in figure 1. The casting manufacture cycle includes a number of main and auxiliary operations which are carried out simultaneously or successively in various departments of the foundry shop. Patterns, core boxes and other appliance are made, as a rule, in pattern making shops.

A sand mould usually consist of two half moulds: upper half (cope) and lower half (drag), which are prepared by compacting the moulding mixture (moulding sand)around the respective (upper and lower) portions of the wood or metallic pattern placed into special metal frames, or flasks. The pattern differs from the casting in that it has definite drafts to facilitate withdrawal of the pattern from the mould, and core points for setting of the core. The latter is needed to form an internal cavity (or hole) in the casting cores are made of a moulding mixture (core sand) which contains binders to bond sand grains firmly upon drying or chemical setting. By using additional pattern parts, a funnel (sprue) and a system of channels (gating system) is formed in the cope to admit the molten metal into the mould cavity and the additional cavity (riser) to feed the metal during solidification.

After compacting of moulding sand, the patterns of the casting proper and those of the gating system and risers are with drawn from the half-moulds. This core is then placed into the drag and the latter is covered by the cope. The required accuracy of connection of mould. Halves is ensured by pins and lugs provided in the flasks. Before pouring the metal, the two mould-halves are fastened together by brackets or a weight is placed onto the cope to prevent its rising under the action of poured metal.

Roughly 80% of the total output of castings are made in sand moulds though they do not fully satisfy the modern production requirements regarding the accuracy and surface finish of casting permanent – mould casting, die casting, chill casting, etc. are finding wider application, mechanization and automatic control are widely used in many casting processes.

2.15. COOLING:

After solidification, the castings are held in the moulds to cool them to the knock–out temperature.

An elevated knock-out temperature can shorten the process cycle. On the other hand, however, an excessively high temperature of castings at knocking-out is undesirable because of the risk of cracking and other casting defects and worsening of the quality of castings. Most alloys have low strength and ductility characteristic near the solidification temperature, and therefore, the risk of failure of castings is especially high. Beside, the castings are cooled in air more quickly than in the moulds and, what is more important, unevenly in the thin and thick sections, which increases the level of internal stresses. Premature knocking-out can lead to cracking Warpage and high residual stresses in the castings.

Long holding time in the moulds with the aim of cooling to a low temperature is inefficient economically, since it increases the cycle of casting process. For that reason, it is a common practice to knock-out castings at the highest temperature depends on the kind of the alloy and the shape of castings. It may be recommended to cool steel castings in the moulds to 500-700^0 and iron castings to400-500^0 C. Intricate casting prone to cracking are cooled in the moulds to 200-300^0 C and those which do not crack, to 800-900 ^{0} C. The knocking out temperature is 300-500^0 C for bronzes, 200-300 ^{0} C for aluminum alloys, and 100-150^0 C, for magnesium alloys.

The time of holding in the moulds is determined by the wall thickness of casting, the properties of the cast metals and the mould, and knock out temperature. It can be calculated or determined experimentally. The time of holding in sand moulds may range from a few minutes to a few days or even weeks depending on the kind of the metals and the shape of castings

In some cases, force method are employed for reducing the time of cooling for castings. For instances, the moulds cast on conveyors can be cooled by air blowing in cooling galleries . cooling of large casting is intensified by means of two coils arranged in the moulds and cooled by air or water. In some cases, air or gas is admitted into gaps between an moulds

The average rate of cooling decasting in moulds may range from 2^0 C per minutes to 150^0 C per minutes. It is chosen by considering the sectional thickness of castings and the strength properties of the metal. Large differences in the cooling rate in various section of a casting can cause high thermal stresses and lead to warpage or cracking of the castings. Forced cooling can equalized the cooling rates in the thin and thick sections and reduced thermal stresses, as well as shorten the cooling time.

In many instances, the castings are knocked out at a high temperature and then cooled more slowly than it would be in the air . For this purpose they may be placed into pits or boxes, left together with the knock-out sand .etc (Harka 1989)

2.16. WEAR

Wear may be defined as the unwanted removed the surface of a metal through the action of friction.

Generally, the performance of an automobile is usually characterized by its operating or performances, characteristic. As far as the automobile engine is concerned, such characteristic, are for example, the speed- horse power dependence, specific fuel and oil consumption, and the absences of knocks and abnormal noises. Any departure of performance characteristic from normal ones points to some or other fault. Such faults may result from wrong adjustment or some changes in the automobile that cannot be remedied through a suitable adjustment. closed with the latter are faults resulting from wear. The original qualitative properties of automotive components parts, established by their working drawings and specification and obtained in manufacture, alter in the course of operation as a result of wear or various defects.

Like any other machine, the automobile consist of individual components parts forming certain joints. The performance of a joint is characterized by its operational factors, which in this cases is the fit of the parts forming the joint, determine by the design of the latter. Thus, for a joint, a fault manifest itself inn a disturbance of the fit of the joined parts, i.e, a disturbance in the specified clearance or interference between the parts. For instance, an engine may lose power as a result of increased clearance between the piston and rod assembly components. Any disturbance of a fit is associated with changes in the dimension, shapes, surface, roughness, chemical composition, structure, and mechanical properties of mating parts.

2.16.1 Classification of types of wear.

The types of defects and wear occurring in automobile components parts, assemble and units are fairly diversified, and Prof.V.I. Kazantsev of the USSR classifies them in two groups- natural and accidental.

Natural wear results from friction and action of high temperature and loads occurring under normal service conditions. This type of wear is characterized by slow progress, i.e, the automobile in this case operate for a long period of time without any substantial worsening of its performances characteristic.

Accidental wear is the result of bad servicing. In some instances it may be caused by manufacturing defects, poor materials, and design errors. This type of wear is characterized by a rapid progress and is accompanied by residual deformation, breakage of components parts and other defects preventing the further operation of the automobile (trailer and semi trailer). The occurrence of accidental wear points to inadequate maintenance, and so automobile operator should try and maintain his fleet so as to allow only for natural wear and prevent accidental wear. Causes of wear and ways to increase services life of components parts:-

The natural wear of a movable joint depends on many factors and particularly on the type and charter of friction, the relative velocity of the mating parts, their initial condition (surface roughens, work hardning.etc), lubrication method and the amount and quality of the lubrication, and the presence of abrasives.

The great diversity of physical mechanical , chemical and physico-chemical properties of the rubbing material themselves extremely complicate the picture of natural wear. This makes it very difficult to reveal the general laws governing the amount and charioteer of wear of a certain joint under various operating conditions. What is common to all movable joint is that the degree of their wear increases with operating time.

Figure 2.1 shows the degree of wear as a function of operating time for three similar movable joints whose rotating components differs in surface roughness. The operation of any adequately designed movable joint under steady state conditions is charateritersed by three periods. Lets us analyzed the general laws governing the operation of movable joint using curve 1 of figure 2.2 as an example. The first, curvlinear section O.A, correspond to the period of intensive wear as a result of which the initial clearance in the joint increases up to a certain value (line segment A_1A_1). During this period there occurs the process of running in of the mating parts in which their original surface irregularities obtained in machining are destroyed and new irregularities are found in their stead. After running-in the surface irregularities of the mating parts change in shape, size, and direction. The resulting roughness of their surface is optimal and remains such through-out the normal operation period of the joint that follows its running – in .

The second, rectilinear section A_1B_1 of the curve 1 is the longest and characterized the normal operation of the joint, I.e; correspond to the period of its natural wear. This section correspond tot he region of permissible clearances where maximum is presented by the line- segment B_1B_1.

When some components parts is said to have a permissible wear, it is understood that it is capable of operating normally throughout its specified time between repairs.

The wear in this region proceeds in a cumulative fashion and is proportional to the operating time of the joints. The useful life of the joint depends on the manner in which it is operated (lubrication, adjustment, storage conditions, etc) and can be prolonged through repairs, i.e, by such methods which provide for the restoration of the original dimension of the mating parts, correction of their geometrical shape, restoration of their original fit, etc.

Thus, proper maintenance and adequate repair materially increases the service life of mating parts in movable joints.

The third, curvilinear section B_1C_1 of curve 1 in figure 2.2 is characterized by a sharp intensification of wear that is no longer proportional to the operating time of the joint.

This section is indicative of wear in excess of the permissible limits. There on in the neighborhood of the line segment B_1B_1 correspond to the ultimate wear with which the further normal operation of the joint should be discontinued. It is therefore of prime importance that the ultimate wear values be determined to repair the automotive fleet implies its running and maintenance in such a way as to prevent the mating parts in movable joints of automobile from reaching the state of ultimate wear prematurely.

There are various theories of soviet scientist explaining the process of wear, including the molecular friction theory advanced by Prof. B.V. Deryagin and the theory of mechanical and molecular mechanical wear by Prof. I.V. Kragetsky. Professor B.I. Kostesky, has studied the chemical and structural changes odccuring in thin surface layers in the process of wears.

According to kostesky, wear occurs as a result of seizure of metallic surface, oxidation, the action of high temperature and abrasive, and flaking.

2.13.2 Seizure (Adhesive) wear:- may be defined as the transfer of contact lumps with or without the resistance of lubricants between members in sliding contact. The contact lumps leave groove on the surface of the suffer parts, or scour the softer surface. Accordingly, this kind of surface failure has come to be known as scouring.

Adhesive wear takes place at high contact stresses it and pressure P,. the wear rate increases with increasing H or P, sliding speed V, and contact areas temperature t.

The seizure (Adhesive) wear is characterized by an intensive destruction of the surface of machine components rubbing without lubrication. The surface metallic layers deform, and on the rubbing surfaces there develop local metallic bonds (seizure) which are then destroyed, metal particles detaching from and adhering to the surfaces. This type of wear also occurs on components parts restored by various methods.

2.16.3 Oxidation wear: is a process of gradual destruction of the surface of rubbing parts under the action of oxygen(from air) on the metallic surfaces subject to deformation. Oxidative wear is typical of crank shaft journals and pins, piston rings and other components operating under similar condition.

2.16.4 Thermal wear:- This result from the action of high specific pressure and sliding velocities on rubbing surfaces. The heat generated in the process of friction softens the metal of the surface and causes their intensive destruction due to fusion, smearing, and transfer of small volumes of the metal between them. Thermal wear occurs on cams, valve push-rod end plates, cylinder faces and so on.

2.16.5 Abrasive wear: Occurs as a result of the action of abrasive particles, wear products included, on rubbing surfaces. As the surfaces slide over each other, these particles cut the microscopic volumes of metal off them. This type of wear inevitably accompanies all the other types, excepts for pitting. It is especially widespread where machine components operate in abrasive media.

2.16.6 Pitting:- is characterized by flaking, sapling and other similar phenomena on rolling-friction surfaces. This type of wear manifest itself most vividly on the surface of all bearing and gear teeth.

2.16.7 Mechanical wear: This kind of wear result from various mechanical processes, such as the cutting off and plastic deformation of surface irregularities when making parts move with respect to one another. Abrasive and fatigue cracking also curve mechanical wear.

2.16.8 Mechano-Chemical wear: is the kind of wear in which corrosion products and protective films of oxides are removed by a mechanical action. Corrosion is pronounced in machines serving outdoor. This wear mechanism also covers fretting or chafing corrosion which is defined as : surface damage usually in an air environment between two surfaces, one or both of which are metals, in close contact under pressure and subject to a slight relative motion.

Fretting can be observed on the mounting surface or various elements (such as bearing races shafts, casting, gears, pulleys and sprocket), in splin and other types of joints, and specially in weakened fits or in assemblies where a slight relative movement of the mating parts is required

2.16.9 Wear Resistance: refers to the ability of a part to resist superficial deterioration in friction, which could eventually distort the original geometry and surface condition of the part. As the amount of wear builds up, clearance increase resulting in additional loads on, and damage to the machine components.

The principal aim of maintenance and repair is to prolong the service life of movable parts. The wear on automotive components can be reduced by making then have an optimal surface roughness through suitable machining operations and ensuring their further operations in liquid friction conditions. The importance of the first factor has been considered above. Lubrication allows the wear of the components to be reduced materially. The introduction of a lubricant coefficient. In the absence of lubrication (dry friction) this coefficient ranges between 0.5 and 1.0, but where lubrication is present it is reduced to 0.01 – 0.001. At the same time, the lubricant serves as a cooling agents for the rubbing surface, keeping their temperature at constant level and washing away metal particles detached from them.

The service life of machine component can be prolonged by improving their wear resistance, for example, by increasing the hardness of their rubbing surface through heat or chemical treatment or surface impregnation (carbonizing, hardening, chrome plating or chroming, etc) or by using polymer. Richew (1976)

2.17.0 Methods of Reconditioning worn out components of the machine

A worn component part is restored to have either the nominal or repair size. It is imparted the true geometrical shape and the necessary surface properties, and its various mechanical damages and sometimes accidental defects are eliminated.

For this purpose, use is made of the following methods:

- Restoration of the original fit of components by using their repair size counterparts;
- Restoration of the original fit of components by using additional repair parts.
- Restoration of the original fit of component by making them have their nominal sizes through building – up, metallization, electrolytic and chemical plating, coating with polymer materials;
- Elimination of various mechanical damage

2.17.1 The restoration of the original fit component by using their repair- size counterpart: consists in that the more costly and critical of two making parts is machined to a repair size, while its counterpart is replaced by anew one of suitable size. For instance, when repairing crankshaft, their journals and pins are machined to have nearest repair size and bearing shall(of repair size) are than selected to fit them with the necessary clearance. Thus, a repair size is one nearest to the nominal size of a given part; which ensures the necessary shape and surface roughness of the part machined to this size.

A distinction is drawn between standard, specified and free repair size.

Standard repair sizes are used for piston, piston rings and pins, value push rods, and thin walled bearing inserts. These parts are manufactured in standard repair sizes commercially. Their making parts (cylinder block, crankshafts etc) are reconditioned by maching them to the standard repair sizes of the above listed components

Specified repair sizes are stipulated by the specification covering the repair of number of components, such as camshaft journals and bushing, values and value guides, and king pins.

Standard and specified repair size are dis advantageous in that, in the process of reconditioning a given part, one has not only to remove its worn surface layer but also to machine it further until its nearest standard or specified repair size is reached. On the other hand, an important advantage of these sizes is that they allow one to have handy ready-made repair parts and make repair by the partial interchangeability methods.

Free repair size: provide for the machining of the parts under repair until their true geometrical shape and the necessary surface roughness are obtained. Thus, similar parts may emerge from the nominal (design) size of shaft and hole respectively.

2.17.2: The restoration of the original fit component by using additional repair parts: is widely applied where the components are reconditioned to have standard repair size or the nominal size. The techniques consist essentially in that the worn surface of the part under repair is machined to true shape and a specially made additional part (make up pieces) is fitted to it, make up pieces are manufactured in the form of various sleeves, linear, rings, threaded inserts, gear ring etc. these methods is used to repair cylinder block, value seats, bell bearing seats in gear box casting, axle casings, wheel hubs and oil and water pump bodiës, worn thread holes in base member etc. these parts are heated or cooled to a certain temperature.For instance, steel sleeves are heated to around 600°C. Cooling is affected in various media: liquid oxygen (vaporization temperature -183 °C.); solid carbondioxide (vaporization temperature – 79 °C.), solid carbondioxide and alcohol (vaporization temperature -100 °C.), and liquid nitrogen (vaporization temperature -196 °C.).

2.17.3 The restoration of the original fit of component by making them have their nominal sizes:

Irrespective of there extent of wear can be done by various techniques, provide that the strength of the components is high enough and the methods find application in repair practice: building-up, metallization, electrolytic plating, plastic working and coating with polymer material. Plasma- jet hard facing. Friction welding, liquid metal surfacing, and tro-physical welding techniques. (diffusion welding, ultrasonic welding, laser welding, etc) are now at the stage of experiment testing.

Building up: Building up has found wide application in restoring the bearing surface of rotating parts, various slides and guides, splines, gear teeth etc where use is made of high a quality adding material, the service life of the parts being restored is substantially increased. The application of cast hard alloys gives, wear resistant built-up surface requiring no thermal treatment.

Metallization:- Metallization is a process of applying a metal coating on to the surface of apart by spraying it with a liquid metal by means of a jet of compressed air or inert gas. The process uses special apparatus metal spraying guns.

Metallization can help to recondition flat and external and internal cylindrical surface, to seal cracks in base (structural) member, to spray-coat with aluminum the surface of a components with a view to improving its heat resistance, to obtained pseudo-alloys processing good anti- friction properties, to apply decorative coating and so on.

Electrolytic plating : The following metals are used for plating worn surface by the electrolytic methods: chromium, iron, nickel and copper. Electrolytic plating is based on the phenomenon of electrolysis which is chemical process occurring when an electric current flows through an electrolyte.

The electrolytic plating process involves three (3) groups of operations: and machining of the plated coating. The preparation of the worn surface include machining, degreasing, electing and dipping. Various metals can be used for plating, and it is these metals that gives name to each particular plating process and ensure the necessary properties of the reconditioned surface.

2.17.4 Reconditioning of parts by plastic working: The methods is based on the used of the plastic properties of metals. Plasticity is the ability of metals and metals alloys to change shape under pressure and retain their newly acquired shape after the pressure is removed.

The following varieties of this method find the widest application in auto repair practice: up-setting, straightening, expansion and reduction in diameter. These can be done both with and without heating of the work pieces.

2.17.5 Reconditioning of parts with polymer material:

Polymer: Materials are finding ever increasing application in auto repair practice. The essence of the process consist In that the thin plastic coatings are applied onto worn metal surface with a view to reconditioning them. To casting are applied (deposited) by spraying. Most frequently used techniques are flame spraying and eddy or vibration spraying. The material are polymer which are divided into three (3) large groups: plastic, elastomers, and fibers.

Plastic are used most extensively in auto repair practices. These material are classes into thermoplastic and thermosetting plastics. The thermoplastic employed for spraying are mainly polyamidamoplastc (or simply polyamides). These are hard thermoplastic polymer, melting at a high temperature. They surpass all the other types of plastic in mechanical strength and wear resistance.

2.17.6 Application of Adhesive composition:

Adhesive bending of components finds extensive application in auto repair practice. In a number of instance; this repair technique compares favorably with other methods (welding, soldering, riveting) because it is easily to apply and requires, no complex equipment. Adhesive can be used to bond components made of similar and dissimilar material, and also those of complex shape and varying size. They find application in repairing automobile bodies, in commenting friction linings on brakes shoe, and clutch drive disks, in applying protection coating and so on.

Automotive components are repaired using various adhesive compositions containing resins, platicizers, hardeners, accelerators, solvents, fillers, and others addition.

2.17.7. Reconditioning of parts by welding:

Welding is applied on a very wide scale in automobile/ machine repair. Welding help to remedy many defect and damages, including all sorts of cracks, breakage, holes, stripped and worn threads, etc. Welding is a process of uniting pieces of metal by heating until molten and fused or until soft enough to hammer or press together. When repairing automobile/ machine components, the metals is heated with a gas flame or an electric arc. Since the components are manufactured from different metals, (steel, gray and malleable cast iron, non ferrous metals and alloys), they require different welding techniques.

2.17.8 Reconditioning of part by Electric Resistance Machining:-

The techniques is used to finish cylindrical flat, and other surface and also to restore slightly worn component. It provides for simultaneous improvement of the mechanical properties of the surface metal layer of the work pieces.

The service tests of components restored by this method have proved it to be effective. The tests were run on the steering knuckles of the truck, whose bearing surface were restored by various methods. New steering knuckles were tested simultaneously. The tests have shown that if the coefficient of wear resistance of new steering knuckles is taken to be unity, it is equal to 1.35 for knuckles restored by electric resistance machining, 1.2 for those reconditioning by chrome plating, 0.73 for steel plated knuckles and 0.74 for metallized ones.

The essence of the techniques consist in that a heavy current (400-200 °A) through the contact between the tool and the components being machined. As a result, the surface metal layer of the work pieces is extensively heated and is deformed, smoothed down and compacted under the pressure exerted by the tool. The process can be conducted using lathes, milling and drilling machine, and other machine tools Borovskiskh (1989)

2.18.0 Description of the component

2.18.1 The Hub cover

The hub cover is that part or component contain in the bearing housing, it prevent the bearing from getting incontact with the soil.

Bearing on Agricultural implement are often required to operate under extremely dusty or dirty conditions. Development of suitable bearing, seal and lubricant, for these conditions has been a real challenge, but great progress has been made in recent years.

Seal, factory- lubricated ball bearing are now employed extensively on most types of harvesting equipment and in many other applications, the added initial cost being justified by reduced repair cost and less daily servicing time

The hub cover mostly get won during the tillage operation, this is as a result of the contact between the implement (hub cover) and the soil, some even got broken completely. The disc set too deep may prevent the plough penetrating and cause excessive wear in the bearing and hub cover. When wear progresses to the point where negatives suction occurs, only the plough weight keeps the shore in the soil. Wear has only a minor effect on draft but a great effect on suction and the penetrating ability of plough

The hub cover is made up of cast iron which consist of the carbon, silica, magnesia, sulphur and phosphorus.

2.18.2 Cam follower (cam roller)

Cam followers and tappet roller are made from cast iron or iron alloy which has a high resistance to wear and corrosion. Although the external appearance varies with engine design, all cam follower or rollers reduces friction and evenly distributed on to the cam shaft the force placed on them during opening and closing of the values or when operating the injector. The cam follower usually slide up and down in there bores as they follow the eccentricity of the camshaft lobes. These bore which are usually in the cylinder block can become worn or damage. Careful inspection of the cam follower bores should be made and any damage or worm bore should be bored and sleeved at this time.

Either a socket which accept the pushrod ball end is machined into the follower or else a replacement socket is pushed into the follower. Some engines, because of the difference in camshaft location and action, here neither a pushrod nor the conventional camfollower.

The Detroit Diesel 149 series engines have the cam roller pinned to the rocker arm which is in direct contact with the camshaft. On overhead camshaft engine, such as 690series Detroit Diesel, the rocker arm are located in the camshaft housing. The rocker arms with the valve- adjustment mechanism are placed directly over the valve, and the camshaft lobes act directly on the roller to actuate the rocker arms. Cummins in-line diesel engine have the camroller pinned to a lever which pivot on a shaft to rest in a replaceable socket.

The wear limit of the camfollower bushing, pin, roller and bore must be checked very carefully. The camfollower surface condition must be free of galling, pitting, or scoring. The rollers, should be checked for flat spots, since any slight defect will affect valve and /or injection timing. Valve lifer having flat surface instead of a roller should be checked for excessive wear and pitting. (Schlitz 1986)

CHAPTER THREE

3.0 EXPERIMENTAL PROCEDURE FOR FOUNDRY SAND CASTING AND TESTING OF CAST PRODUCTS

3.1 PATTERN MAKING

The first step in the casting operation was pattern making. The pattern is a model of the specimen to be cast and it was made from a wooden material.

At the pattern shop, the wood was cut and worked on to form a solid pattern according to the dimension on the working drawing. A draft or taper allowance of 2^0 was allowed in its vertical surface so that the pattern can be easily removed from the sand mould.

3.2 MOULDING

Before Moulding, the sand was prepared and properly mixed. Water was added to the synthetic sand to develop the plasticity and to aid compaction. The quality of water was standardized for the synthetic sand. The reason being that if the water is too little friability of the Mould occurs and handling becomes difficult. And if the water content is too high, evaporation during pouring leads to formation of hydrogen and oxygen which may enter the casting to cause porosity or gaseous inclusions.

The flask (the drag) for moulding was placed on a moulding board. The pattern was then placed inside the flask and then covered with properly mixed sand (facing sand) ramming operation was then carried out and on completion the drag was turned upside down.

Patting sand was applied on the surface of the drag. This is to ensure that both the drag and the cope can be separated without damage to the mould. The cope was then placed on top of the drag and vertical sprue pin that tapered downward was pushed through the cope to the joint of the mould. Moulding sand was then packed round the sprue pin to fill up the cope. Hand rammers were then employed for proper ramming, the pointed rammer type is used first, then follow by the flat rammer type. A line mark running across the cope to the drag was made. This will prevent misalignment of the two flasks when they are to be assembled together after separation.

The sprue pin is now removed and the flask separated. A lifter was then employed to remove the pattern from the sand mould that was contained in the drag. This created the required cavity in the sand mould. A finishing trowel was used to repair the damaged portions of the mould and to construct a runner from the sprue base to the cavity. The two flasks were then joined together so that the line marks were in the correct position to prevent misalignment. The mould was now ready for the pouring in of molton metal.

3.3. MELTING

A cast iron scraps were melted in an electric arc furnance, charging and melting of cast iron took several hours.

Temperature were easily checked with thermocouple. However, cast iron was heated to a temperature of 38^0C. This is to allow for temperature drops encountered during reloading and temperature loss during the time required for pouring the casting.

3.4 POURING

A ladle was employed to removed molten metal to the pouring area. The metal was poured into the mould cavity through a channel called the gating system. The gating system was design in such a way as to allow easy flow of metal into the mould cavity. This is to prevent turbulence, aspiration and erosion of the mould walls which would results into inclusions in the castings.

Pouring was done continuously and at uniform rate until the mould, gates and risers were full. The temperature of the metal was maintained so as to prevent it from being too hot in order to avoid formation of blow holes or premature solidification that would not fill the entire cavity.

3.4.1 MEASUREMENT OF POURING TEMPERATURE

An instrument called thermocouple was employed in determining the pouring temperature of cast iron (hub cover and aluminium casting) castings. The tip of the instrument was allow to make contact with the base of the molten metal which is contain in the pouring ladle.

Two temperature reading were noted and recorded for the cast product. The first being the temperature reading at the beginning of pouring the molten metal into the mould and the second being of the temperature reading immediately the mould is filled-up. The average of the two temperature calculated, is the temperature of a particular casting.

3.5 CLEANING AND FETLING

After the molten metal has been poured into the mould, it was allowed to solidify and cool. When the casting had solidified it was removed from the sand in the moulding box.

Fatling operation was carried out on the castings. These include:-

1. Removal of gates, risers, runners from the castings.

2. Removal of fins and other unwanted projection from the costing

3. Removal of adhering sand and oxide scale from the surface of the castings. Gates, risers, sprue and runners were removed by knocking off with a hammer and saw cutting.

3.6 INSPECTION OF CASTINGS:

After the casting have been cleaned, they were inspected to check if they would perform specified functions during service. A number of methods and techniques were employed to check the qualify of castings. These methods use include:-

i. Visual Inspections

ii. Dimensional Inspections

3.7 MATERIAL SELECTION AND COST ANALYSIS

In engineering design, the economic benefit has to be put into consideration through the selection of the material which has to be very cheap and at the same time meet the specific purpose for which it is design for. In reconditioning the worn out part of the machine by casting, the basis factors put into consideration are the choice of the material, that is availability and cost of material, durability, ease of work or construction. These has to be put into consideration in order to achieve the desire objective. The availability of material will reduce the reconditioned cost and hence will make the price comparatively low making it affordable for the intending worn out component of the machine.

COST ANALYSIS

The cost analysis can be classify into three:

1. Material Cost

2. Labour Cost

3. Over head cost

The table below show cost of material to be used. (TABLE 3-1)

S/No.	Component	Material	Specification	Quantity	Price (₦)
1	Worn-out Hub Cover	Mild Steel		5	1000
2	Worn-out Cam follower	Mild Steel		2	100
3	Hand Rammer (a) Flat Rammer (b) Pointed Rammer	Iron		 1 1	 300
4	Binder (Clay)	Clay		10kg	50
5	Core and Drag Box	Wood	10 x 20mm	1 each	200
6	Scraps	Aluminium		180kg	1000
7	Pattern Making	Wood	12 x 25mm	1	700
					3,550

Labour cost (L. C)

These is taken as 20% of the total material cost i.e.

Labour cost = $^{20}/_{100}$ x 3.350

= 0.2 x 3,350

= N670.00

Over head cost (O.C.)

The overhead cost is 10% the material cost for the reconditioning expressed as:

Overhead cost = $^{10}/_{100}$ x 3350

= 0.1 x 3350 = N335.00

Total cost (T.C.)

The total cost is the summation of material cost, labour cost and overhead cost, i.e.

Total cost = Material cost + Labour cost + Overhead cost

= 3350 + 670 + 335

= N4,355.00

CHAPTER FOUR

4.0 EXPERIMENTATAL RESULT AND DISCUSSION

4.1 DISCUSSION OF RESULTS

The reconditioning of the worn out component of the machine is carried out. In sand casting operation, the quality of casting is influenced by the pouring temperature and speed. For cast iron i.e. sample C as seen in the plate I; at very high temperature the graphite is burnt off and carbon content is reduced.

This result in harder, brittle and unmachinability of the castings. Gas holes and Micro-porosity increase rapidly with increasing pouring temperature; the resultant effect is low strength and very poor Mechanical properties. The maximum pouring temperature of aluminium is 700 – 750^{o}c. At temperature above this range, the castings result in large crystals; low stranger and gases are entrapped in the castings leading to blowholes. Higher pouring speeds above the maximum pouring also present problems such as an inadequate getting system to handle a large volume of metal in a short time, erosion of mould wills, rough surface, excessive shrinkage, drossing and gas pick-up. The combined effect reduced the mechanical properties of the castings.

4.2 QUALITY OF CAST PRODUCTS

SURFACE INSPECTION: Visual inspection of the castings and recondition sample reveals, many of the common defects. These procedure is carried out after the final fetling operation has been accomplished.

For hub cover made of cast iron i.e. sample C gives a very fine surface finish.

In the case of aluminium castings, A' and B' gives the best surface finish followed by sample D' while for sample C' the surface on casting is fairly rough with few sand pick-up and sample E' gives very rough surface finish with sand entrapped in the surface casting. This is a result of high pouring temperature which leads to erosion of the walls, the effect can be remedied by using the optimum pouring temperature.

4.3 **INTERNAL DEFECT ANALYSIS:-** Internal defects means the inspection that occurs in the body of castings.

In case of aluminium sample A' to D' are free from internal defects. This shows that the casting temperature are adequate and sufficient. Specimen E' on machining shows slag penetration or inclusions of dross and gas holes. These defect can be prevented by degassing, removing the dross before pouring and by using the correct casting temperature.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATION

5.1 CONCLUSION

In the present investigation, the reconditioning and the sand castings of aluminium were examined. The casting condition and their effects on casting are also presented. The quality of the castings depend on the pouring temperature and speed.

It also identified the various causes of casting defect during reconditioning, also the causes of wears and their appropriate preventive measures. If these measure are strictly observed, the casting produced with the appropriate temperature would be found to produce high quality sound products.

Some of the casting produced in work shop were not good due to lack of enough working materials. The hollow component like hub cover and came follower were use as samples using aluminium alloys. The following defects were identified: Misrun, gas hole, inclusions, rough surface, contraction cracks and erosion scrab.

There are so many factors causing these defects and those ones responsible for causing these defect were found to be insufficient fluidity due to low pouring temperature, presence of gases in ferrous alloy, improper roughness of the surface to recondition and large amount of gas evolution from low mould and cores, poor flow ability concentration stresses at the junction of thick and thin selections due to poor casting design; Ramming too hard or too soft and unevenly rammed mould and careless skimming.

The following remedial measures are suggested for minimization of these defects:

i. The correct pouring temperature for the castings should be ensured, by measuring the temperature of the melt before pouring.

ii. The casting design should be proper. The junction of thin and thick section should be properly reduced. Gates and risers should be provided at the proper location and the dimension of rises and gating system should be calculated using the formulae developed for the alloy and the moulding system used.

iii. The properties of the mould and core mating mixtures should be controlled to have uniform hardness and density after ramming. Control of incoming materials should be exercised.

iv. The personnel should be well trained for the mould and core production.

v. Recommended melting practice should be used to ensure good quality melt.

vi. Degassing should be done for aluminium. Grain refinement should also be done to improve the properties.

vii. Ladles should be well preheated and pouring should be well pre-hasted and pouring should be done properly to avoid the spillage.

viii. Casting should be removed from the mould once it is fully solid. Premature knock out should be avoided.

ix. Casting should be inspected before the felting operation.

5.2 RECOMMENDATION

At every stage of production, care must be taken to control the quality and suitable materials must be used for mould/cares, melting and melt treatments.

It was also observe that the founding does not have some equipments.

1. Sand Muller should be used for proper mixing of clay bounded sands
2. Suitable metal moulding boxes, preferably of press-forged construction should be used be used.
3. Temperature measuring instrument should be used to check the melt temperature. Immersion type pyrometers should be used.
4. For controlling the quality of moulds and cores some sand testing equipment should be procured and to be used regularly.
5. Inoculation of grey cast iron, degassings and grain refinement of aluminium should be carried out.

It has been observed that temperature range of 1630^{0}C to 1660^{0}C are strongly recommended for cast iron casting. And for Aluminium, a temperature range of 700^{0}C to 750^{0}C is recommended.

5.3 SUGGESTION FOR FURTHER WORK

A study of the reconditioning of the work and component on the structure is important because there is a good correlation between structure and properties of castings. Hence, future investigation of the reconditioning and casting of the worn out component on the structure of sand cast metal and alloys should be carried out.

Furthermore, from a metallurgical engineering points cast iron may be view as a microstructurally sensitive alloy. Microstructure, chemical composition and mechanical properties are intimately related. Therefore the effect of chemical composition on the properties of send cast iron and aluminium is also suggested for further work.

Finally, improvement on sample A B C D E by the optimum reconditioning and casting techniques, thus rendering them for ideal condition of casting is also suggested.

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APPENDIX 1

$$EL = \frac{(Lm - Lo)}{Lo} \times 100\% \ldots\ldots\ldots\ldots (1)$$

$$Ev = \frac{(Vm - Vo)}{Vo} \times 100\% \ldots\ldots\ldots\ldots (2)$$

Where Lm, is the linear dimension of the mould, Lo is the size of the casting of 20^0C after solidification,

Vm is the the mould volume, and Vo is the volume of the casting at 20^0C.

$$Ec = \frac{Lp - Lc}{Lc} \ldots\ldots\ldots\ldots (3)$$

Where Lp is the linear dimension of the pattern and Lc is the linear dimension of the casting.

Ultimate Tensile Stress

$$(u.t.s = \frac{F}{A_0} \ldots\ldots\ldots\ldots (4)$$

Percentage Elongation

$$(= \frac{L - Lo}{Lo} \times 100\% \ldots\ldots\ldots\ldots (5)$$

Percentage Reduction in Diameter

$$(= \frac{\Delta o - \Delta}{\Delta o} \ldots\ldots\ldots\ldots (6)$$

Where F = Maximum laod (N)

(u.t.s = Ultimate tensile stress (N/mm^2)

A_0 = Cross-sectional area (mm^2)

L = Guage length after fraction

Lo = Initial gauge length of the specimen

Δ = Diameter of the specimen after fracture

Δ_0 = Initial diameter of the specimen

Pouring Speed

V = H/T

Where V = Pouring speed of molten metal (cm/sec)

H = Height of ladle above pouring basin (cm)

T = Time of pouring molten metal (sec)

APPENDIX 2

TABLE 2.1 PATTERN MAKERS CONTRACTION ALLOWANCE (MM/M)

METAL	CONTRACTION ALLOWANCE (MM/M)
Aluminium Alloys	10 – 16
Cast Iron (Grey)	8 – 13
Brass	13 – 16
Bronze	18 – 22
Lead, Zinc	26
Tin	21
Steel Carbon	16 – 21

TABLE 2.2 DEFECTS IN CASTING

Misrun	May appear as the Holes in thin section of a casting	Low pouring temperature	Provide hotter metal at the sport of pouring ladle
Shrinkage And draws	Rough cavities entering casting on heavy section	Incorrect pouring temperature and Gating design	Use correct pouring speed and gating design
Slag	Pitted surface or inclusions found on machining	Incorrect gating causing turbulence	Use correct pouring speed and gating
Porosity	Machine surfaces show cavities in thick of fine holes or machined skin	High pouring temp. and high speed	Use correct pouring temp. and speed
Hard metal	Bright areas on machined Faces occur as scattered Herd sports	Low pouring temp. high speed	Avoid splashing of metal down the runner use correct Pouring temp. and Speed

Rough surface	Casting surface rough	Metal penetration due to: 1. High pouring speed 2. High pouring temp.	Use optimum pouring temp. and speed
Blow holes	Rough shaped Holes occurring On the outside of The casting may be Found just below Surface on machining	Two low a pouring temp.	Increase pouring temp.
Dirt	Rough cavities and pits in castings. On examining before cleaning sand is often seen	Too low a temp. and speed	Use correct temp. and speed

TABLE 2.3 REQUIREMENTS OF NATURAL SANDS

	Grade A	Grade B	Grade C
Clay percentage sintering	3 – 5	10 – 15	15 - 20
Temperature in degree Centigrade	1350 – 1450	1200 – 1350	1100 – 1200

TABLE 2.4 REQUIREMENTS FOR HIGH SILICA SANDS

Grade	Silica	Alumina Max.	Iron Oxide Max.	Ca and Mg. Oxide Max.	Alkalis (Max)
A	98	1.0	1.0	1.0	0.5
B	95 – 98	1.5	1.0	1.0	0.5
C	90 – 95	2.0	1.5	2.0	1.5

Plate1: Samples before casting

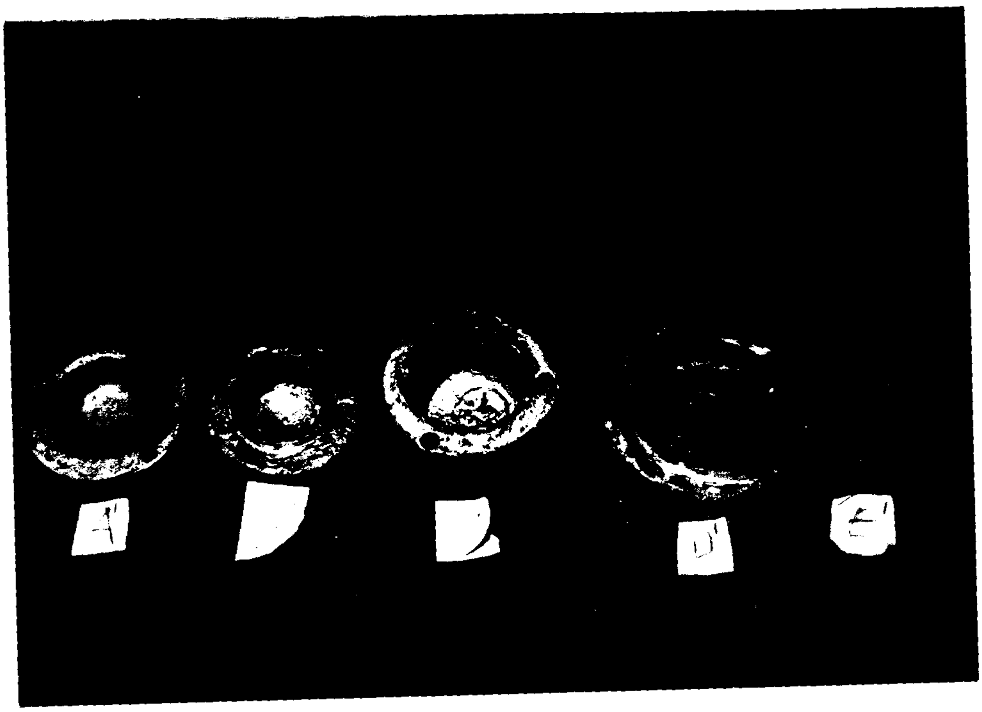

Plate 2: Samples after casting

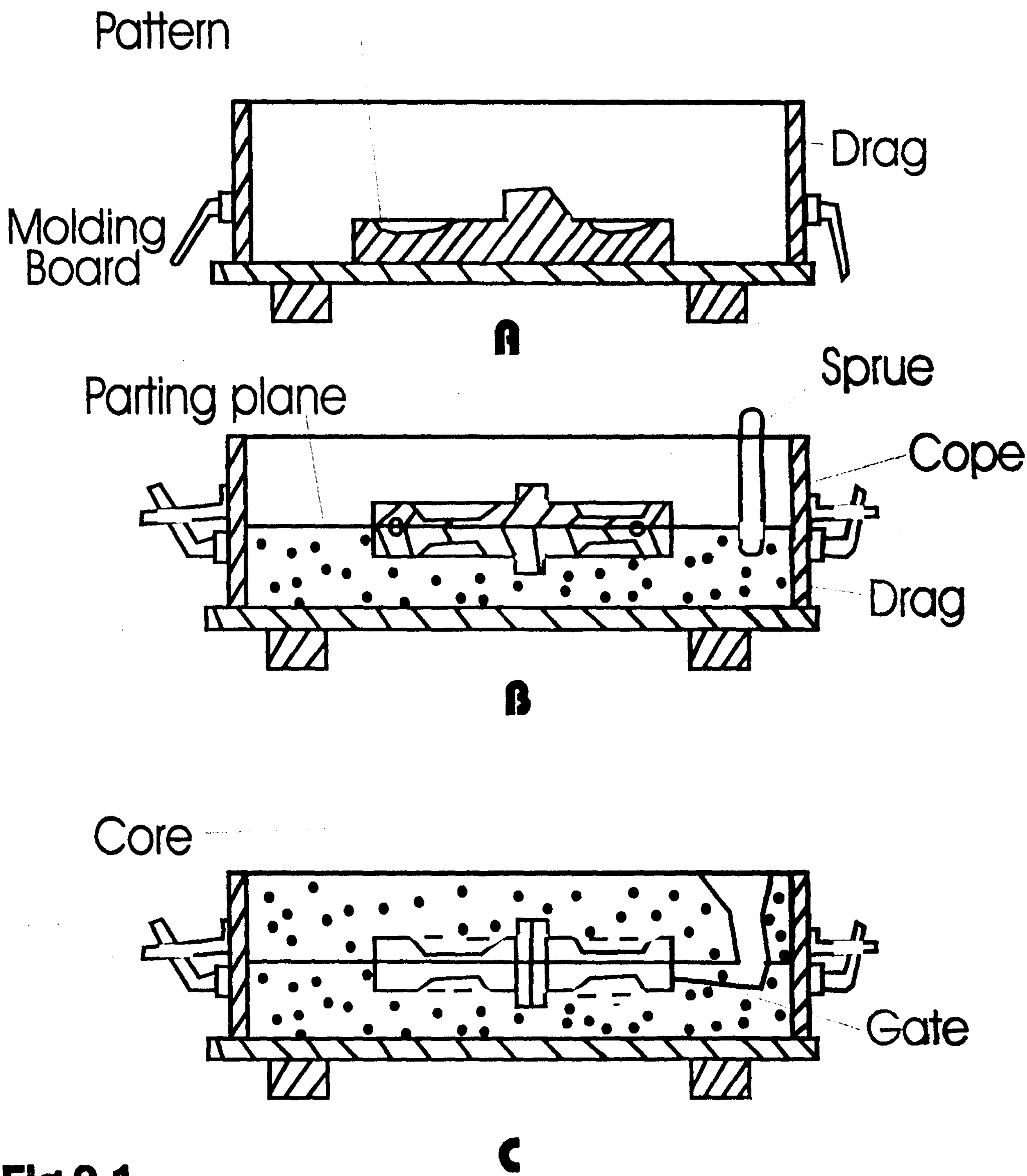

Fig 2.1

Procedure for making green sand molds. A, pattern on molding boarc Ready to nam up the drag. B, Drag rolled over and pattern assembled Ready to ram cope. C, mold complete with dry - sand core in place