AMIRAJ
COLLEGE OF ENGINEERING & TECHNOLOGY

LABORATORY MANUAL

Material Technology

SUBJECT CODE: 3151912

B.E.5th SEMESTER

NAME:______________________________

ENROLLMENT NO: ______________________________

BATCH NO: ______________________________

YEAR: ______________________________

Amiraj College of Engineering and Technology,
Nr.Tata Nano Plant, Khoraj, Sanand, Ahmedabad.

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CERTIFICATE

This is to certify that Mr. / Ms. ____

Of class____________________ Enrolment No ___________________________has Satisfactorily completed the course in ____________________________________as by the Gujarat Technological University for ____ Year (B.E.) semester___ of Mechanical Engineering in the Academic year______.

Date of Submission

Faculty Name and Signature (Subject Teacher) **Head of Department (Mechanical)**

Material Technology

SUBJECT CODE: 3151912

B.E. 5th SEMESTER

Sr. No	Date	Title	Page No	Marks	Date of assessment	sign
1		INTRODUCTION AND OVER VIEW OF VARIOUS MANUFACTURING PROCESS.				
2		TO STUDY DIFFERENT TYPES OF PATTERNS AND ITS ALLOWANCES.				
3		To study about various types of moulding sand and moulding operations.				
4		Design of casting with gatting system, riseR, runner.				
5		STUDY OF WELDING PROCESSES WITH IT'S CLASSIFICATIONS, WELDING DEFECTS, WELDING ELECTRODES AND ELECTRODE COATING.				
6		Performance of Gas welding and Gas cutting.				
7		STUDY OF Resistance welding and performance on spot welding.				
8		STUDY of Arc Welding. sUCH AS (TIG/MIG/SMAW Welding).				
9		To study about NoN conventionalwelding process.				
10		STUDY OF metal working operationS and detail study of hot and cold metal working operation				
11		STUDY OF plastic technology and detail study of plastic part manufacturing process.				
12		STUDY OF SURFACE Finishing ProcessES IN DETAIL.				

Date:

PRACTICAL: 01

AIM: INTRODUCTION AND OVER VIEW OF VARIOUS MANUFACTURING PROCESS.

1.1 INTRODUCTION

The main aim behind advances in engineering and technology has been to raise the standard of living of man and to make his life more comfortable. The major role in this direction has been played by manufacturing science, Manufacturing is an essential component of any industrialized economy. The Word Manufacturing engineering or Production-Engineering can be defined as the study of the various processes required to produce parts and to assemble them into machines and mechanisms. Production or Manufacturing is a critical link in the design. Fig. 1.1 shows cycle, which-starts with a creative idea nd ends with a successful product.

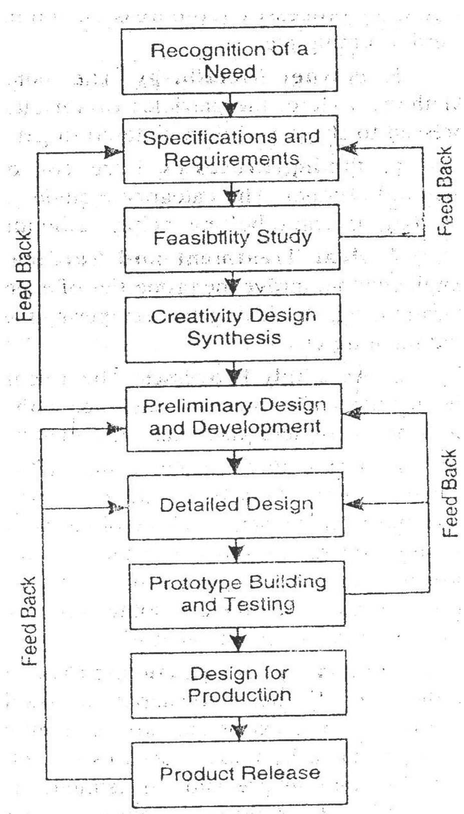


Fig.1.1. Design Cycle

1.2 MANUFACTURING PROCESS

A manufacturing process is the activity (or a combination of activities) of transforming a given material into a product of different forms and sizes and with or without changing the physical and mechanical properties of the product material. Examples of a manufacturing process are casting, welding, bending, forming, rolling and heat-treatment. A manufacturing process is always accomplished with the help of a variety of tools, equipment and other devices or mechanical aids and the human effort.

1.3 CLASSIFICATION OF MANUFACTURING PROCESSES

All the manufacturing processes may be grouped into the following main categories.

1.3.1 Casting processes. Here, the metal in the molten state is poured into a mould and allowed to solidify into a shape. The mould may be expendable or permanent. The examples are Sand casting, Permanent mould casting, Die casting, Precision investment casting and centrifugal casting etc.

1.3.2 Deformation Processes. In these processes, the material is plastically deformed (hot or cold) under the action of an external force, to produce the required shape. No material is removed but is only displaced and deformed to get the final shape. This category includes metal working/ forming processes such as : forging, rolling, extrusion and drawing etc and also sheet metal working processes such as deep drawing and bending etc. The unconventional forming processes such as High Energy Rate Forming (HERF) and High Velocity Forming (HVF) methods also fall under this category.

1.3.3 Machining Processes. In machining processes, also known as Metal cutting or chip forming processes, material is removed from a work piece to get the final shape of the product. The processes include : turning, milling, drilling, broaching, shaving, grinding, polishing, lapping, honing, buffing and sawing etc. The modern unconventional machining processes such as ECM, EDM, USM, AJM and LBM etc. are also included in this category.

1.3.4 Plastic Materials/Polymers processing methods. Under this category are included the various methods for processing plastic material/polymers for example, shape casting, the various molding processes (compression molding, injection molding, transfer molding etc.) and thermoforming etc.

1.3.5 Power Metallurgy. The more appropriate name should be "Particulate Processing Methods". Here the particles of various sizes of metals, ceramics, polymers and glass etc, are pressed to shape and then sintered to get the final product.

1.3.6 Joining Processes. Here, two or more components are joined together to produce the required product. The category includes. All the welding processes, brazing, soldering, diffusion bonding, riveting, bolting, adhesive bonding etc.

1.3.7 Heat Treatment and Surface Treatment Processes. Heat treatment processes are employed to improve of a work piece. The category includes the processes. Annealing, Normalizing, Hardening and tempering methods. Surface treatment processes include electro-plating and painting etc.

1.3.8 Assembly Processes. The assembly process for machines and mechanisms is the part of the manufacturing process concerned with the consecutive joining of the finished parts into assembly units and complete machines, of a quality that meets the manufacturing specifications.

1.4 WELDING PROCESS

1.4.1. Definition. There are many definition of a welding process. But the most comprehensive definition is below.

Welding is defined as a “a localized coalescence of metals, wherein coalescence is obtained by heating to suitable temperature, with of without the application of pressure and with or without the use of filler metal. The filler metal has a melting point approximately the same as the base metals.”

The welding process is used to metallurgical join together two metal pieces, to produce essentially a single piece of metal. The process results in what is known as a ‘permanent joint.’ A good welded joint is as strong as the parent metal. The product is known as ‘Weldment.’

1.4.2. Applications. The welding process finds widespread applications in almost all branches of industry and construction.

- fabrication and creation of steel structures
- industrial construction and civil engineering
- fabrication industries like small as well as large scale
- aero space industries
- maintanance

1.4.3 Advantages.

- Welding results in a good saving of material and reduced labour content of production.
- Low manufacturing costs.
- Dependability of the medium, that is, the weld men are safer.
- It gives the designer great latitude in planning and designing.
- Welding is also useful as a method for repairing broken, worn or defective

metal parts.

- Without welding techniques, the light weight methods of fabrication, so vital to the automotive and aircraft industries, would be unthinkable.

1.5 ARC-WELDING PROCESSES

Arc-welding includes those welding processes wherein heat required for welding is derived from an arc powered by electrical energy, may be AC of DC as shown in figure1.2. Very high temperatures (up to 30,000'C and more) are obtained in the welding are developed between the tip of electrode and the work piece.

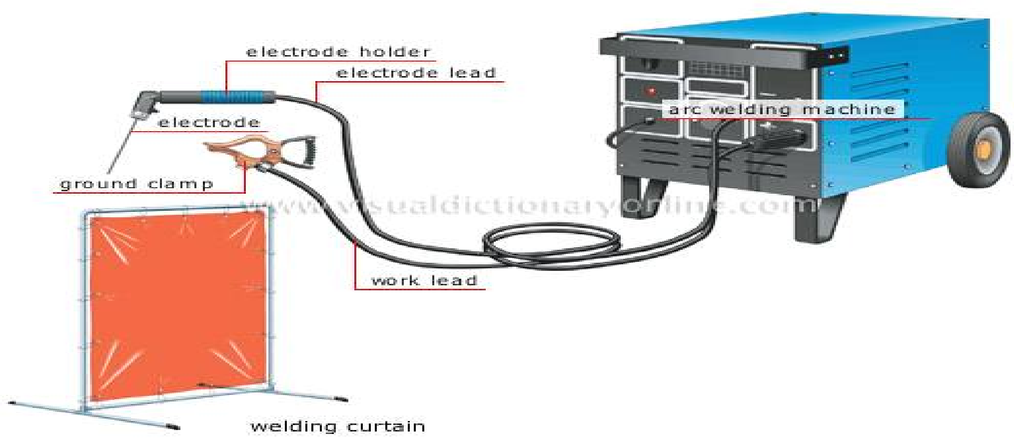


Fig.1.2 Arc Welding set up

In arc-welding, the electrodes used may be consumable type or non-consumable type.

1.6 GAS WELDING

Gas welding is a method of joining two metal pieces (similar or dissimilar) together by melting and fusing their edges at the joint. It involves applying intense concentrated flame on the metal pieces (at the joint) until an area (of both pieces) under the flame becomes molten and forms a liquid puddle such that the molten puddle of one metal piece mixes up and run together with the molten puddle of another metal piece. The welding puddle on cooling and solidification results into a strong joint. The flame for melting the metal pieces is produced by burning various fuel gases.

Fuel gases use in gas welding include: acetylene, hydrogen, city gas, natural gas of liquefied petroleum gas (LPG). The gases (oxygen and fuel gas) are mixed in proper proportion in a welding torch which carries two regulators – one for controlling the quantity of oxygen and the other for controlling the quantity of fuel gas. The mixture of oxygen and acetylene is most popularly use for gas welding and produces temperature within range of 3200’C to 3300’C, which makes it possible to melt and weld all common metals. A filler rod (that also melts during welding) makes the joint stronger on solidification.

1.6.1 Types of Gas Welding Process

Gas welding includes all those welding processes in which gas flame is used as a heat source for melting metals. It is further divided into three main types: (a) Air-acetylene welding, (b) Oxy-acetylene welding and (c) Oxy-hydrogen welding.

1.7 SOLDERING

Soldering is defined as a metal joining process wherein coalescence is produced by heating the surfaces to be joined to a suitable temperature and melting the filler metal, which is a fusible alloy called solder (melting point usually less than 427’c), so that it may be distributed between properly fitted surfaces of the joint through capillary action. Soldering operation is performed by bringing molten solder in contact with the preheated surfaces (being joined) and heating the joint area to a good wetting temperature (about 55 to 80’c above the melting point of soldering alloy). The solder is then left to cool and freeze as quickly as possible to avoid development of internal micro cracks in the joint. The principle underlying soldering is that when the surfaces to be joined are cleaned off well from oxides, they can be joined together using molten solder that may adhere easily to the work piece surfaces due to molecular attraction. The molecules of solder entwine the parent metal molecules and form a strong bond. The various joints of soldering shown in figure 1.3.

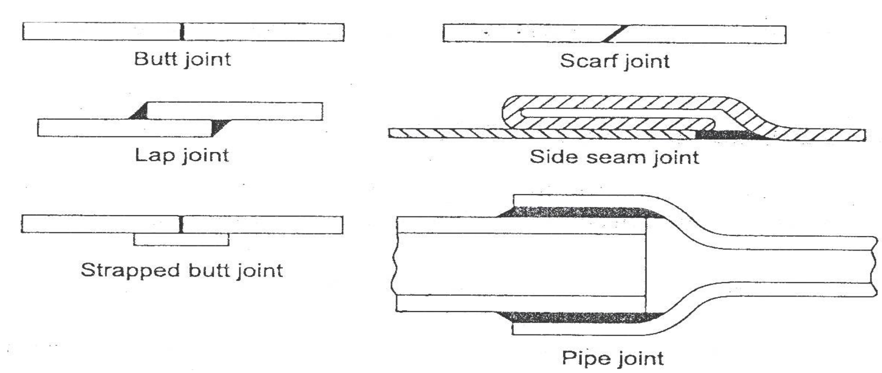


Fig 1.3 Soldering Joints

1.8 BRAZING

Brazing is a technique of joining two similar of dissimilar metal pieces together by heating the surfaces and by using a non-ferrous filler metal having its melting point above 427'C but below the melting points of metals to be brazed. The molten filler metal is distributed between the joint surfaces by the capillary action, which on cooling results in a sound joint. The main advantage of brazing process is the joining of dissimilar metals and thin sections. The process is mostly used for joining pipes and other fittings, carbide tipping on tool shanks, electrical parts, radiator, repair of cast iron parts and heat exchangers.

In brazing, bond is produced either by the formation of solid-state solution (diffusion bonding) of intermetallic compounds of the parent metal (job) and one of the metals in the filler material (brazing alloy). The strength of the brazed joint is provided by metallic bonding.

Various brazing methods torch brazing, furnace brazing, dip brazing, induction brazing, infra-red brazing are in applications.

1.8.1 BRAZING VS WELDING

Following are the differences between brazing and welding.

(i) In brazing, the joint surfaces are not raised to fusion point (or melted) and the joint is produced by the solidification and adhesion of a thin layer of molten filler metal spread between the mating surfaces. In welding, the two surfaces to be joined are always heated to molten state for making a joint.

(ii) The filler metal in brazing spreads between the joint by capillary action. In welding, the molten filler rod solidifies at the same place where it melts.

(iii) In brazing, there is no penetration of the filler metal into base metal whereas in welding it is there.

Brazing as a production process has certain limitations in its application. It calls for a properly machined fitting in making parts to be joined for proper capillary action. Limitation on the size of components to be brazed is there as in the process outer area of the joint is to be heated. Large components, therefore, cannot be heated properly to brazing temperature. Brazed joints develop corrosion is flux is not properly removed. Brazing needs certain degree of skill and experience on the part of the welder for handling special brazing jobs.

Date:

PRACTICAL: 02

AIM: TO STUDY DIFFERENT TYPES OF PATTERNS AND ITS ALLOWANCES.

2.1 INTRODUCTION

A pattern is an element used for making cavities in the mould, into which molten metal is poured to produce a casting. It is not an exact replica of the casting desired. It is not an exact replica of the casting desired. It is slightly larger than the desired casting. as shown figure 2.1

Fig 2.1 Pattern

2.2 PATTERN MATERIALS

The requirements of pattern are:

- Secure the desired shape and size of the casting.
- Cheap and readily available.
- Light in mass and convenient to handle.
- Have high strength.
- Retains its dimensions and rigidity during the entire service of its life.

Based on the above factors, we can choose pattern material as follows:

- Piece and short run production: **Plastic**
- Large scale and mass production: M**etal**

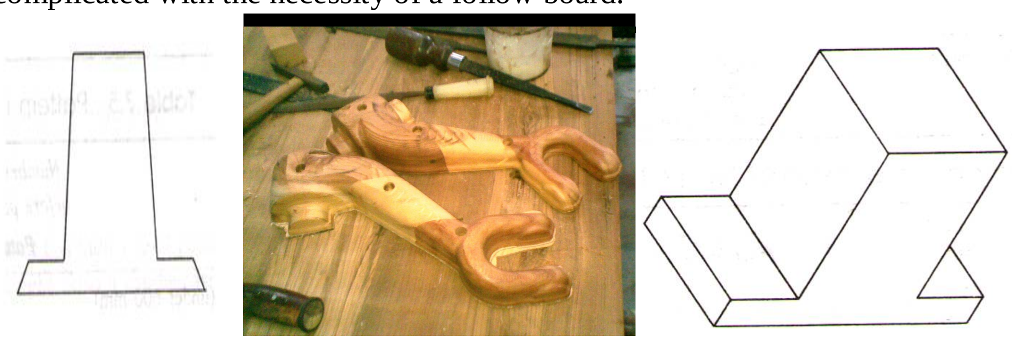
- Batch production: **Plastics**

2.3 TYPES OF PATTERNS

There are various types of patterns depending upon the complexity of the job, the number of castings required and the moulding procedure adopted.

2.3.1 Single piece pattern

These are inexpensive and the simplest type of patterns. As the name indicates, they are made of a single piece as shown in Figure.2.2 this type of pattern is used only in cases where the job is very simple and does not create any withdrawal problems. It is also used for applications in very small scale production or in prototype development. This pattern is expected to be entirely in the drag. One of the surfaces is expected to be flat which is used as the parting plane. If no such flat surface exists, the moulding may become complicated with the necessity of a follow board.



(a) Casting **(b)Casting**

Fig 2.2 Single piece pattern

2.3.2 Split pattern or two piece pattern

This is the most widely used type of pattern for intricate castings. When the contour of the casting make sits withdrawal from the mould difficult, or when the depth of the casting is too high, then the pattern is split into two parts so that one part is in the drag and the other in the cope. The split surface of the pattern is same as the parting plane of the mould. It is shown in the figure (2.3).

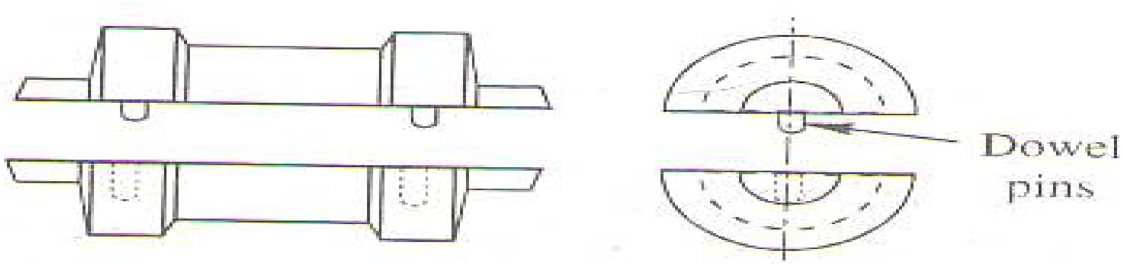


Fig 2.3 Split Pattern

The two halves of the pattern should be aligned properly by making use of the dowel pins which are fitted to the cope half. These dowel pins match with the precisely made holes in the drag half of the pattern and thus align the two halves properly as seen in Figure.

2.3.3 Gated pattern

This is an improvement over the simple pattern where the gating and runner system are integral with the pattern. This would eliminate the hand cutting of the runners and gates and help in improving the productivity of a moulder.

2.3.4 Cope and drag pattern

These are similar to split patterns. In addition to splitting the pattern, the cope and drag halves of the patterns along with the gating and risering systems are attached separately to the metal or wooden plates along with the alignment pins (Figure.2.4). They are called the cope and drag patterns.

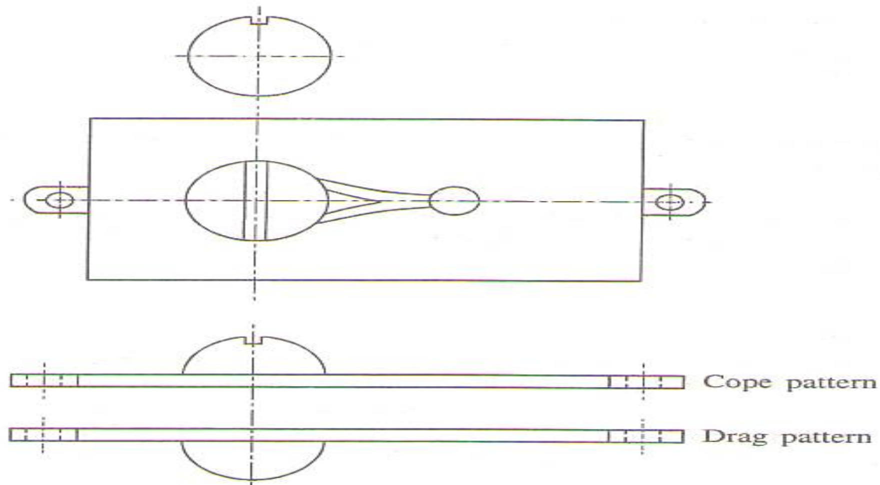


Fig 2.4 Cope and drag pattern

The cope and drag moulds may be produced using these patterns separately by two moulders but they can be assembled to form a complete mould. These types of patterns are used for castings which are heavy and inconvenient for handling as also for continuous production.

2.3.5 Match plate pattern

These are extensions of the previous type. Here the cope and drag patterns along with the gating and the risering are mounted on a single matching metal or wooden plate on either side as shown in Figure.4. On one side of the match plate the cope flask is prepared and on the other, the drag flask. After moulding when the match plate is removed, a complete mould with gating is obtained by joining the cope and the drag together.

The complete pattern with match plate is entirely made of metal, usually aluminum for its light weight and machinability. But when dimensions are critical, the match plate may be made of steel with necessary case hardening of the critical wear points. The pattern and gating are either screwed to the match plate in the case of a flat parting or are made integral in case of an irregular parting plane. This pattern is shown in figure(2.5)

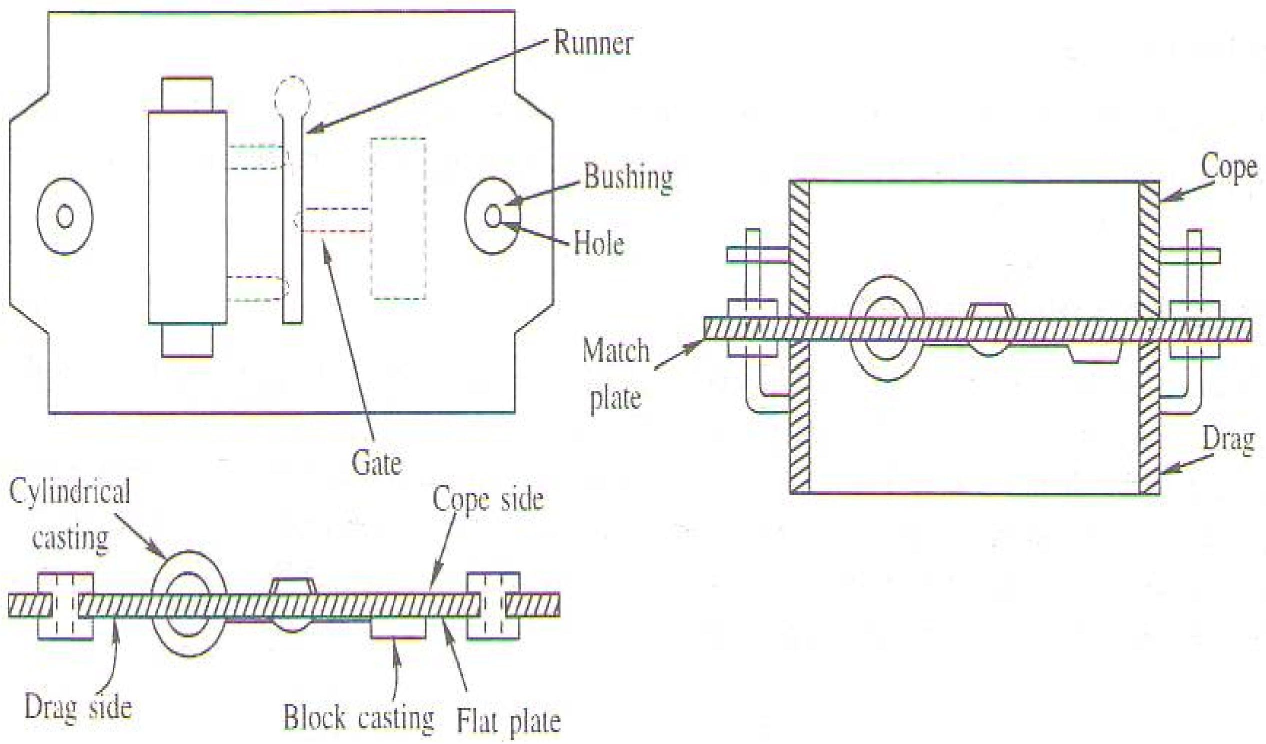


Fig 2.5 Match Plate Pattern

The casting of a match plate pattern is done usually in plaster moulds, but sometimes sand moulds are also used when the cope and the drag patterns are similar, the pattern may be kept on only one side of the plate and is used for making both the drag as well as the cope.

These are generally used for small castings with higher dimensional accuracy. The gating system is already made and attached to the match plate. Several patterns can be fixed to a single match plate, if they are sufficiently small in size. These patterns are used for machine moulding. They are expensive but since they increase productivity, the additional cost is justified.

2.3.6 Loose piece pattern

This type of pattern is also used when the contour of the part is such that withdrawing the pattern from the mould is not possible. Hence during moulding the obstructing part of the contour is held as a loose piece by a wire after moulding is over, first the main pattern is removed and then the loose pieces are recovered through the sap generated by the main pattern (Figure.2.6). Moulding with loose pieces is a highly skilled job and is generally expensive and therefore, should be avoided where possible.

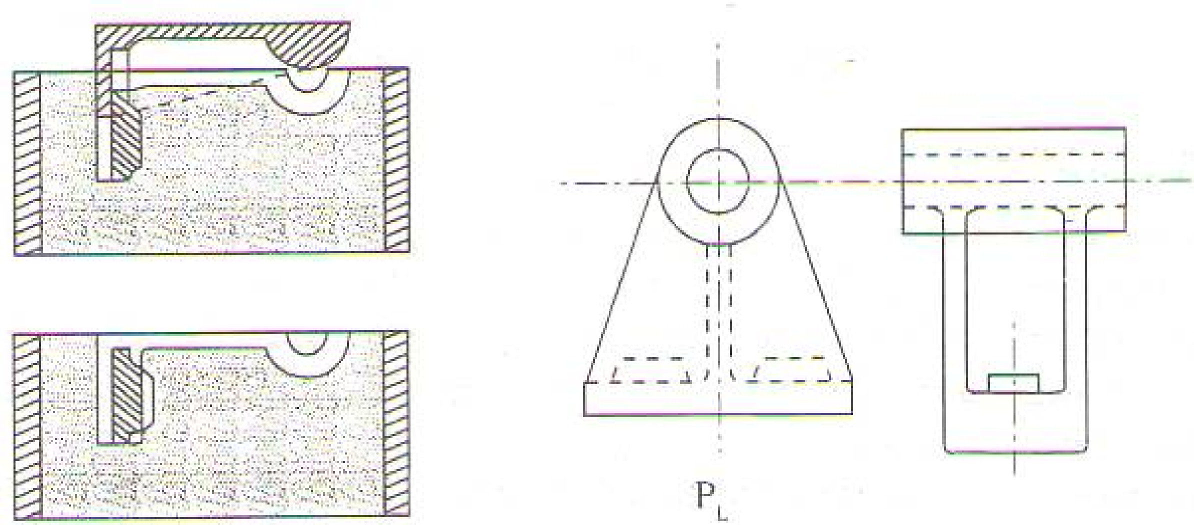


Fig 2.6 Loose Piece Pattern

2.3.7 Follow board pattern

This type of pattern is adopted for those castings where there are some portions which are structurally weak and if not supported properly are likely to break under the force of ramming. Hence the bottom board is modified as a follow board to closely fit the contour of the weak pattern and thus support it during the ramming of the drag. During the preparation of the cope, no follow board is necessary because the sand which is compacted in the drag will support the fragile pattern. An example is shown in Figure.2.7.

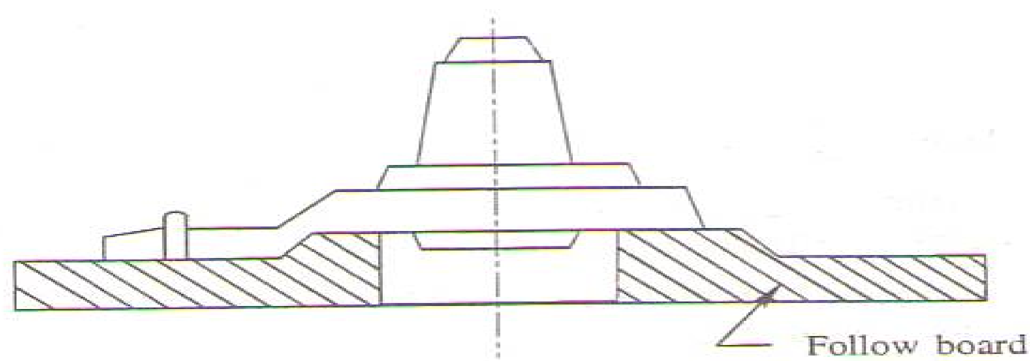


Fig 2.7 Follow Board Pattern

2.3.8 Sweep pattern

It is used to sweep the complete casting by means of a plane sweep. These are used for generating large shapes which are axis-symmetrical or prismatic in nature such as bell shaped or cylindrical as shown in Figure.2.8. This greatly reduces the cost of a three dimensional pattern. This type of pattern is particularly suitable for very large castings such as the bells for ornamental purposes used which are generally cast in pit moulds.

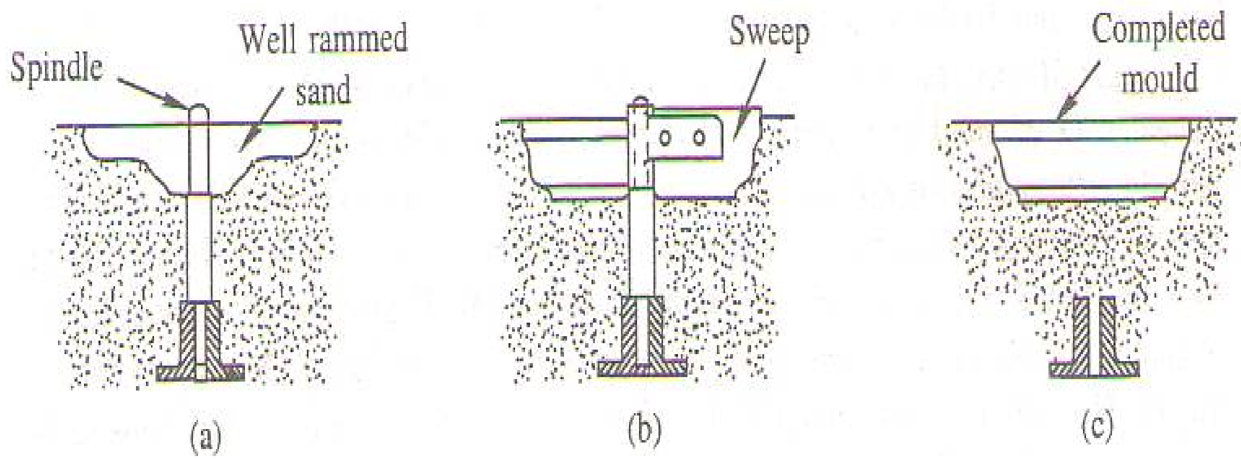


Fig 2.8 Sweep Pattern

2.3.9 Skeleton pattern

A skeleton of the pattern made of strips of wood is used for building the final pattern by packing sand around the skeleton. After packing the sand, the desired form is obtained with the help of a stickle as shown in Figure.8. The type of skeleton to be made is dependent upon the geometry of the work piece. This type of pattern is useful generally for very large castings, required in small quantities where large expense on complete wooden pattern is not justified. It is shown in figure(2.9)

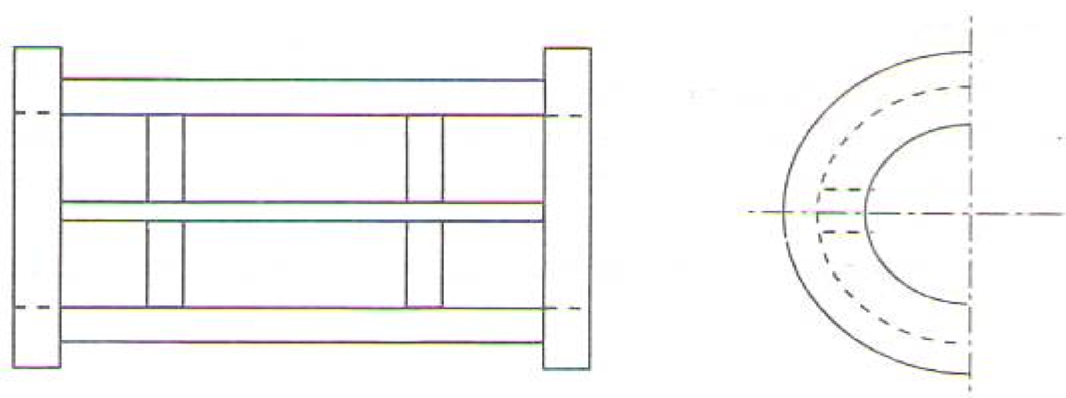


Fig 2.9 Skeleton Pattern

2.4 pattern allowances

The difference in the dimensions of the casting and the patterns is due to the various allowances considered while designing a pattern for casting:

2.4.1 Shrinkage allowance

Since metal shrinks on solidification and contracts further on cooling to room temperature, linear dimensions of the pattern is increased in respect of those of the finishing casting to be obtained. This is called "shrinkage allowance". It is given as mm/m.

Typical values of shrinkage allowance for various metals re given below:

C.I. Malleable iron	= 10mm/m
Brass, Cu, Al	= 15mm/m
Steel	= 20mm/m
Zinc, Lead	= 25mm/m

2.4.2 Machining allowance

Machining allowance or finish allowance indicates how much larger the rough casting should be over the finished casting to allow sufficient material to ensure that machining will "clean up" the surfaces. The amount of finishing allowance depends upon the material of the casting, its size, volume of production, method of moulding, configuration of the casting.

Material Cast	Overall length of external surfaces, cm			
	0 to 30	30 to 60	60 to 105	105 to 150
Al alloys	1.6	3.2	3.0	4.8
Brass, Bronze	1.6	3.2	3.0	4.8
C.I	2.4	3.2	4.8	6.4
C.S	3.2	4.8	6.0	9.6

Table 2.1: Typical Machining Allowance for Sand Casting

2.4.3 Pattern draft or taper

It is also termed as "draw". It is the taper placed on the pattern surface that are parallel to the direction in which the pattern is withdrawn from the mould, to allow the removal of the patter n without damaging mould cavity. The draft depends upon the method of moulding, the sand mixture used, the design and economic restrictions imposed on the casting.

2.4.4 Corners and fillets

The intersection of the surfaces in casting must be smooth and forms no sharp angles. For this, the external and intern corners of patterns are suitably rounded. They are called round corners and fillets respectively.

2.4.5 Rapping or shake allowance

To take pattern out of the mould cavity it is slightly rapped to detach it from the mould cavity. Due to this, the cavity in the mould increases slightly so the pattern is made slightly smaller.

2.4.6 Distortion allowance

This allowance is considered only for casting of irregular shape which are distorted in the process of cooling because of metal shrinkage.

2.5 PATTERN COLOUR CODE

The patterns are normally painted with contrasting colours such that the mould maker would be able to understand the functions clearly. The colour code used is

- Red or orange on surfaces not to be finished and left as cast
- Yellow on surfaces to be machined.
- Black on core prints for unmachined openings.
- Yellow stripes on black on core prints for machined openings.
- 5 Green on seats of and for loose pieces and loose core prints.
- Diagonal black stripes with clear varnish on to strengthen the weak patterns or to shorten a casting.

SPECIAL CASTING PROCESS:

These processes are different from sand casting in that the mould, being repeatedly used. Such moulds are known as dies. They are made of metals. They have helped in increasing production rate, effecting grater economy, improving the quality of casting, minimizing the need for further machining and providing better dimensional control. These methods are known as “Special Casting Process”.

2.6 PERMANENT MOULD CASTING.

This process consists of filling metal mould as in sand casting. Extra pressure is not employed except that obtained from the head of metal in the mould. Since the pouring in permanent mould is simply due to gravity, hence it is known as “Gravity Die Casting”

Advantages of Permanent Mould Casting Process:

1. Close dimensional tolerances can be achieved.
2. A minimum thickness of 2.5 mm can be achieved.
3. It is rapid process and less skilled operator can operate.

Disadvantages of Permanent Mould Casting Process:

1. Cost of mould is higher.
2. Gates, Runner and Riser cannot be shifted as and where required.
3. Complicated and intricate shapes cannot be easily cast by this process.

Application of Permanent Mould casting process.

For automobile pistons, Cooking utensils, Connecting rod, Aircraft fitting, Cylinder block and small gear blank.

2.6. 1 DIE CASTING:

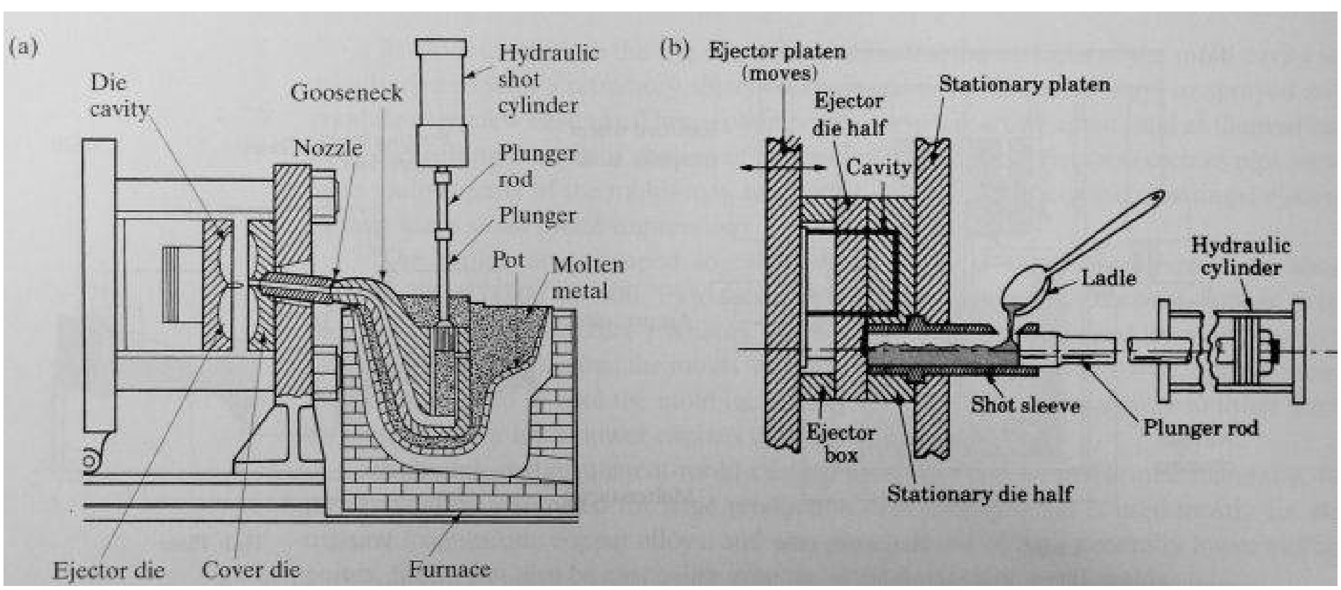
Die Casting is a permanent mould casting technique which involves the preparation of component by injecting molten at high pressure into metallic die. In die casting machine, Die consist of two parts. One part is known as stationary die or cover die which is fixed to the machine. The second part is known as ejector die and is moved out for the extraction of the casting. The lubricant ,(refractory material) is n sprayed on die cavity manually or by the auto lubrication system in order to prevent the die wear and sticking of casting. The Two halves are closed and clamped. Within a fraction of the second, the required amount of molten metal is fed into die under pressure so that it fills entire die including all minute details. Then rapid cooling of metal takes place since die is water cooled. After the casting solidifies, the die is opened and component is forced out automatically by ejector pin.

The two main types of Die casting process.

1. Hot Chamber die casting.
2. Cold Chamber die casting

2.6.1.1 Hot Chamber Die Casting Process:

The metal is kept into a heated holding pot. A pot is provided near the top of cylinder to allow the entry of molten metal. As the plunger ascends, the valve of the cylinder opens and molten metal enters the cylinder. The stroke length of plunger is adjustable to enable a specific amount of molten metal to enter the cylinder or goose neck. As the plunger descends, the valve closes and molten metal is forced through the nozzle into the die. A nozzle at the end of goose neck is kept in close con tact with the die through a sprue.



a). Hot chamber die casting . **b). Cold chamber die casting .**

Casting cycle starts with the closing of the die, when plunger is in highest position in goose neck, thus allowing the molten metal to fill goose neck. When plunger start moving down, the molten metal in the goose neck is forced to be injected into the die cavity. The metal is solidified when held at the same pressure.

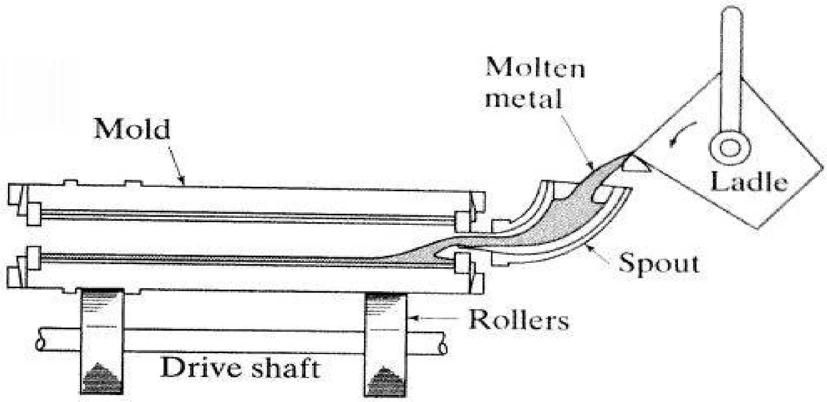
2.6.1.2 Cold Chamber Die Casting Process:
The hot chamber casting process I employed for low meting temperature metals and their alloy such as Zinc, Lead and tin. The cold chamber die casting process is used for casting metal and alloys which require high pressure and high melting temperature such as brass, aluminum and magnesium. The metal melting unit is not integral part of machine in this case and metals are melted in self contained pot in auxiliary furnace.
After closing the die with the core in position, molten metal is ladled into the horizontal chamber through the metal inlet. The plunger is pushed forward hydraulically to force the molten metal in to the die. After the solidification the die is opened and casting is ejected. Material used for die in this casting process is high grade resistant alloy steel.

Advantages and Disadvantages of Die casting:
Advantages:
1. Very high rate of production can be achieved.
2. Close dimensional tolerances of the order of ± 0.025 mm can be achieved.
3. Good surface finish can be achieved.

Disadvantages:
1. The machinery and other equipment used are very costly.
2. Die casting generally contains some porosity because of the entrapped air.

Application of Die Casting.
Used for automobiles, carburetor, crank case and similar components of scooter, motor cycles.
2.7 CENTRIFUGAL CASTING PROCESS:
Centrifugal casting is the process of rotating mould at high speeds as the molten metal is poured into it due to centrifugal force of rotation towards the periphery or inside surface of the mould with considerable pressure. Due to the centrifugal force, continuous pressure will be acting on the metal as it solidifies. The impurities i.e. slag; oxide and other inclusion being lighter get separated from the metal and segregates towards the center. The process produces casting with greater accuracy and better physical properties due to directional solidification compared to sand castings. It is mainly used for symmetrical shape.
Methods of Centrifugal casting.
1. True Centrifugal Casting.
2. Semi – Centrifugal Casting.
3. Centrifuging casting.

2.7.1 True Centrifugal Casting Process:
In this process mould rotates about its axis, which may be horizontal, Vertical for inclined at any suitable angle between 70 to 90 degrees, the metal is poured in so that the internal shapes are formed by centrifugal action. No core is needed for producing concentric hole. Massive thick metal moulds with a thin refractory coat allows the solidification of molten metal faster i.e to procees from the wall of the mould towards insides of the cast pipe.



The mould flask is mounted in between the rollers and rotated slowly. Now the molten metal, in requisite quantity, is poured into the mould through the movable pouring basin. The wall thickness of pipe produced is controlled by the amount of metal poured in to the mould. After pouring is complete, the mould is rotated at its operational speed till it solidifies to generate the requisite tubing.

Advantages of True Centrifugal Casting Process:

1. Casting produced by this process is sound is sound with dense structure.
2. Need of separate runners and risers are eliminated.
3. Production rate is sufficiently high.
4. No cores are required for making concentric holes.

Limitation of True Centrifugal Casting Process:

1. Equipment is expensive and requires skill labour for its maintenance.
2. Too high speed of mould may result in surface crack due to high stresses set up in the mould.

2.7.2 Semi Centrifugal Casting Process:

Semi centrifugal casting is used for jobs which are large sized and more complicated than those possible in true centrifugal casting but are symmetrical shaped. This process is also known as profiled centrifugal casting . It is not essential that these should have a central hole, which is to be obtained with the help of a core. The moulds made of sand or metal are rotated about a vertical axis and molten metal enters the mould through the central pouring basin and gate. The rotation speeds for this type of centrifugal casting are not high as in the case of true centrifugal casting. This process produces dense structure at the outer periphery while the center metal is generally removed.

2.7.3 Centrifuging casting:

In this centrifugal method, several casting cavities are located around the outer portion of mould and metal is fed to this cavities through radial gates or runners from center gate . In this process, the mould is designed with part cavities located away from the axis of rotation so the molten metal poured into mould is distributed to these cavities by centrifugal force. It is used for non-symmetrical casting having intricate detail and for precision casting. A number of similar components can be cast simultaneously. It is possible only in a vertical direction. Bearing caps or small brackets are cast by this process.

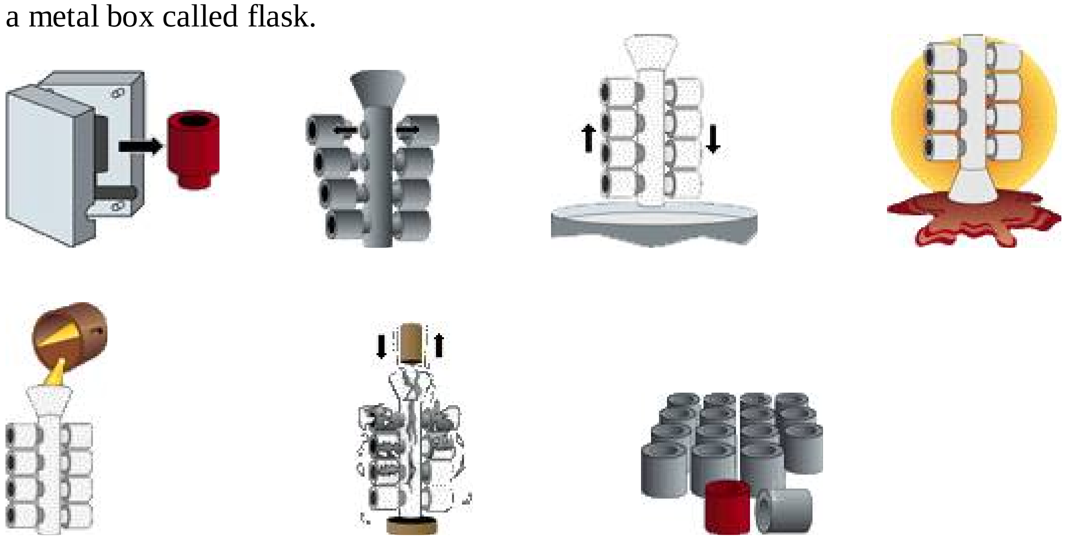
2.8 INVESTMENT CASTING PROCESS.

It is also known as "Lost Wax Process" or "Precision casting process"

Wax pattern used in this process and which is subsequently melted from mould, leaving all the details of original pattern. It is used for making high accuracy and intricate shape casting.

Procedure for Investment Casting Process.

1. **Die Making:** To make a die of suitable material with proper surface finish in which molten wax is poured or injected under pressure to produce pattern. Die can be produced by directly machining of steel block. Dowel pins and corresponding holes are provided on mating surface of two halves of dies to secure them in proper alignment with each other.
2. **Making wax patterns:** Dies halves are closed properly by clamping and molten wax is injected under pressure into the die with the help of wax injection machine. Wax should have suitable grade, good strength, low shrinkage and ability to retain good dimensional accuracy.
3. **Assembling the Wax Pattern:** If each pattern is small in size, several such pattern can be joines together about a common wax sprue or wax gating so that can be placed together in mould . This process of welding is done by hot wire welder. The complete pattern assembly along with gates and riser is then placed in a metal box called flask.



4. **Investment preparation:** The investment material can be applied around the wax pattern to produce the mould with the help of following three methods.
   i. *<u>Mix or Pour method</u>:* It involves the preparation of slurry of finely ground refractory grains by mixing them with a suitable binder and pouring that slurry into the flask carrying pattern tree.

ii. *Dip coated method:* This method involves providing a thin coat on the pattern surfaces of refractory slurry of the same type as discussed in first method above . Another coating of cheaper and coarser investment is applied after the first thin coating gets dried.

iii. *Multiple dip coat method:* This method is also called ceramic shell method. In this process, repeated thin alternate coats of fine slurry, followed by coarser investment material are provided on pattern tree or assembly.

5. **Removal of wax pattern:** the moulds so created are dried in air for 2 to 3 hours and then baked in oven in inverted position so that wax melts out. When temperature reaches 100 to 120 degree centigrade, the wax melts out and is collected through a hole in the borrom plate. After this mould is exposed to a sintering process.
6. **Pouring and Casting:** After the removal of wax, the moulds are heated from 600 to 1000^{o} C depending upon the nature of metal to be cast. The moulds are poured just after their removal from the furnace and both the mould and metal are allowed to cool down, keeping them out of contact with open air.

Advantages and Limitation of investment Casting.

Advantages:
1. Very close tolerances and better surface finish can be produced.
2. Close control of mechanical characteristics such a grains size, grain orientation and directional solidification is possible.
3. This process adapted for all metal and alloys.

Limitation:
1. It is best applicable to casting weighing from a few grams to 5 Kg; so the process has limitation of size and weight of the casting.
2. It is very expensive process due to large manual labour.

2.9 CONTINUOUS CASTING PROCESS:

This process consists of continuously pouring the molten metal into mould which has the facilities for rapid cooling the metal to the point of solidification and withdrawing it from the mould. It is largely applicable to brass , bronze, copper and aluminum but its noteworthy application is in steel making. It is used for production of round ingots, slabs, square billets and sheet metal.

Continuous casting is normally accomplished by pouring molten metal in the mould, which is open at both ends. The metal is rapidly chilled by circulating water in the cooling jacket and solid product is removed from the lower end of the mould.

William's Continuous casting use for casting of carbon and alloy steel. It employs brass or copper moulds of thickness which allow s heat flow rate that is sufficient to protect the mould being damaged by the metal being cast. The molten metal is poured from crucible or ladle first into heated basin known as "Tun dish " and then into a vertical copper mould, which is water cooled and open at both upper and lower ends.

The internal shape of the mould corresponds to that of the cross-section of the casting required. The steel begins to solidify at the outer regions as it travels down through the water cooled mould. By the time the metal leaves the lower end of the mould, solid crust is formed, while interior remains liquid. Water spray accelerates the cooling process in the cooling chamber. The metal is bent from vertical to horizontal orientation while still hot and plastic. The castings are cut to length by oxyacetylene torch. These are then rolled into the plate's sheet stock or other cross sections as required.

Advantages of continuous casting.

1. Casting surface produce better ingots than other processes.
2. This process is cheaper than other rolling process.
3. Labour cost is less.

Application of continuous casting.

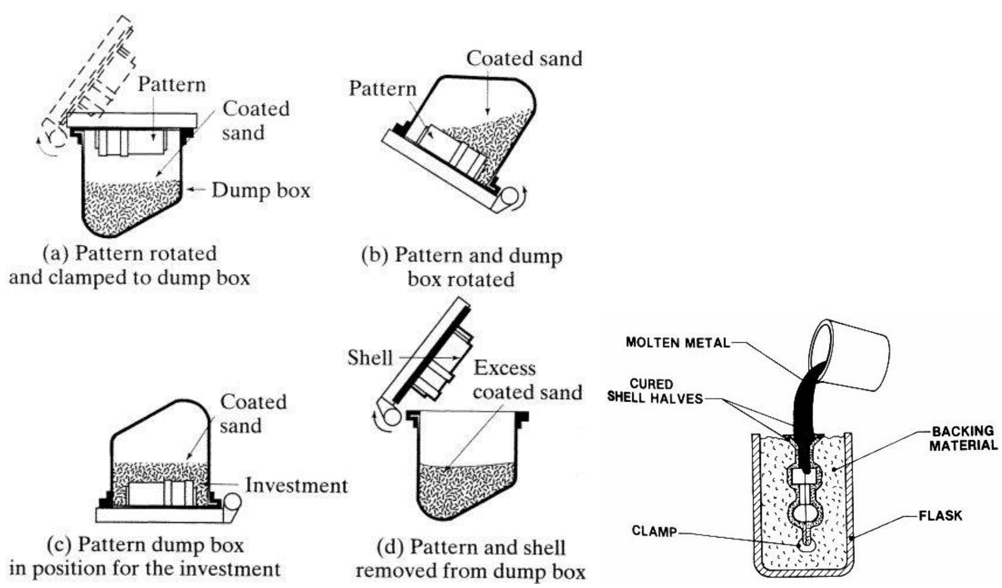
1. For production of bloom, billet and different cross section and sheets.
2. For casting of copper, brass, Zinc aluminum and its alloy.

2.10 SHELL MOULDIND PROCESS:

This process consists of preparing a mould which has two or thin shell like parts consisting of thermosetting resin bonded sand. It is made up of a mixture of dried silica sand snd phenol resin, formed into thin, half mould shells which are clamped together for pouring. The sand free from clay, is first mixed with urea or phenol formaldehyde resin.

This process consists of five steps.

1. A metal pattern heated to about 240 ºC is clamped over a box containing sand mixure discussed above (a)
2. The box and pattern ate inverted for a short time. When the mixture comes in contact with hot pattern, t causes build up of a coherent sand shell next to the pattern due to an initial set.(b)



3. The box and pattern are brought to its original position. The unaffected sand falls into box whereas the shell of resin bond end sand is retained on the pattern

surface. The shell, still on the pattern is placed in the oven and cured for 1 to 3 minutes. (c)

4. The assembly is removed from the oven and the shell is stripped from the pattern by the ejector pin. Usually, a silicon parting agent may be sprayed on the pattern to obtain clean stripping. (d)
5. The shell halves are assembled with clamps and supported in a flask with backing sand . The shell mould is now ready for pouring process.

Advantages of Shell Moulding Process:

1. High dimensional accuracy and good surface finish is obtained.
2. Cleaning and machining costs are reduced due to good dimensional accuracy.
3. Dimensional tolerance of ±0.2 mm can be obtained.

Limitation of Shell Moulding Process:

1. The cost of the equipment including metal pattern is high.
2. Binders used in this process are more expensive than other binders.

2.11 CASTING DEFECTS AND THEIR REMEDIES:

1. Mismatch or mould shift:

It is a shift or misalignment between two mating surfaces or the top and bottom parts of the casting at the mould joint. Shift may occur at the parting surface between two parts of the mould which is called mould shift or at the core prints, thus providing a gap between the core and core seat known as core shift.

Due to filling up of gap or clearance left between the mating surfaces by molten metal, thin projections of metal to main casting are produced which are known as fins. This defect is the result of worn or loose dowel in pattern made in halves, improper alignment of mould boxes due to worn – out.

Remedies: This defect can be prevented by ensuring proper alignment of pattern and moulding box.

2. Blow holes:

Blow holes are smooth, round holes appearing in the form of cluster of large number of small holes occurring below the surface of the casting and not visible from outside. When they are visible on upper surface of the casting, they are known as open blows.

Blow holes are produced in the casting due to production of too much steam and low permeability of moulding sand and gases are generated when there is too much moisture in moulding sand, cores not sufficiently baked. This would happen when sand is rammed too hard, permeability is insufficient and venting is insufficient.

Remedies: To prevent blow holes, the moisture content in the moulding sand should be properly controlled, sand of appropriate grain size should be used, and ramming should not to be hard.

3. Warpage:

Warpage is an undesirable deformation or misalignment in the casting which may during or after solidification. Large and thin sections are particularly prone to warpage. The deformation takes place due to internal stress developed and different rates of

solidification in different section. Warpage in the casting occur due to (a) Faulty casting Design, (b) Absennce of directional solidification.
Remedies: to produce large areas with corrugated wavy construction or sufficient rib to improve cooling rates and make them equal in all area.

4. **Pin holes:**

These are some very small holes revealed on surface of casing. Pin holes are caused due to:

- **a)** Sand with high moisture content.
- **b)** Absorption of hydrogen or carbon monoxide gas in the metal or alloy and alloy not being properly degassed.

Remedies: This defect can be reduced or eliminated by reducing the moisture content of moulding sand and increasing its permeability by employing good melting and fluxing practices.

5. **Fin:**

A thin unintended projection as a part of casting is known as fin .Fins are usually occur at the parting line or core sections. Fins are caused due to:

- **a)** Loose plates and improper clamping of a flasks.
- **b)** Over flexible bottom boards.

Remedies: Correct assembly of the moulds and cores used for casting.

6. **Drop :**

Drop is caused by dropping of the upper surface of mould cavity in the molten metal. This caused by:

- **a)** Low green strength of the moulding sand.
- **b)** Low mould hardness.
- **c)** Insufficient reinforcement of sand projections in the cope.

Remedies: By elimination of above factors.

7. **Swell:**

A swell is an enlargement of the mould cavity (and hence that of casting) due to molten metal pressure, resulting in localized enlargement of casting. It is caused due to:

- **a)** Insufficient or soft ramming.
- **b)** Low mould strength and mould not being adequately supported.

Remedies: Sand should be rammed evenly and properly.

8. Metal penetration:

This defect occurs as a rough and uneven external surface of the casting. It is caused when the molten metal enters into the spaces between the sand grains. This metal penetration takes place due to low strength, large size of moulding sand , its high permeability and soft ramming

Remedies: Use of fine grain and with low permeability and appropriate ramming.

9. Shot metal:

This defect appears in the form of small metal shots embedded in the casting and revealed on the fractured surface of the casting. It so happens, if the molten metal is at a relatively lower temperature and during pouring into the mould, it splashes. The small particles separated from the main stream during the pouring thrown ahead and solidify quickly to form shots. If these shots do not fuse with the rest of the molten metal in the mould, it gives rise to this defect.

Remedies: By proper control over pouring temperature, sulphur content of metal, gating system and moisture content of moulding sand.

10. Fusion:

Sand may fuse and stick to the casting surface with the result this defect appears as a rough surface over the casting. It occurs when molten metal enters the mould cavity and comes in contact with sand, the sand melts and gets fused to the casting surface due to excessive heat of molten metal.

Causes: lack of refractoriness of sand, too high temperature of molten metal, faulting gating and poor facing sand.

Remedies: Use of sand with high refractoriness, improvement in gating system and adequate control over pouring temperature of molten metal.

11. Hot tears:

Internal and external cracks having ragged edges on the surface of casting are known as hot tears. If metals having low strength immediately after solidification develop high stresses during solidification, the metal fails with resulting hot tears.

Causes:

- Excessive mould hardness
- too much shrinkage of molten metal
- low ability of molten metal.

12. Porosity:

A large number of holes in a casting are termed as porosity. This is caused by the gases absorbed or dissolved in the metal during melting and pouring. The gases commonly absorbed are nitrogen, hydrogen and oxygen.

Causes:

- Excessive pouring temperature.
- Slow rate of solidification.
- high moisture content of mould.

Remedies:

- Maintenance of proper melting temperature.
- Permeability of the mould should be improved.

13. Misrun and Cold shuts.

When the molten metal fails to fill the entire mould cavity before the metal starts solidifying, resulting in an incomplete casting, the defect is known as **misrun.**
Two streams of molten metal approach each other in the mould cavity from opposite directions but fail to fuse together properly, with the result of discontinuity between them, it is called **a cold shut.**

Causes:

- Improper gating system.
- Too thin casting sections.

Remedies:

- Providing appropriate pouring temperature to ensure proper fluidity.

Date:

PRACTICAL: 03

AIM: TO STUDY ABOUT VARIOUS TYPES OF MOULDING SAND AND MOULDING OPERATIONS.

3.1. DEFINITION

The process creating the cavity or making of mould is known as moulding.

3.2. MOULDING MATERIALS

Various types of materials are used in the foundries for the manufacture of casting moulds and cores. These materials are divided in to two groups: basic and auxiliary. Basic moldings materials include : Silica sands, which forms the various base and the various binders. The at is auxiliary group includes various additives which impart desired properties to the moulding and core sands.

The essential constituents of moulding sand are:

- It is cheap, plentiful and easily available.
- It is characterized by a high softening temperature and thermal stability, which is highly refractory.
- Easily moulded, reusable and capable of giving good details.Silica sand forms the bulk of moulding sand.

Binder may be present in natural sand or added to silica sand separately. In combination with water, it is the bonding agent in green sand. Although moist particles do adhere to one another slightly, but coating with moist clay, the strength of the mixed sand is increased three folds. Clay imparts cohesiveness and plasticity to the moulding sand in the moist state and increases its strength with sufficient plasticity, the sand is said to be “tempered”.

Additives impart to the moulding sand special properties (strength, thermal stability, permeability, refractoriness, thermal expansion etc.)

3.2.1. Sand according to the amount of clayey matter they contain, the moulding sands are classified as:

- Silica sand: Up to 20% clay.
- Lean or weak sand: 2 to 10% clay
- Moderately strong sand: 10 to 20% clay
- Strong sand: Up to 30% clay

- Extra strong sand: Up to 50% clay.

There are three types of sand used for making moulds: natural, synthetic and chemically coated.

3.2.1.1. Natural sand: A natural sand is the on which is available from natural deposits. Only assistive and water need to be added to it to make it satisfactory for moulding. The clay content of most natural sands is slightly higher than the desired so that new sand can be continuously added to the used sand to replenish that which is lost.

3.2.1.2. Synthetic sand: A synthetic sand is prepared by mixing a relatively clay free and having a specified type of clay binder as well as water and other additives. All are mixed in the foundry. This sand has the advantage that sand grains of specified composition and properties can be prepared on the basis of the metal being cast.

3.2.1.3. Chemically coated sand: clean silica grains are sometimes coated with a non thermosetting hydrocarbon resin, which acts as a binder. An additional binder in the form of clay can also be used. The advantage of this sand is that the carbon in the resin which is an excellent refractory surrounds the sand grains and does not allow the molten metal to reach the sand grains. This produces casting with the clean surface as the sand does not get fused in them. The moisture content in the sand is kept to above 3%.

Moulding sand exhibits maximum strength at a moisture content of 4% for lean sands and of 6 to 7% for loam sands.

Typical green moulding sand for gray iron moulding are given below:

Silica sand = 68 to 86%
Clay = 10 to 20%
Water = 3 to 6%
Additives = 1 to 6%

3.2.2. Binders: Binders used in a foundry are : Inorganic and organic binders. Organic binders used for core making and will be discussed later.

Clay binders are the main inorganic binders. Clays are formed by weathering and decomposition of rocks. the common type of clay used in the moulding sand are fireclay, kaolinite, illite, and bentonite clays are most popular, because they have high thermo chemical stability.

3.2.2.1. Fire clay. Fire clay is refractory clay usually found in the coal measures.

3.2.2.2. Kaolinite. Its general composition is al_2o_3 . $2sio_2$. $2H_2o$. It is one of the decomposition products of slow weathering of graphite and basalt. It is main constituent of china fire clay. Its melting point is 1750 to 1787^0c

3.2.2.3. Illite. This clay has approximate composition. $K_2O.Al_2o_3.Sio_2.H_2O$. it is formed from the weathering of mica rocks. Its particle size is about the same as the kaolinite clay and has similar moulding properties.

3.2.2.4. Bentonite. Its general composition is MgO.Al2O3.Sio2.H2O. it is formed by weathering of volcanic or igneous rocks. It is a creamy white powder. Its melting point is 1250- 1300^o c

The basic constituent which gives refractoriness to a clay is alumina. Of all clays bentonite is the most commonly used clay. It needs smaller amount of water to obtain a given degree of plasticity. This will result in less stream generation when the molten metal is poured into the mould, permitting a lower permeability in the moulding sand.

3.2.3. Other binders can be: Portland cement and sodium silicate. The percentage of binder in the moulding sand is of great importance. The bond must be strong enough to with stand the pressure of and erosion by the melt, yet it must be sufficiently weakened by the heat of metal to allow shrinkage of the casting and finally removal of the sand without damage to the solid casting. However, bond must not destroy the permeability of the sand so that gases present in the melt or produced by the heat of the melt in the binder itself can escape.

3.2.3 Organic binders: The binders are most frequently used in core making. Cereal binders are obtained from wheat, corn or rye; resins; drying oils, for example, linseed oil, fish oil, soybeans oil, and some mineral oils, pitch and molasses.

3.2.3 Additives. Additives are the materials added in small quantities to the moulding sand in order to enhance its exiting properties and to impart to it special properties. These additives may be necessary to give a good surface finish to the casting or to eliminate casting defects that's arise from either the expansion of the moulding sand as it is heated or the contraction of the casting as it cools in the mould. There may be some overlapping between an additive and a binder because many people include organic binders also in the category of additives.

Metal penetration or burning on is penetration of metal between sand grains and also strong adhesion of the fused or sintered sand to the metal of the casting surface. The burnt on sand involves difficulty in cleaning operations and is responsible for rapid wear of cutting tools used to machine the castings. Some common additives used to prevent the above mentioned defects and to improve the quality of the casting are discussed below:

3.2.3.1. Sea Coal. Sea coal or coal dust is finely ground soft coal (pulverized coal). It is added to moulding sand used to make ferrous castings. It tends to obtain smoother and cleaner surfaces of castings and also reduces the adherence of sand particles to the casting. It also increases the strength of the moulding sand. It is added up to 8%. Also, when molten metal fills the mould, coal dust burns and gives off volatile substances containing the gases CO and CO2 which from a gas spacing between the mould walls and metal. This "gas jacket" not only prevents interaction between the metal of the casting and the sand and thus prevents the metal penetration into the sand, but also makes the mould more collapsible when the metal shrinks. Other carbon rich materials which are sometimes substituted for sea coal are: finely group coke, pitch and Asphalt (2%), graphite (0.2to2%).

3.2.3.2. Cereals. Foundry cereal is finely ground corn flour or corn starch. It (0.25-2%) increases the green and dry strengths of the moulding sand. Since the cereal is organic, it is "burned out" when hot metal comes in contact with it. This gives rise to space for accommodating the expansion of silica sand at the surfaces of mould cavity, without buckling these. Because of their low density, about 1%is generally sufficient.
Saw Dust. It increases the gas permeability and deformability of moulds and cores, it must be dry. Instead of saw dust, one can use peat that contains about 70-73% volatile substance, not over 5 or 6% ash and up to 25-30% moisture.

3.2.3.3. Wood Flour. It is ground wood particles or other cellulose materials such as grain hulls. They serve the same purpose as cereals except that they do not increase green strength as much. When required, about 1% is added.

3.2.3.4. Silica Flour. It is very fine ground silica. It is generally mixed with about twice as much conventional moulding sand to make" facing sand" and is used to surround the pattern. It thus improves the surface finish of the casting, and because of its purity, it increases the hot strength of the mould face. It also resists metal penetration and minimizes sand expansion defects.
Some other common additives are:

3.2.3.4.1. Fuel Oil. It improves the mould ability of sand.

3.2.3.4.2. Iron Oxide. It develops hot strength.

3.2.3.4.3. Dextrin. It increases air setting strength, toughness and collapsibility and prevents sand from drying rapidly. During pouring of molten metal, it gasifies, thus producing extra space between the grains without any grain distortion.

3.2.3.4.4. Molasses. It is the by product of sugar industry. It enhances the bench life of sand and imparts high dry strength and collapsibility to moulds and cores. Due to high temperature in the mould; it develops CO2 which sets up a hardening action of the mould.

3.2.4. Facing Materials. These materials when added to the moulding sand tend to obtain smoother and cleaner surfaces of castings, help easy peeling of sand from the casting surface during shake out and prevent metal penetration. Sea coal, pitch (distilled from soft coals), asphalt, graphite and silica flour discussed above, act as facing materials.

3.2.5. Cushion Materials. These materials when added to the moulding sand burn and from gases when the molten metal is poured into the mould cavity. This gives rise to space for accommodating the expansion of the sand at the mould cavity surface. Wood flour, cereals, cereal hulls and cellulose etc. discussed above are called as ‘Cushion materials’.

3.3. OTHER TYPES OF MOULDING SANDS

3.3.1. Facing sand. This sand is used directly next to the surface of the pattern and comes into contact with the molten metal when the mould is poured. As a result, it is subjected to the severest conditions and must possess, therefore, high strength and refractoriness. This sand also provides a smoother casting surface and should be of fine texture. It is made of silica sand and clay, and some additives without the addition of used sand. The layer of facing sand in a mould usually ranges from 25-50mm.

3.3.2. Backing Sand. This is the sand which is used to back up the facing sand and to fill the whole volume of the flask. Old, repeatedly used moulding sand is mainly employed for this purpose.

3.3.3. System Sand. In mechanized foundries, where machine moulding is employed a so called “system sand” is used to fill the whole flask. Since the whole mould is made up of this system sand, the strength, the permeability and refractoriness of the sand must be higher than that of backing sand.

3.3.4. Parting sand. This sand is used to prevent adhering of two halves of mould surfaces in each moulding box when they are separated. Thus, to ensure good parting, the mould surface(at contact of cope and Drag)should be treated with parting sand or some other parting material. It is also sprinkled or applied on the pattern surface (before the moulding sand is put over it)to avoid its sticking and permit its easy Withdrawal from the mould. The parting sand is fine dry sand. There is other parting material also used in foundry.

3.3.5. Dry parting materials. These are applied by dusting. These include : charcoal, ground bone and limestone, lycopodium(a yellow vegetable matter), tripolite(a silicate rock), ground nut shells, Talc(Magnesium silicate,3MgO,4SiO2.H2O)and Calcium phosphate.

3.3.6. Wet parting materials. These are not used with wooden patterns, but are used mostly in machine moulding when metal patterns are used. They are wax based preparation, petroleum jelly mixed with oil, paraffin and stearic acid.

3.3.7. Mould Surface Coating. Mould surfaces are coated (after the pattern is drawn out) with certain materials possessing high refractoriness. It eliminates the possibility of burn-on and enables casting with smooth surface to be obtained. However, the permeability of the mould gets reduced. Therefore, the Coating should not contain gas forming materials. Mould surface coating which are also known as facings, dressings, washes, blackings or whitening, may be applied dry(by dusting) or wet in the form of thin cream. The various mould surface coating materials include: Coal dust, pitch, graphite, china clay, Zircon flour or French chalk (Calcium oxide).

3.3.8. Moulding Sand for Non-ferrous Casting. The melting point of non-ferrous metal is much lower than that of ferrous metals. Therefore, the moulding sands for non-ferrous casting may be less refractory and permeable. Also, a smooth surface is desirable on non-ferrous casting. Due to all this, the moulding sands for non-ferrous casting contain a considerable amount of clay and fine grained.

3.4. PROPERTIES OF THE MOULDING SAND

3.4.1. Permeability. Permeability or porosity of the moulding sand is the measure of its ability to permit air to flow throws it.

3.4.1.1. Strength or Cohesiveness. It is defined as the property of holding together of sand grains.

3.4.1.2. Refractoriness. It is the ability of the moulding sand mixture to withstand the heat of melt without showing any signs of softening or fusion.

3.4.1.3. Plasticity or Flow ability. It is the measure of the moulding sand to flow around and over a pattern during ramming and to uniformly fill the flask.

3.4.1.4. Collapsibility. This is the ability of the moulding sand to decrease in volume to some extent under the compressive forces developed by the shrinkage of metal during freezing and subsequent cooling.

3.4.1.5. Adhesiveness. This is the property of sand mixture to adhere to another body.

3.4.1.6. Co-efficient of Expansion. The sand should have low co-efficient of expansion.

3.5 OTHER REFRACTORY MATERIALS

In addition to silica sand, some other refractory materials which are used for special purposes are :

- Zircon : $Zr\ Si\ O_4$
- Chromites : $Fe\ Cr_2\ O_4$
- Olivine : $((Mg\ Fe)_2\ Si\ O_4)$

3.6. CARBON- DI- OXIDE MOULD

The process of co_2 molding is basically a hardening process for molds and cores. The molds are prepared from clean and dry silica sand with 3 to 5% by weight of sodium silicate liquid base binder and moisture up to 3%. Wood flour, coal dust, pitch or graphite is added to mold sand mixture to increase collapsibility. The sand mixture is later packed around the pattern and gassing of co_2 is done for 15 to 30 seconds before removing the pattern from the sand. The co_2 reacts with sodium silicate, precipitating SiO_2, witch with water forms a silica jel, which is cement like material and binds the sand grains together giving strength and hardness to the mold.

$$Na_2SiO_3 + CO2 + H2O \rightarrow Na_2CO_3 + SiO_2 + H_2O$$

The co_2 hardened cores are also made in a similar way. The co_2 hardened molds are used for casting both ferrous and nonferrous metals and preferred for casting thin sections such as sharp corners and cooling fins on a heat exchanger. Co2 hardened molds and cores can be stored for a longer period.

3.7. SHELL MOLDS

These molds are prepared by pouring a mixture of sand and thermosetting resin over the heated surface of a metallic pattern, which results into the formation of a thin and rigid layer or shell of uniform thickness around the pattern, which, when separated from the pattern surface, forms one part of the shell mold and two such parts are joined together to form the complete shell mold.

The process of making shell mold, a brass or aluminum pattern is clamped on a steel plate which also carries projections to produce runners, risers, etc. in the mold cast on this plate. The assembly of pattern is heated to 175^{0}C to 370^{0}C and later sprayed with a silicon release agent to help easy removal of mold shell from the pattern. A molding mixture comprising fine silica sand and 3 to 10 % synthetic resin is prepared and dumped over the hot pattern and plate assembly held in a box and is allowed to remain in contact with hot pattern assembly for about 30 seconds. This results in the softening of resin and formation of a shell or coating of uniform thickness around the pattern assembly. Latter the assembly of pattern with the formed shell is cured by heating to a temperature. Example of shell mold cast products include: cylinder heads, connecting rods, gear housings and other mechanical parts.

3.8. MOULDING PROCESS

Date:

PRACTICAL:04

AIM: DESIGN OF CASTING WITH GATTING SYSTEM, RISER, RUNNER.

4.1 CASTING

The casting is the solidified piece of metal, which is taken out of the mould is called "casting"

OR

An object at or near finished shape obtain by solidification of a substance in a mould is called "casting"

4.2 FUNDAMENTAL OF METAL CASTING

(1)Melting the material
(2)Allowing the molten metal to cool and solidify in the mould

"A plane where the castings are made is called "foundry". The casting process is also called as "founding". The world founding is derived from Latin word Funder means "Melting and pouring"

Advantages

- Part of intricate shapes can be produced.
- Good mechanical and service properties.
- Mechanical and automobile casting process help decrease the cast of casting

Applications

- There is hardly any machine or equipment which does not have one or
- more cast component
- Automobile engine blocks.
- Cylinder block of automobile,
- Airplane engine.
- Piston or piston ring

The mass of casting may be as great as 70% to 80% of the products mass

4.3 TYPES OF CASTING PROCESS

4.3.1 Die Casting

In the die casting process the, mould used for a casting is permanent called a die casting. it is shown in figure 4.1. It is thus quite different from sand casting where the mould is expandable and must be broken in order to obtain the casting. If the molten metal is forced into a metallic die under external pressure, the process is known as "pressure die casting" or "simply die casting"

Product application of Die-casting

(1). house sold equipment
(2). business equipment
(3). hardware
(4). industrial equipment
(5). music & communication

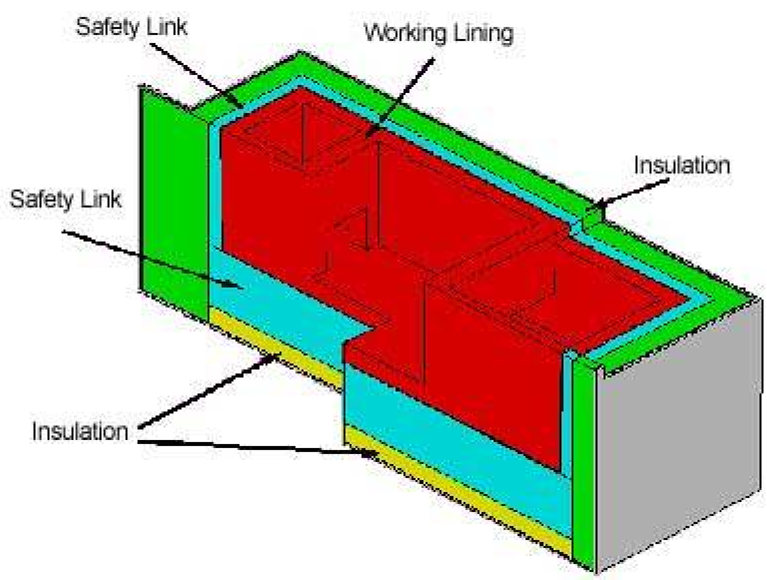


Fig.4.1 Die Casting

A precision casting techniques, die casting uses a permanent die or mould, into which molten metal is directly discharge.

Types of die-casting
(1). Hot chamber machine
(2). cold chamber machine

4.3.2 Sand Casting

- Sand casting is the most common technique used around the world.
- A sand is used as refractory material in sand moulding system.
- Sand casting process is a binder maintains the shape of the mould while pouring molten metal.

- There is a wide range of binder system that are used in san casting. as shown in figure 4.2.

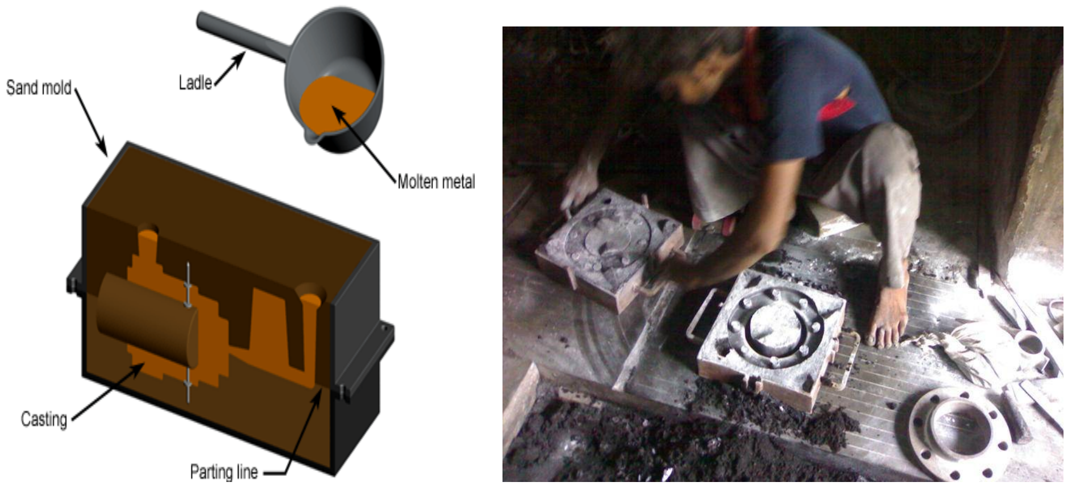


Fig 4.2 Sand Casting

4.3.3 Investment casting

-Investment casting produces very high surface quality and dimensional accuracy.

-Investment casting is commonly used for precision equipment such as surgical equipment, for complex geometries and for precious metals.

-This process is commonly used by artisans to produce highly detailed artwork. The first step is to produce a pattern or replica of the finished mould. Wax is most commonly used to form the pattern, although plastic is also used.

4.4 DESIGN OF GATTING SYSTEM

The molten metal from the ladle is not introduced directly into the mould cavity be it will strike the bottom of the mould cavity with a great velocity. As shown in figure 4.3.

Fundamental of gatting system

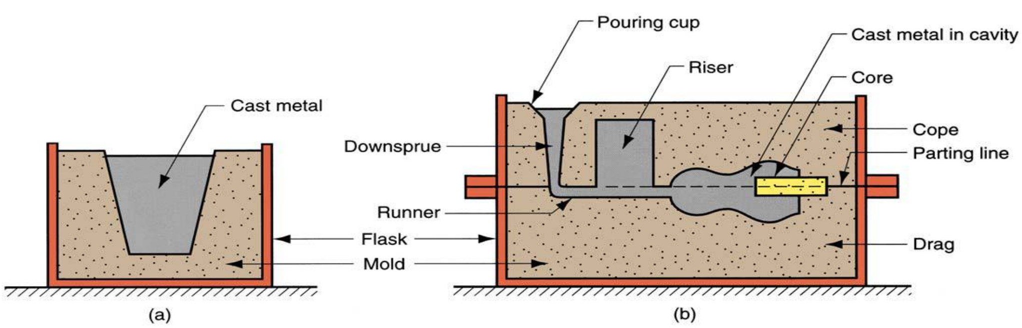


Fig 4.3 Gatting System

The main component of gatting system

- Pouring basin
- sprue
- sprue base
- runner
- choke
- skim bob
- gates and
- riser

The liquid metal that runs through the various channels in the mould obeys the Bernoulli's theorem

$$h + \frac{p}{w} + v^2 = consant$$

Where h= potential head,m
p= pressure, a
v= liquid velocity, $\frac{m}{s}$
w= specific weight of liquid, $\frac{N}{m^3}$
g= gravitational constant

And the liquid flow rate.

$$Q = AV$$

$\rightarrow$ Pouring Time

$$t = k(1.41 + \frac{T}{14.59})\sqrt{w}$$

Where K= $\frac{fluidityofironininch}{40}$
T= average section thickness,mm
w= mass of casting

$\rightarrow$ Chock Area

$$A = \frac{W}{dtc\sqrt{2gh}}$$

Where A= chock area, mm^2
w= casting mass,kg
t= pouring time's
d= mass density, $\frac{kg}{mm^3}$

g= acceleration due to gravity, $\frac{mm}{s^2}$

h= effective metal head,mm

c= efficiency factor

→ Sprue

$$A_t = Ac\sqrt{\frac{h_t}{h}}$$

Where H= Actual sprue height

h_t = H+h

→ Other gatting element

(1).Pouring basin

As per experience shows that the radius of pouring basin is <u>25mm</u>

Pouring basin depth = 2.5 * sprue entrances dia.

(2). Sprue base ball

$$Area = 1\frac{1}{2}A = w\left(\frac{D}{2}\right)$$ (∴ In two runner system)

Well dia.= 2.5 * width of the runner

→ Ingrate Design

Height $h = 1.6\sqrt[3]{\frac{Q^2}{gb^2}} + \frac{v^2}{2g}$

Where Q= metal flow rate

b= gate width,mm

v= metal velocity in runner, $\frac{mm}{s^2}$

g= acceleration due to gravity, $\frac{mm}{s^2}$

→ Rise ring design

(1).clans method

$$t_s = k\left(\frac{v}{s_a}\right)^2$$

t_s = solidification time,s

v= volume of the casting

s_A = surface area

k= mould constant

Freezing ratio

$$X = \frac{s_{Acasting} / V_{casting}}{S_{Ariser} / V_{riser}}$$

$$X = \frac{a}{y-b} - c$$

y= riser volume

a,b,c= constant whose values are as per Material use

(2). Modulus method

$$\text{Volume}= \frac{\pi D^3}{4}$$

D= dia. of the riser

$$\text{Surface area}= \frac{\pi D^2}{4} + \pi D^2$$

$$\text{Ranginess factor R}= \frac{\text{mod}\, ulusofthecube}{\text{mod}\, ulusofcasting}$$

Date:

PRACTICAL NO: 05

AIM :STUDY OF WELDING PROCESSES WITH IT'S CLASSIFICATIONS, WELDING DEFECTS, WELDING ELECTRODES AND ELECTRODE COATING.

5.1 WELDING DEFINITION

5.1.1 As per American welding society (AWS)

Welding is defined as "a localized coalescence of metals or non-metals produced either by heating the material to suitable temperature, with or without the application of pressure or by the application of pressure alone and with or without the use of filler material."

The filler metal has a melting point approximately the same as the base mates**.**

5.1.2 As per Indian standard (IS 812-1957)

Define weld as "a union between two pieces of a metal at faces rendered plastic or liquid by heat or by pressure or both filler metal may be used to effect the union"

5.2 CLASSIFICATION OF WELDING PROCESSES

The classificated depending upon the nature of heat source and its movement resulting in spot, seam or zonal welds; or on the extent of heat generation viz., low heat and high heat.

1.Cast-weld processes

- Thermit welding
- Electoslag welding

2. Arc , Beam, and Flame welding processes

A.) Seam welds

- Carbon Arc
- Submerged Arc
- Shielded metal Arc
- Fus Arc
- Gas tungsten Arc
- Gas metal Arc
- Plasma Arc
- Plasma –MIG

- Electrogas welding
- Electron beam welding
- Laser welding
- Oxy-acetylene welding

B.) Spot welds

- GTAW
- GMAW
- Stud welding

2. Resistance welding processes

A.) Spot welds

- Spot welding
- Projection welding

B.) Seam welds

- Seam welding
- Electric resistance welding
- H.F. Resistance welding
- H.F. Induction welding

C.) Zonal welds

- Resistance Butt welding
- Flash Butt welding
- Percussion welding

3. Solid-state welding processes

A.) High heat input processes

- Friction welding
- Forge welding
- Diffusion bonding

B.) Low heat input processes

- Ultrasonic welding
- Explosion welding
- Cold pressure welding
- Thermo-compression bonding

5.3 TYPES OF WELDED JOINTS

Welded joints are primarily of five kinds.

5.3.1 Lap or fillet joint

Lap joint is obtained by overlapping the plates and welding their edges. The fillet joints may be single transverse fillet, double transverse fillet or parallel fillet joints.

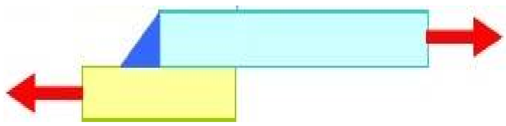


Fig 5.1 : Lap or fillet joint:

5.3.2Butt joints:

formed by placing the plates edge to edge and welding them. Grooves are sometimes cut (For thick plates) on the edges before welding. According to the shape of the grooves, the butt joints may be of different types, e.g.,

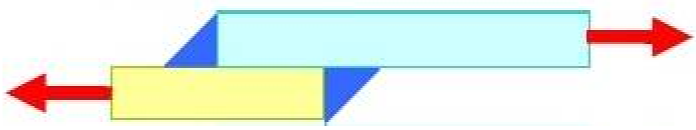


Fig 5.2 : Butt joints

- Square butt joint
- Single V-butt joint, double V-butt joint
- Single U-butt joint, double U-butt joint
- Single J-butt joint, double J-butt joint
- Single bevel-butt joint, double bevel butt joint

5.3.3 Corner joint

The flush corner joint is designed primarily for welding sheet metal that is 12 gauge or thinner. It is restricted to lighter materials.

5.3.3.1 The half-open corner joint is used for welding materials heavier than 12 gauge. Pene- tration is better than in the flush corner joint, but its use is only recommended for moderate loads.

5.3.3.2 The full-open corner joint produces a strong joint, especially when welded on both sides. It is useful for welding plates of all thicknesses.

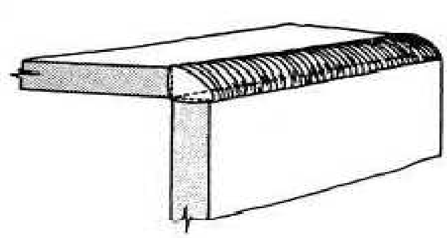


Fig5.3: corner joint

5.3.4 Tee joints:

- The square tee joint requires a fillet weld that can be made on one or both sides. It can be used for light or fairly thick materials. For maximum strength, considerable weld metal should be placed on each side of the vertical plate.

5.3.5 Edge joints:

The flanged edge joint is suit- able for plate 1/4 inch or less in thickness and can only sustain light loads. Edge preparation for this joint may be done.

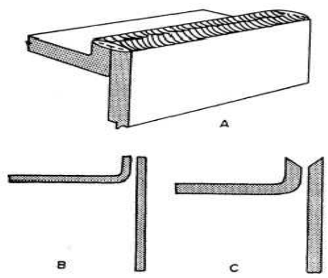


Fig 5.5: edge joint

5.4 WELDING POSITIONS

1. **Flat Position** - usually groove welds, fillet welds only if welded like a "V"
2. **Horizontal** - Fillet welds, welds on walls (travel is from side to side).
3. **Vertical** - welds on walls (travel is either up or down).
4. **Overhead** - weld that needs to be done upside down.

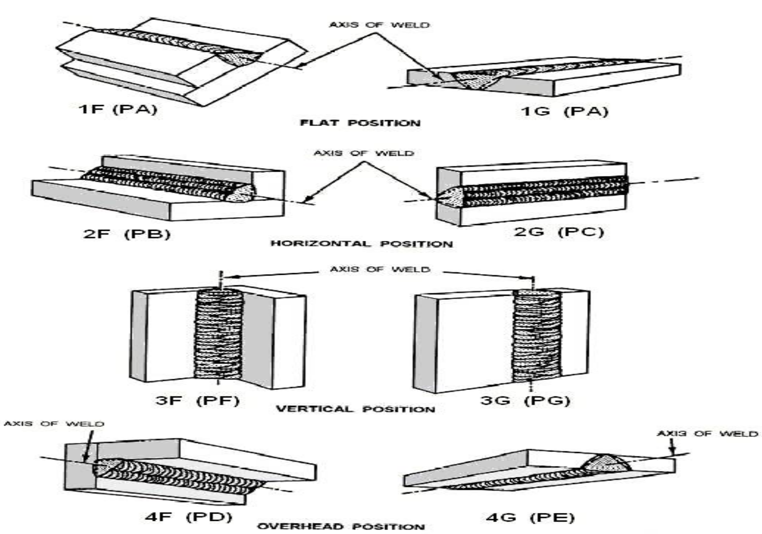


Fig 5.6: Welding position

5.5 WELDING DEFECTS

5.5.1 Definition

A discontinuity is an objective lack of material, an interruption in the physical consistence of a part. Examples are cracks, seams, laps, porosity or inclusions. It may or may not be considered a defect depending if it its presence endangers or not the integrity, the usefulness and the serviceability of the structure.

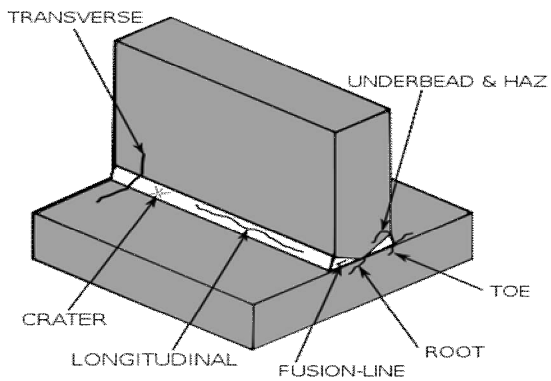


Fig 5.7: welding defect

By knowing what is likely to produce Welding-defects one should learn how to avoid them. It is essential to distinguish discontinuities from harmful defects. Production without defects saves work time, materials, repair costs, decrease in productivity.

5.5.2 Common welds defects :

1. Lack of fusion
2. Lack of penetration or excess penetration
3. Porosity
4. Inclusions
5. Cracking
6. Undercut
7. Lamellar tearing

1. Lack of fusion :

Lack of fusion is the poor adhesion of the weld bead to the base metal; incomplete penetration is a weld bead that does not start at the root of the weld groove. These types of defects occur when the welding procedures are not adhered to; possible causes include the current setting, arc length, electrode angle, and electrode manipulation. To achieve a good quality join it is essential that the fusion zone extends the full thickness of the sheets being joined. Thin sheet material can be joined with a single pass and a clean square edge will be a satisfactory basis for a join.

2. Porosity

This occurs when gases are trapped in the solidifying weld metal. These may arise from damp consumables or metal or, from dirt, particularly oil or grease, on the metal in the vicinity of the weld. This can be avoided by ensuring all consumables are stored in dry conditions and work is carefully cleaned and degreased prior to welding.

3. Inclusions

These can occur when several runs are made along a V join when joining thick plate using flux cored or flux coated rods and the slag covering a run is not totally removed after every run before the following run.

4. Cracking

This can occur due just to thermal shrinkage or due to a combination of strain accompanying phase change and thermal shrinkage. In the case of welded stiff frames, a combination of poor design and inappropriate procedure may result in high residual stresses and cracking.

Welding Cracks are of the following type:

- Micro Cracks: They are very small and are revealed only under a microscope.
- Macro cracks: These cracks can be seen by the eye or bye use of a low power magnifier.
- Fissures: These are wide cracks which emerge to the surface of metal.

Crack Location

- In the weld metal zone.
- In the base metal zone.
- Sometimes, the cracks originate in one zone and then spread to other zones.

5. Undercut

Undercutting is when the weld reduces the cross-sectional thickness of the base metal, which reduces the strength of the weld and work pieces. One reason for this type of defect is excessive current, causing the edges of the joint to melt and drain into the weld; this leaves a drain-like impression along the length of the weld. A third reason is using an incorrect filler metal, because it will create greater temperature gradients between the center of the weld and the edges. Other causes include too small of an electrode angle, a dampened electrode, excessive arc length, and slow speed.

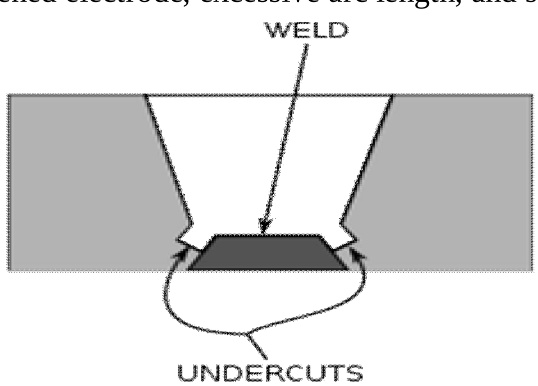


Fig 5.8: Undercut

6. Lamellar tearing

This is mainly a problem with low quality steels. It occurs in plate that has a low ductility in the through thickness direction, which is caused by non metallic inclusions, such as sulphides and oxides that have been elongated during the rolling process. These inclusions mean that the plate can not tolerate the contraction stresses in the short transverse direction. Lamellar tearing can occur in both fillet and butt welds, but the most vulnerable joints are 'T' and corner joints, where the fusion boundary is parallel to the rolling plane.

5.6 INSPECTION AND TESTING OF WELDING

5.6.1 Visual Inspection

Prior to any welding, the materials should be visually inspected to see that they are clean, aligned correctly, machine settings, filler selection checked, etc.As a first stage of inspection of all completed welds, visual inspected under good lighting should be carried out. A magnifying glass and straight edge may be used as a part of this process. Undercutting can be detected with the naked eye and (provided there is access to the reverse side) excess penetration can often be visually detected.

5.6.2. X - Ray Inspection

Sub-surface cracks and inclusions can be detected 'X' ray examination. This is expensive, but for safety critical joints - eg in submarines and nuclear power plants - 100% 'X' ray examination of welded joints will normally be carried out.

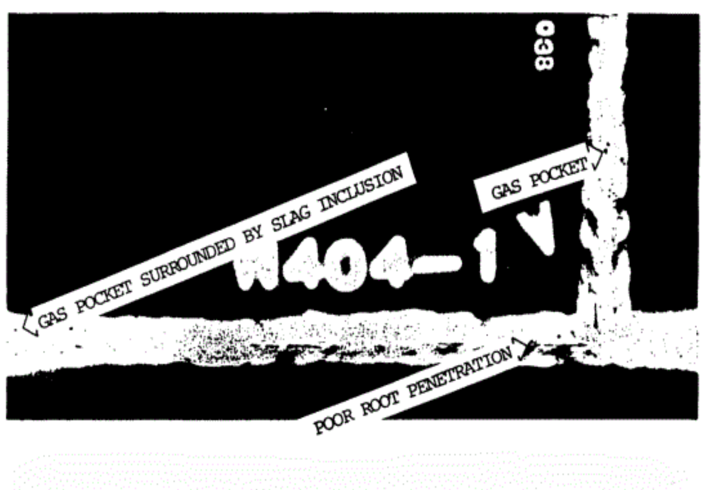


Fig 5.9 : x- ray testing

5.6.3. Ultrasonic Inspection

Surface and sub-surface defects can also be detected by ultrasonic inspection. This involves directing a high frequency sound beam through the base metal and weld on a predictable path. When the beam strikes a discontinuity some of it is reflected beck. This reflected beam is received and amplified and processed and from the time delay.

Fig 5.10: Ultrasonic Inspection

Porosity, however, in the form of numerous gas bubbles causes a lot of low amplitude reflections which are difficult to separate from the background noise. Results from any ultrasonic inspection require skilled interpretation.

5.6.4. Radiographic Testing (RT)

This method of weld testing makes use of X-rays, produced by an X-ray tube, or gamma rays, produced by a radioactive isotope. The basic principle of radiographic inspection of welds is the same as that for medical radiography. Penetrating radiation is passed through a solid object. The amount of energy absorbed by the object depends on its thickness and density. Energy not absorbed by the object will cause exposure of the radiographic film. These areas will be dark when the film is developed. Areas of the film exposed to less energy remain lighter. Inclusions of low density, such as slag, will appear as dark areas on the film while inclusions of high density, such as tungsten, will appear as light areas. All discontinuities are detected by viewing shape and variation in density of the processed film.

Fig 5.15 : Radiographic Testing

This is a slow and expensive method of **nondestructive testing**; it is a positive method for detecting porosity, inclusions, cracks, and voids in the interior of welds. There are obvious safety considerations when conducting radiographic testing. X-ray and gamma radiation is invisible to the naked eye and can have serious heath and safety implications. Only suitably trained and qualified personnel should practice this type of testing.

5.7 Electrodes

Electodes used for arc welding are of two types

1. Non consunable
2. Consumable

5.7.1 Non Consumable electrodes

These electrode are made of carbon,Graphite or Tungsten.Carbon and Graphite electrode are used for D.C. welding only.tungsten electrode are used for D.C. as well as A.C. welding. When non consumable electrodes are used, the filler material is added separately. Since the electrode is virtually not consumed,the arc length remains constant, so that it is stable and easy to maintain.

5.7.2 Consumable electrodes

Consumable electrode provides the also filler material also.these may be made of various metals, but should have the same composition as the material to be welded.

The consumable electrode are of three kind

1. Bare electrodes
2. Fluxed or lightly coated electodes
3. Coated or exurted/ shielded electrodes

5.7.2.1 Bare electrodes

Bare electrodes may be used to weld wrought iron or mild steel. They must be used only with straight polarity. Bare electrodes in the form of sticks or rod are used for hand arc welding.

5.7.2.2 Lightly coated electrodes

Lightly coated electodes have a coating layer several tenths of a millimeter thick,the weight of coating is from 1 to 5 per cent of the electrode weight.these electodes are used in welding only noncriticle structure.these weld have poor mechanical efficiency.

5.7.2.3 Coated electrodes

Coated electrodes are covered with a relatively high quality covering applied in a layer of 1 to 3 mm. The weight of such a coating is from 15 to 30 % of the electrode. The greatest amount of welding is done with coated electrodes.

The sticks are available in the size of 3.2, 4, 5, 6, 8, 9 and 12 mm diameter and lenths of 350 or 450 mm.

5.7.3 Function of coatings

- Improves arc stability by providing certain chemicals which have this ability, by ionizing the path of arc.
- Provides a protective slag over hot metal
- Reduces flux,which helps to remove oxides and other impurities from the molten weld metal.
- Acts as deoxidizer.

- Adds alloying elements.
- Increase deposition efficiency.
- Slows down the cooling rate of weld to prevent hardening.
- Coating are normally insulation of electricity and so permit the use of electrodes in narrow grooves

Date:

PRACTICAL NO: 06

AIM: PERFORMANCE OF GAS WELDING AND GAS CUTTING.

6.1 GAS WELDING

6.1.1 Definition

Metal joining process in which the ends of pieces to be joined are heated at their interface by producing coalescence with one or more gas flames (such as oxygen and acetylene), with or without the use of a filler metal.

6.1.2 Types of Gas Welding

Gas welding involves the use of a gas-fed flame torch to heat the metal work piece and the filler material to create a weld. The gas is generally a mixture of a fuel gas and oxygen to create a clean, hot flame. Many different gases can be used as fuel for gas welding, and electricity is not needed to power the welding system, resulting in a flexible and portable fabrication method. All gas welding techniques require proper safety equipment for the welder and storage of the welding gases.

6.1.2.1 Oxy-Acetylene Welding

Oxy-acetylene welding uses a mixture of acetylene gas and oxygen gas to feed the welding torch. Oxy-acetylene welding is the most commonly used gas welding technique. This gas mixture also provides the highest flame temperature of available fuel gases, however acetylene is generally the most expensive of all fuel gases. Acetylene is an unstable gas and requires specific handling and storage procedures.

6.1.2.2 Oxy-Gasoline Welding

Pressurized gasoline is used as a welding fuel where fabrication costs are an issue, particularly in locations where acetylene canisters are not available. Gasoline torches can be more effective than acetylene for torch-cutting thick steel plates. The gasoline can be hand-pumped from a pressure cylinder, a common practice by jewelry makers in impoverished areas.

6.1.2.3 MAPP Gas Welding

Methyl acetylene-propadiene-petroleum (MAPP) is a gas mixture that is much more inert than other gas mixtures, making it safer for hobbyists and recreational welders to use and store. MAPP can also be used at very high pressures, allowing it to be used in high-volume cutting operations.

1. Butane/Propane Welding

Butane and propane are similar gases that can be used alone as fuel gases or mixed together. Butane and propane have a lower flame temperature than acetylene, but are less expensive and easier to transport. Propane torches are more frequently used for soldering, bending and heating. Propane requires a different type of torch tip to be used than an injector tip because it is a heavier gas.

2. Hydrogen Welding

Hydrogen can be used at higher pressures than other fuel gases, making it especially useful for underwater welding processes. Some hydrogen welding equipment works off electrolysis by splitting water into hydrogen and oxygen to be used in the welding process.

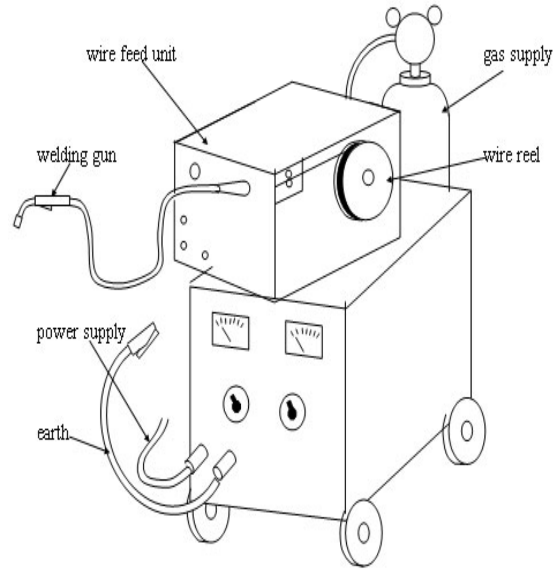


Fig. 6.1 Modern setup

This type of electrolysis is often used for small torches, such as those used in jewelry making processes.

6.1.3 GAS Welding Equipments

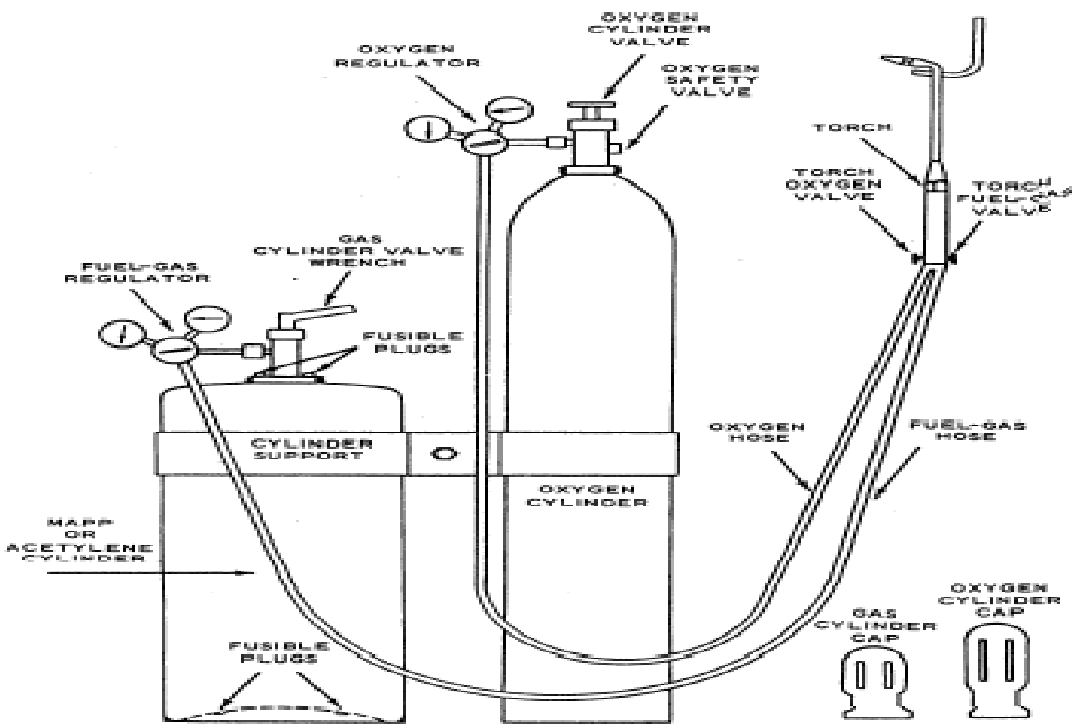


Figure 5.2 Gas Welding Equipment

The basic equipments used to carry out gas welding are:
1. Oxygen gas cylinder.
2. Acetylene gas cylinder.
3. Oxygen pressure regulator.
4. Acetylene pressure regulator.
5. Oxygen gas hose (Blue).
6. Acetylene gas hose (Red).
7. Welding torch or blow-pipe with a set of nozzles and gas lighter.
8. Trolleys for the transportation of oxygen and acetylene cylinders.
9. A set of keys and spanners.
10. Filler rods and fluxes.

6.1.4 Advantages of Gas Welding:

1. It is probably the most versatile process. It can be applied to a wide variety of manufacturing and maintenance situations.
2. Welder has considerable control over the temperature of the metal in the weld zone. When the rate of heat input from the flame is properly coordinated with the speed of welding, the size, viscosity and surface tension of the weld puddle can be controlled, permitting the pressure of the flame to be used to aid in positioning.
3. The equipment is versatile, low cost, self sufficient and usually portable. Besides gas welding, the equipment can be used for preheating, post heating, braze welding, torch brazing and it is readily converted to oxygen cutting.
4. The cost and maintenance of the welding equipment is low when compared to that of some other welding processes

6.1.5 Disadvantages of Gas Welding

1. Heavy sections cannot be joined economically.
2. Flame temperature is less than the temperature of the arc.
3. Fluxes used in certain welding and brazing operations produce fumes that are Irritatingt o the eyes, nose, throat and lungs.
4. Refractory metals (e.g., tungsten, molybdenum, tantalum, etc.) and reactive metals (e.g., titanium and zirconium) cannot be gas welded.
5. Gas flame takes a long time to heat up the metal than an arc.
6. Prolonged heating of the joint in gas welding results in a larger heat affected area.
7. More safety problems are associated with the handling and storing of gases.

6.1.6 TYPES OF FLAMES

There are three types of Flames

1. Neutral Flame

Addition of little more oxygen give a bright whitish cone surrounded by the transparent blue envelope is called **Neutral flame** (It has a balance of fuel gas and oxygen).Most commonly used flame because it has temperature about 32000c

Used for welding steels, aluminum, copper and cast iron.

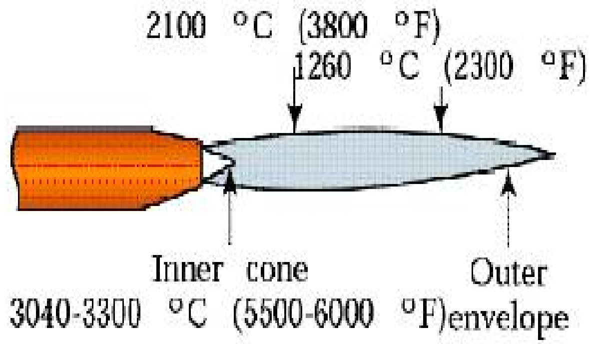


Fig.5.3 : Neutral flame

2.Oxidizing Flame

If more oxygen is added, the cone becomes darker and more pointed, while the envelope becomes shorter and more fierce is called **Oxidizing flame.** It has the highest temperature about 34000c. Used for welding brass and brazing operation

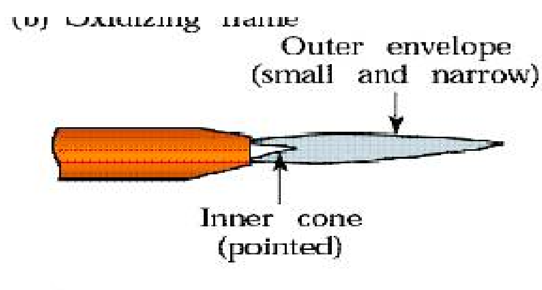


Fig.5.4 Oxidizing Flame

3. Carburizing flame

Oxygen is turned on, flame immediately changes into a long white inner Area (Feather) surrounded by a transparent blue envelope is called **Carburizing Flame** (30000c). This flames are used for hardening the surfaces.

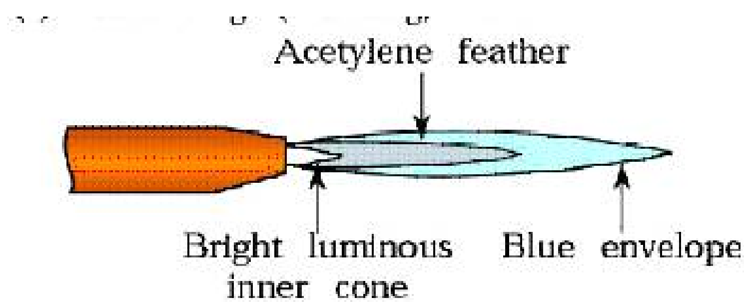


Fig. 6.6 Carburizing Flame

6.1.7 Advantages of gas welding

1. Equipment has versatile
2. Same equipment can be used for oxy acetylene cutting and brazing by varying the torch size
3. Heat can controlled easily

6.1.8 Disadvantages

1. Slower process
2. Risk is involved in handling gas cylinders

6.2 GAS CUTTING

1. Ferrous metal is heated in to red hot condition and a jet of pure oxygen is projected onto the surface, which rapidly oxidizes
2. Oxides having lower melting point than the metal, melt and are blown away by the force of the jet, to make a cut
3. Fast and efficient method of cutting steel to a high degree of accuracy
4. Torch is different from welding
5. Cutting torch has preheat orifice and one central orifice for oxygen jet
6. **PIERCING** and **GOUGING** are two important operations
7. **Piercing**, used to cut a hole at the centre of the plate or away from the edge of the plate
8. **Gouging**, to cut a groove into the steel surface

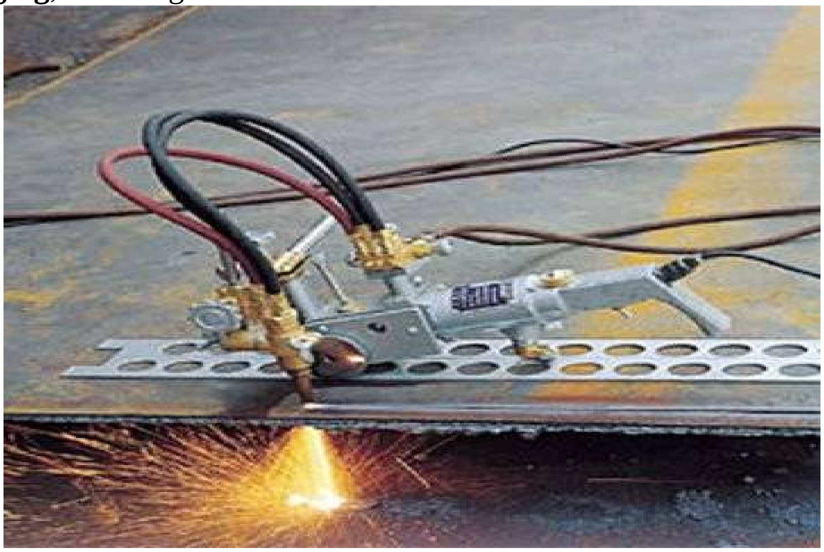


Figure6.7: Automatic Gas Cutting

Figure6.8: Manual Gas Cutting

Date:

PRACTICAL NO 07

AIM: STUDY OF RESISTANCE WELDING AND PERFORMANCE ON SPOT WELDING.

7.1 RESISTANCE WELDING

7.1.1 DEFINTION

Resistance welding is a group of welding processes where in coalescence is produced by the heat obtained from resistance of the work to the flow of electric current in a circuit of which the work is a part and by the applications pressure No filler metal is needed.

7.1.2 FUNDAMENTALS OF ELECTRIS RESISTANCE WELDING

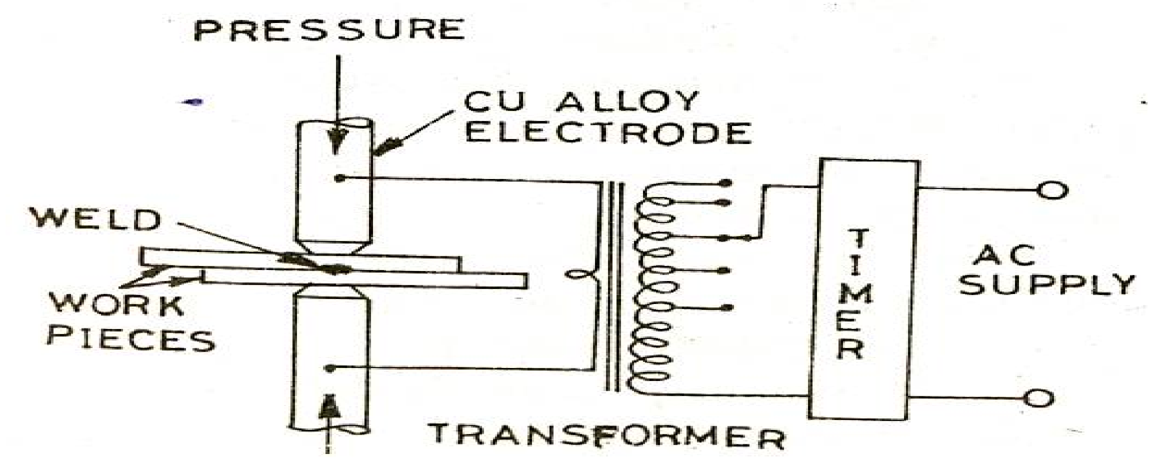


Fig: 7.1-Principal of resistance welding

The two factors or variables mainly responsible for resistance.

1. The generation of heat at the place where two pieces are to be joined.
2. The application of pressure at where a weld joint is to be formed.

7.1.2.1 Heat, H

-The heat, H for electrical resistance welding is generated by passing a large electrical current (of the order of 3000 to 100,000 Amps with a voltage between 1 and 25 volts) through two pieces of metal that are touching each other.

$$H=I^2 RT$$

Where H is the heat generated indicated in joules,

I is the current in root-mean-square amperes,

R is the resistance in ohms,.

T is the time (from fraction of a second Tc a few seconds) of current flow through the pieces to be welded.

7.1.2.2 Current, I

- With other parameters kept constant, the temperature in resistance welding is regulated by controlling the magnitude and timing of the the welding current

-Enough welding current is required to heat the metal pieces being welded to their plastic state

-The current is obtained from a step-down transformer. The magnitude of current may be controlled through taps on the primary of the transformer [Fig.5.1] or by an autotransformer. That varies of the primary voltage supplied to the main transformer.

-Low welding current does not provide proper fusion whereas if welding current is too high, the entire thickness of the work metal between the electrodes is heated to the plastic state by the time the weld zone reaches that fusion temperature, and the electrodes embed themselves deeply into the metal.

-As the current / current density* is increased, the weld time can be decreased sufficiently to produce a weld without overheating the electrode contact surfaces.

-As the welding current increases, the nugget diameter, breaking load of welded joint and the electrode indentation into the work pieces, all, increase.

-In resistance welding, three types of current supply systems generally are used

(i) AC systems.
(ii) DC systems.
(iii) Stored-energy current systems.

By far the majority of resistance welding machines operate on single-phase alternating current of the power lion frequency, usually 50 cycles / second. A single phase transformer converts the power line voltage to a low voltage and provides the high currents needed for welding.

High frequency resistance welding is used for applications of continuous seam or butt seam welding. The welding current frequencies are of the order of 450,000 cycles per second.

In DC systems, energy is delivered directly from the power line and rectifier to direct current on the secondary side of the welding transformer.

Stored energy systems are ; storage batteries, electromagnetic type, the homo polar generator and capacitor type. Capacitor stored-energy type involves charging a group of capacitors from a high-voltage rectifier unit and subsequent discharge of the energy from the capacitors through a welding transformer.

7.1.2.3 RESISTANCE, R

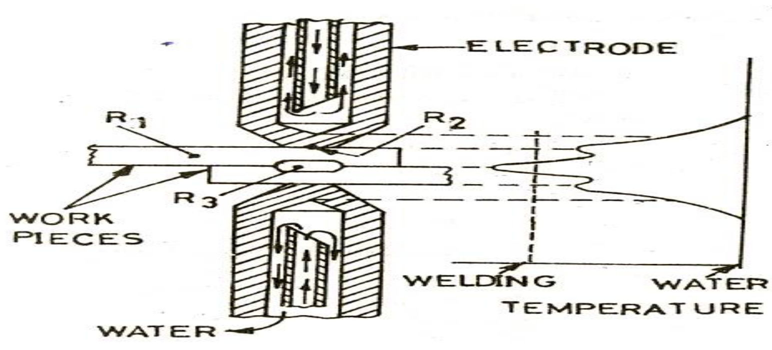


Fig: 7.2. Resistance welding

The total resistance of the system between the electrodes consists of

(i) The resistance of the work piece R_1

(ii) The contact resistance between the electrodes and the work, R_2, and

(iii) the resistance between faying surfaces of the two metal pieces to be welded together, R_3.

-In order to obtain a sound weld and to avoid overheating of the welding electrode as, R_1, and R_2 should be kept as low as possible with respect to resistance R_3.

*R1, the resistance of the work piece, depends upon the nature of the material and its thickness. It cannot be changed otherwise. If the work piece material has low electrical resistance, such as aluminum, it requires very high currents in order to produce the required welding temperature and hence proper weld.

*R2, the contact resistance between the electrode and the work piece can be minimized by

(i) Keeping the electrode tip and the work piece surface properly cleaned.

(ii) Using the welding electrodes of highly conductive materials such as Cu- Cd or Cu-Cr alloys.

(iii) Controlling the shape and size of the electrodes.

(iv) Using the proper pressure between the electrodes and the work pieces.

*R3, the resistance between the contacting surfaces of the two work pieces, varies with the quality of the surfaces. Surfaces that have not been cleaned and possess seal, bright or other contaminants on them offer more resistance to the flow of welding current.

Smooth work piece surfaces and high electrode pressures reduce resistance R3.

Overheating of the welding electrodes is avoided by circulating either water or a refrigerant through them

The main aim is to obtain a sound weld without overheating either the electrodes or the work-pieces.

7.1.2.4 TIME, T

Four definite segments or periods of timing are set up on a resistance spot welding machine during one welding cycle.

1. Squeeze time.
2. Weld time.
3. Hold time.
4. Off time.

1. Squeeze time

It is the time between the initial application of the electrode pressure on the work and the initial application of current to make the weld. During this period the upper electrode comes in contact with the work piece and develops full electrode force. At the end of the squeeze time, the welding current is applied.

2. Weld time.

During this period the welding current flows through the circuit, i.e., it enters from one electrode, passes through the work pieces and goes out from the second electrode.

3. Hold time.

It is the time during which force acts at the point of welding after the last impulse of welding current ceases. The electrode pressure is maintained until the metal has somewhat cooled.

4. Off time.

It is the interval from the end of the hold time to the beginning of the squeeze time for the next (resistance) welding cycle.

In automatic machines all these segments of times of times are controlled automatically whereas in manually operated machines, only the weld time is controlled automatically and the remaining time periods are adjusted by the operator himself.

Weld time can be controlled automatically by using a suitable (electronic) timer. Weld times range from one-half cycle of 50 cycle frequency for thinnest sheets to as long as several seconds for thicker plates, depending somewhat upon the metal are being welded.

Pressure or Electrode force

Pressure exerted on the work pieces by the welding electrodes does the following;

(i) It brings the various interfaces into intimate contact and thus affects the contact resistance between the two work pieces.

(ii) It ensures the completion of the electrical circuit between the electrodes and through the work.

(iii) It permits the weld to be made at lower temperatures.

pressure on the work piece is exerted by the electrodes extending form the arms of the welding machine.

Besides this, the other functions performed by electrodes ere;

(i) They carry the current which passes through and generates heat at the place where the two work pieces are in pressed contact.

(ii) Depending upon the area of the electrodes face or tip, they determine the current density in the weld zone.*

(iii) They dissipate the heat from the weld zone and thus prevent surface fusion of the work.

7.1.3 VARIABLES IN RESISTANCE WELDING

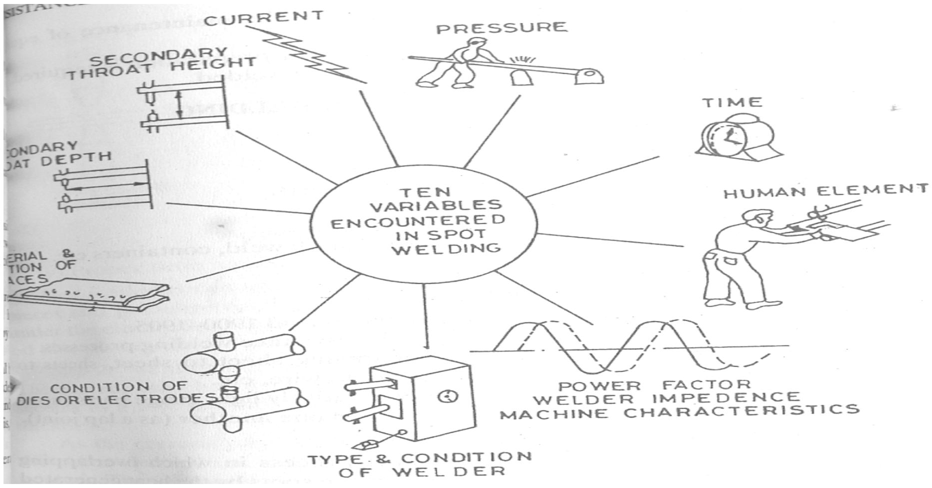


Fig:7.3 Variables in Resistance Welding

Variables commonly encountered and considered carefully by but the design and welding engineers are;

1. Current.
2. Electrode pressure.
3. Welding time.
4. Human element.
5. Welding machine characteristics.
6. Type and condition of machines.
7. Conditions of electrodes and arms.
8. Condition of the material and surfaces of material.
9. Throat depth.

7.1.4 ADAVANTAGES OF RISISTANCE WELDING

- Fast rate of production.
- No filler rod is needed.
- Semi-automatic equipments.
- Less -skilled workers can do the job.
- Both similar and dissimilar metal can be welded.
- High reliability and reproducibility are obtained.
- More general elimination of warping or distortion of parts.

7.1.5 DISADVANTAGES OF RESISTANCE WELDING

- The initial cost of equipments is high.
- Skilled person are needed for the maintenance of equipments and its controls.
- In some material, special surface preparation is required.
- Bigger job thicknesses can not be welded.

7.2 SPOT WELDING

7.2.1 Introduction and Use

- Spot welding came into use in the period 1900-1905.

- It is now the most widely used of resistance welding processes.
- Spot welding is employed for joining sheet to sheet, sheets to rolled sections or extrusions, wire to wire, etc.
- Spot welding is used for joining relatively light gauge parts (up to about 3 mm thick) superimposed on one another (as a lap joint).

7.2.2 DEFINITION

Spot welding is a resistance welding process in which overlapping sheets are joined by local fusion at one or more spots by the heat generated by resistance to the flow of electric current through work pieces that are held together under force by two electrodes, one above and the other below the two overlapping sheets (fig.5.1).

7.2.3 PROCEDURE

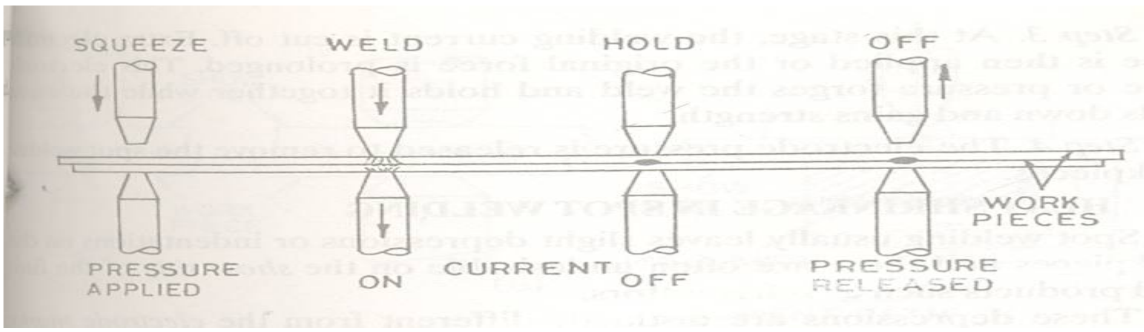


Figure 7.4 Stages in making a spot welding

The steps involved in making a spot weld are listed below and shown but before spot welding one must make sure that

(i) The job is clean, i.e. free form grease, dirt, paint, scale, oxide etc.

(ii) Electrode tip surface is clean, since it has to conduct the current into the work with as little loss as possible. Very fine emery cloth may be used for routine cleaning.

(iii) Water is running through the electrodes in order to
  (a) Avoid them form getting overheated and thus damaged,
  (b) Cool the weld.

(iv) Proper welding current has been set on the current selector switch.

(v) Proper time has been set on the weld-timer.

Step 1. Electrodes are brought together against the overlapping work pieces and pressure applied so that the surfaces of the two work pieces under the electrodes come in physical contact after breaking any unwanted film existing on the work pieces.

Step 2. Welding current is switched on for a definite period of time. The current may be of the order of 3000 to 100,000 A for a fraction of second to a few seconds depending upon the nature of material and its thickness.

As the current passes through one electrode and the work pieces to the other electrode, a small area where the work pieces are in contact is heated. The temperature of this weld zone is approximately 815°C to 930°C.To achieve a satisfctory spot weld, the nugget of coalesced metal should from with no melting of the material between the faying surfaces.

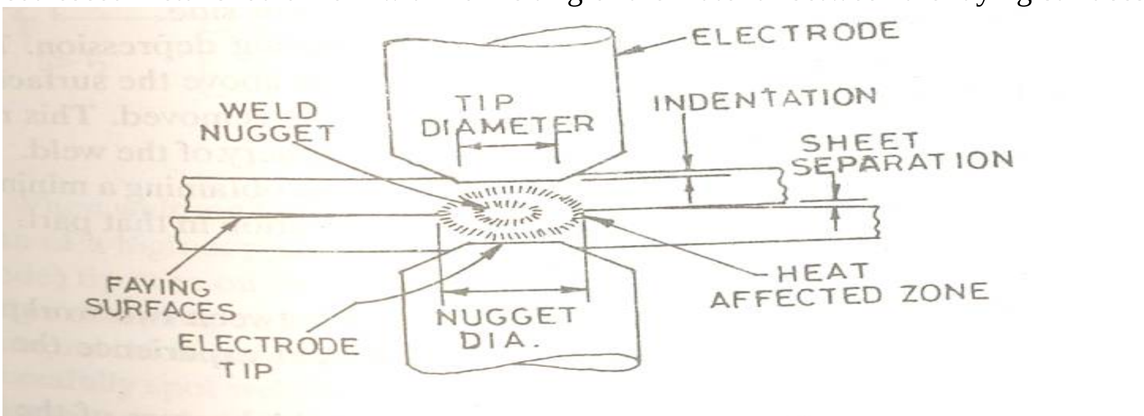


Fig 7.5 Spot welding process-details

Step 3. At this stage, the welding current is cut off. Extra electrode force is then applied or the original force is prolonged. This electrode force or pressure forges the weld and holds it together while the metal cools down and gains strength.

Step 4. The electrode pressure is released to remove the spot welded work pieces.

7.2.4 SPOT WELDING METHODS

Different spot welding methods are:

(i) Direct
(ii) Indirect (or series)
(iii) Push-pull

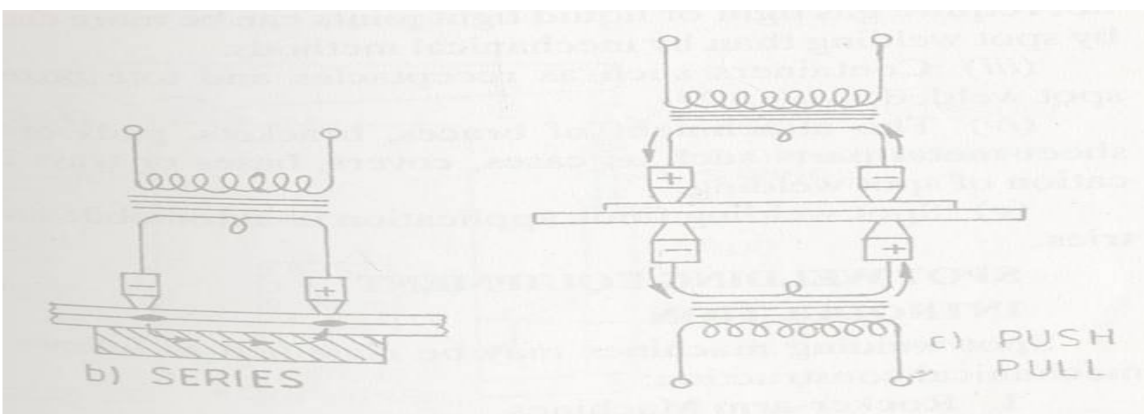


Fig 7.6 Spot welding methods

(i) Direct welds.

It is a welding method in which one or more electrodes oppose each other, contacting both sides of the work and with the current passing form the electrodes on one side directly through the work into the electrodes on the other side and back to the welding transformer.

(ii) Series welds.

It is a welding method in which two or more spots are produced simultaneously with only one common but indirect current path.

In series welding, a portion of the secondary current by-passes (shunts) any weld nugget being formed. This shunt current passes through one of the panels being welded.

(iii) Push-pull welds

- A push-pull system employs transformers with an electrically reversed polarity arrangement wherein two transformers complement each other to form circulating welding current circuit.
- Opposing electrodes are connected to different transformers and are of opposite polarity.
- Two spot welds may be obtained simultaneously.

7.2.5 SPOT WELDING EQUIPMENT INTRODUCTION

Spot welding machines may by classified as follows on the basis of mechanical Construction;

1. Rocker-arm Machines
2. Press-type machines,
3. Portable machines or Guns, and
4. Multiple-electrodes machines.

A standard spot welding machine possesses the following:

Basic Elements;

1. The frame, which is the main body the machine and houses the transformer and tap switch.
2. A nipper arm which is movable and a fixed lower arm.
3. Welding electrodes.
4. The electrical circuit consisting of a step down transformer which reduces the voltage and proportionally increases the current.
5. The different controls that adjust the magnitudes of current, length of welding time, the contact period and the flow of cooling water.

7.2.6 SPOT WELDING ELECTRODES

7.2.6.1 Functions

- To conduct the welding current to the work pieces.
- To transmit to the work pieces in the weld area the amount of force needed to produce a satisfactory weld.
- To dissipate the heat form the weld zone and thus prevent surface fusion of the work.

7.2.6.2 Requirements of spot Welding Electrodes

A spot welding electrode must

- Be a good conductor of electricity
- Be a good conductor of heat
- Have good mechanical strength and hardness at high temperatures.
- Have a minimum tendency to combine with the metal being welded.

7.2.7 APPLICATIONS OF SPOT WELDING

- Spot welding of two 12.5 mm thick steel plates has been done satisfactorily as a replacement for riveting.
- Many assemblies of two or more sheet metal stampings that do not require gas tight or liquid tight joints can be more economically joined by spot

welding than by mechanical methods.

- Attachment of braces, brackets, pads or clips to formed sheet-metal parts such as cases, covers, bases or trays is another application of spot welding.
- Spot welding finds application in automobile and aircraft industries.

Date:

PRACTICAL NO: 08

AIM: STUDY OF ARC WELDING. SUCH AS (TIG/MIG/SMAW WELDING).

8.1. TUNGSTEN INERT GAS ARC WELDING OR (TIG WELDING)

8.1.2 Introduction

Tungsten Inert Gas (TIG) or Gas Tungsten Arc (GTA) welding is the arc welding process in which arc is generated between non consumable tungsten electrode and work piece. The tungsten electrode and the weld pool are shielded by an inert gas normally argon and helium.

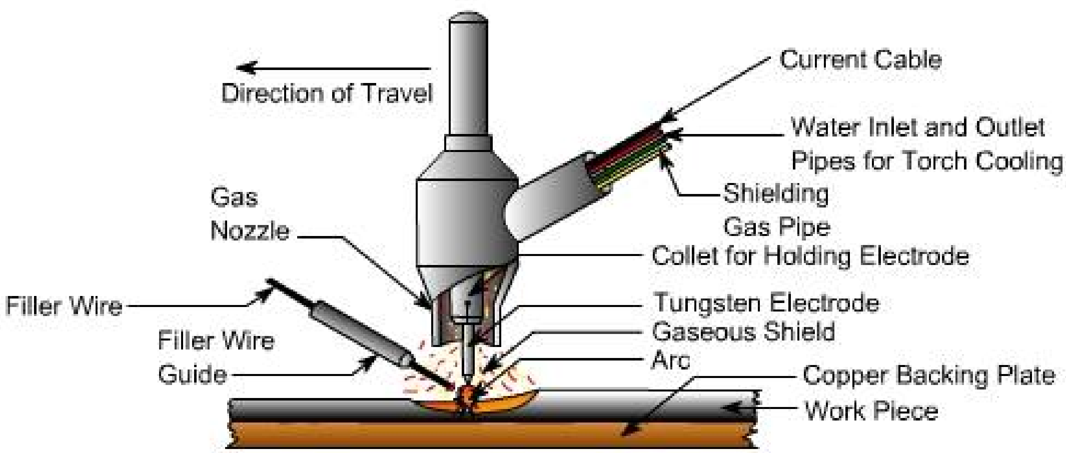


Fig 8.1 Principle of TIG Welding.

8.1.3 Principal of operation

The tungsten arc process is being employed widely for the precision joining of critical components which require controlled heat input. The small intense heat source provided by the tungsten arc is ideally suited to the controlled melting of the material. Since the electrode is not consumed during the process, as with the MIG or MMA welding processes, welding without filler material can be done without the need for continual compromise between the heat input from the arc and the melting of the filler metal. As the filler metal, when required, can be added directly to the weld pool from a separate wire feed system or manually, all aspects of the process can be precisely and independently controlled i.e. the degree of melting of the parent metal is determined by the welding current with respect to the welding speed, whilst the degree of weld bead reinforcement is determined by the rate at which the filler wire is added to the weld pool. In TIG torch the electrode is extended beyond the shielding gas nozzle. The arc is ignited by high voltage, high frequency (HF) pulses, or by touching the electrode to the work piece and withdrawing to initiate the arc at a preset level of current.

Selection of electrode composition and size is not completely independent and must be considered in relation to the operating mode and the current level. Electrodes for DC welding are pure tungsten or tungsten with 1 or 2% thoria, the thoria being added to improve electron emission which facilitates easy arc ignition. In AC welding, where the electrode must operate at a higher temperature, a pure tungsten or tungsten-zirconia electrode is preferred as the rate of tungsten loss is somewhat lesser than with thoriated electrodes and the zirconia aids retention of the balled' tip.

Table gives chemical composition of tungsten electrodes as per American Welding Society (AWS) classification.

AWS Classification	Tungsten, min. percent	Thoria, percent	Zirconia, percent	Total other elements, max. percent
EWP	99.5	-	-	0.5
EWTh-1	98.5	0.8 to 1.2	-	0.5
EWTh-2	97.5	1.7 to 2.2	-	0.5
EWZr	99.2	-	0.15 to 0.40	0.5

Table 8.1: Chemical Composition of TIG Electrodes.

Tungsten electrodes are commonly available from 0.5 mm to 6.4 mm diameter and 150 - 200 mm length. The current carrying capacity of each size of electrode depends on whether it is connected to negative or positive terminal of DC power source. Table 8.2 gives typical current ranges for TIG electrodes when electrode is connected to negative terminal (DCEN) or to positive terminal (DCEP).

Electrode Dia. (mm)	DCEN	DCEP
	Pure and Thoriated Tungsten	Pure and Thoriated Tungsten
0.5	5-20	-
1.0	15-80	-
1.6	70-150	10-20
2.4	150-250	15-30
3.2	250-400	25-40
4.0	400-500	40-55
4.8	500-750	55-80

Table 8.2 Typical Current Ranges for TIG Electrodes

The power source required to maintain the TIG arc has a drooping or constant current characteristic which provides an essentially constant current output when the arc length is varied over several millimeters. Hence, the natural variations in the arc length which occur in manual welding have little effect on welding current. The capacity to limit the current to the set value is equally crucial when the electrode is short circuited to the work piece, otherwise excessively high current shall flow, damaging the electrode. Open circuit voltage of power source ranges from 60 to 80 V.

Pure argon can be used for welding of structural steels, low alloyed steels, stainless steels, aluminum, copper, titanium and magnesium. Argon hydrogen mixture is used for welding of some grades of stainless steels and nickel alloys. Pure helium may be used for aluminum and copper. Helium argon mixtures may be used for low alloy steels, aluminum and copper.

TIG welding can be used in all positions. It is normally used for root pass(es) during welding of thick pipes but is widely being used for welding of thin walled pipes and tubes. This process can be easily mechanised i.e. movement of torch and feeding of filler wire, so it can be used for precision welding in nuclear, aircraft, chemical, petroleum, automobile and space craft industries. Aircraft frames and its skin, rocket body and engine casing are few examples where TIG welding is very popular.

8.1.4 Advantages of Tungsten Inert Gas Arc Welding (TIG/GTAW):

- Weld composition is close to that of the parent metal;
- High quality weld structure
- Slag removal is not required (no slag);
- Thermal distortions of work pieces are minimal due to concentration of heat in small zone.

8.1.5 Disadvantages of Tungsten Inert Gas Arc Welding (TIG/ GTAW):

- Low welding rate;
- Relatively expensive;
- Requires high level of operator’s skill.

8.1.6 Applications

- Welding aluminum, magnesium, copper, nickel and their alloys, carbon, alloy or Stainless steel, high temperature and hard surfacing alloys like zirconium, Titanium etc.
- Welding sheets metal and thinner sections.
- Precision welding in atomic energy, aircraft, chemical and instrument industries.
- Rocket motor chamber fabrications in launch vehicles.

8.2. GAS METAL ARC WELDING OR MIG WELDING

8.2.1 Introduction

Gas Metal Arc Welding (GMAW) is frequently referred to as MIG welding. MIG welding is a commonly used high deposition rate welding process. Wire is continuously fed from a spool. MIG welding is therefore referred to as a semiautomatic welding process.

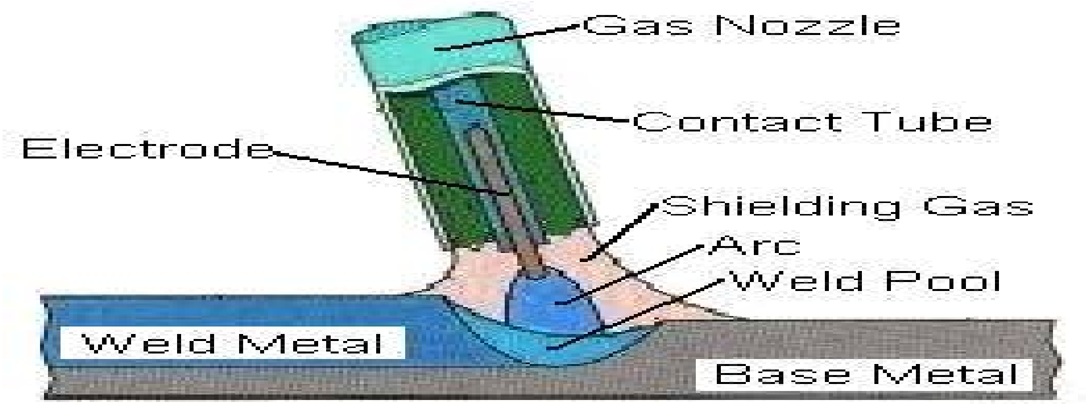


Fig 8.2: MIG Welding

8.2.2 Principal of operation

The basic technique for GMAW is quite simple, since the electrode is fed automatically through the torch. By contrast, in gas tungsten arc welding, the welder must handle a welding torch in one hand and a separate filler wire in the other, and in shielded metal arc welding, the operator must frequently chip off slag and change welding electrodes. GMAW requires only that the operator guide the welding gun with proper position and orientation along the area being welded. Keeping a consistent contact tip-to-work distance (the *stick out* distance) is important, because a long stick out distance can cause the electrode to overheat and will also waste shielding gas. Stick out distance varies for different GMAW weld processes and applications. For short-circuit transfer, the stick out is generally 1/4 inch to 1/2 inch, for spray transfer the stick out is generally 1/2 inch. The position of the end of the contact tip to the gas nozzle is related to the stick out distance and also varies with transfer type and application.

MIG is used to weld many materials, and different gases are used to form the arc depending on the materials to be welded together. An argon CO_2 blend is normally used to weld mild steel, aluminum, titanium, and alloy metals. Helium is used to weld mild steel and titanium in high speed process and also copper and stainless steel. Carbon dioxide is most often used to weld carbon and low alloy steels. Magnesium and cast iron are other metals commonly welded used the MIG process.

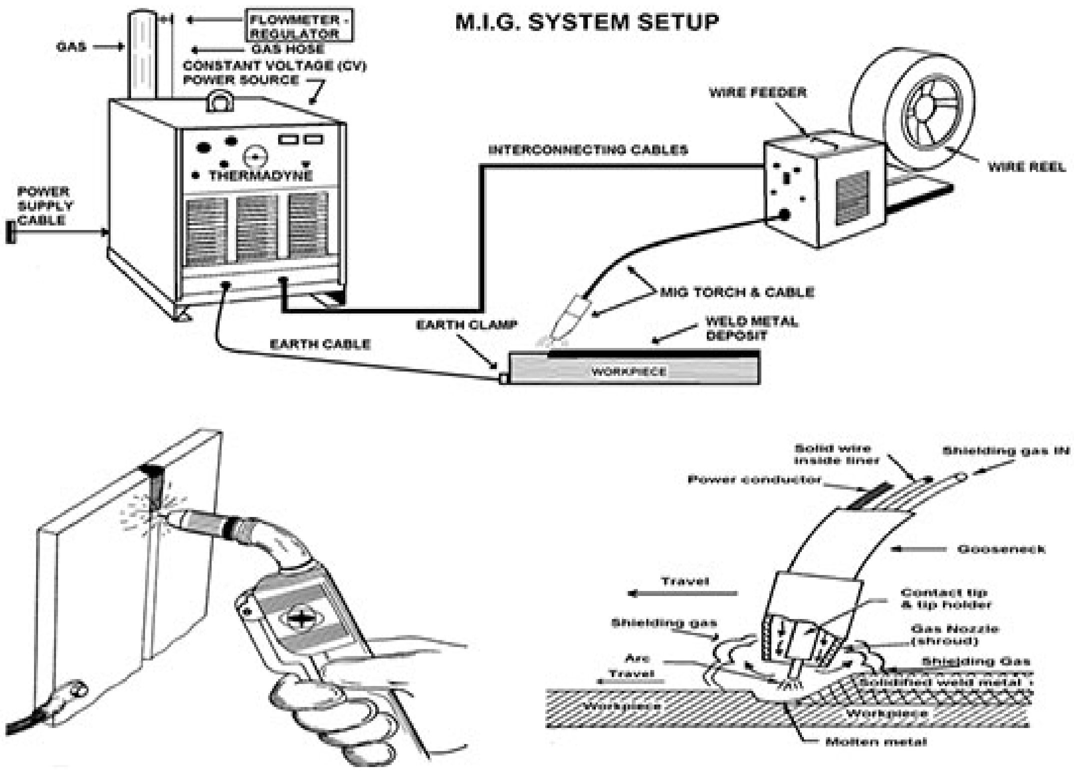


Fig 8.3 MIG Welding Setup

8.2.3 Advantages of Metal Inert Gas welding (MIG/GMAW)

- All position capability
- Higher deposition rates than SMAW
- less operator skill required
- Long welds can be made without starts and stops
- provides a uniform weld bead,
- produces a slag-free weld bead
- No flux is used.

8.2.4 Disadvantages of Metal Inert Gas welding (MIG/GMAW)

- Weld metal cooling rates are higher than with the processes that deposited slag Over the weld metal.
- Welding equipment is more complex, more costly and less portable.
- Since air drafts may disperse the shielded gas; MIG welding may not work well in out door welding applications.

8.2.5 Applications

- The process can be used for the welding of carbon, silicon , and low alloys Steels, stainless steels, aluminum ,magnesium, copper, nickel, and their alloys, Titanium etc.

- for welding tool steels and dies.
- for the manufacture of refrigerator parts.
- MIG welding has been used successfully in industries like aircraft,
- Automobiles , pressure vessels , and ship building.

8.3. Shielded metal arc welding OR (SMAW)

8.3.1 Introduction

Shielded metal arc welding (SMAW), also known as manual metal arc (MMA) welding or informally as stick welding, is a manual welding process that uses a consumable electrode coated in flux to lay the weld. An electric current, in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination.

8.3.2 Principal of operation

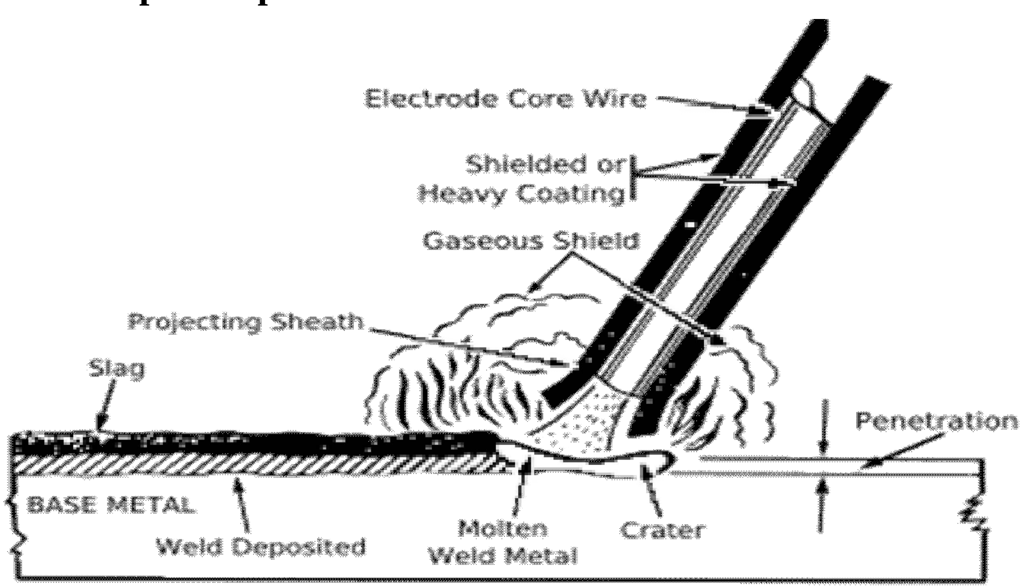


Fig 8.4: SMAW Welding Operation

To strike the electric arc, the electrode is brought into contact with the work piece by a very light touch with the electrode to the base metal then is pulled back slightly. This initiates the arc and thus the melting of the work piece and the consumable electrode, and causes droplets of the electrode to be passed from the electrode to the weld pool. As the electrode melts, the flux covering disintegrates, giving off shielding gases that protect the weld area from oxygen and other atmospheric gases. In addition, the flux provides molten slag which covers the filler metal as it travels from the electrode to the weld pool. Once part of the weld pool, the slag floats to the surface and protects the weld from contamination as it solidifies. Once hardened, it must be chipped away to reveal the finished weld. As welding progresses and the electrode melts, the welder must periodically stop welding to remove the remaining electrode stub and insert a new electrode into the electrode holder. In general, the operator factor, or the percentage of operator's time spent laying weld, is approximately 25%.

8.3.4 Equipment

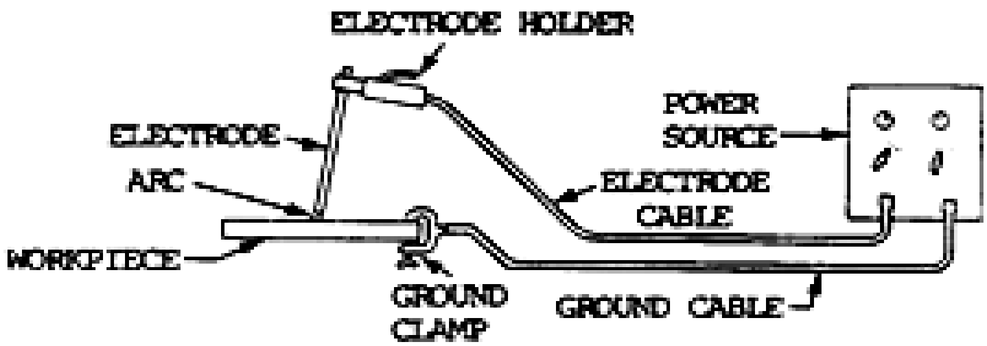


Fig.8.5 SMAW Welding Equipment

8.3.6 Experimental Set Up

Shielded metal arc welding equipment typically consists of a constant current welding power supply and an electrode, with an electrode holder, a ground clamp, and welding cables (also known as welding leads) connecting the two.

8.3.6.1 Power supply

Power source requirement may be DC or AC. Normally electrode is connected to positive terminal of DC power source. Sometime depending on the nature of flux AC can be used with single electrode wire or with multiple electrodes where one electrode may be connected to DC and other to AC if independent power sources are to be used.

The power supply used in SMAW has constant current output, ensuring that the current (and thus the heat) remains relatively constant, even if the arc distance and voltage change. This is important because most applications of SMAW are manual, requiring that an operator hold the torch. Maintaining a suitably steady arc distance is difficult if a constant voltage power source is used instead, since it can cause dramatic heat variations and make welding more difficult.

8.3.6.2 Electrode

Fig 8.6 Various welding electrodes and an electrode holder

The choice of electrode for SMAW depends on a number of factors, including the weld material, welding position and the desired weld properties. The electrode is coated in a metal mixture called flux, which gives off gases as it decomposes to prevent weld contamination, introduces deoxidizers to purify the weld, causes weld-protecting slag to form, improves the arc stability, and provides alloying elements to improve the weld quality

Electrodes coatings can consist of a number of different compounds, including retile, calcium fluoride, cellulose, and iron powder. Rutile electrodes, coated with 25%–45% TiO_2, are characterized by ease of use and good appearance of the resulting weld. However, they create welds with high hydrogen content, encouraging embitterment and cracking. Electrodes containing calcium fluoride (CaF_2), sometimes known as basic or low-hydrogen electrodes, are hygroscopic and must be stored in dry conditions. Finally, iron powder is a common coating additive, as it improves the productivity of the electrode, sometimes as much as doubling the yield

8.3.7 Advantages of Shielded Metal Arc Welding (SMAW):

- Simple, portable and inexpensive equipment;
- Wide variety of metals, welding positions and electrodes are applicable;
- Suitable for outdoor applications.

8.3.8 Disadvantages of Shielded Metal Arc Welding (SMAW):

- the process is discontinuous due to limited length of the electrodes;
- Weld may contain slag inclusions;
- Fumes make difficult the process control.

8.3.9 Applications

- Shielded metal arc welding is used both as a fabrication process and for maintenance and repair jobs.

- The process finds application in: Air receiver, tank, boiler and pressure vessel fabrications, ship building, Pipes and Penstock joining, Building and bridge construction, Automotive and aircraft industries etc.

Date:

PRACTICAL NO: 09

AIM: TO STUDY ABOUT NON CONVENTIONALWELDING PROCESS.

9.1 FORGE WELDING

Forge welding is an old technique that involves connecting pieces of metal using heat and force. The metal is generally heated with fire and the force is typically applied by hammering, but there are other methods. Forge welding is considered a core technique. It is still taught and used, but it is commonly replaced with more modern welding techniques. Forge welding is generally not considered difficult but can be dangerous. Some methods are complex and may require good concentration, memory, and safety skills. It is also beneficial to know the characteristics of the metal that is being welded and the heat source that is being used

9.1.1 Applications of Forge Welding

If made correctly, a forge welded joint has every quality of the original metal and is as good in strength as an arc or oxy acetylene welded joint.

Forge welding finds use in blacksmith shops, rail road shops and repair shops of general character. It is also used for making pipes from plates by rolling the plate to cylindrical form and making the longitudinal junction by forge welding. Strip/plate is pulled through dies to form a rolled cylinder, the long edges being butted together in the dies at the high temperature required to form a forge weld.

9.2 FRICTION WELDING

Friction welding (FW) is a class of solid-state welding processes that generates heat through mechanical friction between a moving work piece and a stationary component, with the addition of a lateral force called "upset" to plastically displace and fuse the materials. Technically, because no melt occurs, friction welding is not actually a welding process in the traditional sense, but a forging technique. However, due to the similarities between these techniques and traditional welding, the term has become common. Friction welding is used with metals and thermoplastics in a wide variety of aviation and automotive applications.

9.2.1 Benefits

The combination of fast joining times of the order of a few seconds, and the direct heat input at the weld interface, gives rise to relatively small heat affected zones. Friction welding techniques are generally melt-free, which offers the advantage of avoiding grain growth in engineered materials such as high-strength heat-treated steels. Another advantage is that the motion tends to "clean" the surface between the materials being welded, which means they can be joined without as much prior preparation. During the welding process, depending on the method being used, small pieces of the "plastic" metal will be forced out of the working mass in rippled sheets of metal known as "flash". It is believed that the flash carries away debris and dirt. Another advantage of friction welding is that it allows dissimilar materials to be joined. This is particularly useful in the aerospace field, where it is used to join lightweight aluminum stock to high-strength steels. Friction welding provides a "full strength" bond with no additional weight. Another common use for these sorts of bi-metal joins is in the nuclear industry, where copper-steel joints are common in the reactor cooling systems. Friction welding is also used with thermoplastics, which act in a fashion analogous to metals under heat and pressure. The heats and pressures used on these materials are much lower than on metals, but the technique can be used to join metals to plastics with the metal interface being machined.

9.3 ELECTRON BEAM WELDING

Electron Beam Welding (EBW) is a fusion joining process that produces a weld by impinging a beam of high energy electrons to heat the weld joint. Electrons are elementary atomic particles characterized by a negative charge and an extremely small mass. Raising electrons to a high energy state by accelerating them to roughly 30 to 70 percent of the speed of light provides the energy to heat the weld.

An EBW gun functions similarly to a TV picture tube. The major difference is that a TV picture tube continuously scans the surface of a luminescent screen using a low intensity electron beam to produce a picture. An EBW gun uses a high intensity electron beam to target a weld joint. The electron beam is always generated in a high vacuum. Although, high vacuum welding will provide maximum purity and high depth to width ratio welds.

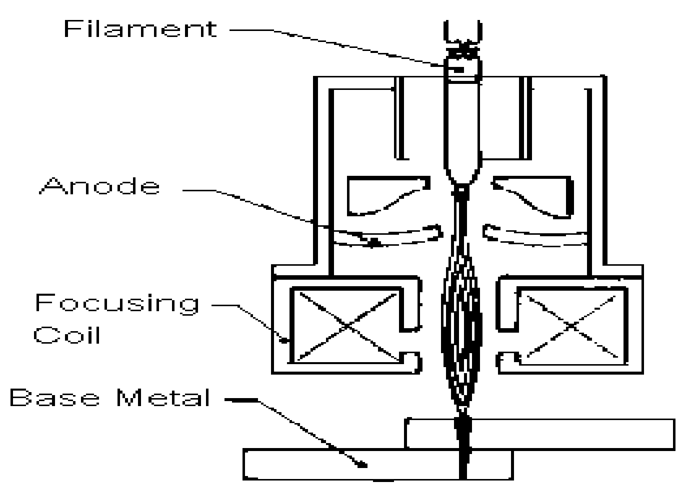


Fig 9.1 EBW

9.3.1 EBW Benefits

- Single pass welding of thick joints
- Hermetic seals of components retaining a vacuum
- Low distortion
- Low contamination in vacuum
- Weld zone is narrow
- Heat affected zone is narrow
- Dissimilar metal welds of some metals
- Uses no filler metal

9.3.2 EBW Limitations

- High equipment cost
- Work chamber size constraints
- Time delay when welding in vacuum
- High weld preparation costs
- X-rays produced during welding
- Rapid solidification rates can cause cracking in some materials

9.3.3 EBW Problems and Discontinuities

- Undercutting
- Porosity
- Cracking
- Under fill
- Lack of fusion
- Shrinkage voids
- Missed joints

9.4 LASER BEAM WELDING (LBW)

Laser Beam Welding (LBW) is a modern welding process; it is a high energy beam process that continues to expand into modern industries and new applications because of its many advantages like deep weld penetration and minimizing heat inputs. The turn by the manufacturers to automate the welding processes has also caused to the expansion in using high technology like the use of laser and computers to improve the product quality through more accurate control of welding processes. The focal spot is targeted on the work piece surface which will be welded. At the surface the large concentration of light energy is converted into thermal energy. The surface of the workpiece starts melting and progresses through it by surface conductance. For welding, the beam energy is maintained below the vaporization temperature of the work piece material, because hole drilling or cutting vaporization is required. Because the penetration of the workpiece depends on conducted heat, the thickness of the materials to be welded is generally less than 0.80 inches if the ideal metallurgical and physical characteristics of laser welding must be realized.

Fig 9 .2 LBW Machine

Concentrated energy produces melting and coalescence before a heat affected zone is developed and when the materials to be welded are thick and have high thermal conductivity like for example aluminum the advantage of having a minimal heat affected zone can be seriously affected. This combination results in photon oscillation within the cavity specific output beam energy patterns, these patterns are called Transverse Energy Modes (TEMs). The function of all laser beam welding processes whether they be gas (carbon dioxide, helium, neo, etc.) or other lasing sources is based on the principles of the excitation of atoms using intense light, electricity, chemicals, etc.. and the spontaneous and stimulated release of photons. The role of focusing lenses in this process is really important because it concentrates the beam energy into a focal spot as small as 0.005 in diameters or even less.

9.4.1 Industrial Applications

- Aerospace.
- Defense/military.
- Electronics.
- Research & development.
- Medical.
- Petrochemical refining.
- Communications & energy.

9.4.2 Advantages

- Deep and narrow welds can be done.
- Absence of distortion in welds created.
- Minimal heat affected zones in welds created.
- Excellent metallurgical quality will be established in welds.
- Ability to weld smaller, thinner components.
- Increased travel speeds.

9.5 DIFFUSION WELDING (DFW)

Diffusion welding (DFW) is a solid state welding process by which two dissimilar metals can be bonded together. Diffusion involves the migration of atoms across the joint, due to concentration gradients. The two materials are pressed together at an elevated temperature usually between 50 and 70% of the melting point. The pressure is used to relieve the void that may occur due to the different surface topographies.

Fig 9.3 DFW Machine

DFW is usually used on sheet metal structures. Typical materials that are welded include titanium, beryllium, and zirconium. It is usually used on low volume workpieces mainly for aerospace, nuclear, and electronics industries. The equipment cost is considerably high and is figured by the area that is being diffusion-bonded. In many military aircraft diffusion bonding will help to allow for the conservation of expensive strategic materials and the reduction of manufacturing costs. Some aircraft have over 100 diffusion-bonded parts, including; fuselages, outboard and inboard actuator fittings, landing gear trunnions, and nacelle frames.

9.6 THERMIT WELDING

Thermit welding is an exothermic welding process that uses thermit to melt metal, which is poured between two workpieces to form a welded joint. It was developed by Hans Goldschmidt around 1895.

9.6.1 Overview

Commonly the reacting composition is 5 parts iron oxide red (rust) powder and 3 parts aluminium powder by weight, ignited at high temperatures. A strongly exothermic (heat-generating) reaction occurs that produces through reduction and oxidation a white hot mass of molten iron and a slag of refractory aluminium oxide. The molten iron is the actual welding material; the aluminium oxide is much less dense than the liquid iron and so floats to the top of the reaction, so the set-up for welding must take into account that the actual welding material is on the bottom and covered by floating slag. Thermit welding is widely used to weld railroad rails. The weld quality of chemically pure Thermit is low due to the low heat penetration into the joining metals and the very low carbon and alloy content in the nearly pure molten iron. To obtain high-quality railroad welds, the ends of the rails being Thermit welded are usually preheated with a torch to induce a good fusion with the working pieces of metal. Because the thermit reaction yields relatively pure iron, not the much stronger steel, some small pellets or rods of high-carbon alloying metal are included in the thermit mix; these alloying materials melt from the heat of the thermit reaction and mix into the weld metal.

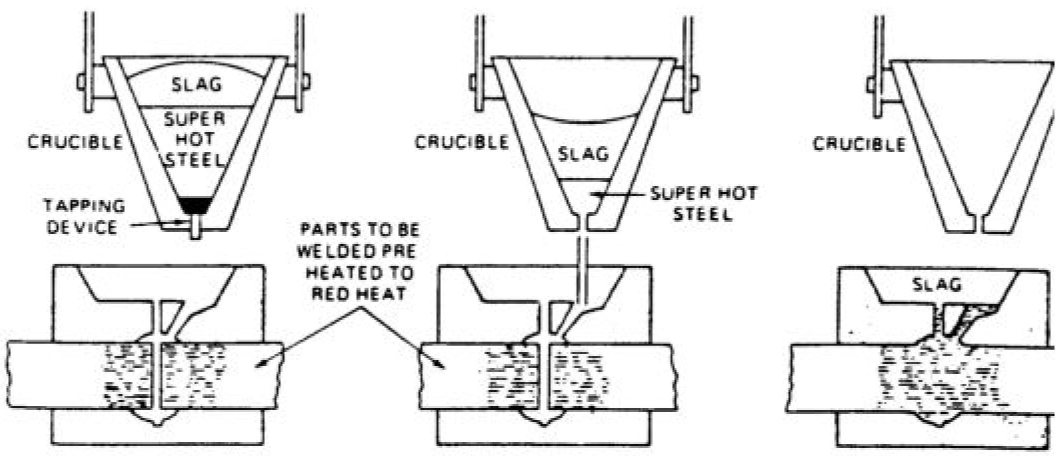


Fig 9.4 Thermit welding Process Sketch

Thermit welding (TW) (sometimes called thermit welding) is a process which joins metals by heating them with super heated liquid metal from a chemical reaction between a metal oxide and aluminum or other reducing agent, with or without the application of pressure. Filler metal is obtained from the liquid metal.

The heat for welding is obtained from an exothermic reaction or chemical change between iron oxide and aluminum. This reaction is shown by the following formula:

$$8A1 + 3fe_30_4 = 9FE + 4A1_20_3 + Heat$$

The temperature resulting from this reaction is approximately 4500°F (2482°C).

9.6.2 THERMIT WELDING EQUIPMENT (TW)

General. Thermit material is a mechanical mixture of metallic aluminum and processed iron oxide. Molten steel is produced by the Thermit reaction in a magnesite-lined crucible. At the bottom of the crucible, a magnesite stone is burned, into which a magnesite stone thimble is fitted. This thimble provides a passage through which the molten steel is discharged into the mold. The hole through the thimble is plugged with a tapping pin, which is covered with a fire-resistant washer and refractory sand. The crucible is charged by placing the correct quantity of thoroughly mixed Thermit material in it. In preparing the joint for Thermit welding, the parts to be welded must be cleaned, alined, and held firmly in place. If necessary, metal is removed from the joint to permit a free flow of the Thermit metal into the joint. A wax pattern is then made around the joint in the size and shape of the intended weld. A mold made of refractory sand is built around the wax pattern and joint to hold the molten metal after it is poured. The sand mold is then heated to melt out the wax and dry the mold. The mold should be properly vented to permit the escape of gases and to allow the proper distribution of the Thermit metal at the joint. A Thermit welding crucible and mold is shown in figure .

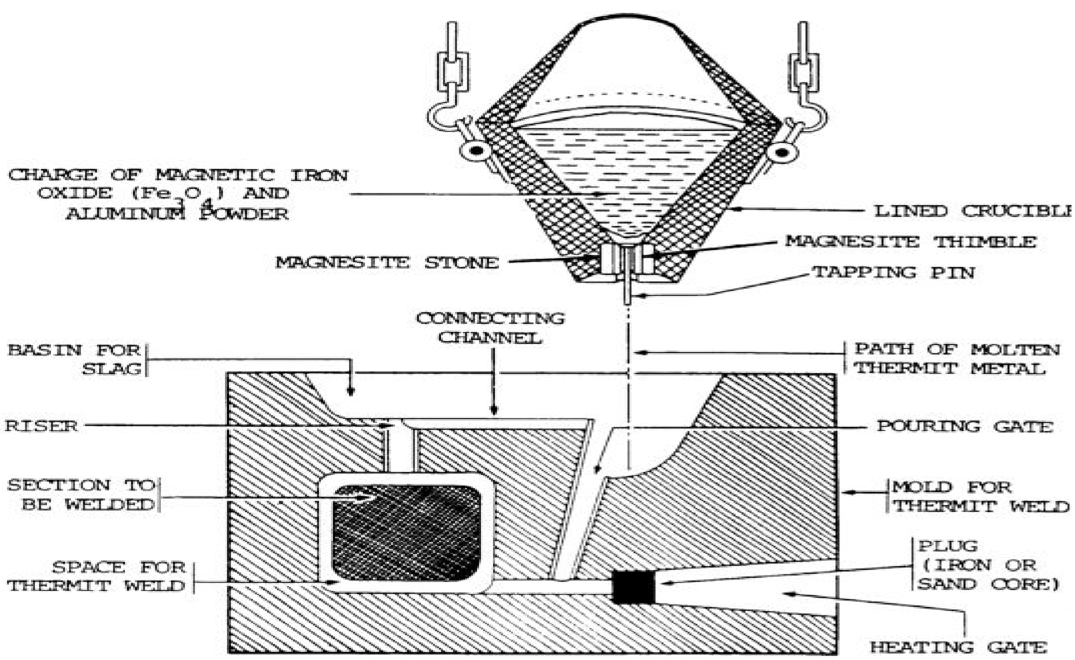


Fig 9.6 Thermit Welding Equipment

9.6.3 THERMIT WELDING USE (TW)

Thermit Welding has been successfully used for many years in the Railroad industry to weld rails together. Equipment similar to the above sketches is set up at the welding joint. After the process has been completed and the weld has cooled enough, the thermit fixture is removed. The slag is chipped off and the excess weld is ground off to conform with the shape of the rails.

9.7 ELECTRO SLAG WELDING

Electro slag welding is a very efficient, single pass process carried out in the vertical or near vertical position and used for joining steel plates/sections in thicknesses of 25mm and above. It was developed by the Paton Institute in the Ukraine in the early 1950s and superseded the very high current submerged arc process for making longitudinal welds in thick-walled pressure vessels. Filler wire, which is also the current carrier, is then fed into this cavity, initially striking an arc through a small amount of flux. Additional flux is added which melts forming a flux bath which rises and extinguishes the arc. The added wire then melts into this bath sinking to the bottom before solidifying to form the weld. For thick sections, additional wires may be added and an even distribution of weld metal is achieved by oscillating the wires across the joint. As welding progresses, both the wire feed mechanism and the copper shoes are moved progressively upwards until the top of the weld is reached. See Fig 9.7

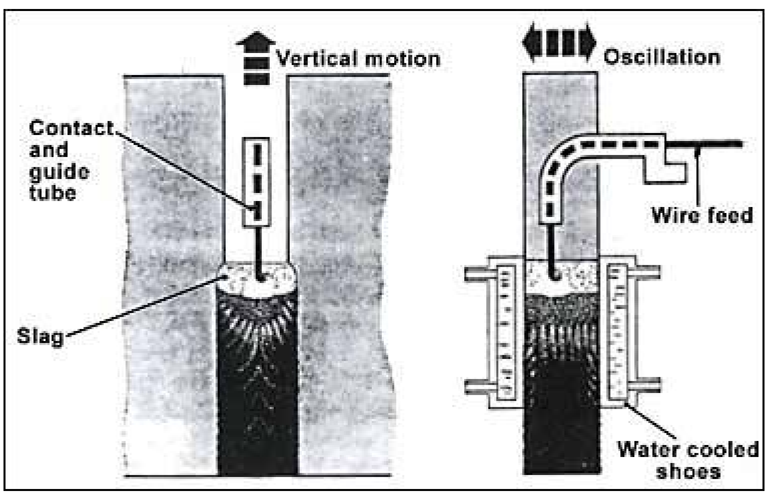


Fig 9.7 Electro Slag Welding

The consumable guide variant of the process uses a much simpler set-up and equipment arrangement which does not require the wire feed mechanism to climb. In this case, the wire is delivered to the weld pool down a consumable, thick-walled tube which extends from the top of the joint to the weld pool. Support for the molten bath is provided by two pairs of copper shoes which are moved upwards, leapfrogging each other as welding progresses. The tubular guides can be further supplemented by additional consumable plates attached to the tube. Generally, as the thickness of plate increases, the number of wires/guides increases, approximately in the ratio of one wire per 50mm of thickness.

9.7.1 Benefits

The principal benefits of the process are:

- speed of joint completion; typically 1 hour per metre of seam, irrespective of thickness
- lack of angular distortion
- lateral angular distortion limited to 3mm per metre of weld
- high quality welds produced
- simple joint preparation, i.e. flame-cut square edge

Date:

PRACTICAL NO: 10

AIM: STUDY OF METAL WORKING OPERATIONS AND DETAIL STUDY OF HOT AND COLD METAL WORKING OPERATION

10.1 INTRODUCTION

Metal working processes are processes used to produce wrought products. These product include angles, channels, I-beams, round, square and hexagonal, bar stock, sheet metal, forging, tubes, pipe and extrusion sections. they are produced by squeezing or application of pressure in the hot or cold state. Mechanical working of a metal is essentially a plastic deformation process done to change dimensions, shape, properties or surface condition by applying mechanical pressure.

10.2 ELASTIC AND PLASTIC DEFORMATION

When a sufficient load is applied to a metal or other structural material, it will cause the material to change shape. This change in shape is called deformation. When the stress is sufficient to permanently deform the metal, it is called plastic deformation. Plastic deformation involves the breaking of a limited number of atomic bonds by the movement of dislocations. A slip band appears as a single line under the microscope, but it is in fact made up of closely spaced parallel slip planes.

10.3 TENSILE PROPERTIES

Tensile properties indicate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, tensile strength, yield point, yield strength and other tensile properties

10.4 HOT WORKING

A process is defined as hot working if it takes place when the workpiece is above the recrystallization temperature.

10.4.1 Hot Working Advantages

- Hardness and ductility of metal is not changed.
- Porosity is eliminated.
- Structure is improved by reforming smaller crystals.
- Large shape changes are possible without ruptures.
- Smaller, faster acting machines.
- Impurities are broken up and distributed throughout material.
- Surfaces need not be clean and scale free.

10.4.2 Hot Working Advantages

- Oxide scale produced on surface.
- Close dimensional tolerances are difficult.
- Carbon lost from surface layer (creating a weak surface)

10.5 COLD WORKING

Cold working takes place below the recrystallization temperature, and therefore is fundamentally different at the atomic level with effects up to the macroscopic level.

10.5.1 Advantages of Cold Working

- No heating required.
- Close dimensional tolerances possible.
- Surface finishes are better.
- Strength, hardness, and directional properties are improved.

10.5.2 Disadvantages of Cold Working

- Produces stresses that sometimes have to be removed by heat treating.
- Higher forces and heavier equipment needed.
- Metal must be clean and scale free.

10.6 EXTRUSION

10.6.1 Introduction

- Extrusion is a process used to create objects of a fixed cross-sectional profile. A material is pushed or drawn through a die of the desired cross-section.
- The two main advantages of this process over other manufacturing processes are its ability to create very complex cross-sections and work materials that are brittle, because the material only encounters compressive and shear stresses.

- It also forms finished parts with an excellent surface finish.
- Hollow cavities within extruded material cannot be produced using a simple flat extrusion die, because there would be no way to support the center barrier of the die. Instead, the die assumes the shape of a block with depth, beginning first with a shape profile that supports the center section.
- The process begins by heating the stock material. It is then loaded into the container in the press. A dummy block is placed behind it where the ram then presses on the material to push it out of the die. Afterward the extrusion is stretched in order to straighten it.
- The extrusion ratio is defined as the starting cross-sectional area divided by the cross-sectional area of the final extrusion.
- One of the main advantages of the extrusion process is that this ratio can be very large while still producing quality parts.

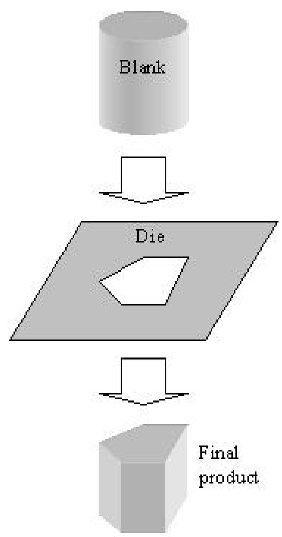


Fig 10.1 Extrusion of a round blank through a die.

10.6.2 Hot extrusion

- Hot extrusion is a hot working process, which means it is done above the material's recrystallization temperature to keep the material from work hardening and to make it easier to push the material through the die.
- Most hot extrusions are done on horizontal hydraulic presses that range from 230 to 11,000 metric tons . Pressures range from 30 to 700 MPa
- oil or graphite is used for lower temperature extrusions, or glass powder for higher temperature extrusions.
- The biggest disadvantage of this process is its cost for machinery and its upkeep.

10.6.3 Direct extrusion

- Direct extrusion, also known as forward extrusion, is the most common extrusion process.
- It works by placing the billet in a heavy walled container.

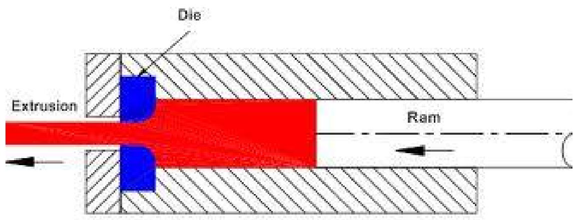


Fig 10.2 Direct extrusion

- The billet is pushed through the die by a ram or screw. There is a reusable dummy block between the ram and the billet to keep them separated.

10.6.4 Indirect extrusion

In indirect extrusion, also known as backwards extrusion, the billet and container move together while the die is stationary. The die is held in place by a "stem" which has to be longer than the container length. The maximum length of the extrusion is ultimately dictated by the column strength of the stem.

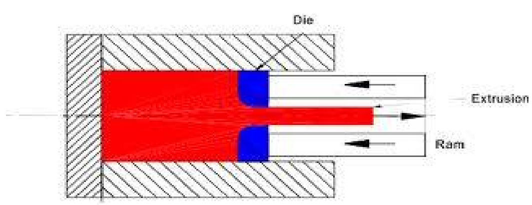


Fig 10.3: Indirect Extrusion

10.6.5 Cold extrusion

- Cold extrusion is done at room temperature or near room temperature.
- The advantages of this over hot extrusion are the lack of oxidation, higher strength due to cold working, closer tolerances, good surface finish, and fast extrusion speeds if the material is subject to hot shortness.

10.6.6 Hydrostatic extrusion

- In the hydrostatic extrusion process the billet is completely surrounded by a pressurized liquid, except where the billet contacts the die.

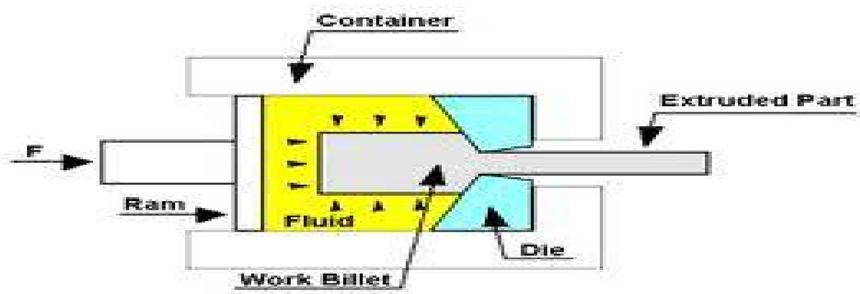


Fig 10.4: Hydrostatic extrusion

- This process can be done hot, warm, or cold, however the temperature is limited by the stability of the fluid used.
- The process must be carried out in a sealed cylinder to contain the hydrostatic medium.

10.6.7 Warm extrusion

- Warm extrusion is done above room temperature, but below the recrystallization temperature of the material the temperatures ranges from 424 to 975 °C.
- It is usually used to achieve the proper balance of required forces, ductility and final extrusion properties.

10.6.8 Extrusion defects

- **Surface cracking** - When the surface of an extrusion splits. This is often caused by the extrusion temperature, friction, or speed being too high. It can also happen at lower temperatures if the extruded product temporarily sticks to the die.
- Internal cracking - When the center of the extrusion develops cracks or voids. These cracks are attributed to a state of hydrostatic tensile stress at the centerline in the deformation zone in the die.
- Surface lines - When there are lines visible on the surface of the extruded profile. This depends heavily on the quality of the die production and how well the die is maintained, as some residues of the material extruded can stick to the die surface and produce the embossed lines.

10.7 FORGING

10.7.1 INTRODUCTION

In modern times, industrial forging is done either with presses or with hammers powered by compressed air, electricity, hydraulics or steam. These hammers may have reciprocating weights in the thousands of pounds. Smaller power hammers, 500 lb (230 kg) or less reciprocating weight, and hydraulic presses are common in art smithies as well. Some steam hammers remain in use, but they became obsolete with the availability of the other, more convenient, power sources.

10.7.2 Processes

There are many different kinds of forging processes available, however they can be grouped into three main classes:

- Drawn out: length increases, cross-section decreases
- Upset: Length decreases, cross-section increases
- Squeezed in closed compression dies: produces multidirectional flow

10.7.3 Common forging processes include:

Drop forging

i. Open die drop forging
ii. Close die drop forging

Press forging

i. Automatic hot forging
ii. Upsetting.

10.7.4 Drop forging

There are two types of drop forging:

i. Open-die drop forging
ii. Closed-die drop forging.

- As the names imply, the difference is in the shape of the die,
- Open die drop forging does not fully enclosing the workpiece,
- Close die drop forging does fully enclosing the workpiece,
- The similarity between the two is that a hammer is raised up and then dropped onto the workpiece to deform it according to the shape of the die.

10.7.4.1 Open die drop forging

- Open-die forging is also known as *smith forging*. In open-die forging, a hammer strikes and deforms the workpiece, which is placed on a stationary anvil

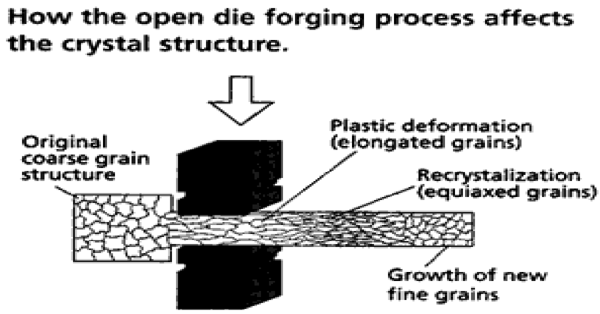


Fig 10.5 Open die forging

- The operator needs to orient and position the workpiece to get the desired shape. The dies are usually flat in shape, but some have a specially shaped surface for specialized operations. For example, a die may have a round, concave, or convex surface or be a tool to form holes or be a cut-off tool.

10.7.4.2 Closed die drop forging

Closed-die forging is also called Impression-die forging. In impression-die work metal is placed in a die resembling a mold, which is attached to the anvil. Usually the hammer die is shaped as well. The hammer is then dropped on the work piece, causing the metal to flow and fill the die cavities. The hammer is generally in contact with the work piece on the scale of milliseconds.

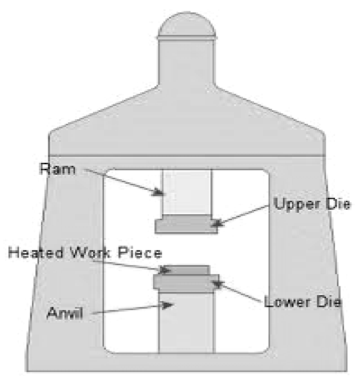


Fig 10.6 Close dies drop forging

10.7.5 Press forging

- Press forging works slowly by applying continuous pressure or force.
- which differs from the near-instantaneous impact of drop-hammer forging. The amount of time the dies are in contact with the workpiece is measured in seconds The press forging operation can be done either cold or hot.

10.7.6 Upset forging

- Upset forging increases the diameter of the workpiece by compressing its length. Based on number of pieces produced this is the most widely used forging process.

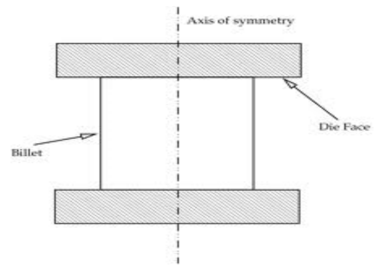


Figure 10.7 Upset forging

- A few examples of common parts produced using the upset forging process are engine valves, couplings, bolts, screws, and other fasteners.
- Upset forging is usually done in special high speed machines called crank presses, but upsetting can also be done in a vertical crank press or a hydraulic press. .
- The initial workpiece is usually wire or rod, but some machines can accept bars up to 25 cm in diameter and a capacity of over 1000 tons.

10.8 ROLLING

10.8.1 Introduction

Rolling is classified according to the temperature of the metal rolled. If the temperature of the metal is above its recrystallization temperature, then the process is termed as **hot rolling**. If the temperature of the metal is below its recrystallization temperature, the process is termed as **cold rolling**. In terms of usage, hot rolling processes more tonnage than any other manufacturing process and cold rolling processes the most tonnage out of all cold working processes.

10.8.2 Type of Rolling Processes

- Flat Rolling
- Foil Rolling
- Ring rolling
- Roll Bending
- Roll Forming
- Controlled Rolling

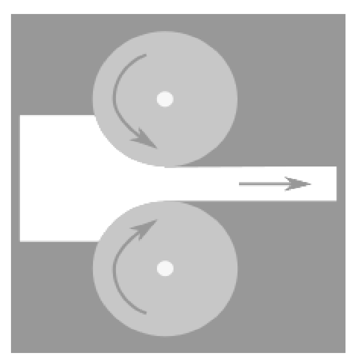


Fig. 10.8 Rolling

10.8.2.1 Flat rolling

Flat rolling is the most basic form of rolling with the starting and ending material having a rectangular cross-section

10.8.2.1 Foil rolling

Foil rolling is a specialized type of flat rolling, specifically used to produce foil, which is sheet metal with a thickness less than 200 µm (0.0079 in).

10.8.2.2 Ring rolling

Ring rolling is a specialized type of hot rolling that increases the diameter of a ring.

10.8.2.3 Roll bending

Roll bending produces a cylindrical shaped product from plate or steel metal.

10.8.2.4 Hot rolling

Hot rolling is a metalworking process that occurs above the recrystallization temperature of the material. Hot rolling is used mainly to produce sheet metal or simple cross sections, such as rail tracks.

10.8.2.5 Cold rolling

Cold rolling occurs with the metal below its recrystallization Temperature.

Date:

PRACTICAL NO: 11

AIM: STUDY OF PLASTIC TECHNOLOGY AND DETAIL STUDY OF PLASTIC PART MANUFACTURING PROCESS.

11.1 INTRODUCTION

Plastic belongs to the family of organic materials. Organic materials are those materials which derived directly from carbon. They consist of carbon chemically combined with hydrogen, oxygen and other non-metallic substances, and their structures, in most cases, are fairly complex. The large and diverse organic group includes the natural materials: wood, coal, petroleum, natural rubber, animal fibers and food, which have biological origins. Synthetics include the large group of solvents, adhesives, synthetic fibers, rubbers, plastics, explosives, lubricants, yes, soaps and cutting oils etc. which have no biological origins. Of them, plastic and synthetic rubbers are termed as "polymers".

11.2 POLYMERS

The term "polymer" is derived from the two Greek words: poly, meaning "many", and meros meaning "parts" or "units". Thus polymers are composed of a large number of repeating units (small molecules) called monomers. A polymer is, therefore, made up of thousands of monomers joined together to form a large molecules of colloidal dimension, called macromolecules. The unique characteristic of a polymer is that each molecule is either a long chain or network of repeating units all covalently bonded together. Polymer molecular materials and are generally non-crystalline solids at ordinary temperature, but pass through a viscous stage in course of their formation when, shaping is readily carried out.

The most common polymers are those made from compounds of carbon, but polymers can also be made from inorganic chemicals such as silicates and silicones. The naturally occurring polymer include: protein, cellulose, resins, starch, shellac and lignin. They are commonly found in leather, fur, wool, cotton, silk, rubber, rope, wood, and many others. There are also synthetic polymers such as polyethylene, polystyrene, nylon, Terylene,etc..

11.3 POLYMERIZATION

The process of linking together of monomers, that is, of obtaining macromolecules is called "polymerization". It can be achieved by one of the two processing techniques:

i. Addition polymerization:

ii. Condense polymerization;

11.4 PROPERTIES OF PLASTIC

Their great variety of physico- chemical and mechanical properties, and ease with they can be made into various articles have found plastic their wide application in the engineering and other industries.

- Their comparatively low density (1 to 2 g/cm3). Substantial mechanical strength, higher strength – to-weight ratio and high anti friction properties have enabled plastic to be efficiently used as substitute for metals, for example, non ferrous metals and alloys- bronze, lead, tin, Babbitt etc., for making bearing.
- With certain special properties (silent operation, corrosion resistance etc.,), plastic can sometime replace ferrous metals.
- From the production point of view, their main advantage is their relative low melting point and their ability to flow into a mould.
- Simple processing to obtain machine parts. Generally there is only one production operation required to convert the chemically manufactured plastic into a finished article.
- In mass production, plastic substitute for ferrous metals allow the production cost to be required by factor of 1.5 to 3.5 and for non- ferrous metals by a factor 5 to 20.
- Good damping capacity and good surface finish of the product.
- the high heat and electric insulation of plastics permits them to be applied in the radio and electrical engineering industries as dielectrics and as substitute for porcelain, ebonite, shellac, mica, natural rubber, etc..

11.5 PLASTICS

Polymer can be divided into three broad divisions: plastics, fibers, and elastomers. Synthetic resins are usually referred to as plastics. Plastic derive their name from the fact that in a certain phase of their manufacture, they are present in a plastic stage (that is, acquire plasticity), which makes it possible to impart any desire shape to the product. Plastics fall into a category known chemically as high polymers.

Thus, “plastics” is a term applied to compositions consisting of a mixture of high molecular compounds (synthetic polymers) and fillers, plasticizers, stains and pigments, lubricating and other substances. Some of the plastic can contain nothing but resin (for instance, polyethylene, polystyrene).

11.6 TYPES OF PLASTICS

Plastics are classified on the broad basis of whether heat causes them to set (thermosetting) or causes them to soften and melt (thermoplastic).

11.6.1 THERMOSETTING PLASTICS

This plastic undergoes a number of chemical changes on heating and cure to infusible and practically insoluble articles. The chemical change is not reversible thermosetting plastics do not soften on reheating and can not be reworked. They rather become harder due to completion of any left-over polymerization reaction. Eventually, at high temperatures, the useful properties of the plastic get destroyed. This is called degradation. The commonest thermosetting plastics are: alkyds, epoxides, polyesters, phenolics and urea.

11.6.2 THERMOPLASTIC PLASTICS

These plastic soften under heat, harden on cooling, and can be resoften under heat. Thus, they retain their fusibility, solubility, and capability of being repeatedly shape. The mechanical properties of these plastics are rather sensitive to temperature and to sunlight and exposure to temperature may cause thermal degradation. Common thermoplastic plastics are: acrylics, poly tetra fluoro ethylene (PTFE), polyvinyl chlorides (PVC), nylons, polyethylene, polypropylene, polystyrene etc,

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11.6.3 PLASTICS MOLDING PROCESSES

There are various methods of producing components from the plastics materials which are supplied in the granular, power and other forms.

Various plastics molding processes discussed in this chapter are:

1. Compression molding.
2. Transfer molding.
3. Injection molding.
4. Blow molding.
5. Extrusion molding.
6. Slush moulding.
7. Calendaring.

11.6.3.1 Compression moulding

In compression molding, a material normally in power or perform shape , is loaded directly into the hot die cavity, pressure from 150 to 700 kg/cm2 is applied , held for a curing period and then the finished part is ejected. Press stays closed while the heat cures hardens and sets the plastic part. The time for curing depends upon the design, small thin-wall pieces require as little as 20 seconds. The curing temperature is to the order of 200 C. Compression molding is largely utilized for molding thermosetting materials.

A measured amount of power plastics is placed in the power female cavity continuously heated by steams or electricity. The movable bolster is raised so that the female mold portion contacts the male die which also is heated. The combined effect of temperature and pressure causes the plastic to flow into the mold cavity

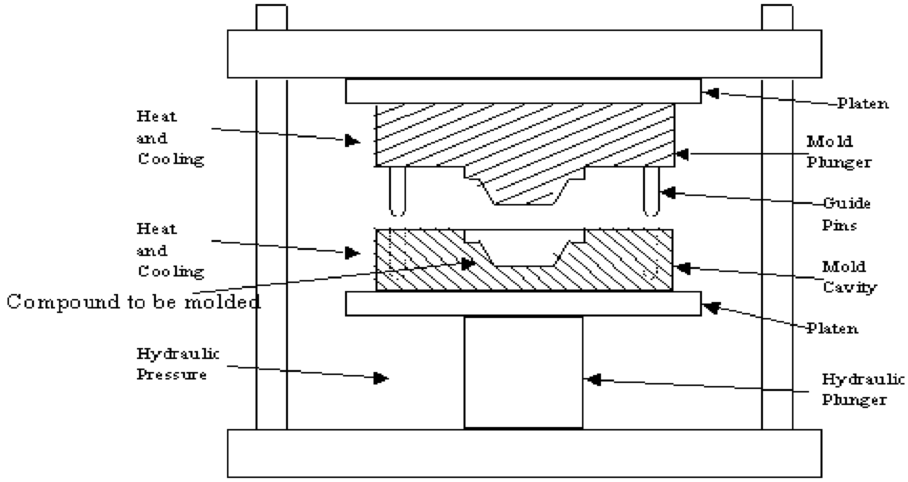

Fig.11.1 compression moulding

11.6.3.2 Transfer molding

Transfer molding was developed largely to avoid the disadvantages found which compression molding.

- Transfer molding can make intricate or quite accurate parts than possible with compression molding.
- Transfer molding permits the use of intricate inserts and slender cores not practicable with compression molding method.
- Transfer molding produces components of better quality and at economical rates.

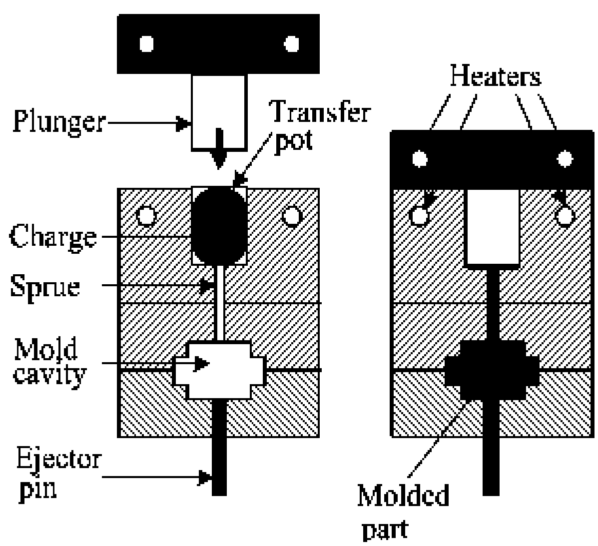

Fig.11.2 Transfer molding

The plastic in the power or pellet form is placed in the transfer chamber. Under heat and pressure of approximately 1000 kg/cm2, it is transferred or injected into the closed mold cavity. The curing time required after transfer is just one-third of the compression molding curing time. Another method known as jet molding brings the transfer method closer or injection molding as used for thermoplastics. The plastic materials is forced by ram or screw through a heated jet where it become soft before entering the closed die. Good flowing materials with a long flow period are desirable.

11.6.3.3. Blow molding

Blow molding has been used for making plastic bottles, toys, doll bodies and many other items. The blow molding commences with the extrusion of the tubular pieces of plastic, known as parison, which is transferred to the two piece mold.

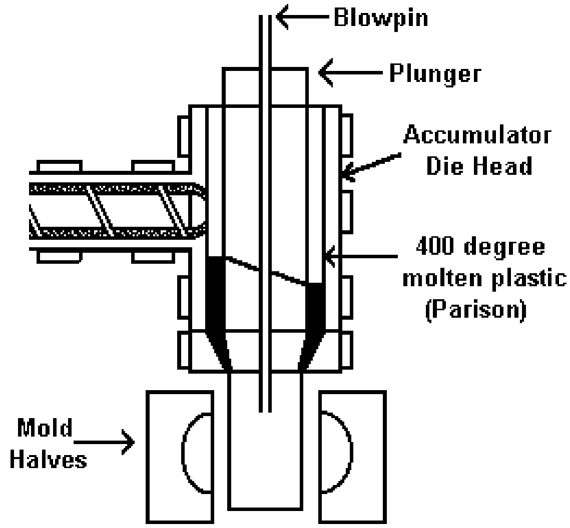

Fig.11.3 Blow molding

11.6.3.4 Injection moulding

An important industrial method of producing articles of thermoplastics is injection moulding. The moulding material is loaded into a hopper from which it is transferred to a heating section by a feeding device, where the temperature is raised to 150 c to 370 c. and pressure is built up. The material melts and is forced by an injection ram at high pressure through a nozzle and sprue into a closed mould which forms the parts. The mould is in at least two sections, so that it may be spilt in order to eject the finished component. For the process to be competitive the mould must be fairly cool and consequently the mold must be cooled by circulating water. Injection moulding machines have a high production capacity: some can produce from 12 to 16 thousand parts per shift. This method is suitable for making parts within complex threads and intricate shapes, thin-walled parts etc.

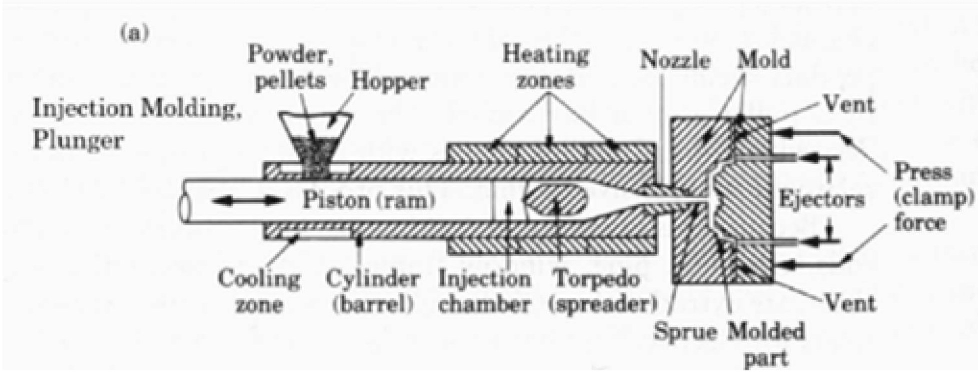

Fig.11.4 Injection moulding

The limitation of the process is:- Equipment of cylinder and die should be non-corrosive. Also, reliable temperature controls are essential. Injection moulding machines range in size from an injection capacity of 12,000 mm3 to 2,200,000 mm3. The locking forces are applied to be the mould usually by hydraulic means, and may vary from 0.1 MN to 8.0 MN or even more. The injection pressure may range from 100 MPa to 150 MPa.

11.6.3.5 EXTRUTION PROCESS :-

The extrusion process, in many cases produces material in an intermediate form for subsequent reprocessing to its final component form. The process is the same as for metals, that is, the expulsion of material through a die of the required cross-section. Simplicity in operation and a controlled pressure which can be virtually high as required. If the polymer can be plasticized by pressure, then the ram extruder is advantageous in view of its simplicity. But for plastics which require heat, the separate pre-processing mat be regarding as a draw back. Another major drawback of this type of machine is the reciprocating action of ram which is time wasting since the ram must be withdrawn after its power stroke and a new dolly of material inserted in the container. Also, with many materials, the die office must be cleaned between each working stroke.

Nowadays, the ram machine is mainly used for “wet extrusion” that is for extruding plastics which have been softened by the addition of solvents. Solvent has to be removed.

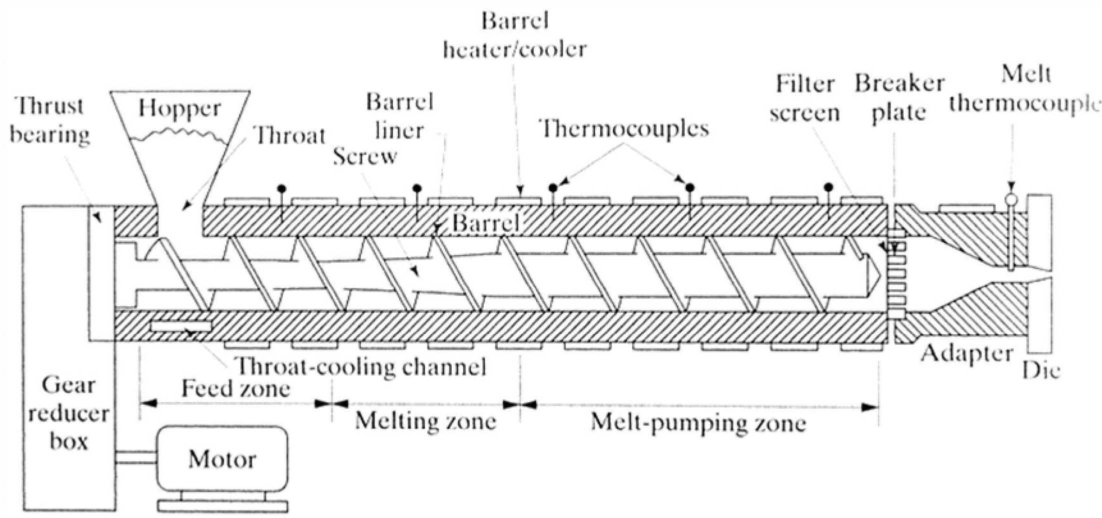

Fig.11.5 Extrusion Process

For extrusion of plastics, single-screw machine has completely replaced the ram type machine. There are two basic types of screw extruders: the melt extruder and the plasticizing extruder. In the formal, the material is delivered to the extruder already melted and thus the function of the extruder is merely to push the material to the die and through the orifice. In the plasticizing extruder the material is in the form of granules or particles and so the extrude has to compress and work it until it melts before delivering it, under pressure, to the die orifice.

11.6.3.6 Slush moulding

Slush moulding is an excellent method for producing open-end objects. It is an inverse process of dipping, in which the inside of the mould is coated whereas the outside is coated in this case. This process is followed for the production of a wide variety of articles this paper will focus the use of TPU'S in slush moulding. For making skins for automotive inside parts such as instruments panels,consoles,glove door boxes, door panels,etc

The main components of the process are:

- The mould
- The powder box
- The movement: rotation, vibration change of position

It is a process that also involves the application of plastisol to a mould, but in this case the piece is gelated in hot bath, temperature around 200-230 oC. The time spent inside the hot bath depends on the required thickness. The remaining non-gelated plastisol is extracted, and gelation of PVC in the mould is completed. The piece is finally demolded. Applications for this process include automotive pieces and PVC masks.

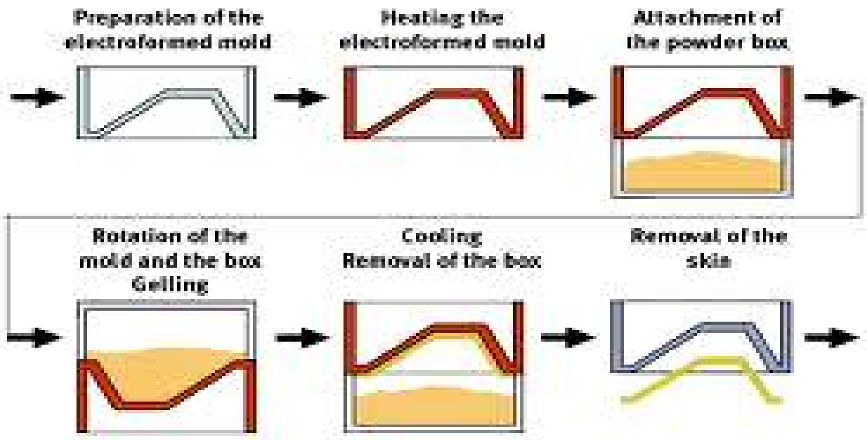

Fig.11.6 slush moulding

Date :

PRACTICAL NO:12

AIM: STUDY OF SURFACE FINISHING PROCESSES IN DETAIL.

12.1 INTRODUCTION

As the name of this group of abrasive operations suggests, their objective is to achieve superior surface finish up to mirror-like finishing and very close dimensional precision. The finishing operations are assigned as the last operations in the single part production cycle usually after the conventional or abrasive machining operations, but also after net shape processes such as powder metallurgy, cold flashless forging, etc.

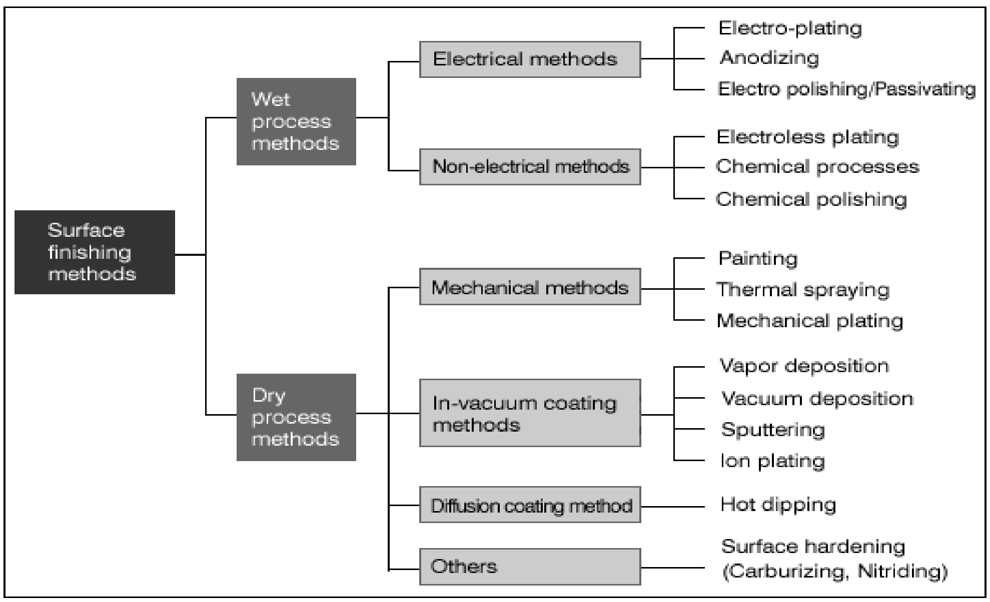

Fig 12.1 Different type of surface finishing method

The finishing processes discussed in this section include:

- Honing.
- Lapping.
- Super finishing.
- Polishing.
- Buffing.

The typical surface finishes for these operations are presented in the figure. Also presented for comparison are surface roughness values for fine grit size grinding.

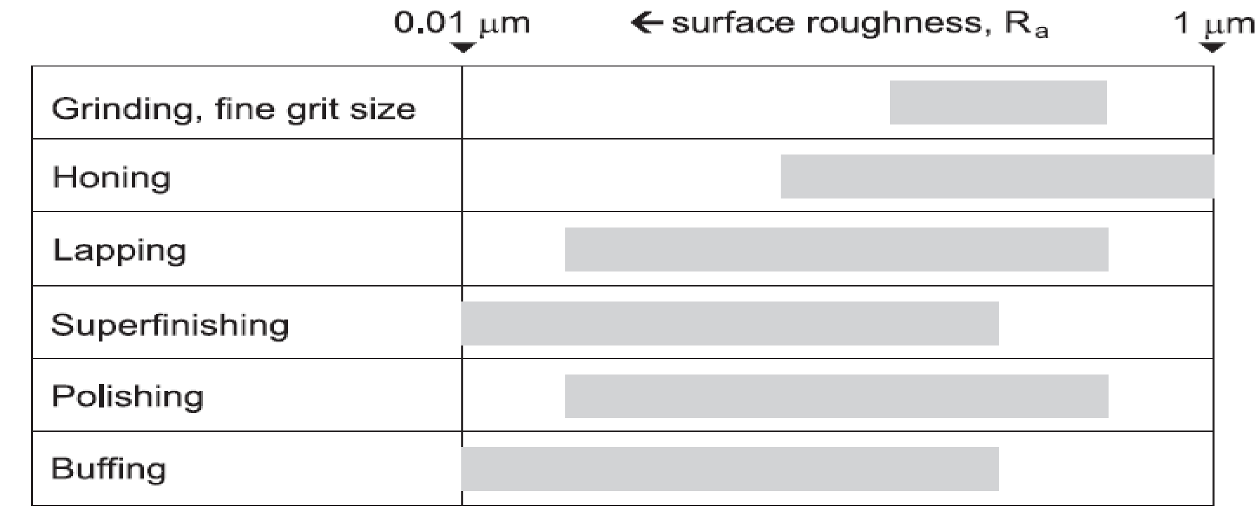

Figure 12.2 Surface roughness diagrams

Honing is an abrasive machining process that produces a precision surface on a metal workpiece by scrubbing an abrasive stone against it along a controlled path. Honing is primarily used to improve the geometric form of a surface, but may also improve the surface texture. Typical applications are the finishing of cylinders for internal combustion engines, air bearing spindles and gears. Types of hone are many and various but all consist of one or more abrasive stones that are held under pressure against the surface they are working on. In everyday use, honing steel is used to hone knives, especially kitchen knives, and is a fine process, there contrasted with more abrasive sharpening. Honing is a finishing process performed by a honing tool, which contains a set of three to a dozen and more bonded abrasive sticks. The sticks are equally spaced about the periphery of the honing tool. They are held against the work surface with controlled light pressure, usually exercised by small springs. The honing tool is given a complex rotational and oscillatory axial motion, which combine to produce a crosshatched lay pattern of very low surface roughness:

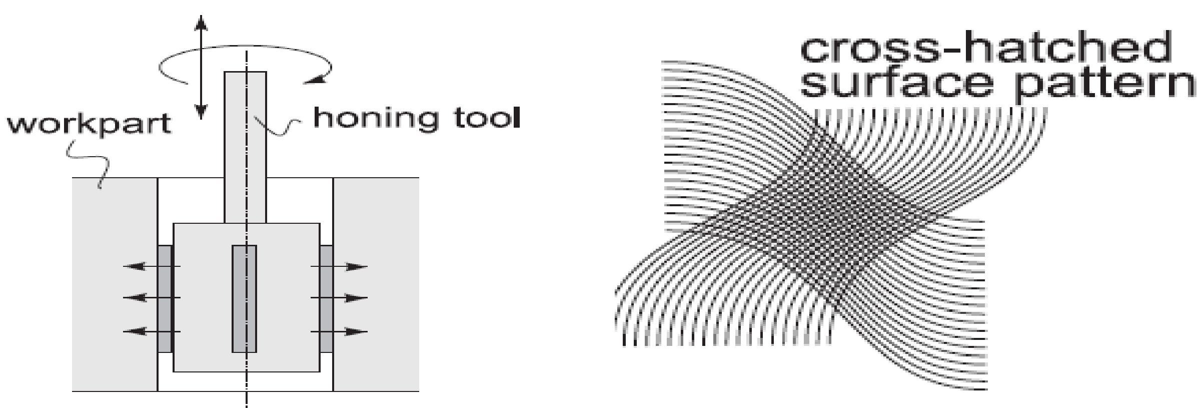

Fig 12.3 Honning Process

In addition to the surface finish of about 0.1 µm, honing produces a characteristic crosshatched surface that tends to retain lubrication during operation of the component, thus contributing to its function and service life. A cutting fluid must be used in honing to cool and lubricate the tool and to help remove the chips.

12.1.1 Honing stones (Honing tools)

Honing uses a special tool, called a honing stone or a hone, to achieve a precision surface. The hone is a composed of abrasive grains that are bound together with an adhesive. Generally, honing grains are irregularly shaped and about 10 to 50 micrometers in diameter (300 to 1,500 mesh grit). Smaller grain sizes produce a smoother surface on the workpiece. A honing stone is similar to a grinding wheel in many ways, but honing stones are usually more friable so that they conform to the shape of the workpiece as they wear in. To counteract their friability, honing stones may be treated with wax or sulfur to improve life; wax is usually preferred for environmental reasons. Any abrasive material may be used to create a honing stone, but the most commonly used are corundum, silicon carbide, cubic boron nitride, or diamond. The choice of abrasive material is usually driven by the characteristics of the workpiece material. In most cases, corundum or silicon carbide are acceptable, but extremely hard workpiece materials must be honed using super abrasives. The hone is usually turned in the bore while being moved in and out. Special cutting fluids are used to give a smooth cutting action and to remove the material that has been abraded. Machines can be portable, simple manual machines, or fully automatic with gauging depending on the application.

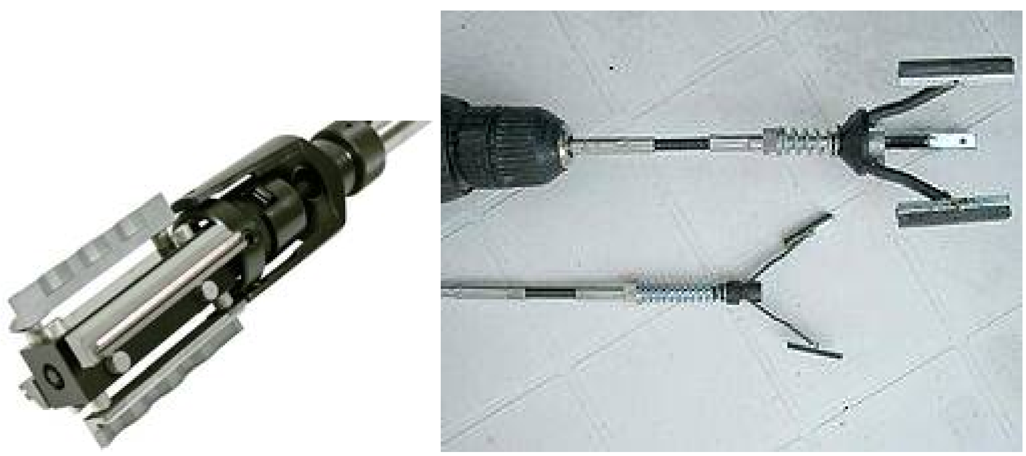

Fig 12.4 Honning Tools

12.1.2 Performance advantages of honed surfaces

Since honing is a relatively expensive manufacturing process, it can only be economically justified for applications that require very good form accuracy. The improved shape after honing may result in a quieter running or higher precision component.

12.1.3 Application

- Bores of internal
- Combustion engines

- Bearings
- Hydraulic cylinders
- And gun barrels

12.2 LAPPING

Lapping is a machining operation, in which two surfaces are rubbed together with an abrasive between them, by hand movement or by way of a machine. This can take two forms. The first type of lapping (traditionally called grinding), typically involves rubbing a brittle material such as glass against a surface such as iron or glass itself (also known as the "lap" or grinding tool) with an abrasive such as aluminum oxide, jeweler's rouge, optician's rouge, emery, silicon carbide, diamond, etc., in between them. This produces microscopic conchoidal fractures as the abrasive rolls about between the two surfaces and removes material from both. The other form of lapping involves a softer material such as pitch or a ceramic for the lap, which is "charged" with the abrasive. The lap is then used to cut a harder material—the workpiece. The abrasive embeds within the softer material which holds it and permits it to score across and cut the harder material. Taken to the finer limit, this will produce a polished surface such as with a polishing cloth on an automobile, or a polishing cloth or polishing pitch upon glass or steel.

12.2.1 Lapping Operation

Fig 12.5 Small lapping machine

Fig 12.6 Small lapping plate made of cast iron

By way of example, a piece of lead may be used as the lap, charged with emery, and used to cut a piece of hardened steel. The small plate shown in the first picture is that of a hand lapping plate. The lap or lapping plate in this machine is 30 centimeters (12 in) in diameter. For a commercial machine, that is about the smallest size available. At the other end of the size spectrum, machines with 8-to-10-foot-diameter (2.4 to 3.0 m) plates are not uncommon, and systems with tables 30 feet (9.1 m) in diameter have been constructed. Referring to the second picture again, the lap is the large circular disk on the top of the machine. On top of the lap are two rings. The weights can also be seen in the picture along with two fiber spacer disks that are just used to even the load.

Due to the dimensions of such small samples, traditional loads and weights are too heavy as they would destroy delicate materials. The jig sits in a cradle on top of the lapping plate and the dial on the front of the jig indicates the amount of material removed from the specimen. In lapping, instead of a bonded abrasive tool, oil-based fluid suspension of very small free abrasive grains (aluminum oxide and silicon carbide, with typical grit sizes between 300 and 600) called a lapping compound is applied between the work piece and the lapping tool.

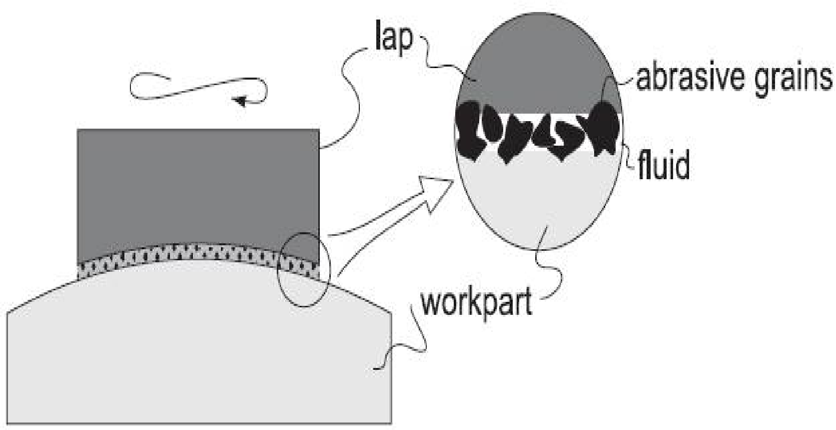

Fig 12.7 Lapping Process

The lapping tool is called a lap, which is made of soft materials like copper, lead or wood. The lap has the reverse of the desired shape of the work part. Lapping is sometimes performed by hand, but lapping machines accomplish the process with greater consistency and efficiency.

12.2.1 Applications

- Optical lenses
- Metallic bearing surfaces
- Gages

12.2.2 Disadvantages of lapping

- Lapping is still somewhat of an art. It requires experience and skill.
- Trial and error still may be needed to get the optimum results.

12.3 SUPER FINISHING

Super finishing is a finishing operation similar to honing, but it involves the use of a single abrasive stick. Super finishing, also known as micromachining and short-stroke honing, is a metalworking process that improves surface finish and workpiece geometry. This is achieved by removing just the thin amorphous surface layer left by the last process with an abrasive stone; this layer is usually about 1 μm in magnitude. Super finishing, unlike polishing which produces a mirror finish, creates a cross-hatch pattern on the workpiece. the super finishing process was developed by the Chrysler Corporation in 1934.

12.3.1 Process of Super Finishing

After a metal piece is ground to an initial finish, it is super finished with a finer grit solid abrasive. The abrasive is oscillated or rotated while the work piece is rotated in the opposite direction; these motions are what cause the cross-hatching. The geometry of the abrasive depends on the geometry of the work piece surface; a stone (rectangular shape) is for cylindrical surfaces and cups and wheels are used for flat and spherical surfaces The first phase is when the abrasive first contacts the work piece surface the dull grains of the abrasive fracture and fall away, which produces a sharp new cutting surface. In the second phase the abrasive "self dresses", where a most of the stock is removed. The pressure applied to the abrasive is very light, usually between 0.02 to 0.07 MPa (3 to 10 psi), but can be as high as 2.06 MPa (299 psi). When a stone is used it is oscillated at 200 to 1000 cycles with an amplitude of 1 to 5 mm (0.039 to 0.20 in).Super finishing can give a surface finish of 0.01 μm.

The reciprocating motion of the stick is performed at higher frequency and smaller amplitudes. Also, the grit size and pressures applied on the abrasive stick are smaller. A cutting fluid is used to cool the work surface and wash away chips.

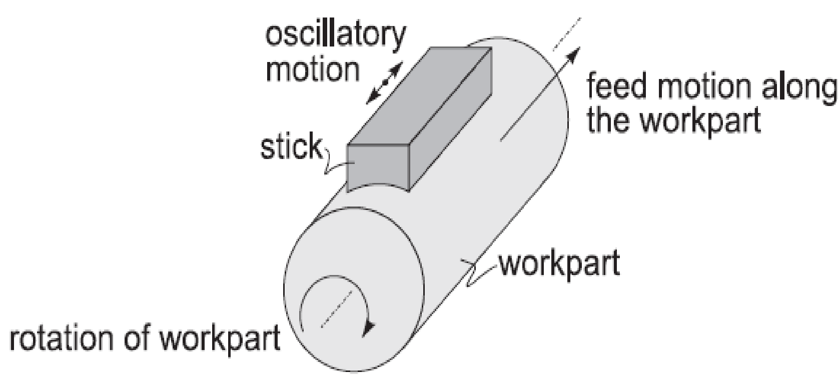

Fig 12.8 Principle of Super Finishing

In super finishing, the cutting action terminates by itself when a lubricant film is built up between the tool and work surface. Thus, super finishing is capable only of improving the surface finish but not dimensional accuracy.

The result of these operating conditions is mirror like finishes with surface roughness values around 0.01 μm.

12.3.4 Types of Super Finishing Process

There are three types super finishing: Through-feed, plunge, and wheels.

12.3.4.1 Through-feed

This type of super finishing is used for cylindrical workpieces. The workpiece is rotated between two drive rollers, which also move the machine as well. Four to eight progressively finer abrasive stones are used to super finish the workpiece. The stones contact the workpiece at a 90° angle and are oscillated axially. Examples of parts that would be produced by process include tapered rolls, piston pins, shock absorber rods, shafts, and needles.

12.3.4.2 Plunge

This type is used to finish irregularly shaped surfaces. The workpiece is rotated while the abrasive plunges onto the desired surface.

12.3.4.3 Wheels

Abrasive cups or wheels are used to super finish flat and spherical surfaces. The wheel and workpiece are rotated in opposite directions, which creates the cross-hatching. If the two are parallel then the result if a flat finish, but if the wheel is tilted slightly a convex or concave surfaces will form.

12.3.5 Advantages & disadvantages

Advantages of super finishing include: increasing part life, decreasing wear, closer tolerances, and higher load bearing surfaces, better sealing capabilities, and elimination of a break in period.

The main disadvantage is that super finishing requires grinding or a hard turning operation beforehand, which increases cost. Super finishing has a lower cutting efficiency because of smaller chips and lower material removal rate. Super finishing stones are softer and wear more quickly, however they do not need to be dressed.

12.3.6 Applications

- Finish flat
- External cylindrical surfaces.

12.4 Polishing and buffing

Polishing is a finishing operation to improve the surface finish by means of a polishing wheel made of fabrics or leather and rotating at high speed. The abrasive grains are glued to the outside periphery of the polishing wheel. Polishing operations are often accomplished manually.

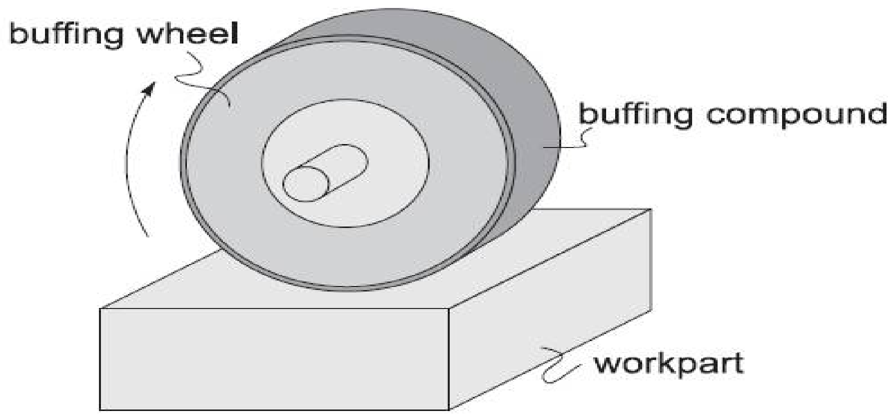

Fig 12.9 Buffing Process

- Buffing is a finishing operation similar to polishing, in which abrasive grains are not glued to the wheel but are contained in a buffing compound that is pressed into the outside surface of the buffing wheel while it rotates. As in polishing, the abrasive particles must be periodically replenished. As in polishing, buffing is usually done manually, although machines have been designed to perform the process automatically.