Mechanics

Level-II

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Module Title: Performing basic foundry

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Acronyms

IND : Industrial development

TTLM: Teaching, Training and Learning Materials

Introduction to Perform basic foundry

Foundry is a very important metal working process. It is one of the oldest processes known. The art of metal casting is over 5000 years. Foundry is also the name given to a shop in which metal products are cast, It is a place where different products are made by casting. A foundry is a place that has the equipment to melt metals and make molds. The product of the foundry is a casting (cast, casts, castings), which may vary from a fraction of a pound to several tons; it may also vary in composition, as practically all metals and alloys can be cast.

Casting operations are usually carried out in foundries. Although these operations have traditionally involved much manual labor, modern foundries are equipped with automated and computer-integrated facilities in all aspects of their operations. They produce a variety of shapes and sizes of castings; at high btween rates, At low cost, and With good quality control.

The most common metals casting processed are aluminum and cast iron, In addition. Gold has been used for specific purposes. i.e. for ornaments, copper heads, and various other objects. Casting is a process of giving a shape to an object by forcing liquid material in to a formed hole or cavity called the mold and allowing the liquid to solidify. Because metals contact during solidification and cooling, cavities can form in the casting. As the material is solidifies in then shaped cavity, it retains the desired shape. The mold is then removed, leaving the solid shaped object. Casting, metal-shaping metal by pouring the metal in molten form into a mold and letting it harden. Basically in foundry shop or metal-casting processes initially involve two separate activities.

The **1st** is pattern and mold making

2nd activity in foundry is melting the metals, controlling their compositions, impurities and pouring them in to appropriate mold.

Module units

- job requirements and Sequence of operation
- Select and prepare patterns, hand tools and equipment
- mould
- Clean and restore work area

Learning objectives of the Module

At the end of this session, the students will able to:

- Identify job requirements and Sequence of operation
- Select and prepare patterns, hand tools and equipment
- Make mould
- Clean and restore work area

Module Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the information Sheets
4. Accomplish the Self-checks
5. Perform Operation Sheets
6. Do the “LAP test”

Unit One: Identify Job Requirements And Sequence Of Operation

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Job requirements
- Select Material
- Sequence of operation including job set up.

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify job requirements correctly from drawings, instructions and specifications
- Select material appropriate to job requirements
- Determine sequence of operation including job set up for maximum safety, efficiency and to meet job specifications

1.1 Job requirements

Metal castings form integral components of devices that perform useful functions for human beings,

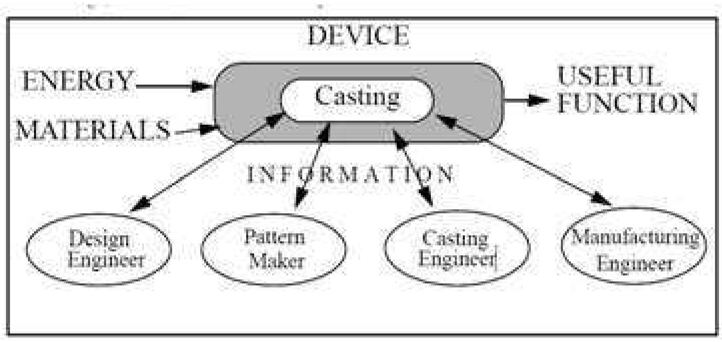


Fig 1.1 casting device has to pass-through this.

The cast component has a shape, size, chemical composition and metallurgical microstructure which is determined by engineering decisions arrived at by: Design Engineers (Mechanical Engineers), Pattern Makers (Skilled craftsman, CAD), Casting Engineers (Metallurgical Engineers), Manufacturing Engineers (Mechanical, Metallurgical Engineers).

The engineering professionals that carry out this process work together, sharing information so that the casting will perform as intended in a timely and cost effective manner. It should be noted that the casting may only be a small part of the useful device (usually in more sophisticated devices like an automobile where there may be hundreds of components), or it may be the entire device (simple device like a frying pan).

1.1.1 Advantage of cashing

The process of casting has certain advantages over the other processes of shaping:

1) It can be adapted to the requirements of mass production
2) Castings have more uniform properties from the directional point of view than does wrought iron;
3) Heavy pieces **(100-200** ton) can be cast, while it would be difficult to make these in any other way;
4) the design of parts can be simp1ified so that machining or forging is reduced to a minimum;
5) Some metals or alloys cannot be hot worked from ingots into other shapes.
6) It is possible to make extremely intricate components (such as turbine blades, finned air-cooled cylinders) with good dimensional accuracy. It would be extremely costly to machine such components.

The predominant factor in every process is its economic aspect. The design of the product may dictate whether a single process of shaping or a combination of several methods is suitable.

1.1.2 Casting Applications

Transport: automobile, aerospace, railways and shipping

Heavy equipment: construction, farming and mining

Machine tools: machining, casting, plastics moulding, forging, extrusion and forming

Plant machinery: chemical, petroleum, paper, sugar, textile, steel and thermal plants

Defense: vehicles, artillery, munitions, storage and supporting equipment

Electrical machines: motors, generators, pumps and compressors

Municipal castings: pipes, joints, valves and fittings

Household: appliances, kitchen and gardening equipment, furniture and fittings

Art objects: sculptures, idols, furniture, lamp stands and decorative items

1.1.3 Major Types of Casting

- Sand casting - Green or resin bonded sand mold.
- Lost-foam casting - Polystyrene pattern with a mixture of ceramic and sand mold.
- Investment casting - Wax or similar sacrificial pattern with a ceramic mold.

- Plaster casting - Plaster mold.
- V-Process casting - Vacuum is used in conjunction with thermoformed plastic to form sand molds. No moisture, clay or resin is needed for sand to retain shape.
- Die casting - Metal mold.
- Billet (ingot) casting - Simple mold for producing ingots of metal normally for use in other foundries.

Flow sheet for production of castings

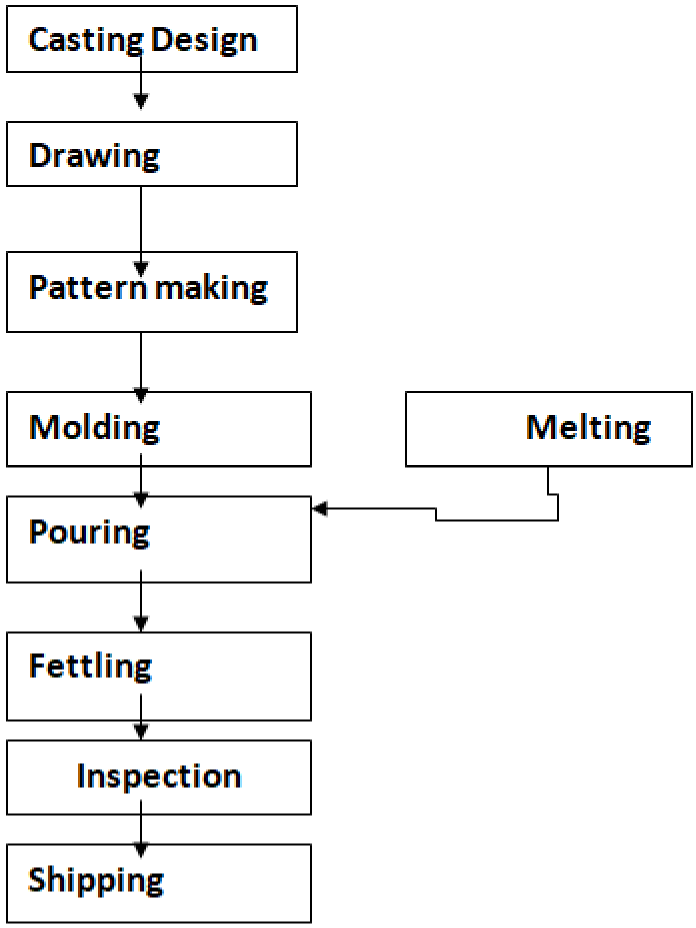


Fig.1.2 Flow sheet for production of castings

1.1.4. Casting considerations

Metal Casting size and shape

The principles of successful casting design involve a systematic blend of experience and engineering basics to allow the creation of a successful casting, from inception through production.

The major components of the design process are outlined in the six steps listed below and described graphically and schematically in the figure 1.2 shown.

Important characteristics of casting

The important characteristics requiring consideration for many engineering components are:

- **mechanical properties**-stiffness, strength and ductility;
- **physical properties**-thermal, electrical, magnetic and optical properties;
- **Environmental resistance and wear**, including applicability of corrosion protection; capacity for fabrication; and cost, which includes material, manufacturing, operating and replacement costs

✓ **Steps**

1. Physical Design of Part to be Cast Purpose of Casting (Size, Shape), Tolerances (manufacturing and engineering), Dimensional change in processes, Relationship of this Part to Others to Optimize its Design (Concurrent Engineering)
2. Material Selection for Part to be Cast Mechanical and physical properties, castability, section size sensitivity, fluid flow properties
3. Pattern Production For Molds and Cores Gating and Riser Design, Fluid flow and Heat Transfer
4. Casting Process Selection, Casting Production Limitations due to metal cast, casting size, dimensional requirements Cost to Produce
5. After Casting Processing Machining, heat treating, welding
6. Evaluation of Cast Product

Material selection

The system must take into consideration:

1. the duty or function of the component;
2. the materials properties;
3. the manufacturing route;
4. shape, dimensions and failure mode; and
5. the relative cost of the materials, manufacturing routes and designs considered.

Process Selection

We shall be describing several casting methods green sand molding to investment casting techniques. Each method is best suited for certain materials and specific components, though a given component factors to be considered while selecting a casting process or moulding method are:

- ❖ Size of the casting
- ❖ Number of castings required
- ❖ Surface finish
- ❖ Composition of the cast alloy and
- ❖ Properties and structure of the casting.

Drawing of pattern

The main objective of using a pattern is to reproduce the external shapes of a casting. The core reproduces the internal shape of a casting. The pattern equipment also includes a set of gate or riser patterns and patterns of the core boxes in which cores are made.

Molding is nothing but the mould preparation activities for receiving molten metal. Molding usually involves:

(i) Preparing the combined sand mould around a pattern held within a supporting metal frame,

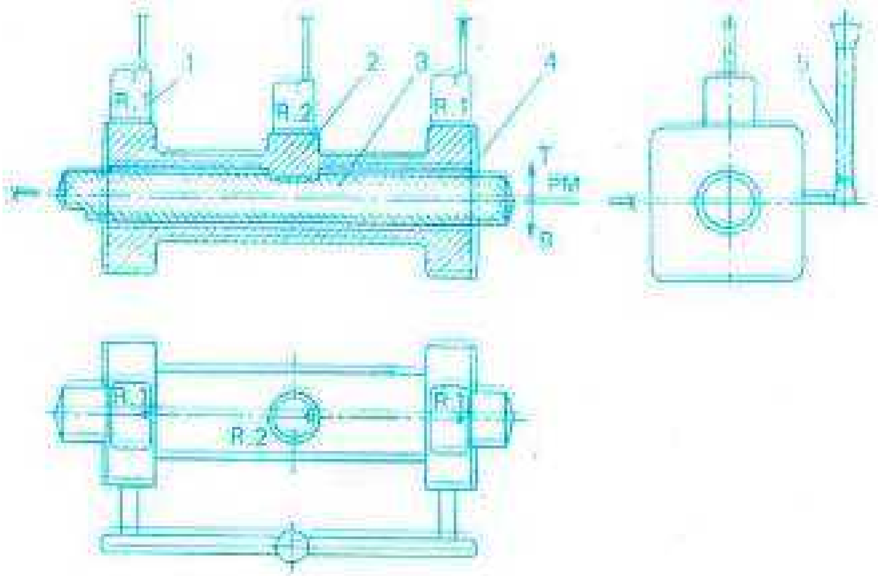
(ii) Removing the pattern to leave the mould cavity with cores.

Mould cavity is the primary cavity. The mould cavity contains the liquid metal and it acts as a negative of the desired product. The mould also contains secondary cavities for pouring and channeling the liquid material in to the primary cavity and will act a reservoir, if required.

A). **the drawing of the part** to be cast, such a process is the main process document. The drawing is define all the features of the casting process and is the basis for the design and manufacture of the moulds and patterns and selection of other appliances, which are needed for the manufacturing of the casting mold (flask, template, etc.).

The elements of foundry technology indicated on the drawing should specify the following:

1. The best parting plane for the mold and pattern.
2. The positions of the mold for pouring which is depending on the shape of casting, kind of metal, gating system geometry, specifications of cast metal density, surface finish and many others.



1-riser; 2- casting; 3- core; 4- machining allowanes; 5- gating system

Figure 1.1.Engineering design of a casting

3. The machining allowances of the casting (thickness of metals to be removed after casting).
4. Draft allowances of the casting.

The following figure illustrates the manner in which taper (draft), and machining allowances are included in the pattern for a simple shape casting. Since allowances tend to be removed by machining, efforts made to reduce the allowances will be well received.

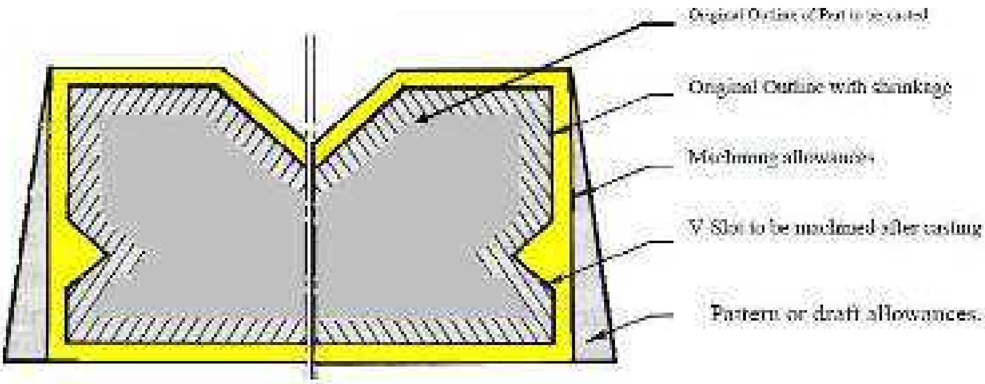


Figure 1.2.taper (draft), and machining allowances

5. The number of cores to form the internal cavities in the castings or some shaped-portions at its extension. The cores are numbered in the order they will be set in the mold.

B). **The assembled mould** of the casting with all its measurements is represented in a drawing or sketch, the drawing should outline the location of cores, Gating system elements, chils, and sections drawing of the mould are made so that the molder could assemble the mold without referring to the casting drawing.

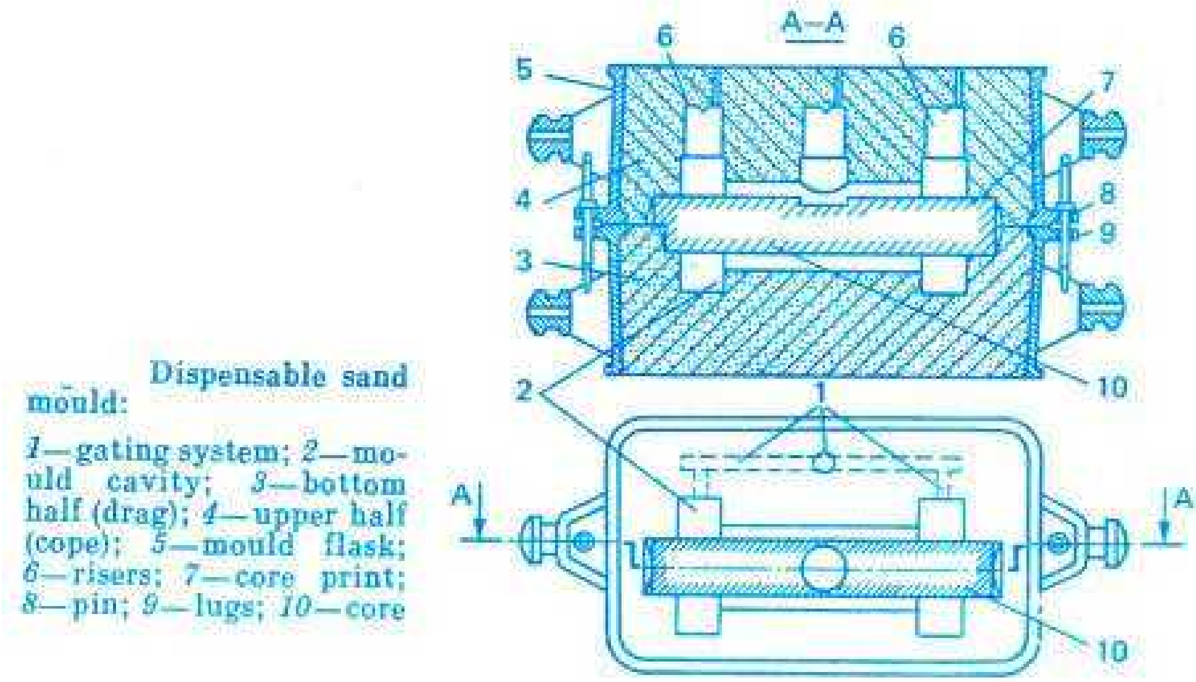


Figure 1.3.dispensable sand mould

The pattern maker's drawing should show not only the casting, but also the cores, core prints, etc. and where practicable the pattern maker's drawing should be full size, in order that the dimensions may be taken directly from the drawing with the dividers.

1.2 Select Material.

The six basic principles in making sand castings are, Pattern making, (i) Core making, (ii) Moulding, (iii) Melting and pouring, (iv) Cleaning

The system must take into consideration: the duty or function of the component; the materials properties; the manufacturing route; shape, dimensions and failure mode; and the relative cost of the materials, manufacturing routes and designs considered.

The common materials used for making patterns are wood, metal, plastic, plaster, wax, mercury, etc. The some important pattern materials are discussed as under.

1.2.1 Pattern Materials

The common materials used for making patterns are wood, metal, plastic, plaster, wax or mercury. The some important pattern materials are discussed as under. The common materials used for making patterns are wood*, metal, plastic, plaster, wax or mercury*.

A. Wood

Wood is the most popular and commonly used material for pattern making. It is cheap, easily available in abundance, repairable and easily fabricated in various forms using resin and glues. It is very light and can produce highly smooth surface. Wood can preserve its surface by application of a shellac coating for longer life of the pattern. But, in spite of its above qualities, it is susceptible to ***shrinkage*** and ***warp-age*** and its life is short because of the reasons that it is highly affected by moisture of the molding sand. After some use it warps and wears out quickly as it is having less resistance to sand abrasion. It cannot withstand rough handily and is weak in comparison to metal. In the light of above qualities, wooden patterns are preferred only when the numbers of castings to be produced are less. The main varieties of woods used in pattern-making are shisham, kail, deodar, teak and mahogany.

✓ **Shisham**

Shisham is dark brown in color having golden and dark brown stripes. It is very hard to work and blunts the cutting tool very soon during cutting. It is very strong and durable. Besides making pattern, it is also used for making good variety of furniture, tool handles, beds, cabinets, bridge piles, plywood etc.

✓ **Kail**

Kail has too many knots. It is available in Himalayas and yields a close grained, moderately hard and durable wood. It can be very well painted. Besides making pattern, it is also utilized for making wooden doors, packing case, cheap furniture etc.

✓ **Deodar**

Seodar is white in color when soft but when hard, its color turns toward light yellow. It is strong and durable. It gives fragrance when smelled. Seodar has some quantity of oil and therefore it is not easily attacked by insects. This available in Himalayas at a height from 1500 to 3000 meters.It is used for making pattern, manufacturing of doors, furniture, patterns, railway sleepers etc. It a soft wood having a close grain structure unlikely to warp. easily workable and its cost is also low. It is preferred for making pattern for production of small size castings in small quantities.

✓ **Teak Wood**

Teak Wood is hard, very costly and available in golden yellow or dark brown color. Special stripes on it add to its beauty. This is very strong and durable and has wide applications. It can maintain good polish. Besides making pattern, it is used for making good quality furniture, plywood, ships etc. It is a straight-grained light wood. It is easily workable and has little tendency to warp. Its cost is moderate.

✓ **Mahogany**

Mahogany is a hard and strong wood. Patterns made of this wood are more durable than those of above mentioned woods and they are less likely to warp. It has got a uniform straight grain structure and it can be easily fabricated in various shapes.

This is costlier than teak and pine wood, It is generally not preferred for high accuracy for making complicated pattern. It is also preferred for production of small size castings in small quantities.Used for pattern making are deodar, walnllt, kail, maple, birch, cherry and shisham.

Advantages of wooden patterns

- Wood can be easily worked,
- It is light in weight,
- It is easily available,
- It is very cheap,
- It is easy to join,
- It is easy to obtain good surface finish,
- Wooden laminated patterns are strong,
- It can be easily repaired.

Disadvantages

- It is susceptible to moisture,
- It tends to warp,
- It wears out quickly due to sand abrasion,
- It is weaker than metallic patterns.

B. **Metal**

Metallic patterns are preferred when the number of castings required is large enough to justify their use. These patterns are not much affected by moisture as wooden pattern. The wear and tear of this pattern is very less and hence posses longer life. Moreover, metal is easier to shape the pattern with good precision, surface finish and intricacy in shapes. It can withstand against corrosion and handling for longer period. This is possesses excellent strength to weight ratio. The main disadvantages of metallic patterns are higher cost, higher weight and tendency of rusting.It is preferred for production of castings in large quantities with same pattern. The metals commonly used for pattern making are cast iron, brass and bronzes and aluminum alloys.

✓ **Cast Iron**

Cast Iron is cheaper, stronger, tough, and durable and can produce a smooth surface finish. It also possesses good resistance to sand abrasion. The drawbacks of cast iron patterns are that they are hard, heavy, brittle and get rusted easily in presence of moisture.

Advantages

- It is cheap,
- It is easy to file and fit,
- It is strong,
- It has good resistance against sand abrasion,
- Good surface finish

Disadvantages

- It is heavy,
- It is brittle and hence it can be easily broken,
- It may rust in the presence of moisture.

✓ **Brasses and Bronzes**

Heavier and expensive than cast iron and hence are preferred for manufacturing small castings. They possess good strength, machinability and resistance to corrosion and wear. They can produce a better surface finish. Brass and bronze pattern is finding application in making match plate pattern

Advantages

- Better surface finish than cast iron,
- Very thin sections can be easily casted.

Disadvantages

- It is costly,
- It is heavier than cast iron.

✓ **Aluminum Alloys**

Aluminum alloy patterns are more popular and best among all the metallic patterns because of their high lightness, good surface finish, low melting point and good strength.They also possess good resistance to corrosion and abrasion by sand and thereby enhancing longer life of pattern. These materials do not withstand against rough handling. These have poor repair ability and are preferred for making large castings.

Advantages

- Aluminum alloys pattern does not rust,
- They are easy to cast,
- They are light in weight,
- They can be easily machined.

Disadvantages

- They can be damaged by sharp edges,
- They are softer than brass and cast iron,
- Their storing and transportation needs proper care.
- White Metal (Alloy of Antimony, Copper and Lead)

Advantages

- It is best material for lining and stripping plates,
- It has low melting point around 260°C,
- It can be cast into narrow cavities.

Disadvantages

- It is too soft,
- Its storing and transportation needs proper care
- 3. It wears away by sand or sharp edges.

✓ **Plastic**

Plastics are getting more popularity now days because the patterns made of these materials are lighter, stronger, moisture and wear resistant, non sticky to molding sand, durable and they are not affected by the moisture of the molding sand. Moreover they impart very smooth surface finish on the pattern surface. These materials are somewhat fragile, less resistant to sudden loading and their section may need metal reinforcement. The plastics used for this purpose are thermosetting resins. Phenolic resin plastics are commonly used. These are originally in liquid form and get solidified when heated to a specified temperature. To prepare a plastic pattern, a mould in two halves is prepared in plaster of paris with the help of a wooden pattern known as a master pattern. The phenolic resin is poured into the mould and the mould is subjected to heat. The resin solidifies giving the plastic pattern. Recently a new material has stepped into the field of plastic which is known as foam plastic. Foam plastic is now being produced in several forms and the most common is the expandable polystyrene plastic category. It is made from benzene and ethyl benzene.

✓ **Plaster**

This material belongs to gypsum family which can be easily cast and worked with wooden tools and preferable for producing highly intricate casting. The main advantages of plaster are that it has high compressive strength and is of high expansion setting type which compensate for the shrinkage allowance of the casting metal. Plaster of Paris pattern can be prepared either by directly pouring the slurry of plaster and water in moulds prepared earlier from a master pattern or by sweeping it into desired shape or form by the sweep and stickle method. It is also preferred for production of small size intricate castings and making core boxes.

C. Wax

Patterns made from wax are excellent for investment casting process. The materials used are blends of several types of waxes, and other additives which act as polymerizing agents, stabilizers, etc. The commonly used waxes are paraffin wax, shellac wax, bees-wax, cerasin wax, and micro-crystalline wax. The properties desired in a good wax pattern include low ash content up to 0.05 per cent, resistant to the primary coat material used for investment, high tensile strength and hardness, and substantial weld strength. The general practice of making wax pattern is to inject liquid or semi-liquid wax into a split die. Solid injection is also used to avoid shrinkage and for better strength. Waxes use helps in imparting a high degree of surface finish and dimensional accuracy castings. Wax patterns are prepared by pouring heated wax into split moulds or a pair of dies. The dies after having been cooled down are parted off. Now the wax pattern is taken out and used for molding. Such patterns need not to be drawn out solid from the mould. After the mould is ready, the wax is poured out by heating the mould and keeping it upside down. Such patterns are generally used in the process of investment casting where accuracy is linked with intricacy of the cast object.

- ✓ **Characteristics of pattern materials**

Table 1.Characteristics of pattern materials

Characteristic	Pattern material			
	Wood	Aluminum	Cast iron	Polyurethane
Machinability	E	G	F	G
Wear resistance	P	G	E	E
Strength	P	G	E	F
Repairability	E	E	G	E
Corrosion resistance	E	E	P	E

1.2.2 Classification of Moulding

There are two classification of moulding. They are Die mould and Sand mould

✓ **Sand casting**

Sand casting is used to produce a wide variety of metal components with complex geometries. These parts can vary greatly in size and weight, ranging from a couple ounces to several tons. For sand casting, the most commonϖ materials are iron, steel, brass and aluminum.

With these alloys, sand casting can produce small parts that weigh less than one pound or large parts that weight several tons. It is a cost effective and efficient process for small lot production, and yet, when using automated equipment, it is an effective manufacturing process for high volume production. Sand casting is also common in producing automobile components, such as engine blocks, engine manifolds, cylinder heads, and transmission cases.

Advantages

- Low cost of mould materials andϖ equipment.
- Large casting dimensions may be obtained.
- Wide variety of metals and alloys (ferrous and non – ferrous) may be cast (including high melting point metals)

Disadvantages

- Rough surface.
- Poor dimensional accuracy.
- High machining tolerances.
- Coarse Grain structure.
- Limited wall thickness: not higher than 0.1" – 0.2" (2.5 – 5 mm).

1.2.3 Moulding sands

Sand is the principal moulding material in the foundry shop where it is used for all types of castings, irrespective of whether the cast metal is ferrous or non-ferrous, iron or steel. This is because it possesses the properties vital for foundry purposes. The most important characteristic of sand is its refractory nature due to which it can easily withstand the high temperature of molten metal and does not get fused. Moulding sand has chemical resistivity.

It does not chemically react or combine with molten metal and can therefore be used time and again. Sand has a high degree of permeability; it allows gases and air to escape from the mould when molten metal is poured without interfering with the rigidity and strength of the mould. The degree of strength, hardness, and permeability can also be adjusted, as desired, by varying the composition or the ingredients of the sand. Such flexibility is extremely difficult to achieve with any other moulding material.

But the properties vary from ones sand to another, and it should be noted that only those sands, characterized by the foregoing features, are considered suitable for moulding work.

1.2.3.1 Types sands mould

Two basic kinds of sand used for making molds is:

- Synthetic sand and
- Natural bonded.

Sources of Molding Sand: Sand used in foundries is available in; (i). river beds, (ii). sea,(iii).desert, (IV).lakes. Friable sands In the routine testing of materials taken directly from production lines great care is also needed to minimize errors by the use of systematic techniques for collection and storage of samples.

1.2.3.2 Principal ingredients of moulding sands

The principal ingredients of moulding sands are

- silica sand grains
- clay (bond)
- moisture

A. Silica Sand Grains

Silica sand grains are of paramount importance in moulding sand because they impart refractoriness, chemical resistivity, and permeability to the sand. They are specified according to their average size and shape. The finer the grains, the more intimate will be the contact and lower the permeability. However, fine grains tend to fortify the mould and lessen its tendency to get distorted. The shapes of the grains may vary from round to angular (Fig. 3.1). The grains are classified according to their shape.

(i) Rounded Grains These grains have the least contact with one another in a rammed structure, thereby making the sand highly permeable to gases. Sand having rounded grains, however, lacks strength and does not pack up to the optimum extent. The binder requirements are minimum.

(ii) Subangular Grains These grains have comparatively lower permeability and greater strength than the rounded ones.

(iii) Angular Grains These grains have defined edges, and the surfaces are nearly flat. They produce higher strength and lower permeability in the mould than sub- angular grains. The binder consumption is likely to be high.

(iv) Compounded Grains In some cases, the grains are cemented together such that they fail to separate when screened. They may consist of rounded, subangular, or angular grains or a combination of the three. Such grains are called compounded grains and are least desirable due to their tendency to break down at high temperature.

In practice, sand grains contain mixed grain shapes, depending on origin. A subangular-to-rounded grain mixture would be the best combination.

- ✓ **Silica Sand:**

The sand which forms the major portion of the moulding sand (up to 96%)is essentially silica grains, the rest being the other oxides such as alumina, sodium (Na_2O +K_2O) and magnesium oxide (MgO + CaO). These impurities should be minimized to about 2% since they affect the fusion point of the silica sand. The main source is the river sand which is used with or without washing. Ideally the fusion point of sands should be about 1450°C for cast irons and about 1550°C for steels. In the river sand, all sizes and Shapes of grains are mixed. The sand grains may very in size from a few micrometers to a few millimeters. Shape of the grain may be round, sub-angular, angular and very Angular. The size and shapes of these sand grains greatly affect the properties of the moulding sands.

- ✓ **Zircon Sands:**

It is basically a zirconium silicate ($ZrSiO_4$). The typical composition is ZrO_2 – 66.25%, SiO_2 – 30.94%, Al_2O_3 – 1.92%, Fe_2O_3 – 0.74% and traces of other oxides. It is very expensive. In India, it is available in the Quilon beach of Kerala. It has a fusion point of about 2400°C and also a low coefficient of thermal expansion. The other advantages are high thermal conductivity, high chilling power and high density. It requires a very small amount of binder (about 3%). It is generally used to manufacture precision steel casting requiring better surface finish and for precision investment casting. Chromite sand is crushed from the chrome ore whose typical composition is Cr_2O_3 – 44%, Fe_2O_3 – 28%,

SiO_2 – 2.5%, CaO – 0.5%, and Al_2O_3 + MgO – 25%. The fusion point is about 1800°C. It also requires a very small amount of binder (about 3%). It is also used to manufacture heavy steel castings requiring better surface finish. It is best suited to austenitic manganese steel castings.

- ✓ **Olivine Sand:**

Contains the minerals fosterite (Mg_2SiO_4) and fayalita (Fe_2SiO_4, It is very versatile sand and the same mixture can be used for a range of steels. Comparative properties relevant for moulding of these various base sands.

B. Clay

Clay imparts the necessary bonding strength to the moulding sand so that after ramming, the mould does not lose its shape. However, as the quantity of the clay is increased, the permeability of the mould is reduced.

Clay is defined by the American Foundry men's Society (AFS), as those particles of sand (under 20 microns in diameter) that fail to settle at a rate of 25 mm per minute, when suspended in water. Clay consists of two ingredients: fine silt and true clay. Fine silt is a sort of foreign matter of mineral deposit and has no bonding power.

True clay supplies the necessary bond. Under high magnification, true clay is found to be made up of extremely minute aggregates of crystalline particles, called clay minerals. These clay minerals are further composed of flake-shaped particles, about 2 microns in diameter, which are seen to lie flat on one another.

C. Moisture

Clay acquires its bonding action only in the presence of the requisite amount of moisture. When water is added to clay, it penetrates the mixture and forms a microfilm which coats the surface of each Hake. The molecules of water forming this film are not in the original fluid state but in a fixed and definite position.

As more water is added, the thickness of the film increases up to a certain limit after which the excess water remains in the fluid state. The thickness of this water film varies with the clay mineral. The bonding quality of clay depends on the maximum thickness of water film it can maintain.

When sand is rammed in a mould, the sand grains are forced together. The clay coating on each grain acts in such a way that it not only locks the grains in position but also makes them retain that position. If the water added is the exact quantity required to form the film, the bonding action is best. If the water is in excess, strength is reduced and the mould gets weakened. Thus, moisture content is one of the most important parameters affecting mould and core characteristics and consequently, the quality of the sand produced.

1.2.3.4 CONSTITUENTS OF MOULDING SAND

The main constituents of moulding sand involve silica sand, binder, moisture content and additives.

A. Silica sand

Silica sand in form of granular quarts is the main constituent of moulding sand having enough refractoriness which can impart strength, stability and permeability to moulding and core sand. But along with silica small amounts of iron oxide, alumina, lime stone, magnesia, soda and potash are present as impurities.

The chemical composition of silica sand gives an idea of the impurities like lime, magnesia, alkalis etc. present. The presence of excessive amounts of iron oxide, alkali oxides and lime can lower the fusion point to a considerable extent which is undesirable.

The silica sand can be specified according to the size (small, medium and large silica sand grain) and the shape (angular, subangular and rounded).

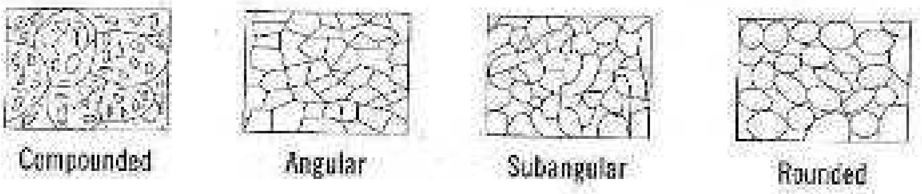


Figure1.4. *Types of Sand Grains*

B. Binder

A binder is the natural earthy material added to sand or provided by nature with sand that imparts strength to the sand. The binders for foundry sands are of three kinds; clay binders, organic binders, and inorganic binders.

In general, the binders can be either inorganic or organic substance. The inorganic group includes clay sodium silicate and port land cement etc. In foundry shop, the clay acts as binder which may be Kaolonite, Ball Clay, Fire Clay, Limonite, Fuller's earth and Bentonite. Binders included in the organic group are dextrin, molasses, cereal binders, linseed oil and resins like phenol formaldehyde, urea formaldehyde etc.

The major types of clays are: Bentonite (montmorillonite), Fire clays, essentially kaolinite, and other clays including illite and halloysite.

When sand grains are coated with clay many of the properties of sand mixtures are developed. The moisture content controls most of the properties.

Organic Binders: - The commonly used organic binders are cereals, resins and gums, proteins, Pitch, and Drying oils.

Organic binders are mostly used for core making. Among all the above binders, the bentonite variety of clay is the most common. However, this clay alone cannot develop bonds among sand grins without the presence of moisture in moulding sand and core sand.

C. Moisture

The amount of moisture content in the moulding sand varies generally between 2 to 8 percent. This amount is added to the mixture of clay and silica sand for developing bonds. This is the amount of water required to fill the pores between the particles of clay without separating them. This amount of water is held rigidly by the clay and is mainly responsible for developing the strength in the sand.

The effect of clay and water decreases permeability with increasing clay and moisture content. The green compressive strength first increases with the increase in clay content, but after a certain value, it starts decreasing. For increasing the moulding sand characteristics some other additional materials besides basic constituents are added which are known as additives.

D. Additives

Additives are the materials generally added to the **moulding and core** sand mixture to develop some special property in the sand. Some common used additives for enhancing the properties of moulding and core sands are discussed as under.

- ✓ **Coal dust:** Coal dust is added mainly for producing a reducing atmosphere during casting. This reducing atmosphere results in any oxygen in the poles becoming chemically bound so that it cannot oxidize the metal. It is usually added in the moulding sands for making moulds for production of grey iron and malleable cast iron castings.

- ✓ **Corn flour:** It belongs to the starch family of carbohydrates and is used to increase the collapsibility of the moulding and core sand. It is completely volatilized by heat in the mould, thereby leaving space between the sand grains. This allows free movement of sand grains, which finally gives rise to mould wall movement and decreases the mould expansion and hence defects in castings. Corn sand if added to moulding sand and core sand improves significantly strength of the mould and core.

- ✓ **Dextrin:** Dextrin belongs to starch family of carbohydrates that behaves also in a manner similar to that of the corn flour. It increases dry strength of the moulds.

- ✓ **Sea coal:** Sea coal is the fine powdered bituminous coal which positions its place among the pores of the silica sand grains in moulding sand and core sand. When heated, it changes to coke which fills the pores and is unaffected by water. Because to this, the sand grains become restricted and cannot move into a dense packing pattern. Thus, sea coal reduces the mould wall movement and the permeability in mould and core sand and hence makes the mould and core surface clean and smooth.

- ✓ **Pitch:** It is distilled form of soft coal. It can be added from 0.02 % to 2% in mould and core sand. It enhances hot strengths, surface finish on mould surfaces and behaves exactly in a manner similar to that of sea coal.

- ✓ **Wood flour:** This is a fibrous material mixed with a granular material like sand; its relatively long thin fibers prevent the sand grains from making contact with one another. It can be added from 0.05 % to 2% in mould and core sand. It volatilizes when heated, thus allowing the sand grains room to expand. It will increase mould wall movement and decrease expansion defects. It also increases collapsibility of both of mould and core.

✓ **Silica flour:** It is called as pulverized silica and it can be easily added up to 3% which increases the hot strength and finish on the surfaces of the moulds and cores. It also reduces metal penetration in the walls of the moulds and cores.

SAND ADDITIVES

- Clay
- Bentonite, Southern (Ca-Bentonite)
- Bentonite, Western (Na-Bentonite)
- Fireclay
- Kaolin Clay

1.2.4. Types of moulding sand by their uses

Moulding sands can also be classified according to their use into number of varieties which are described below.

A. Green sand

Green sand is also known as tempered or natural sand which is a just prepared mixture of silica sand with 18 to 30 percent clay, having moisture content from 6 to 8%. The clay and water furnish the bond for green sand. It is fine, soft, light, and porous. Green sand is damp, when squeezed in the hand and it retains the shape and the impression to give to it under pressure.

Moulds prepared by this sand are not requiring backing and hence are known as green sand moulds. This sand is easily available and it possesses low cost. It is commonly employed for production of ferrous and non-ferrous castings.

B. Dry sand

Green sand that has been dried or baked in suitable oven after the making mould and cores, is called dry sand. It possesses more strength, rigidity and thermal stability. It is mainly suitable for larger castings. Mould prepared in this sand are known as dry sand moulds.

C. Loam sand

Loam is mixture of sand and clay with water to a thin plastic paste. Loam sand possesses high clay as much as 30-50% and 18% water. Patterns are not used for loam moulding and shape is given to mould by sweeps. This is particularly employed for loam moulding used for large grey iron castings.

D. Facing sand

Facing sand is just prepared and forms the face of the mould. It is directly next to the surface of the pattern and it comes into contact molten metal when the mould is poured. Initial coating around the pattern and hence for mould surface is given by this sand. This sand is subjected severest conditions and must possess, therefore, high strength refractoriness.

It is made of silica sand and clay, without the use of used sand. Different forms of carbon are used to prevent the metal burning into the sand. A facing sand mixture for green sand of cast iron may consist of 25% fresh and specially prepared and 5% sea coal. They are sometimes mixed with 6-15 times as much fine moulding sand to make facings. The layer of facing sand in a mould usually ranges from 22-28 mm. From 10 to 15% of the whole amount of moulding sand is the facing sand.

E. Backing sand

Backing sand or floor sand is used to back up the facing sand and is used to fill the whole volume of the moulding flask. Used moulding sand is mainly employed for this purpose. The backing sand is sometimes called black sand because that old, repeatedly used moulding sand is black in color due to addition of coal dust and burning on coming in contact with the molten metal.

F. System sand

In mechanized foundries where machine moulding is employed. A so-called system sand is used to fill the whole moulding flask. In mechanical sand preparation and handling units, no facing sand is used. The used sand is cleaned and re-activated by the addition of water and special additives. This is known as system sand. Since the whole mould is made of this system sand, the properties such as strength, permeability and refractoriness of the moulding sand must be higher than those of backing sand.

G. Parting sand

Parting sand without binder and moisture is used to keep the green sand not to stick to the pattern and also to allow the sand on the parting surface the cope and drag to separate without clinging. This is clean clay-free silica sand which serves the same purpose as parting dust.

H. Core sand

Core sand is used for making cores and it is sometimes also known as oil sand. This is highly rich silica sand mixed with oil binders such as core oil which composed of linseed oil, resin, light mineral oil and other bind materials. Pitch or flours and water may also be used in large cores for the sake of economy.

1.2.5 Properties of moulding sand

The basic properties required in moulding sand and core sand are described as under.

The molding sand should posses the following properties. They are

- ✓ **Permeability**

It is also termed as porosity of the moulding sand in order to allow the escape of any air, gases or moisture present or generated in the mould when the molten metal is poured into it. All these gaseous generated during pouring and solidification process must escape otherwise the casting becomes defective.

Permeability is a function of grain size, grain shape, and moisture and clay contents in the moulding sand. The extent of ramming of the sand directly affects the permeability of the mould. Permeability of mould can be further increased by venting using vent rods

- ✓ **Porosity**

It is that property of sand which permits the steam and other gases to pass through the sand mould. When hot molten metal is poured into the sand mould, it evolves a great amount of other gases while coming in contact with the moist sand. If these gases do not escape completely through the mould, the casting will contain gas holes and pores. Thus the sand from which the mould is made must be sufficiently porous or permeable. The porosity of sand depends upon its grain size, grain shape, and moisture and clay contents in the molding sand. The extent of ramming of sand directly affects the porosity of the mould. If the sand is too fine, its porosity will be low.

- ✓ **Plasticity:**

It is that property of sand due to which it flows to all portions of the molding box and acquires a predetermined shape under ramming pressure and retain this shape when the pressure is removed. The sand must have sufficient plasticity to produce a good mould. The plasticity is increased by adding water and clay to sand.

- ✓ **Adhesiveness:**

It is the property of sand due to which it adhere or cling to the sides of the molding box. Good sand must have sufficient adhesiveness so that heavy sand masses can be successfully held in molding box without any danger of its falling out when the box is removed.

- ✓ **Cohesiveness**

It is property of moulding sand by virtue which the sand grain particles interact and attract each other within the moulding sand. Thus, the binding capability of the moulding sand gets enhanced to increase the green, dry and hot strength property of moulding and core sand.

It is of the following three types

(a) Green strength:

The green sand, after water has mixed to it, must have adequate strength and plasticity for making and handling of mould. The green strength depends upon the grain shape and size, amount and type of clay and the moisture content. For this, the sand grains must be adhesive, i.e. they must be capable of attaching themselves to another body and. therefore, and sand grains having high adhesiveness will cling to the sides of the moulding box.

Also, the sand grains must have the property known as cohesiveness i.e. ability of the sand grains to stick to one another. By virtue of this property, the pattern can be taken out from the mould without breaking the mould and also the erosion of mould wall surfaces does not occur during the flow of molten metal. The green strength also depends upon the grain shape and size, amount and type of clay and the moisture content.

(b) Dry strength:

When the molten metal is poured, the sand adjacent to the hot metal quickly loses water content as steam. The dry sand must have the strength to resist erosion and also the metallostatic pressure of the molten metal, otherwise the mould may enlarge.

(c) Hot strength:

After the moisture has evaporated, the sand may be required to possess strength at some elevated temperature, above 100°c.If the sand does not possess hot strength, the metallostatic pressure of the liquid metal bearing against the mould walls may cause mould enlargement or if metal is still flowing, it may cause erosion, cracks or breakage.

- ✓ **Refractoriness**

Refractoriness is defined as the ability of moulding sand to withstand high temperatures without breaking down or fusing thus facilitating to get sound casting. It is a highly important characteristic of moulding sands. Refractoriness can only be increased to a limited extent. Moulding sand with poor refractoriness may burn on to the casting surface and no smooth casting surface can be obtained.

The degree of refractoriness depends on the SiO2 i.e. quartz content, and the shape and grain size of the particle. The higher the SiO2 content and the rougher the grain volumetric composition the higher is the refractoriness of the moulding sand and core sand. Refractoriness is measured by the sinter point of the sand rather than its melting point.

- ✓ **Flow ability:**

It is the property of sand due to which it behaves like a fluid so that, when rammed, it flows to all portions of a mould and distributes the ramming pressure evenly. Generally, sand particles resist moving around corners or projections. In general, flow ability increases with decrease in green strength and decrease in grain size. It also varies with moisture content.

- ✓ **Collapsibility:**

It is the property the sand due to which the sand mould collapses automatically after the solidification of the casting in order to allow free contraction of the metal. This property of sand is dependent upon the amount and type of binder, the temperature to which it is heated in contact with the metal and the time of contact.

1.2.6 Materials of core

Materials required to making cores

- Core sand
- Bentonite clay: - It is the most suitable material used in molding sands. Limonite and Kaolinite are not commonly used as binders as they have comparatively low binding properties.
- Pulverized coal
- Resin oil

1.2.6.1 Requirements for cores

Green strength: In the green condition, there must be adequate strength for handling. In the hardened state, it must be strong enough to handle the forces of casting; therefore, the compression strength should be 100 to 300 psi (0.69 to 2.07 MPa). Permeability must be very high to allow for the escape of gases.

Friability: As the casting or molding cools, the core must be weak enough to break down as the material shrinks. Moreover, they must be easy to remove during shakeout.

Good refractoriness is required as the core is usually surrounded by hot metal during casting or molding.

- A smooth surface finish.
- Minimum generation of gases during metal pouring.

In core making, as in green-sand molding, the principal material is sand. In green sand molding the grains of sand are held together by the alumina. In dry core work the grains of sand are held together by the binder which the molder introduces, the amount and kind of which he controls as best suits his use and convenience. A naturally free sand must be used as a base. A sand containing alumina would cake in baking, and also when in contact with the hot metal, thus becoming very hard to remove from the casting. To this free sand some organic material possessing binding qualities must be added. This holds the grains of sand together until the metal has formed about the core. At the same time that the metal is cooling, the binder should be burning out. The core can then be easily removed. Like, Binder, catalyst, Sand additives**,** Break down agents, raisen

Binders: - the materials most generally used and answering the above requirements are:

- ✓ Flour: - the most universal material is wheat flour, which acts in the core as it acts in bread.
- ✓ Rosin: - a hard vegetable gum which, when finely powdered and mixed with the sand, has a strong binding action; this is due to the fact that it melts in the oven, forming a coating over the sand grains which cements them together upon cooling.
- ✓ Linseed oil: - when mixed with sand, acts very much like the rosin. It is also used in connection with flour when a very strong core is wanted.
- ✓ Glue: - when dissolved in water and used to temper the sand, makes a good binder.
- ✓ Molasses water is used for wetting the sand in making small cores. It is made by mixing one cup of molasses with a pail of water.

Catalyst: - All the resins used in hot box systems are heat/acid catalyzed. Each particular system will have a specific catalyst depending on the properties of the mixed sand required. The acid catalyst may be in the form of an ammonium salt of a strong acid, a sulphonic acid or other buffered acids. Urea is normally a constituent of the catalyst. This reacts rapidly at core box temperature with either formaldehyde or the resin, reducing fume evolution on cure.

Sand additives: - Additives are the materials generally added to the molding and core sand mixture to develop some special property in the sand. Some common used additives for enhancing the properties of molding and core sands are; Coal dust , Corn flour, Dextrin, Sea coal, Wood flour. You have to read from above listed page types and uses.

Break down agents:

All core binders are sticky, but some are less so than others. It is this characteristic that requires the use of release agents/parting compounds on core boxes, regardless of the type of core box material. The desirability of having a dense core compounds the problem of core release, because binder-coated sand is packed or blown against the surface with force, which enhances sticking. In the heat-activated processes, the binder melts or softens and migrates to the heated surface.

It is necessary to start with a good core box; no amount of release agent will overcome roughness and scoring. The core box should be chromium plated if it is to be used for high production, and it should be broken in gradually. If a release agent is functioning properly, some buildup will occur; it should be removed frequently because it adversely affects core dimensions and quality. One method of removing buildup is blasting with ground walnut hulls, corn cobs, or other soft media. Solvents can also be used. Minimum amounts of release agents should be used, and when adding them during mixing, they should be added near the end of the cycle. The release agent should be chemically compatible with the binder system.

Oleic acid diluted with kerosene (usually 10:1) is used as a release agent for core-oil cores. It is added to the sand mixture and used to keep the core boxes clean. The amounts used are 125 to 250 mL/450 kg (1 pt to 1 qt/1000 lb) of sand. Shell and other heat-cured processes use emulsified silicone release agents diluted in water. A low surface tension silicone should be used for spraying core boxes. Stearates, usually calcium, are added to shell sand during the coating process. Amounts recommended are 2 to 5%, based on resin solid weight. Small amounts of core oil or silicone emulsion can be added to hot box sand during mixing.

The no-bake and cold box processes use a wide variety of release agents. Small-to-medium size high-production core systems will normally use liquid types, which can be sprayed through jet nozzles and integrated into an automatic cycle or sprayed with a hand gun. No-bake systems normally use liquids, suspensions in liquids, or dry materials for larger cores. The suspension systems usually use a solvent carrier that evaporates readily. Materials can be sprayed, brushed, dusted, or hand rubbed onto the core boxes. Ingredients include (in many combinations) water, alcohol, chlorinated solvents, mica, talc, silicones, aluminum powder, graphite, and soybean oil (lecithin).

1.2.7 Sand testing techniques

The quality of molding sand depends partly on the manner of its preparation. In addition, economic utilization requires the recovery and processing of the large quantities of materials employed. The sand system is therefore of great importance, its central feature being the mixing plant. The need for systematic evaluation of the working qualities of moulding materials under foundry conditions has led to the development of a wide range of tests, the work of many committees and individuals. Some other tests are concerned with basic chemical and physical characteristics, but the majority are designed to measure bulk properties.

The molding sand is prepared by milling or even by hand. After casting, the moulds are knocked out, the floor sand being watered and re-used after riddling, aeration, or re milling. At intervals the sand heap is reconditioned with additions of new sand and binder.

Natural molding sands are best adapted to this practice since the binder is already well distributed and the moisture content less critical The relevance of some of these properties has already been stressed, and an account of the associated testing techniques will now be given. Many of the tests are long established and reflect the pioneering work of H. W. Dietert, the American Foundry men's Society, BCIRA and other individuals and organizations who undertook the design of tests, the manufacture of the necessary equipment and the publication of reports, handbooks and papers, many of which still remain relevant.

Further developments include the availability of closely similar metric and imperial versions of much of the equipment, and increased attention to the key properties of chemically bonded sands. Sources containing details of numerous tests include.

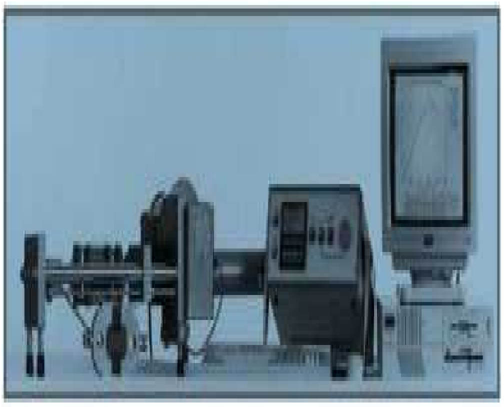
Other references on some of the tests and related points will be included in the following sections. The bulk properties of an aggregate are sensitive to variations in mixing conditions and specimen preparation, so that rigid standardization is needed at all stages. Even under these conditions results usually need to be derived from two or more determinations.

Original studies showed the molding material: properties, preparation and testing 183 reproduce ability to be best in permeability and least in strength tests on some of the more.

1.2.7.1 Specimens for bulk testing

Mechanical properties and certain other characteristics are determined on specimens compacted to a bulk density similar to that encountered in a well rammed mould.

Many tests utilize the 2 in **d** 2 in cylindrical AFS specimen or its 50mm d 50mm DIN equivalent, prepared by subjecting a weighed quantity of sand to a selected number of blows from a compatible standard rammer, transmitted to a close fitting piston in a tubular mould



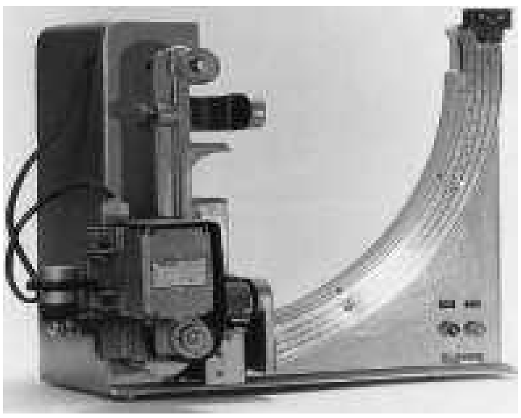


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FIGURE1.5 Universal sand strength testing machine **FIGURE1.6** Testing machine for higher strength materials

Appropriate to the practice for the particular bonding material. compression tests, like Shear tests, tensile test, The tensile test, The transverse test.

After molding, melting is the major factor which controls the quality of the casting. There are a number of methods available for melting foundry alloys such as pit furnace, rotary furnace, cupola furnace etc. the choice of the furnace depend on the amount and the type of alloy being melted. For melting cast iron, cupola in its various forms is extensively used basically because of its lower initial cost and lower melting cost. We will see more details of the cupola in the following article. The molding sand should posses the following properties like, Porosity or permeability, Porosity, Plasticity, Adhesiveness, Cohesiveness (Green strength, Dry strength, Hot strength), Refractoriness, Flow ability, Collapsibility, etc.

1.2.7 Melted metal

In foundry is melting the metals, controlling their compositions, impurities and pouring them in to appropriate mold. Materials and its melting practice.

- ✓ **Major cast metals**

Metal alloys, by virtue of composition, are often grouped into two classes **ferrous** and **nonferrous**. **Ferrous alloys**—those of which iron is the prime constituent are produced in larger quantities than any other metal type.

Table 1.2 major metals in use today (by weight) along with their main characteristics and typical applications

METAL	USE	CHARACTERISTICS	APPLICATIONS
Grey Iron	54%	Heat resistance, damping, low cost, high fluidity, low shrinkage.	Automobile cylinder block, clutch plate, brake drum, machine tool beds, housings
Ductile Iron	20%	Strength, wear and shock resistance, dimensional stability, machinability.	Crank shafts, cam shafts, differential housing, valves, brackets, rollers.

Aluminum	12%	Strength to weight ratio, corrosion resistance.	Automobile pistons, oil and fuel pumps, connecting rod, clutch housings.
Steel	9%	Strength, machinability, weldability	Machine parts, gears, valves
Copper base	2%	High ductility, corrosion resistance.	Marine impellers, valves, hydraulic pump parts.
Zinc base	1%		

The cast component has a shape, size, chemical composition and metallurgical microstructure which are determined by engineerings.

The engineering professionals that carry out this process work together, sharing information sothat the casting will perform as intended in a timely and cost effective manner.

1.3 Sequence of operation including job set up.

Casting is a process of giving a shape to an object by forcing liquid material in to a formed hole or cavity called the mold and allowing the liquid to solidify. Because metals contact during solidification and cooling, cavities can form in the casting. As the material is solidifies in then shaped cavity, it retains the desired shape. The mold is then removed, leaving the solid shaped object. Casting, metal-shaping metal by pouring the metal in molten form into a mold and letting it harden also called foundry. Basically, metal-casting processes initially involve two separate activities.

The **1**st is pattern and mold making

2nd activity in foundry is melting the metals, controlling their compositions, impurities and pouring them in to appropriate mold.

On the cast making process perform six basic principles in making sand castings are, (i).Pattern making, (ii).Core making, (iii).Moulding, (iv).Melting and pouring, (v).cleaning.

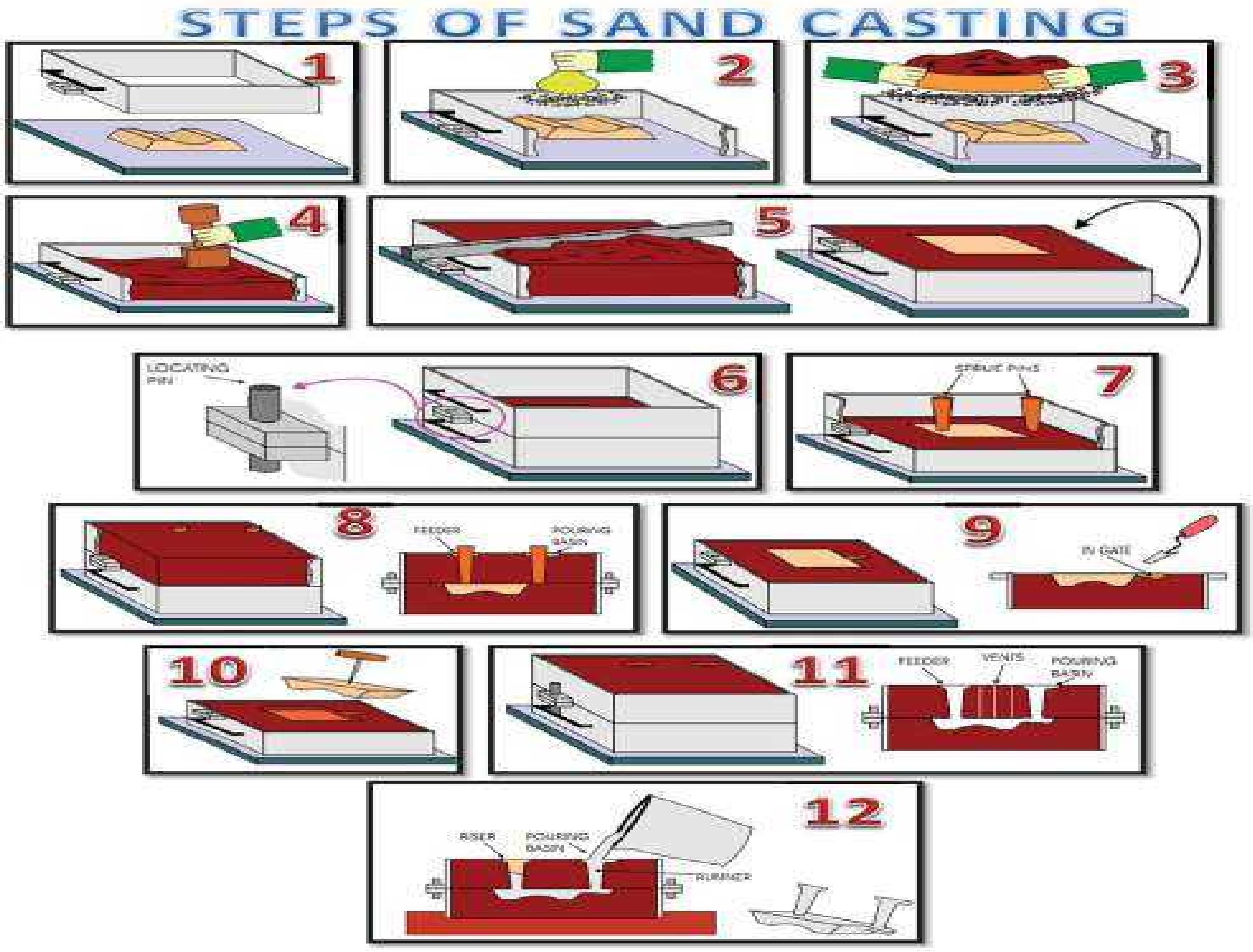


Figure 1.6 cast making process

i. **Pattern making**

Pattern: Replica of the part to be cast and is used to prepare the mould cavity. It is the physical model of the casting used to make the mould. Made of either wood or metal. The mould is made by packing some readily formed aggregate material, such as moulding sand, surrounding the pattern. When the pattern is withdrawn, its imprint provides the mould cavity. This cavity is filled with metal to become the casting. If the casting is to be hollow, additional patterns called 'cores' are used to form these cavities.

Types of pattern:

- Loose piece pattern
- Solid or single piece pattern
- Split pattern:
- Match plate pattern:
- Gated patterns etc**.**

ii. **Core making:**

Cores are placed into a mould cavity to form the interior surfaces of castings. Thus the void space is filled with molten metal and eventually becomes the casting.

iii. Moulding making

Molding is nothing but the mould preparation activities for receiving molten metal. Molding usually involves: (i) preparing the consolidated sand mould around a pattern held within a supporting metal frame, (ii) removing the pattern to leave the mould cavity with cores. Mould cavity is the primary cavity. The mould cavity contains the liquid metal and it acts as a negative of the desired product. The mould also contains secondary cavities for pouring and channeling the liquid material in to the primary cavity and will act a reservoir, if required.

iv. Melting and Pouring

The preparation of molten metal for casting is referred to simply as melting. The molten metal is transferred to the pouring area where the moulds are filled.

v. Cleaning

Cleaning involves removal of sand, scale, and excess metal from the casting. Burned-on sand and scale are removed to improved the surface appearance of the casting. Excess metal, in the form of fins, wires, parting line fins, and gates, is removed. Inspection of the casting for defects and general quality is perform.

1.3.1 **Pattern making sequence**

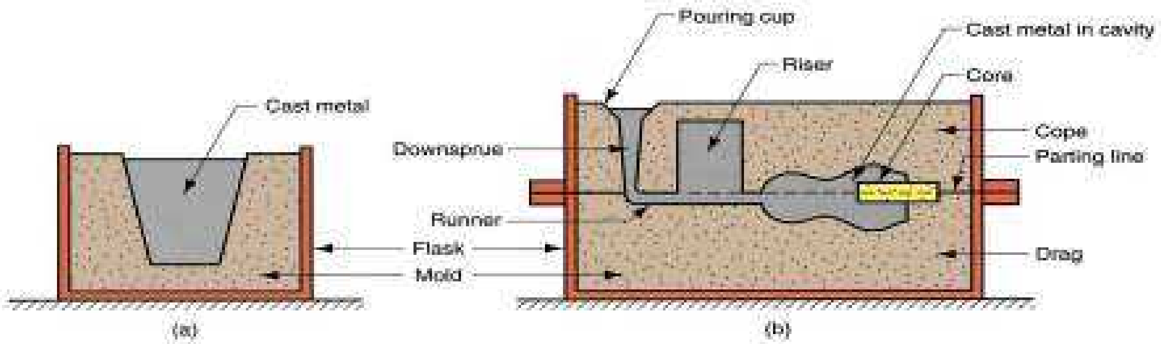
You have to refer some procedure of pattern making sequence.

1.3.2 Mold-making sequence

The first step in the sand casting process is to create the mold for the casting. In an expendable mold process, this step must be performed for each casting. A sand mold is formed by packing sand into each half of the mold. The sand is packed around the pattern, which is a replica of the external shape of the casting. When the pattern is removed, the cavity that will form the casting remains. Any internal features of the casting that cannot be formed by the pattern are formed by separate cores which are made of sand prior to the formation of the mold. Further details on mold-making steps will be described in the next section. The mold-making time includes positioning the pattern, packing the sand, and removing the pattern. The mold-making time is affected by the size of the part, the number of cores, and the type of sand mold. If the mold type requires heating or baking time, the mold-making time is substantially increased. Also, lubrication is often applied to the surfaces of the mold cavity in order to facilitate removal of the casting. The use of a lubricant also improves the flow the metal and can improve the surface finish of the casting. The lubricant that is used is chosen based upon the sand and molten metal temperature.

Two forms of mold.

- **Open mold**, simply a container in the shape of the desired part
- **Closed mold**, in which the mold geometry is more complex and requires a gating system (passageway) leading into the cavity



A sand casting mould usually consists of two mould pieces, the upper section is named Cope and the lower section is named Drag. Sand core is a preformed sand aggregate inserted in a mould to shape the interior or that part of a casting that cannot be shaped by the pattern. It may have to be broken in order to remove it afterwards. Flask is a frame, normally made by metal or wood, as the main structure to carry the sand and avoid looseness of sand while assembling of the mould halves. Figure shows a typical sand casting mould.

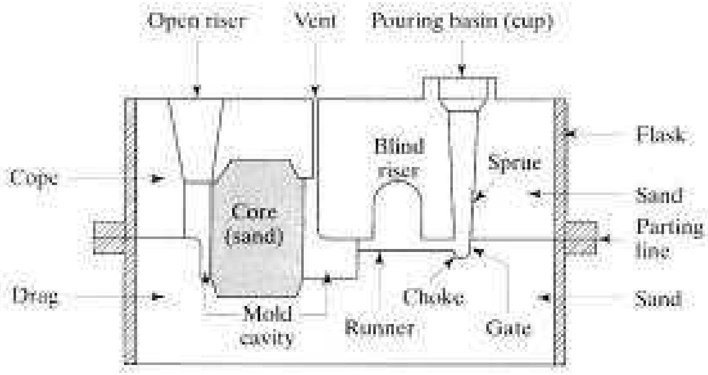


Figure1.8. Cross section view of a sand mould assembly

Steps involved in making a sand mould

1. Initially a suitable size of moulding box for creating suitable wall thickness is selected for a two piece pattern. Sufficient care should also be taken in such that sense that the

moulding box must adjust mould cavity, riser and the gating system (sprue, runner and gates etc.).

2. Next, place the drag portion of the pattern with the parting surface down on the bottom (ram-up) board as shown in
3. The facing sand is then sprinkled carefully all around the pattern so that the pattern does not stick with moulding sand during withdrawn of the pattern.
4. The drag is then filled with loose prepared moulding sand and ramming of the moulding sand is done uniformly in the moulding box around the pattern. Fill the moulding sand once again and then perform ramming. Repeat the process three four times,
5. The excess amount of sand is then removed using strike off bar to bring moulding sand at the same level of the moulding flask height to completes the drag.
6. The drag is then rolled over and the parting sand is sprinkled over on the top of the drag
7. Now the cope pattern is placed on the drag pattern and alignment is done using dowel pins.
8. Then cope (flask) is placed over the rammed drag and the parting sand is sprinkled all around the cope pattern.
9. Sprue and riser pins are placed in vertically position at suitable locations using support of moulding sand. It will help to form suitable sized cavities for pouring molten metal etc.
10. The gaggers in the cope are set at suitable locations if necessary. They should not be located too close to the pattern or mould cavity otherwise they may chill the casting and fill the cope with moulding sand and ram uniformly.
11. Strike off the excess sand from the top of the cope.
12. Remove sprue and riser pins and create vent holes in the cope with a vent wire. The basic purpose of vent creating vent holes in cope is to permit the escape of gases generated during pouring and solidification of the casting.
13. Sprinkle parting sand over the top of the cope surface and roll over the cope on the bottom board.
14. Rap and remove both the cope and drag patterns and repair the mould suitably if needed and dressing is applied
15. The gate is then cut connecting the lower base of sprue basin with runner and then the mould cavity.

16. Apply mould coating with a swab and bake the mould in case of a dry sand mould.
17. Set the cores in the mould, if needed and close the mould by inverting cope over drag.
18. The cope is then clamped with drag and the mould is ready for pouring,

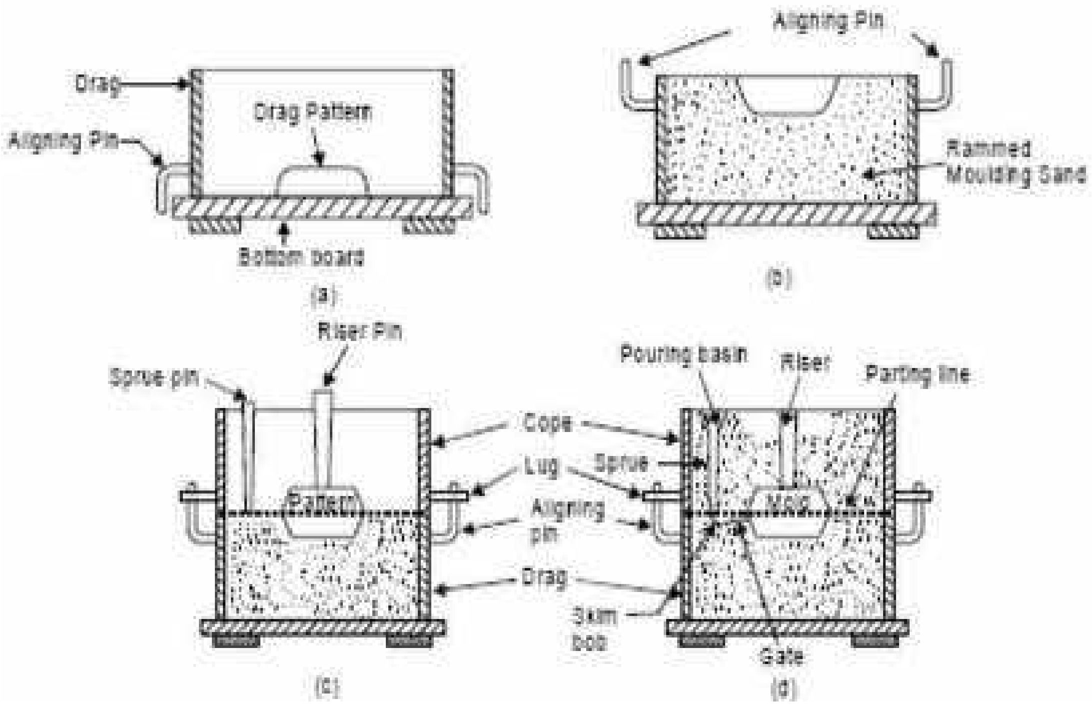


Fig.1.9. Mould making

1.3.3 Core making sequence

Core making: Cores are made separately in a core box made of wood or metal. The various steps in core making are ramming of core sand in the box, venting, reinforcing, removing of core from box, baking, pasting, sizing etc. This work of producing cores can either be done by hand or by some machines designed for this purpose. In machine molding, the core-sand mixture is rammed by jolting, squeezing or blowing by means of suitable machine. Venting, reinforcing and other operations are carried out by hand.

Core binders: - are materials used to stick or bind the grains of sand together in making cores, such as flour, rosin, linseed oil, etc.

A core is a device used in casting and molding processes to produce internal cavities and reentrant angles (an interior angle that is greater than 180°). The core is normally a disposable item that is destroyed to get it out of the piece. They are most commonly used in sand casting, but are also used in die casting and injection molding.

Tools and accessories used in the making of cores are the same as those used for making molds, with the addition of core boxes, sweeps, core driers, and special venting rods. Cores are shaped by the use of the core boxes, by the use of sweeps, or by a combination of these methods. Sweeps are limited in their use and will not be discussed here. Core driers are special racks used to support complicated cores during baking. They are usually not used unless a large number of cores of a particular design are being made. Complicated cores can often be made as split cores, baked on flat drying plates, and then assembled by pasting.

1.3.3.1Types of Cores

- **According to Sand**

  ✓ Baked Sand Cores

Core work aboard ship is concerned primarily with baked sand cores. They have the desired properties, are easy to handle, and may be made up ahead of time and stored in a dry place for future use. Baked sand cores have higher strengths than dry-sand cores. This means that complicated cores can be made most easily as baked cores.

  ✓ Dry-Sand Cores

Dry-sand cores are made from green-sand mixtures to which additional amounts of binders have been added. They are dried in the air or with a torch and their strength comes from the large amount of binder. Dry-sand cores are not as strong as baked sand cores and require more internal support and careful handling. Although they can be made faster than baked sand cores, this is often offset by disadvantages of lower strength and the need for more careful handling.

- **According to Shape and Position in the Mold**

✓ Horizontal core: −A horizontal core is positioned horizontally in the mold. Refer Fig. 1.1 According to the shape of the cavity required in the casting, a horizontal core may have any shape. Uniformly sectioned horizontal cores are mostly placed at parting line.

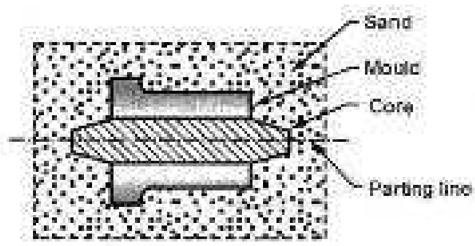


Figure1.1. Horizontal core

✓ Vertical core: - it is similar to horizontal core, except that it is fitted in the mold with its axis vertical. Refer Fig. 1.2. The top end of the core is provided with more amount of taper, to have a smooth fitting of the cope on the core. A major portion of the vertical core generally remains in the drag.

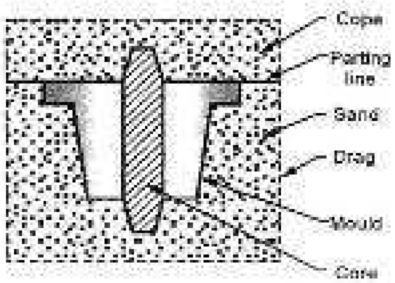


Figure 1.2. Vertical core

✓ Hanging core: −Hanging core is also called as cover core as shown in Fig.1.3. It is supported from above and it hangs vertically in the mold cavity. It has no support from the bottom. They are provided with a hole through which molten metal reaches the mold cavity.

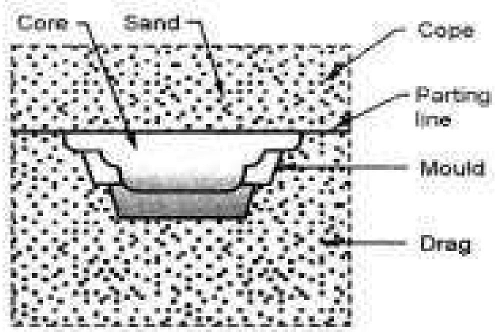


Figure 1.3. hanging core

✓ Balanced core :−Balanced core is supported and balanced from its one end only.−It requires long core seat, so that the core does not fall into the mould cavity. Refer Fig. 1.4.It may be supported on chaplets.

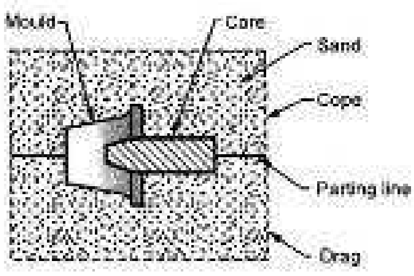


Figure 1.4. balanced core

✓ Ram up core :−Ram up core is placed in the sand along with pattern before ramming the mould. Refer Fig. 1.5.It is used to make internal or external details of a casting.−It cannot be placed in the mould after the mould has been rammed.

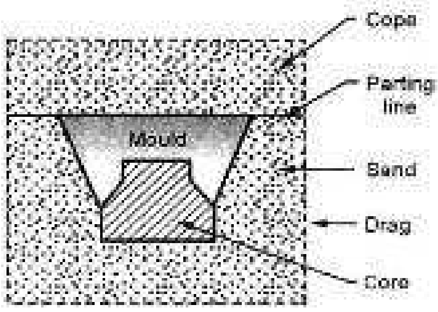


Figure 1.5. Ram-up core

✓ Kiss core:−It does not require core seats for getting support. It is held in position between drag and cope due to the pressure exerted by core on the drag.To obtain a number of holes in a casting, a number of kiss cores can be simultaneouslypositioned. Refer Fig. 1.6.

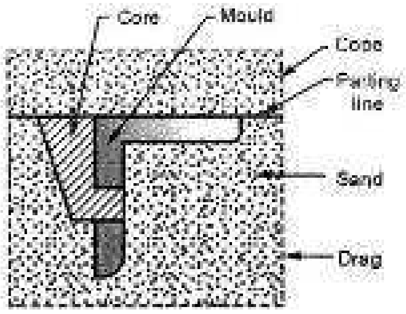


Figure 1.6. kiss core

1.3.4. **Melting and pouring sequence**

You have to follow the sequence of metal melting and pouring sequence according to manufacturer's and organizational policies.

Self-check-1

Test I: multiple choice

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The ________________ preparation activities for receiving molten metal.

   A, mould B, Casting C, Foundry D, None

2. The _______________ is defining all the features of the casting process.

   A, mould B, Foundry C, Drawing D, All

3. ____________ are included in the pattern for a simple shape casting.

   A, Allowances B, Moulds C, Foundries D, Sands

4. The first step in the sand casting process.

   A, Assembling the cast B, Pouring the molten C, create the mold D, All.

5. Any internal features of the casting that cannot be formed by the pattern are formed by _____________.

   A, Cores B, Runners C, Gates D, None

6. Too soft ramming will generate ________ mould.

   A, Good B, hard C, weak D, Smooth

Test-II Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

Column A	**Column B**
1. Types of mould	A. permeability

2. Addition of dimension	B. Synthetic
3. Process of metal meting and poring to the mould	C. wood
4. Common material of pattern	D. Sand mould
5. Types of mould sand properties	E. Allowance
6. Uses of core on in the mould	F. Hole
7. Silica sand, binder, clay, moister	G. Die mould
8. Making of cores	H. Casting / Foundry
9. pattern	I. hand or machine
	J. mould cavity size

Test III: writing short Answer

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. Write types of allowance added to the drawing of patterns?
2. In the foundry shop, why taper (draft), machining, shrinkage allowances will be added?
3. Write ingredients of moulding sand?
4. List at least four (4) material used during making of pattern, mould, and core.
5. Write the main constituents of moulding?
6. Write the sequence of pattern making, mould making, core making?

Operation sheet-1 Sequence of operation including job set up

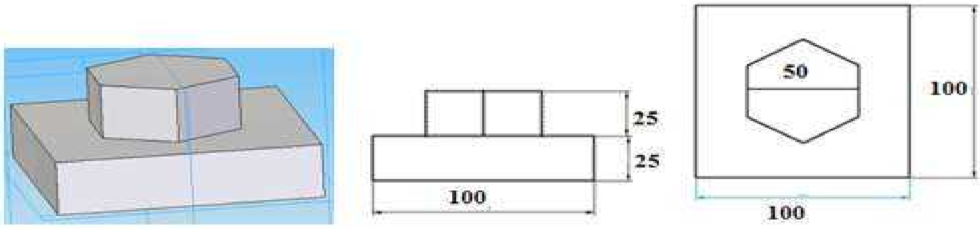
Operation Title: to perform Sequence of operation including job set up

Purpose: to prepare sequence of operation solid pattern / procedure of Pattern making

Instruction: Given all the necessary materials the simulation room/ Lab must conducive to perform the demonstration and the trainees must be in right and healthy condition.

- Demonstrate all the principal pattern making processes on the timber by using the wood lathe (if available) with the recommended tools and safety requirements correctly.
- Prepare the following Solid Pattern from wood by using workshop hand tools. All dimensions are given by mm.
- Using the figure below and given data/ information
- You have given 4 Hours for the task.

Operations to be carried out**:** Planning, Marking, Sawing, Finishing.



All dimensions are given by mm.

Required tools and equipment: Steel rule, Try square, Marking guage, Rip saw, Tenon saw, Mallet, Jack plane, Wood rasp file, etc

Precautions: take care during operate of wood lathe machine

- do not forget to use and select appropriate wood lathe tools & equipment
- follow pre/post set up and material preparation activities

Procedures:

1.
2.
3.
4.

Quality criteria: 1. Wood should be free from moisture

2. Marking is done without parallax error
3. To make Pattern success fully or modifying pattern drawing.

LAP Test	Practical Demonstration

Name: ___________________________ Date: _____________

Time started: ____________________ Time finished: _______________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1: Sequence of operation including job set up

Unit Two: Select And Prepare Patterns, Hand Tools And Equipment
This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics: • Pattern equipment. • Inspecting Pattern equipment and damaged patterns. • Assembling Pattern. • Set up pattern equipment This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Identify Pattern equipment correctly from specifications to standard operating procedures • Inspect pattern equipment to specifications, and identify damaged patterns for repair or replacement to standard operating procedures ii. Assemble pattern to specification iii. Set up pattern equipment to specification according to standard operating procedures

2.1 Pattern equipment

2.1 .1 PATTERN

The pattern shop area involves the making, assembly and storage of patterns for use in moulding and core-making foundry processes .pattern is a replica of the final object to be made by casting process, with some modifications

Patterns are used to mold the sand mixture into the shape of the casting and may be made of wood, plastic, or metal. The selection of a pattern material depends on the size and shape of the casting, the dimensional accuracy and the quantity of castings required, and the molding process. Because patterns are used repeatedly to make molds, the strength and durability of the material selected for a pattern must reflect the number of castings that the mold will produce

Patterns may be made of a combination of materials to reduce wear in critical regions, and they usually are coated with a parting agent to facilitate the removal of the casting from the molds.

Patterns can be designed with a variety of features to fit specific applications and economic requirements. One-piece patterns, also called loose or solid patterns, generally are used for simpler shapes and low-quantity production; they generally are made of wood and are inexpensive. Split patterns are two piece patterns, made such that each part forms a portion of the cavity for the casting; in this way, castings with complicated shapes can be produced.

The pattern is the principal tool during the casting process. It is the replica of the object to be made by the casting process, with some modifications. The main modifications are the addition of pattern allowances, and the provision of core prints. If the casting is to be hollow, additional patterns called cores are used to create these cavities in the finished product. The quality of the casting produced depends upon the material of the pattern, its design, and construction. The costs of the pattern and the related equipment are reflected in the cost of the casting. The use of an expensive pattern is justified when the quantity of castings required is substantial.

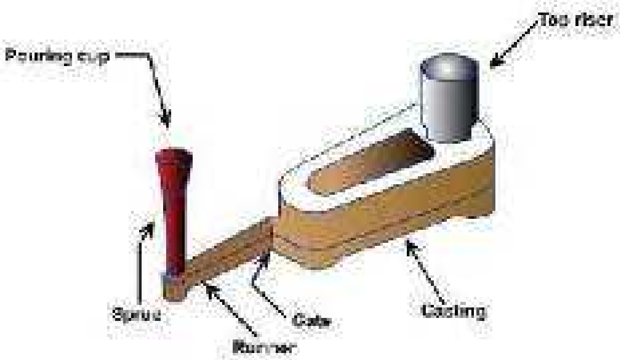


Fig 2.1 a typical pattern attached with gating and risering system

2.1.2. Uses of the Pattern

1. A pattern prepares a mould cavity for the purpose of making a casting.
2. A pattern may contain projections known as core prints if the casting requires a core and need to be made hollow.
3. Runner, gates, and risers used for feeding molten metal in the mould cavity may form a part of the pattern.
4. Patterns properly made and having finished and smooth surfaces reduce casting defects.
5. A properly constructed pattern minimizes the overall cost of the castings.

2.1.3 PATTERN MATERIAL

Patterns may be constructed from the following materials. Each material has its own advantages, limitations, and field of application. Some materials used for making patterns are: wood, metals and alloys, plastic, plaster of Paris, plastic and rubbers, wax, and resins. To be suitable for use, the pattern material should be:

1. Easily worked, shaped and joined
2. Light in weight
3. Strong, hard and durable
4. Resistant to wear and abrasion
5. Resistant to corrosion, and to chemical reactions
6. Dimensionally stable and unaffected by variations in temperature and humidity
7. Available at low cost

The usual pattern materials are wood, metal, and plastics. The most commonly used pattern material is wood, since it is readily available and of low weight. Also, it can be easily shaped and is relatively cheap. The main disadvantage of wood is its absorption of moisture, which can cause distortion and dimensional changes. Hence, proper seasoning and upkeep of wood is almost a pre-requisite for large-scale use of wood as a pattern material.

Since patterns are the forms for the castings, the casting can be no better than the patterns from which it is made. Where close tolerances or smooth casting finishes are desired, it is particularly important that patterns be carefully designed, constructed, and finished.
Patterns serve a variety of functions, the more important being:

(1) to shape the mold cavity to produce castings,
(2) to accommodate the characteristics of the metal cast,
(3) to provide accurate dimensions,
(4) to provide a means of getting liquid metal into the mold (gating system), and
(5) to provide a means to support cores by using core prints outside of the casting.

Pattern material for sand castings up to 600 mm in size may be selected as follows:
1 – 99 castings …………Wood.

100 – 499 castings……..Hard Wood or metal

Above 500………..Metal

At sharp corners in patterns, a fillet with a radius should be provided. Fillets are made of wood, leather or wax

Usual allowances built into the pattern to ensure dimensional accuracy include the following:

- ✓ **Draft:** Draft the taper on the vertical walls of the casting which is necessary to extract the pattern from the mold without disturbing the mold walls and is also required when making the core.
- ✓ **Shrinkage allowance**: Shrinkage allowances a correction to compensate for the solidification shrinkage of the metal and its contraction during cooling. These allowances vary with the type of metal and size of casting. Typical allowances for cast iron are to in/ft; for steel, to in/ft; and for aluminum, to in/ft. A designer should consult appropriate references (AFS, "Cast Metals Handbook"; ASM, "Casting Design Handbook"; "Design of Ferrous Castings") or the foundry. These allowances also include a size tolerance for the process so that the casting is dimensionally correct. (See also Secs. 6.1, 6.3, and 6.4.) Table 13.1.1 lists additional data for some commonly cast metals.
- ✓ **Machine finish allowance**

Machine finish allowance is necessary if machining operations are to be used so that stock is provided for machining. Tabulated data are available in the references cited for shrinkage allowances.

- ✓ **distortion allowance**

If a casting is prone to distortion, a pattern may be intentionally distorted to compensate. This is a distortion allowance.

2.1.4. Pattern allowances

Pattern allowance is a vital feature as it affects the dimensional characteristics of the casting. The selection of correct allowances greatly helps to reduce machining costs and avoid rejections. The allowances usually considered on patterns and core boxes are as follows

1. Shrinkage or contraction allowance
2. Machining or finish allowance
3. Draft or taper allowance
4. Rapping or Shake allowance
5. Distortion or camber allowance
6. Mould wall Movement Allowance

1. Shrinkage or Contraction Allowance

All most all cast metals shrink or contract volumetrically on cooling. The metal shrinkage is of two types:

i. **Liquid Shrinkage**: it refers to the reduction in volume when the metal changes from liquid state to solid state at the solidus temperature. To account for this shrinkage; riser, which feed the liquid metal to the casting, are provided in the mould.

ii. **Solid Shrinkage:** it refers to the reduction in volume caused when metal loses temperature in solid state. To account for this, shrinkage allowance is provided on the patterns.

The rate of contraction with temperature is dependent on the material. For example steel contracts to a higher degree compared to aluminum. To compensate the solid shrinkage, a shrink rule must be used in laying out the measurements for the pattern.

A shrink rule for cast iron is 1/8 inch longer per foot than a standard rule. If a gear blank of 4 inch in diameter was planned to produce out of cast iron, the shrink rule in measuring it 4 inch would actually measure 4 -1/24 inch, thus compensating for the shrinkage. The various rate of contraction of various materials are given in Table 2.1.

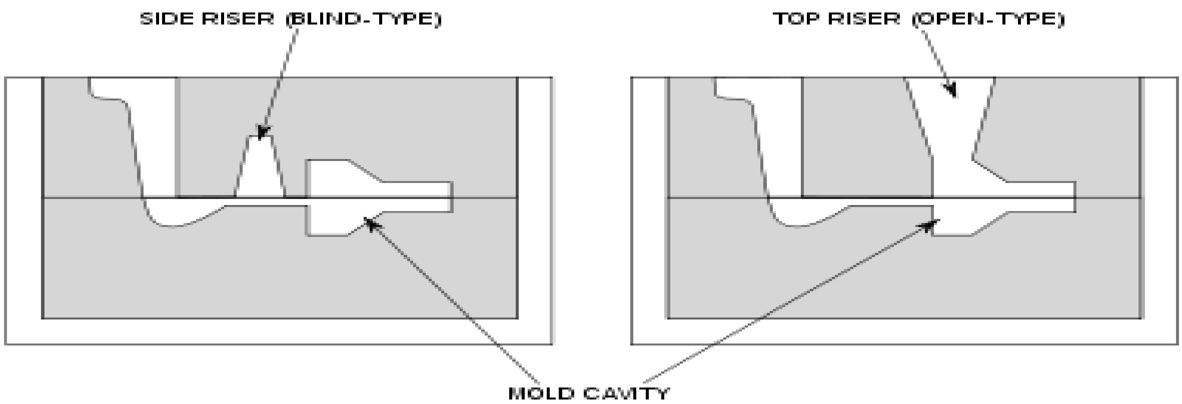
Table 2.1: Rate of Contraction of Various Metals

Material	**Dimension**	**Shrinkage allowance** (inch/ft)
Grey Cast Iron	Up to 2 feet	0.125

	2 feet to 4 feet	0.105
	over 4 feet	0.083
Cast Steel	Up to 2 feet	0.251
	2 feet to 6 feet	0.191
	over 6 feet	0.155
Aluminum	Up to 4 feet	0.155
	4 feet to 6 feet	0.143
	over 6 feet	0.125
Magnesium	Up to 4 feet	0.173
	Over 4 feet	0.155

Patternmaker's shrinkage refers to the shrinkage that occurs when the material is cooled from the solidification temperature to room temperature, which occurs due to thermal contraction.

✓ **Risers and riser aids**



- ✓ **Different types of risers**

Risers, also known as *feeders*, are the most common way of providing directional solidification. It supplies liquid metal to the solidifying casting to compensate for solidification shrinkage. Riser to work properly the riser must solidify after the casting; otherwise it cannot supply liquid metal to shrinkage within the casting. Risers add cost to the casting because it lowers the *yield* of each casting; i.e. more metal is lost as scrap for each casting. Another way to promote directional solidification is by adding chills to the mold. A chill is any material which will conduct heat away from the casting more rapidly that the material used for molding.

- ✓ **Risers are classified by three criteria**

The first is if the riser is open to the atmosphere, if it is then it's called an *open* riser, otherwise its known as a *blind* type.

The second criterion is where the riser is located; if it is located on the casting then it is known as a *top riser* and if it is located next to the casting it is known as a *side riser*.

Finally, if riser is located on the gating system so that it fills after the molding cavity, it is known as a *live riser* or *hot riser*, but if the riser fills with materials that's already flowed through the molding cavity it is known as a *dead riser* or *cold riser*.

2. **Machining Allowance**

It is a positive allowance given to compensate for the amount of material that is lost in machining or finishing the casting. If this allowance is not given, the casting will become undersize after machining. The amount of this allowance depends on the size of casting, methods of machining and the degree of finish. In general, however, the value varies from 3 mm. to 18 mm.

3. Draft or Taper Allowance

Taper allowance is also a positive allowance and is given on all the vertical surfaces of pattern so that its withdrawal becomes easier. The normal amount of taper on the external surfaces varies from 10 mm to 20mm/mt. On interior holes and recesses which are smaller in size, the taper should be around 60 mm/mt.

These values are greatly affected by the size of the pattern and the moulding method. In machine moulding its, value varies from 10 mm to 50 mm/mt.

dimensions.

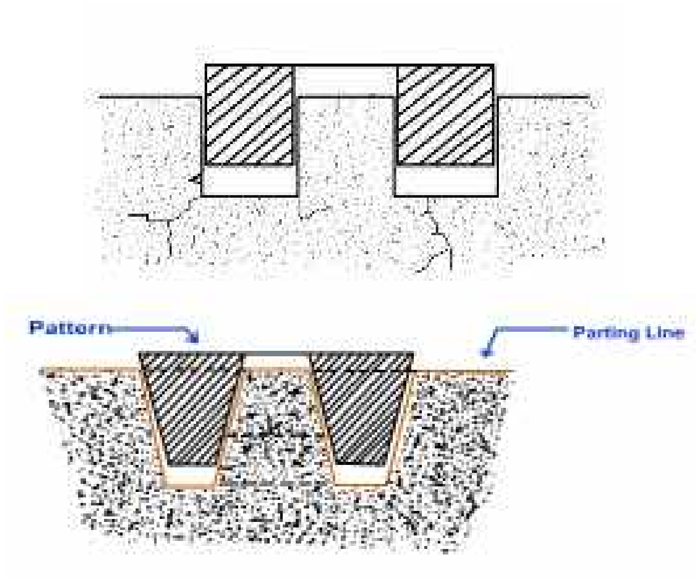


Fig. 2.2 Draft Allowance

4. Rapping or Shake Allowance

Before withdrawing the pattern it is rapped and thereby the size of the mould cavity increases. Actually by rapping, the external sections move outwards increasing the size and internal sections move inwards decreasing the size. This movement may be insignificant in the case of small and medium size castings, but it is significant in the case of large castings. This allowance is kept negative and hence the pattern is made slightly smaller in dimensions 0.5-1.0 mm.

5. Distortion Allowance

This allowance is applied to the castings which have the tendency to distort during cooling due to thermal stresses developed. For example a casting in the form of U shape will contract at the closed end on cooling, while the open end will remain fixed in position. Therefore, to avoid the distortion, the legs of U pattern must converge slightly so that the sides will remain parallel after cooling.

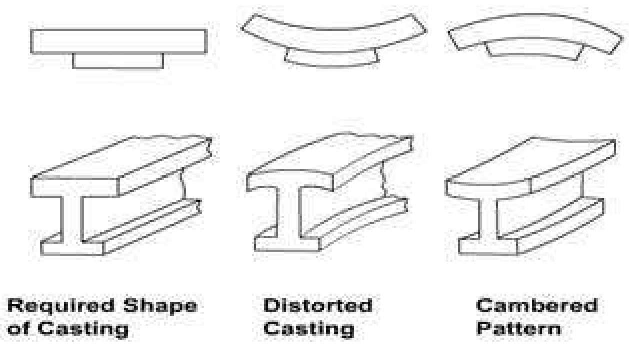


Fig. 1.3 Distortion in castings

6. Mould wall Movement Allowance

Mould wall movement in sand moulds occurs as a result of heat and static pressure on the surface layer of sand at the mould metal interface. In ferrous castings, it is also due to expansion due to graphitization. This enlargement in the mould cavity depends upon the mould density and mould composition. This effect becomes more pronounced with increase in moisture content and temperature.

Patterns vary in complexity, depending on the size and number of castings required. **Loose patterns** are single prototypes of the casting and are used only when a few castings are needed. They are usually constructed of wood, but metal, plaster, plastics, urethanes, or other suitable material may be used. With advancements in solids modeling utilizing computers, CAD/CAM systems, and laser technology, rapid prototyping is possible and lends itself to the manufacture of protype patterns from a number of materials, including dense wax paper, or via stereolithographic processes wherein a laser-actuated polymerized plastic becomes the actual pattern or a prototype for a pattern or a series of patterns.

The gating system for feeding the casting is cut into the sand by hand. Some loose patterns may be split into two parts to facilitate molding.

Gated patterns incorporate a gating system along with the pattern to eliminate hand cutting.

Match-plate patterns have the cope and drag portions of the pattern mounted on opposite sides of a wooden or metal plate, and are designed to speed up the molding process. Gating systems are also usually attached.

These patterns are generally used with some type of molding machine and are recommended where a large number of castings are required.

For fairly large castings or where an increase in production rate is desired, the patterns can be mounted on separate pattern plates, which are referred to as **cope- and drag-pattern** plates. They are utilized in horizontal or vertical machines. In horizontal molding machines, the pattern plates may be used on separate machines by different workers, and then combined into completed molds on the molding floor prior to pouring. In vertical machines, the pattern plates are used on the same machine, with the flaskless mold portions pushed out one behind the other. Vertical machines result in faster production rates and provide an economic edge in overall casting costs.

- ✓ **Special Patterns and Devices**

For extremely large castings, **skeleton** patterns may be employed. Large molds of a symmetric nature may be made for forming the sand mold by **sweeps,** which provide the contour of the casting through the movement of a template around an axis.

Follow boards are used to support irregularly shaped loose patterns which require an irregular parting line between cope and drag. A **master pattern** is used as an original to make up a number of similar patterns that will be used directly in the foundry.

2.1.5 Types of pattern

The types of the pattern and the description of each are given as under: 1. One piece or solid pattern, 2.Two piece or split pattern, 3. Cope and drag pattern, 4. Three-piece or multi- piece pattern, 5.Loose piece pattern, 6. Match plate pattern, 7. Follow board pattern, 8. Gated pattern, 9.Sweep pattern, 10.Skeleton pattern, 11.Segmental or part pattern.

1. Single-piece or solid pattern

Solid pattern is made of single piece without joints, partings lines or loose pieces. It is the simplest form of the pattern. Typical single piece pattern is shown in Fig. 2.2

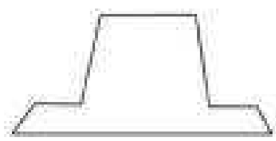


Fig. 2.2 Single piece pattern

2. Two-piece or split pattern

When solid pattern is difficult for withdrawal from the mould cavity, then solid pattern is splited in two parts. Split pattern is made in two pieces which are joined at the parting line by means of dowel pins. The splitting at the parting line is done to facilitate the withdrawal of the pattern. A typical example is shown in Fig. 2.4.

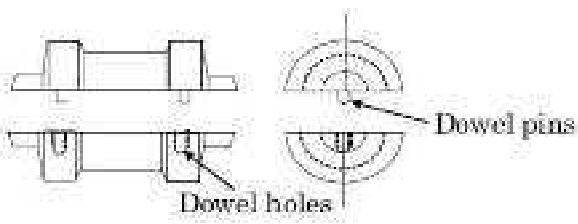


Fig. 2.3 Two piece pattern

3. Cope and drag pattern

In this case, cope and drag part of the mould are prepared separately. This is done when the complete mould is too heavy to be handled by one operator. The pattern is made up of two halves, which are mounted on different plates. A typical example of match plate pattern is shown in Fig. 2.4.

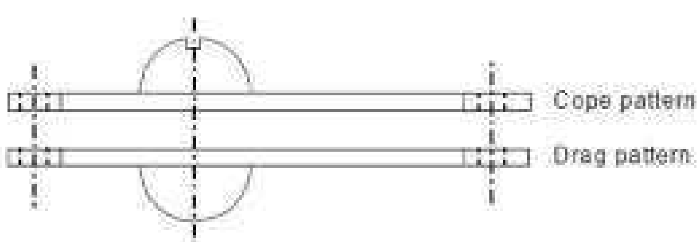


Fig. 2.4 Cope and drag pattern

4. Three-piece or multi-piece pattern

Some patterns are of complicated kind in shape and hence cannot be made in one or two pieces because of difficulty in withdrawing the pattern. Therefore these patterns are made in either three pieces or in multi-pieces. Multi moulding flasks are needed to make mould from these patterns.

5. Loose-piece Pattern

Loose piece pattern (Fig. 2.5.) is used when pattern is difficult for withdrawal from the mould. Loose pieces are provided on the pattern and they are the part of pattern. The main pattern is removed first leaving the loose piece portion of the pattern in the mould. Finally the loose piece is withdrawal separately leaving the intricate mould.

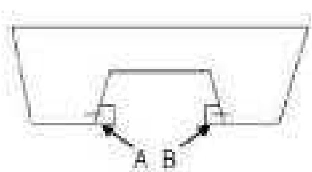


Fig.2.5. Loose piece pattern

6. Match plate pattern

This pattern is made in two halves and is on mounted on the opposite sides of a wooden or metallic plate, known as match plate. The gates and runners are also attached to the plate. This pattern is used in machine moulding. A typical example of match plate pattern is shown in Fig. 2.6.

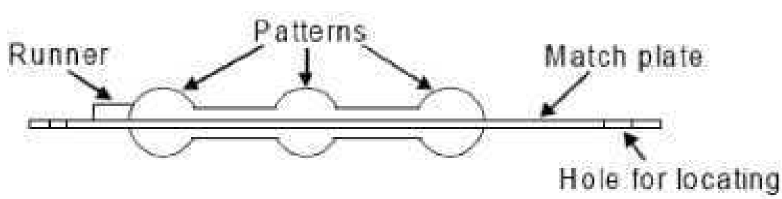


Fig. 2.6 Match plate pattern

7. Follow board pattern

When the use of solid or split patterns becomes difficult, a contour corresponding to the exact shape of one half of the pattern is made in a wooden board, which is called a follow board and it acts as a moulding board for the first moulding operation as shown in Fig. 2.7.

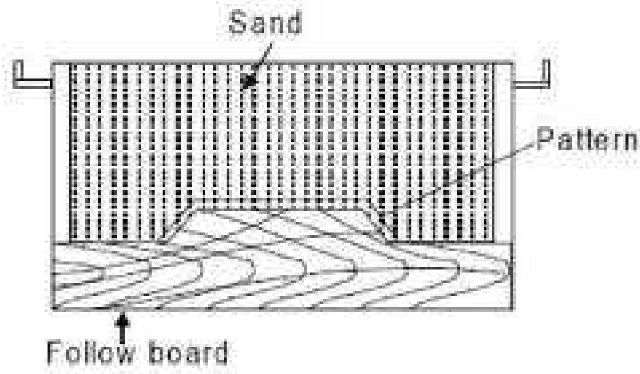


Fig. 2.7 Follow board pattern

8. Gated pattern

In the mass production of casings, multi cavity moulds are used. Such moulds are formed by joining a number of patterns and gates and providing a common runner for the molten metal, as shown in Fig. 2.8. These patterns are made of metals, and metallic pieces to form gates and runners are attached to the pattern.

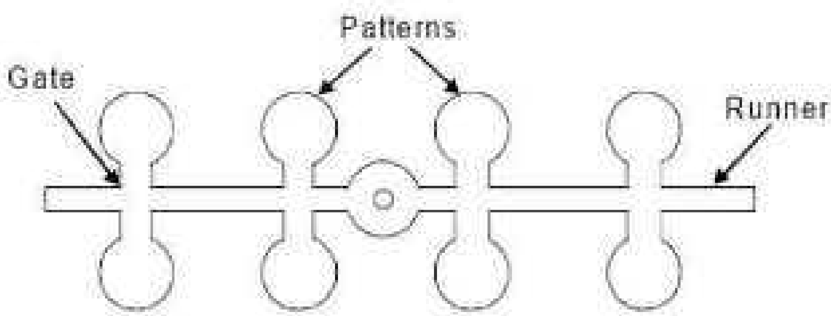


Fig. 2.8 Gated pattern

9. Sweep pattern

Sweep patterns are used for forming large circular moulds of symmetric kind by revolving a sweep attached to a spindle as shown in Fig. 2.9. Actually a sweep is a template of wood or metal and is attached to the spindle at one edge and the other edge has a contour depending upon the desired shape of the mould. The pivot end is attached to a stake of metal in the center of the mould.

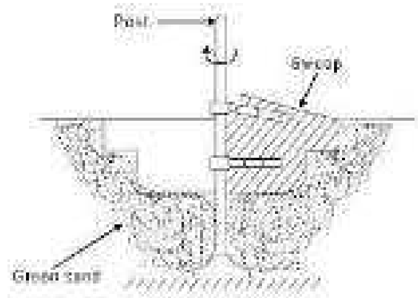


Fig. 2.9 Sweep pattern 25

10. Skeleton pattern

When only a small number of large and heavy castings are to be made, it is not economical to make a solid pattern. In such cases, however, a skeleton pattern may be used. This is a ribbed construction of wood which forms an outline of the pattern to be made.

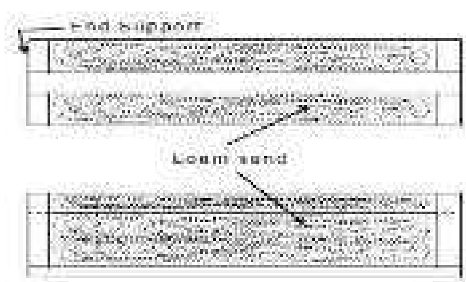


Fig. 2.10 Skeleton pattern

This frame work is filled with loam sand and rammed. The surplus sand is removed by strickle board. For round shapes, the pattern is made in two halves which are joined with glue or by means of screws etc. A typical skeleton pattern is shown in Fig. 2.10.

11. Segmental pattern

Patterns of this type are generally used for circular castings, for example wheel rim, gear blank etc. Such patterns are sections of a pattern so arranged as to form a complete mould by being moved to form each section of the mould. The movement of segmental pattern is guided by the use of a central pivot. A segment pattern for a wheel rim is shown in Fig. 2.11.

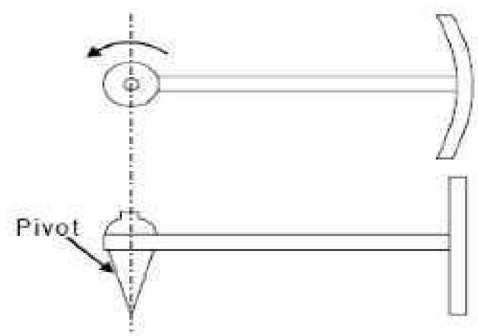


Fig. 2.11 Segmental or part pattern

2.1.6 Life expectancy of patterns

The life of patterns and core boxes can be expressed in terms of the number of moulds or cores that can be produced. The material of the pattern, type of construction, method of moulding and core-making, care with which patterns are handled, and type of storage affect the life expectancy. Table 2.2 gives the expected life of patterns for guidance purposes.

Table 2.2 Life expectancy of patterns

SL. *No.*	Method of Using Pattern	Pattern Material	Type of Construction	Expected Life in Number of Moulds
1.	Loose	Soft wood	Skeleton	10
2.	Loose		Segmental, disc, box, etc.	50
3.	Loose	Hard wood	Ring, tongue and groove,	200

4.	Mounted		header and stave, disc, box and composite	1000
5.	Mounted	Epoxy resin	Cast in plaster or plastic moulds	2000
6.	Mounted	Epoxy resin with filler	Gel coat, lamination with glass fibre	5000
7.	Mounted	Aluminium pressure cast	As cast artd cleaned	3000-5000
8.	Mounted	Aluminium, sand cast	Machined all over and polished	30,000
9.	Mounted	Brass, SG iron, grey iron, steel	Machined all over	50,000

2.1.7 Pattern storage and repair

In order to be able to use the patterns for a long time, it is essential to give due consideration to storage and repair requirements. It is advisable that the patterns, after use in the foundry, are carefully inspected for any breakage or loss, adequately repaired, and sent for safe storage. Similarly, when a pattern is requisitioned by the foundry, it should be obtained from storage, inspected, repairs, if any, carried out, and then issued to the foundry.

It is also desirable to maintain a complete history of each pattern by recording, date-wise on a card, the issue and return of patterns to and from the foundry, number of moulds produced, inspection carried out, and nature of repairs done.

The principal factors governing space requirements for pattern storage are

- Quantity and volume of patterns
- Rate of acquisition of new patterns to be added to storage
- Types Of Patterns
- General rate of obsolescence due to changes in casting design, or design of product.

Pattern-storage areas should be so designed that they are weather-proof and fireproof, with adequate arrangements for extinguishing fires. For expensive patterns, it is also desirable to have temperature and humidity controls. Separate areas or floors should be earmarked for light, medium and heavy patterns. Small patterns are kept in racks, and large ones are placed on the floor with proper identification marks.

Repair of patterns is often required for various reasons. It is relatively easier to manufacture new patterns than repair old ones. It needs skill, hard work and experience to correctly repair the pattern equipment. Pattern repair may be required due to normal wear and tear during use, breakage during transportation and handling, careless moulding work, falling of slag or molten metal, seasonal effects, improper placement when not in use, use of sub-standard material, wrong designs and weak construction.

In case of foundries with a large turnover of patterns, it is preferable to have a repair section attached to the storage area and separate from the main pattern shop. A properly organized pattern-repair facility can help improve the technological discipline amongst patternmakers, keep a constant check on undesirable and careless practices during manufacture, and even guide in improving moulding and core-making practices.

2.1.8 Core box

2.1.8.1 Core and Core Box: Cores are compact mass of core sand that when placed in mould cavity at required location with proper alignment does not allow the molten metal to occupy space for solidification in that portion and hence help to produce hollowness in the casting. The environment in which the core is placed is much different from that of the mold.

In fact has to withstand the severe action of hot metal which completely surrounds it. Cores are classified according to shape and position in the mold. There are various types of cores such as; Horizontal core, Vertical core, balanced core, Drop core, and, Hanging core,

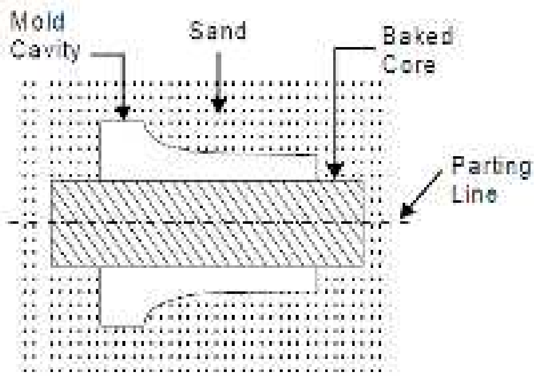


Fig. 2.13 Horizontal core

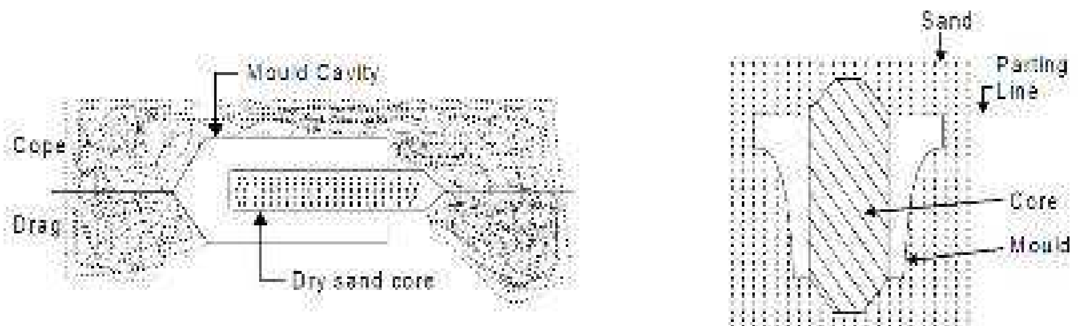


Fig.2.14 Vertical core and Balanced core respectively

Fig 2.15 Drop core and Hanging core respectively

There are various functions of cores which are given below

- Core is used to produce hollowness in castings in form of internal cavities,
- It may form a part of green sand mold,
- It may be deployed to improve mold surface,
- It may provide external undercut features in casting,
- It may be used to strengthen the mold,
- It may be used to form gating system of large size mold,
- It may be inserted to achieve deep recesses in the casting.

Core Box: Any kind of hollowness in form of holes and recesses in castings is obtained by the use of cores. Cores are made by means of core boxes comprising of either single or in two parts. Core boxes are generally made of wood or metal and are of several types. The main types of core box are; Half core box, Dump core box, Split core box, Strickle core box, Right and left hand core box, and Loose piece core box.

A. **Half core box**

This is the most common type of core box. The two identical halves of a symmetrical core prepared in the half core box. Two halves of cores are pasted or cemented together after baking to form a complete core.

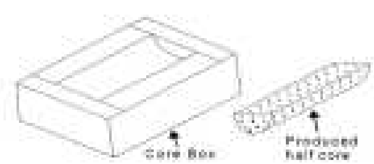


Fig.2.16 Half core box

B. **Dump core box**

Dump core box is similar in construction to half core box. The cores produced do not require pasting, rather they are complete by themselves. If the core produced is in the shape of a slab, then it is called as a slab box or a rectangular box. A dump core-box is used to prepare complete core in it. Generally cylindrical and rectangular cores are prepared in these boxes.

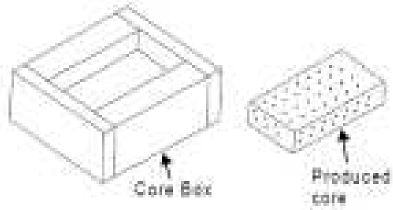


Fig.2.17 Dump core-box

C. **Split core box**

Split core boxes are made in two parts They form the complete core by only one ramming. The two parts of core boxes are held in position by means of clamps and their alignment is maintained by means of dowel pins and thus core is produced.

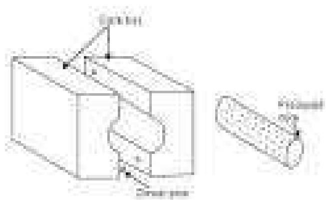


Fig.2.18 Split core boxes

2.1.8.2 CORE BOX ALLOWANCES

Materials used in making core generally swell and increase in size. This may lead to increase the size of core. The larger cores sometimes tend to become still larger.

This increase in size may not be significant in small cores, but it is quite significant in large cores and therefore certain amount of allowance should be given on the core boxes to compensate for this increase the cores.

It is not possible to lay down a rule for the amount of this allowance as this will depend upon the material used, but it is customary to give a negative allowance of 5 mm /m.

- ✓ **Core Prints**

When a hole blind or through is needed in the casting, a core is placed in the mould cavity to produce the same. The core has to be properly located or positioned in the mould cavity on pre-formed recesses or impressions in the sand.

To form these recesses or impressions for generating seat for placement of core, extra projections are added on the pattern surface at proper places.

These extra projections on the pattern (used for producing recesses in the mould for placement of cores at that location) are known as ***core prints***. Core prints may be Horizontal, Vertical, Balanced, Wing and

Core types. Horizontal core print produces seats for horizontal core in the mould. Vertical core print produces seats to support a vertical core in the mould. Balanced core print produces a single seat on one side of the mould and the core remains partly in this formed seat and partly in the mould cavity, the two portions balancing each other. The hanging portion of the core may be supported on chaplets. Wing core print is used to form a seat for a wing core.

2.1.9 Tools and equipments of foundry shop

There are large numbers of tools and equipments used in foundry shop for carrying out different operations such as **sand preparation**, **molding, melting**, **pouring and casting, pattern making**. They can be broadly classified as hand tools, sand conditioning tool, flasks, power operated equipments, metal melting equipments and fettling and finishing equipments. Different kinds of hand tools are used by molder in mold making operations. Sand conditioning tools are basically used for preparing the various types of molding sands and core sand.coatings.

The selection of the type of pattern equipment used to make a casting depends on:

- Number of castings to be produced,
- the size and shape of the casting,
- the molding or casting process to be used, and
- Other special requirements such as the dimensional accuracy required.

The general tools and equipment used in the pattern making shop classified in to two category hand tools and machineries:

1. Measuring and layout tools; wooden or steel scale or rule, diveders, callipers, try square, calliper rules, flexible rule, marking gauge, T- bevel, combination square, etc
2. Sawing tools; compress saw, rip saw, coping saw, dovetail saw, back saw, panel saw, miter saw, etc
3. Planning tools; jack plane, circular plane, router plane, rabbet plane, block plane, bench plane, core box plane, etc

- Boring tool; hand operating drills, machine operated drills, twist drill, countersunk, brace, auger bit, bit gauge, etc.

- Clamping tools; bench vice, c-clamp, bar clamp, hand screw, pattern maker's vice, pinch dog, etc.

- Miscellaneous tool; screw driver, various types of hammers, chisel, rasp, file, nail set, bardawl, brad pusher, cornering tool.

2.1.10 Finishing the pattern

After the patterns are prepared they should be finished by sanding or other finishing methods. Because finishing of casting is depend on the finishing of pattern. The finished patterns are colored according to their purposes

Surface	*Colour/Mark*
Surface to be left as cast (unmachined) :	Blue (Steel) Red (Grey cast iron) Grey (Malleable cast iron) Orange (Heavy metal castings) Brown (Light metal castings)
Surfaces to be machined :	Yellow
Core prints for unmachined openings and end prints :	
Periphery	Black
Ends	Black
Core prints for machined openings :	
Periphery	Yellow stripes or black
Ends	Black
Pattern joints (split pattern) :	
Cored section	Black
Metal section	Clear varnish
Touch core :	
Core shape	Black
Legend	"Touch"
Seats of and for loose core prints :	Green
Stop-offs :	Diagonal black stripes or clear varnish
Chilled surfaces :	
Outlined in legend	Black "chill"
Fillets :	Black broken line

The pattern shop area involves the making, assembly and storage of patterns for use in moulding and core-making foundry processes .pattern is a replica of the final object to be made by casting process, with some modifications

The main modifications are:

- The addition of pattern allowances,
- The provision of core prints,
- Elimination of fine details which cannot be obtained by casting and hence are to be obtained by further processing

✓ **HAND TOOLS USED IN FOUNDRY SHOP**

The common hand tools used in foundry shop are fairly numerous. A brief description of the Following foundry tools used frequently by molder is given as under

a. Hand riddle

Hand riddle is shown in Fig. 11.1(a). It consists of a screen of standard circular wire mesh equipped with circular wooden frame. It is generally used for cleaning the sand for removing foreign material such as nails, shot metal, splinters of wood etc. from it. Even power operated riddles are available for riddling large volume of sand.

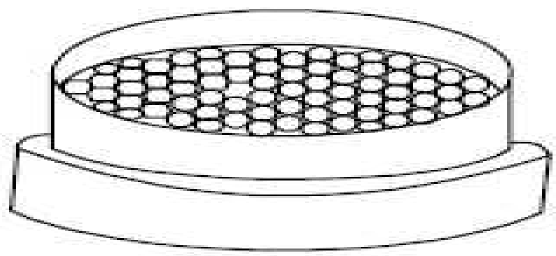


Figure 2.19 hand ride

b. Shovel

Shovel is shown in Fig. 11.1(b). It consists of a steel pan fitted with a long wooden handle.
It is used in mixing, tempering and conditioning the foundry sand by hand. It is also used for moving and transforming the molding sand to the container and molding box or flask. It should always be kept clean.

c. Rammers

These are required for striking the molding sand mass in the molding box to pack or compact it uniformly all around the pattern. The common forms of rammers used in ramming are hand rammer, peen rammer, floor rammer and pneumatic rammer which are briefly described as

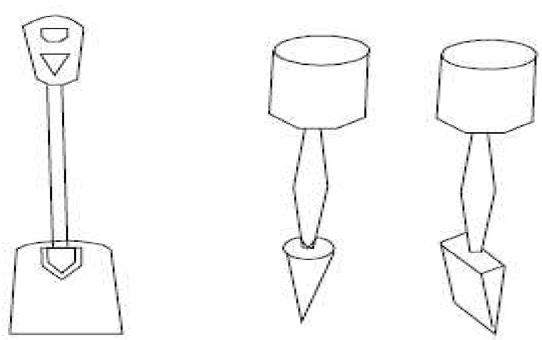


Fig. 2.20 rammer

(*i*) Hand rammer

It is generally made of wood or metal. It is small and one end of which carries a wedge type construction, called peen and the other end possesses a solid cylindrical shape known as butt. It is used for ramming the sand in bench molding work.

(*ii*) Peen rammer

It has a wedge-shaped construction formed at the bottom of a metallic rod. It is generally used in packing the molding sand in pockets and comers.

(*iii*) Floor rammer

It consists of a long steel bar carrying a peen at one end and a flat portion on the other. It is a heavier and larger in comparison to hand rammer. Its specific use is in floor molding for ramming the sand for larger molds. Due to its large length, the molder can operate it in standing position.

(*iv*) Pneumatic rammers

They save considerable time and labor and are used for making large molds

D. Sprue pin

Sprue pin is shown in Fig. 11.1(d). It is a tapered rod of wood or iron which is placed or pushed in cope to join mold cavity while the molding sand in the cope is being rammed. Later its withdrawal from cope produce a vertical hole in molding sand, called sprue through which the molten metal is poured into the mould using gating system. It helps to make a passage for pouring molten metal in mold through gating system

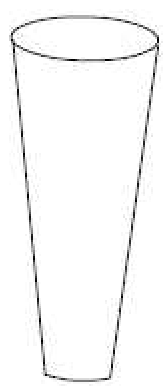


Fig. 2.21 **Sprue pin**

1. By setting the pavers in the ground as edging around flower beds, where they will not endure heavy traffic that causes major cracks in pavers.

E. Strike off bar

is a flat bar having straight edge and is made of wood or iron. It is used to strike off or remove the excess sand from the top of a molding box after

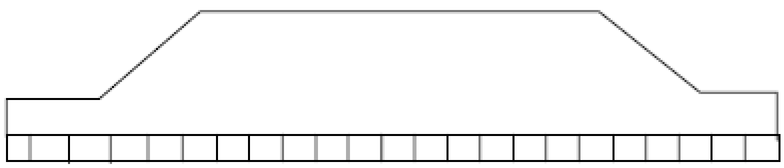


Fig. 2.22 **Strike off bar**

F. Mallet

Mallet is similar to a wooden hammer and is generally as used in carpentry or sheet metal shops. In molding shop, it is used for driving the draw spike into the pattern and then rapping it for separation from the mould surfaces so that pattern can be easily withdrawn leaving the mold cavity without damaging the mold surfaces.

G. Draw spike

It is a tapered steel rod having a loop or ring at its one end and a sharp point at the other. It may have screw threads on the end to engage metal pattern for it withdrawal from the mold. It is used for driven into pattern which is embeddedin the molding sand and raps the pattern to get separated from the pattern and finally draws out it from the mold cavity.

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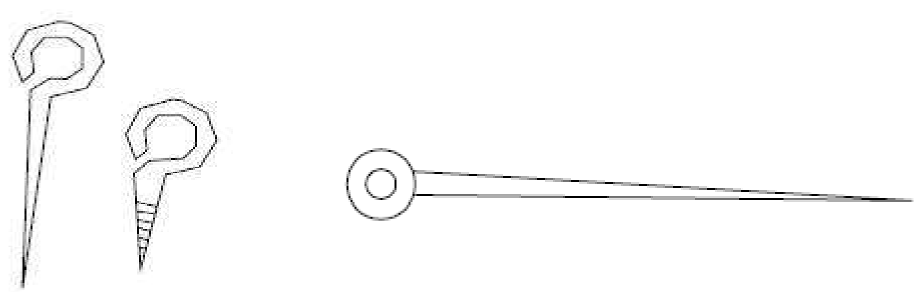


Fig. 2.23 Draw spike

H. Vent rod

Vent rod is shown in Fig. 11.1(g). It is a thin spiked steel rod or wire carrying a pointed edge at one end and a wooden handle or a bent loop at the other. After ramming and striking off the excess sand it is utilized to pierce series of small holes in the molding sand in the cope portion. The series of pierced small holes are called vents holes which allow the exit or escape of steam and gases during pouring mold and solidifying of the molten metal for getting a sound casting.

I. Lifters

Lifters are shown in Fig. 11.1(h, i, j and k). They are also known as cleaners or finishing tool which are made of thin sections of steel of various length and width with one end bent at right angle. They are used for cleaning, repairing and finishing the bottom and sides of deep and narrow openings in mold cavity after withdrawal of pattern. They are also used forremoving loose sand from mold cavity.

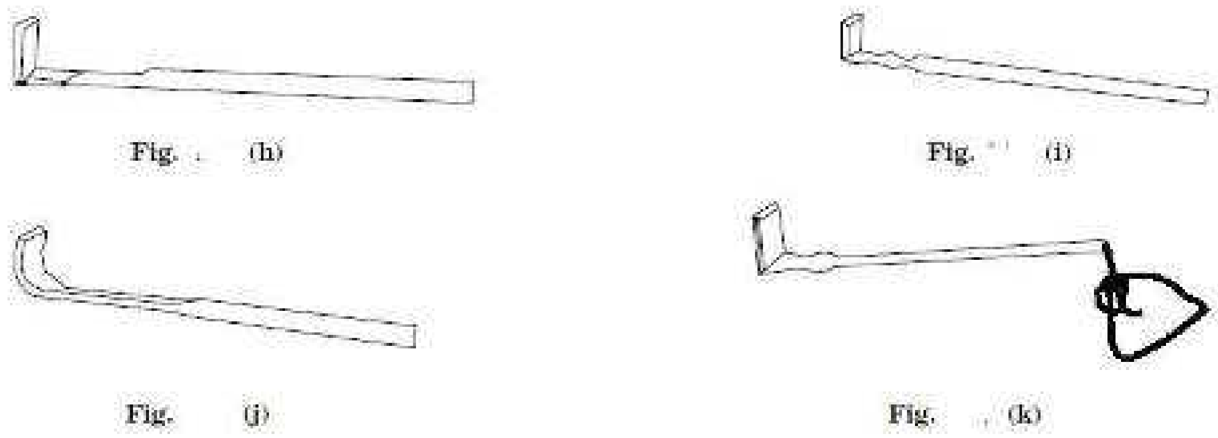


Fig. 2.24 Lifters

J. Trowels

Trowels are shown in Fig. 11.1(l, m and n). They are utilized for finishing flat surfaces and joints and partings lines of the mold. They consist of metal blade made of iron and are equipped with a wooden handle. The common metal blade shapes of trowels may be pointed or contoured or rectangular oriented. The trowels are basically employed for smoothing or slicking the surfaces of molds. They may also be used to cut in-gates and repair the mold surfaces

Fig. (l)

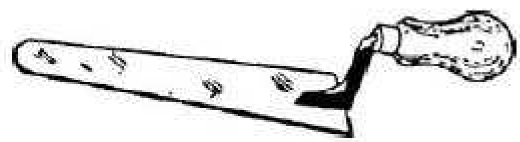


Fig. (m)

Fig. (n)

Fig. 2.25 trowels

K. Slicks

Slicks are shown in Fig. 11.1(o, p, q, and r). They are also recognized as small double ended mold finishing tool which are generally used for repairing and finishing the mold surfaces and their edges after withdrawal of the pattern. The commonly used slicks are of the types of heart and leaf, square and heart, spoon and bead and heart and spoon. The nomenclatures of the slicks are largely due to their shapes.

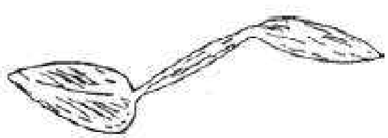


Fig. (o)

Fig. (p)

Fig. (q)

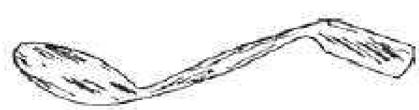


Fig. (r)

Fig. 2.26 slicks

L. Smoothers

Smothers are shown in Fig. 11.1(s and t). According to their use and shape they are given different names. They are also known as finishing tools which are commonly used for repairing and finishing flat and round surfaces, round or square corners and edges of molds

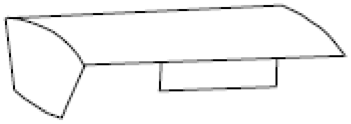


Fig. (s)

Fig. (t)

Fig. 2.27smothers

M. Swab

Swab is shown in Fig. 11.1(u). It is a small hemp fiber brush used for moistening the edges of sand mould, which are in contact with the pattern surface before withdrawing the pattern. It is used for sweeping away the molding sand from the mold surface and pattern. It is also used for coating the liquid blacking on the mold faces in dry sand molds

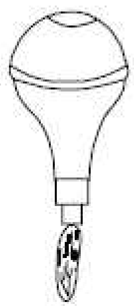


Fig. (u)

Fig. 2.28 swab

N. Spirit level

Spirit level is used by molder to check whether the sand bed or molding box is horizontal or not.

O. Gate cutter

Gate cutter (Fig. 11.1(v)) is a small shaped piece of sheet metal commonly used to cut runners and feeding gates for connecting sprue hole with the mold cavity.

Fig. (v)

Fig. 2.29 gate cutter

P. Gaggers

Gaggers are pieces of wires or rods bent at one or both ends which are used for reinforcing the downward projecting sand mass in the cope are known as gaggers. They support hanging bodies of sand. They possess a length varying from 2 to 50 cm. A gagger is always used in cope area and it may reach up to 6 mm away from the pattern. It should be coated with clay wash so that the sand adheres to it. Its surface should be rough in order to have a good grip with the molding sand. It is made up of steel reinforcing bar.

Q. Spray-gun

Spray gun is mainly used to spray coating of facing materials etc. on a mold or core surface.

R. Nails and wire pieces

They are basically used to reinforce thin projections of sand in the mold or cores.

S. Wire pieces, spring and nails

They are commonly used to reinforce thin projections of sand in molds or cores. There also used to fasten cores in molds and reinforce sand in front of an in-gate.

T. Bellows

Bellows gun is shown in Fig. 11.1(w). It is hand operated leather made device equipped with compressed air jet to blow or pump air when operated. It is used to blow away the loose Common hand tools used in foundry or unwanted sand from the surfaces of mold cavities.

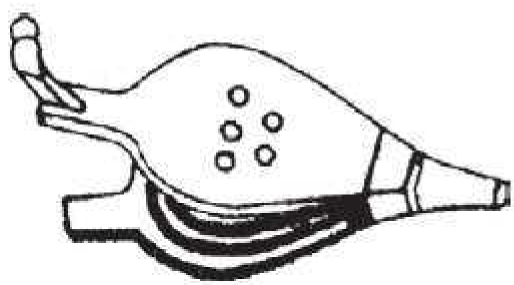


Fig. (w)

Fig. 2.30 bellows

U. Clamps, cotters and wedges

They are made of steel and are used for clamping the molding boxes firmly together during pouring.

V. FLASK

The common flasks are also called as containers which are used in foundry shop as mold boxes, crucibles and ladles.

- ✓ Moulding Boxes

- ✓ Mould boxes are also known as molding flasks.

Boxes used in sand molding are of two types: Open molding boxes ,and Closed molding boxes**.**

i. Open molding boxes. Closed molding boxes.

Open molding boxes the hinge at one corner and a lock on the opposite corner. They are also known as snap molding boxes which are generally used for making sand molds. A snap molding is made of wood and is hinged at one corner. It has special applications in bench molding in green sandwork for small nonferrous castings. The mold is first made in the snap flask and then it completion of ramming thereby making its surface plane and smooth. Its one edge is made beveled and the other end is kept perfectly smooth and plane. removed and replaced by a steel jacket. Thus, a number of molds can be prepared using the same set of boxes. As an alternative to the wooden snap boxes the cast-aluminum tapered closed boxes are finding favor in modern foundries. They carry a tapered inside surface which is accurately ground and finished. A solid structure of this box gives more rigidity and strength than the open type. These boxes are also removed after assembling the mould. Large molding boxes are equipped with reinforcing cross bars and ribs to hold the heavy mass of sand and support gaggers. The size, material and construction of the molding box depend upon the size of the casting

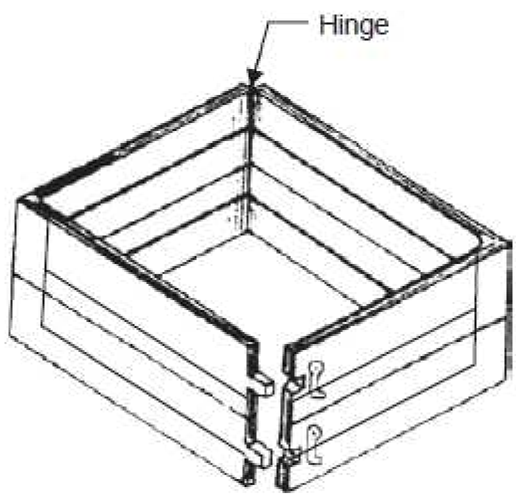


FIGURE 2.31 Open molding box

ii. Closed molding boxes.

Closed molding boxes are shown in Fig. 11.3 which may be made of wood, cast-iron or steel and consist of two or more parts.The lower part is called the drag, the upper part the cope and all the intermediate parts, if used, cheeks. All the parts are individually equipped with suitable means for clamping arrangements during pouring. Wooden Boxes are generally used in green-sand molding. Dry sand moulds always require metallic boxes because they are heated for drying. Large and heavy boxes are made from cast iron or steel and carry handles and grips as they are manipulated by cranes or hoists, etc. Closed metallic molding boxes may be called as a closed rectangular molding box (Fig. 11.3) or **molding box**

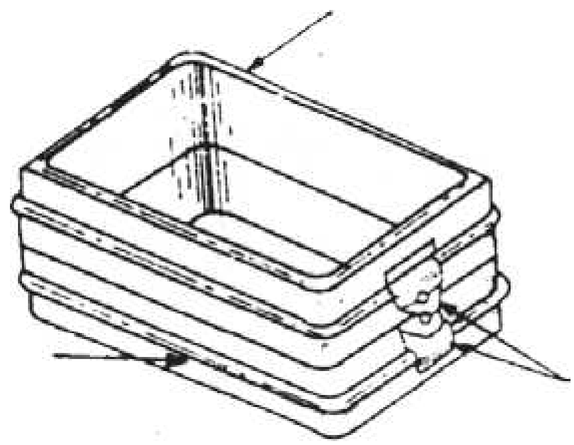


Figure: 2.32 Closed rectangular

a. Crucible

Crucibles are made from graphite or steel shell lined with suitable refractory material like fire clay. They are commonly named as metal melting pots. The raw material or charge is broken into small pieces and placed in them. They are then placed in pit furnaces which are coke-fired. In oil- fired tilting furnaces, they form an integral part of the furnace itself and the charge is put into them while they are in position. After melting of metals in crucibles, they are taken out and received in crucible handle. Pouring of molten is generally done directly by them instead of transferring the molten metal to ladles. But in the case of a oilfiredfurnace, the molten metal is first received in a ladle and then poured into the molds.

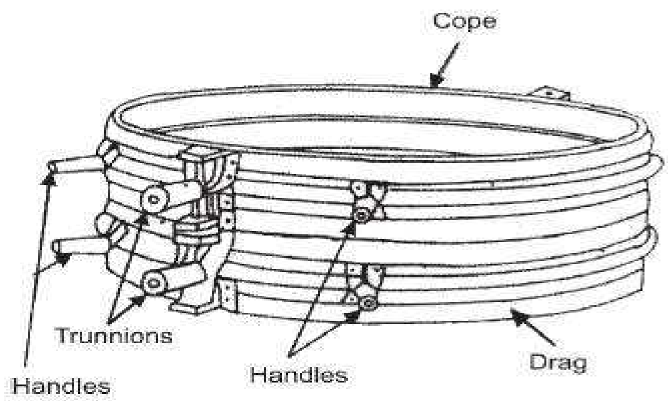


Figure: 2.33 Closed round molding box

b. Ladle

It is similar in shape to the crucible which is also made from graphite or steel shell lined with suitable refractory material like fire clay. It is commonly used to receive molten metal from the melting furnace and pour the same into the mold cavity. Its size is designated by its capacity. Small hand shank ladles are used by a single foundry personal and are provided with only one handle. It may be available in different capacities up to 20 kg

✓ **POWER OPERATED EQUIPMENTS**

Power operated foundry equipments generally used in foundries are different types pattern making machines, different types of molding machines and sand slingers, core making, core baking equipment, power riddles, mechanical conveyors, sand mixers, material handling equipment and sand aerators etc. Few commonly used types of such equipments are discussed as under.

I. Pattern making machines

Selecting appropriate wood working machines, Different machines are needed to save time and labor in carpentry work for various quick wood working operations especially for turning and sawing purposes. The general wood working machines are wood working lathe, circular saw and band saw.

1. Wood Working Lathe

A general wood working lathe is shown in Fig. 2.1 which resembles roughly to an engine lathe. It consists of a cast iron bed, a headstock, tailstock, tool rest, live and dead centres and drawing mechanisms.

The long wooden cylindrical jobs are held and rotated between the two centres.

The tool is then fed against the job and the round symmetrical shape on the jobs is produced. Scrapping tool and turning gauge are generally used as a turning tool on a woodworking lathe.

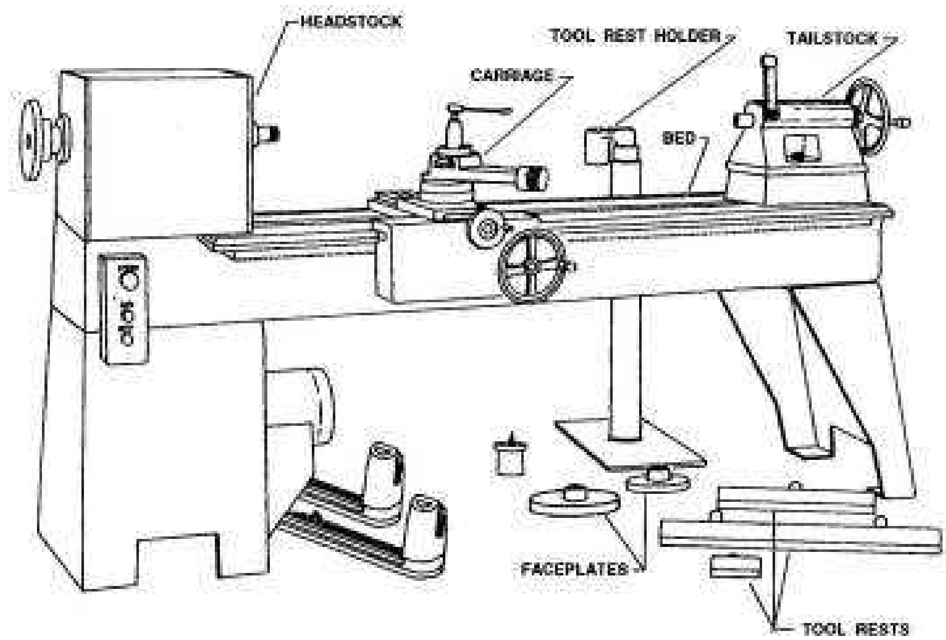


Fig. 2.34 wood lathe

2. Band Saw

Band saw is shown in Fig. 2.2. This generally used to cut the heavy logs to required lengths, cutting fine straight line and curved work. It consists of a heavy cast bed, which acts as a support for the whole machine, a column, two wheel pulleys, one at the top and other at the bottom, an endless saw blade band, a smooth steel table and guide assembly. It is manufactured in many sizes ranging from little bench saw to a larger band saw mill.

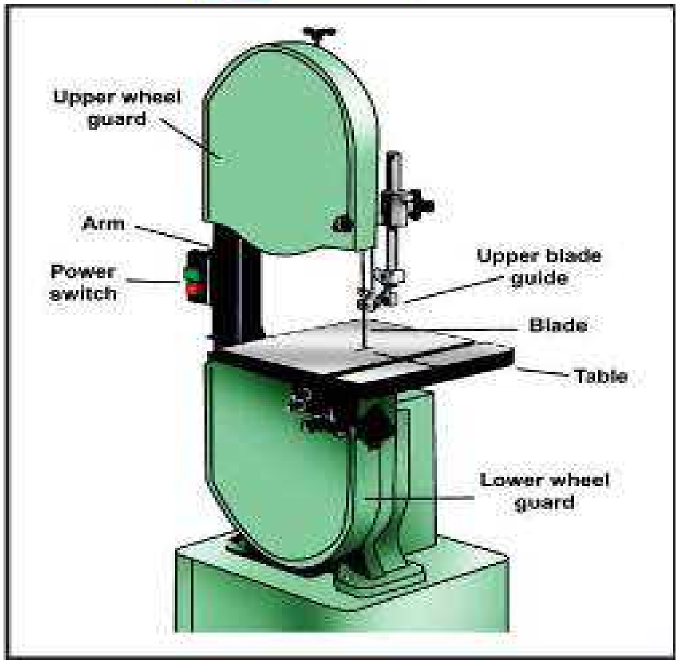


Fig. 2.35 Band saw

3. CIRCULAR SAW:

A circular saw is a power-saw is using a toothed or a abrasive disc or blade to cut different materials using a rotary motion spinning around an arbour. In woodworking, the term “circular saw” refers specifically to the hand-held type and the table saw and chop saw are other common forms of circular saws. “Skilsaw” has become a generic trademark for conventional hand-held circular saws. Circular saw blades are specially designed for each particular material they are intended to cut and in cutting. A circular is used to perform various operations such as grooving, rebating, chamfering etc. It consists of a cast iron table, a circular cutting blade, cut off guides, main motor, saw guide, elevating hand wheel, tilting hand wheel etc. The work is held on the table and moved against the circular saw to perform the quick and automatic sawing operation and other operation on wood as said above. The principal parts include the frame, arbour, table, blade, guides for taking cuts, guards and fencing.

Fig .2.36 Hand-held circular saw

4. Table saw

A table saw or saw bench is a woodworking tool consisting of a circular saw blade, mounted on an arbour, that is driven by an electric motor (either directly, by belt, or by gears).

The blade protrudes through the surface of a table, which provides support for the material, usually wood, being cut.

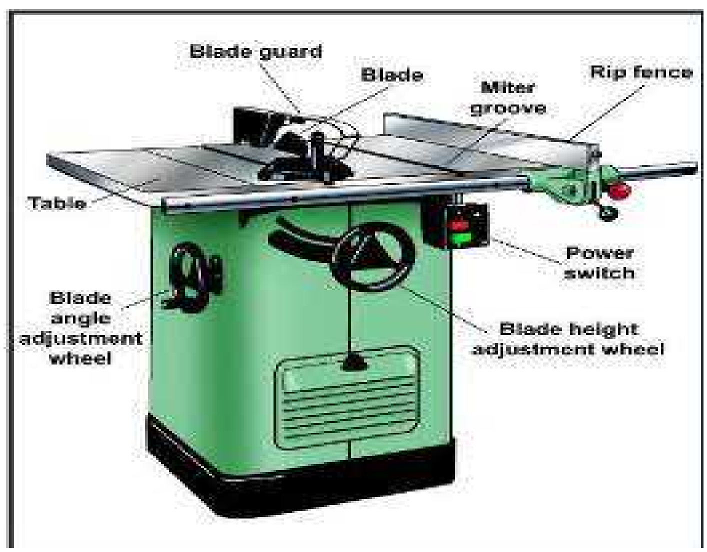


Fig.2.37 table saw

5. Jointers

Jointers come in different sizes and perform functions similar to those of a hand plane. Small jointers are portable and large jointers are stationary. Main parts of a jointer include an on/off switch, in feed table adjustment levers, in feed table, tilting fence, cutter guard, and out feed table. See Figure 2.5. The three main adjustable parts are the in feed table, tilting fence, and out feed table. The out feed table must be set at the same height as the cutter edges at the highest point of their rotation. See Figure 2.5. This adjustment is important to avoid tapering or biting the surface.

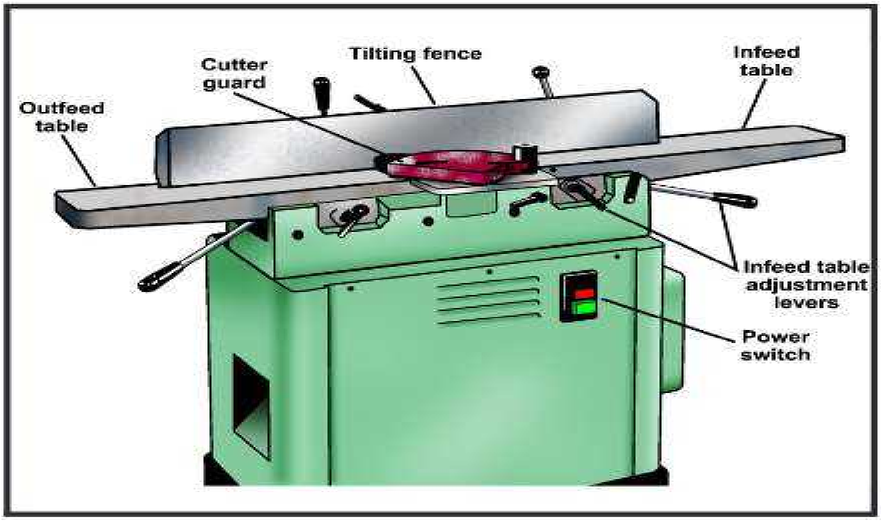


Fig. 2.38 Jointer

6. **Drill Press**

The drill press provides you with the ability to do precision drilling and deliver especially accurate large-diameter holes. One of the best features of a drill press is the ability for you to set the depth of the hole. This is especially useful when you have a number of holes you need to drill, all to the same depth. The drill press also allows you to use forstner bits, hole saws and spade bits, drilling large diameter holes. to depths that would be very difficult to drill by hand

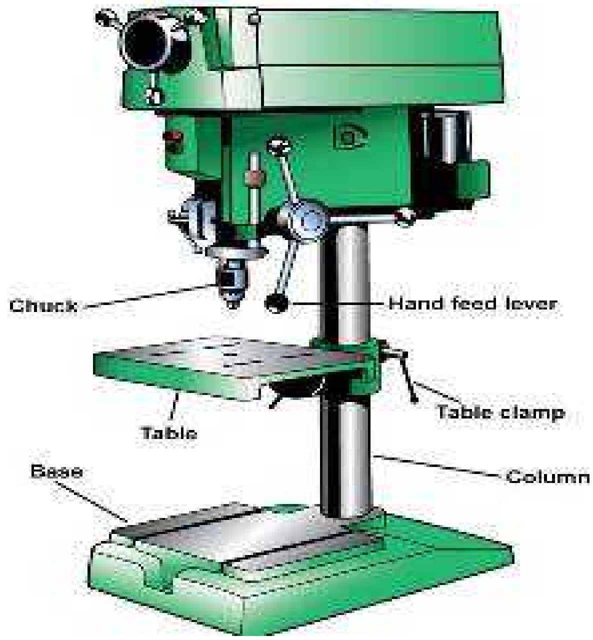


Fig .2.39 floor drill press

7. Portable Hand drill

Drills are commonly used in woodworking, metalworking, construction and do-it-yourself projects. Specially designed drills are also used in medicine, space missions and other applications. Drills are available with a wide variety of performance characteristics, such as power and capacity.

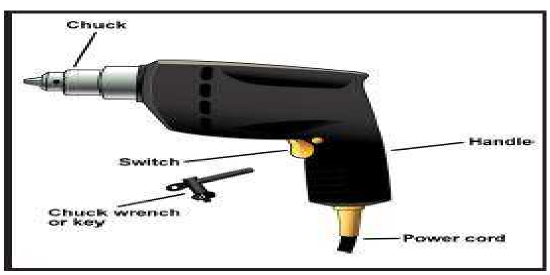


Fig.2.40 Portable hand drill

Safety considerations for a portable power drill include the following:

- ✓ Choose the right drill bit for the job. For example, do not use a square-shank bit in an electric drill.
- ✓ Make sure the bit is tight in the chuck. Use the chuck key in each hole of the chuck to tighten the bit. Be sure to remove the key before starting the drill to avoid throwing the key.
- ✓ Use a center punch to mark stock when working with metal. The indentation helps guide the bit.

- ✓ Make sure the work is held securely in place. Use a clamp or vise to hold a small piece.
- ✓ Hold the drill perpendicular to the piece to avoid binding the bit.
- ✓ Remove the bit from the drill after completing the job.

8. Orbital Sander

Orbital sanders (also known as finishing sanders) sand in a circular motion, and are used to achieve a fine, smooth finish on timber surfaces. They are not suitable for 'flushing off' joints or removing wood quickly. A reciprocating sander is very similar to the orbital sander but its motion is back and forth rather than circular. The base of the sander has a soft rubber pad and the abrasive paper is held to it by a spring clip.

Fig.2.41 sander machine

9. **Bench Grinders**

A bench grinder does work similar to a portable grinder, but it is a stationary machine mounted on a bench.

Main parts of a bench grinder include an on/off switch, grinding wheels, safety shields, and adjustable tool rest. See Figure 2.9. The adjustable tool rest is used for supporting and guiding small objects for grinding. See Figure 2.10. Bench grinders are used for sharpening and reconditioning tools and for shaping and cleaning metal. Another type of stationary grinder is called the pedestal grinder. It is similar to a bench grinder but is larger and is anchored to the floor. Both a bench grinder and a pedestal grinder have a double-shafted motor, which allows a wheel to be mounted on each side. Usually one wheel is coarser in texture and is used for removing material from the surface of the piece. The other wheel is finer in texture and is used for finishing work.

Safety considerations for a bench grinder include the following:

- ✓ Wear appropriate eye and face protection.
- ✓ Wear additional protective clothing, such as a leather apron or an appropriate filter or respirator, if needed.
- ✓ Adjust the tool rest for the job.
- ✓ Stand to the side of the wheel when starting the grinder and let the wheel run for a short period before using it. Wheels that are going to break usually do so within the first minute of use.
- ✓ Move the work slowly back and forth across the face of the wheel to avoid overheating the metal.
- ✓ Do not forces work into the grinding wheel. Allow the speed and grit of the wheel to do the work.

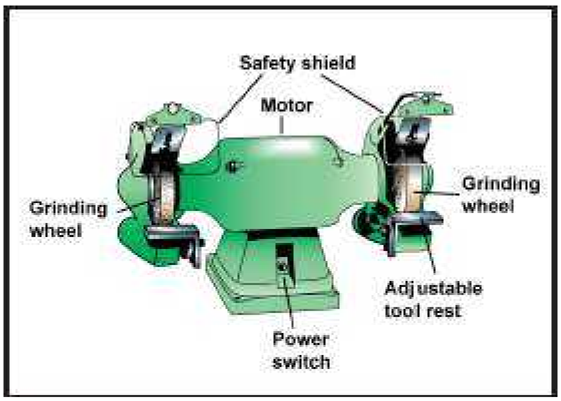


Fig.2.42 bench grinder

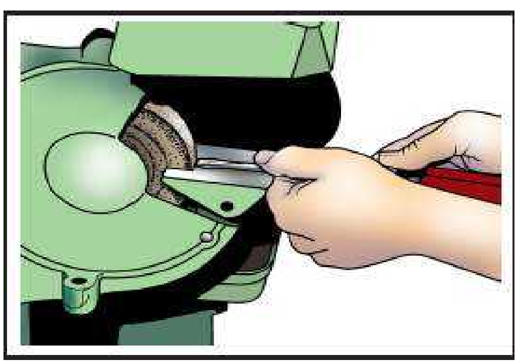


Figure 2.43 - Reconditioning a Screwdriver on a Bench Grinder, With Tool Supported by the Tool Rest

Materials Used in Carpentry:

Basic materials used in pattern making shop are ***timber and plywood***. Auxiliary materials used are ***nails, screws, adhesives, paints, varnishes,*** etc.

- ✓ **Timber:**

Timber is the name given to wood obtained from exogenous (outward growing) trees.

In these trees, the growth is outward from the centre, by adding almost concentric layers of fresh wood every year known as annual rings.

After the full growth, these trees are cut and sawed to convert into rectangular sections of various sizes for engineering purposes.

Timber is available in market in various shapes and size. The common shapes and sizes an: given below:

Log: This is the trunk of die tree which is tree from branches.

Balk: This is the log after sawing roughly to square cross section.

Deal: This is the log after sawing into rectangular cross section of width about 225 mm and thickness up to 100 mm.

Plank: This is the timber piece having width more than 275 mm and thickness 50 lo 150 mm.

Board: This is the timber piece below 50 mm in thickness and above 125 mm in width,

Batten: This is the timber piece below 175 mm in width and thickness between 30 mm to 50 mm in thickness.

Scantlings: These are timber pieces of various assorted and nonstandard sizes other than the types given above

Classification of Wood

The timber used for commercial purposes can he divided into two classes as soft wood and hard wood

- ✓ **Soft wood**

A soft wood is light in weight and light colour. They may have distinct annual rings but the medullar rays (radial lines) are not visible and the colour of the *sap wood* (outer layers) is not distinctive from the heart wood (inner layers). These woods cannot resist stresses developed across their fibres; hence, not suitable for wood working.

- ✓ **Hard wood**

In this type of wood the annual rings are compact and thin and the medullar rays (radial lines} are Visible in most cases. Hard woods are nearly equally strong both along and across the fibres.

Hand wood is the material used for wood working

Classification of timber

According to the manner of growth of trees, timber can be classified as. Exogenous or out ward growing) Endogenous or in ward growing

- ✓ **Exogenous or out ward growing**

In exogenous trees the growth take place from the centre by the addition of concentric layers of fresh wood every year, known as annual rings. These varieties of trees are suitable for building and other engineering uses the exogenous trees are again classified as

- **Conifers or ever green trees**

The conifer give soft woods and the deciduous gives hard wood common example of hard wood are Sal, teak, rose wood, sandal, shisham, oak beach, ash ebony, mango, neem, babool, etc., soft wood include kail pine, deodar chair, walnut seemal etc.

- ✓ **Endogenous or in ward growing timber**

These trees grow in wards i.e. .every fresh layer of sap wood is added inside instead of outside cane, bamboo, coconut

- ✓ **Seasoning**

Seasoning of wood carried out for removing the sap and reducing the moisture content the presence of sap and moisture will render the wood unsuitable for engineering works due to uneven shrinkage, crack, wrapping and decay.

Different methods of seasoning

- ✓ Air seasoning or Natural seasoning
- ✓ Water seasoning
- ✓ Electrical seasoning

- ✓ Kiln seasoning

✓ **Ply wood**

Thick sheet formed by pasting veneers of wood is called ply. Three or more ply joined by glues is called plywood.

The grains of adjacent layers are kept at right angle to each other in order to get better strengthening both directions the outer layer are called facing ply and good hard wood veneers are used for this inner ones are called core ply and low quality wood is used for this the ply wood is made by either cold pressing or hot pressing.

II. Moulding Machines

Moulding machine acts as a device by means of a large number of co-related parts and mechanisms, transmits and directs various forces and motions in required directions so as to help the preparation of a sand mould. The major functions of molding machines involves ramming of molding sand, rolling over or inverting the mould, rapping the pattern and withdrawing the pattern from the mould. Most of the molding machines perform a combination of two or more of functions. However, ramming of sand is the basic function of most of these machines. Use of molding machine is advisable when large number of repetitive castings is to be produced as hand molding may be tedious, time consuming, laborious and expensive comparatively.

Classification of Moulding Machines: The large variety of molding machines that are available in different designs which can be classified as squeezer machine, jolt machine, jolt-squeezer machine, slinging machines, pattern draw machines and roll over machines. These varieties of machines are discussed as under.

A. Squeezer machine

These machines may be hand operated or power operated. The pattern is placed over the machine table, followed by the molding box. In hand-operated machines, the platen is lifted by hand operated mechanism. In power machines, it is lifted by the air pressure on a piston in the cylinder in the same way as in jolt machine. The table is raised gradually. The sand in the molding box is squeezed between plate and the upward rising table thus enabling a uniform pressing of sand in the molding box. The main advantage of power operated machines in comparison hand operated machines is that more pressure can be applied in power operated.

B. Jolt machine

This machine is also known as jar machine which comprises of air operated piston and cylinder. The air is allowed to enter from the bottom side of the cylinder and acts on the bottom face of the piston to raise it up. The platen or table of the machine is attached at the top of the piston which carries the pattern and molding box with sand filled in it. The upward movement of piston raises the table to a certain height and the air below the piston is suddenly released, resulting in uniform packing of sand around the pattern in the molding box. This process is repeated several times rapidly. This operation is known as jolting technique.

C. Jolt-squeezer machine

It uses the principle of both jolt and squeezer machines in which complete mould is prepared. The cope, match plate and drag are assembled on the machine table in a reverse position, that is, the drag on the top and the cope below. Initially the drag is filled with sand followed by ramming by the jolting action of the table. After leveling off the sand on the upper surface, the assembly is turned upside down and placed over a bottom board placed on the table. Next, the cope is filled up with sand and is rammed by squeezing between the overhead plate and the machine table. The overhead plate is then swung aside and sand on the top leveled off, cope is next removed and the drag is vibrated by air vibrator. This is followed by removal of match plate and closing of two halves of the mold for pouring the molten metal. This machine is used to overcome the drawbacks of both squeeze and jolt principles of ramming molding sand.

D. Slinging machines

These machines are also known as sand slingers and are used for filling and uniform ramming of molding sand in molds. In the slinging operations, the consolidation and ramming are obtained by impact of sand which falls at a very high velocity on pattern. These machines are generally preferred for quick preparation of large sand moulds. These machines can also be used in combination with other devices such as, roll over machines and pattern draw machines for reducing manual operations to minimum. These machines can be stationary and portable types. Stationary machines are used for mass production in bigger foundries whereas portable type machines are mounted on wheels and travel in the foundry shop on a well planned fixed path. A typical sand slinger consists of a heavy base, a bin or hopper to carry sand, a bucket elevator to which are attached a number of buckets and a swinging arm which carries a belt conveyor and the sand impeller head. Well prepared sand is filed in a bin through the bottom of which it is fed to the elevator buckets. These buckets discharge the molding sand to the belt conveyor which conveys the same to the impeller head. This head can be moved at any location on the mold by swinging the arm. The head revolves at a very high speed and, in doing so, throws stream of molding sand into the molding box at a high velocity. This process is known as slinging. The force of sand ejection and striking into the molding box compel the sand gets packed in the box flask uniformly. This way the satisfactory ramming is automatically get competed on the mold. It is a very useful machine in largefoundries.

E. Pattern draw machines

These machines enable easy withdrawal of patterns from the molds. They can be of the kind of stripping plate type and pin lift or push off type. Stripping plate type of pattern draw machines consists of a stationary platen or table on which is mounted a stripping plate which carries a hole in it. The size and shape of this hole is such that it fits accurately around the pattern. The pattern is secured to a pattern plate and the latter to the supporting ram. The pattern is drawn through the stripping plate either by raising the stripping plate and the mould up and keeping the pattern stationary or by keeping the stripping plate and mould stationary and moving the pattern supporting ram downwards along with the pattern and pattern plate. A suitable mechanism can be incorporated in the machine for these movements.

F. Roll-over machine

This machine comprises of a rigid frame carrying two vertical supports on its two sides having bearing supports of trunnions on which the roll-over frame of the machine is mounted. The pattern is mounted on a plate which is secured to the roll-over frame. The platen of the machine can be moved up and down. For preparation of the mould, the roll-over frame is clamped in position with the pattern facing upward. Molding box is placed over the pattern plate and clamped properly. Molding sand is then filled in it and rammed by hand and the extra molding sand is struck off and molding board placed over the box and clamped to it. After that the roll-over frame is unclamped and rolled over through 180° to suspend the box below the frame.

The platen is then lifted up to butt against the suspending box. The box unclamped from the pattern plate to rest over the platen which is brought down leaving the pattern attached to the plate. The prepared mold is now lowered. The frame is then again rolled over to the original position for ramming another flask. Other mechanisms are always incorporated to enable the above rolling over and platen motion. Some roll-over machine smay carry a pneumatic mechanism for rolling over. There are others mechanism also which incorporate a jolting table for ramming the sand and an air operated rocking arm to facilitate rolling over. Some machines incorporate a mechanically or pneumatically operated squeezing mechanism for sand ramming in addition to the air operated rolling over mechanism. All such machines are frequently referred to as combination machines to carry out the molding tasks automatically.

III. Core making Machines

A number of types of machines have been developed for the rapid production of cores as well. Suitability of a particular type depends on factors such as the number of cores required, the size of the cores, and the intricacy and design of the cores. The commonly used core-making machines are now discussed.

a. Core-blowing Machine:

The core-blowing machine is indispensable for core making in a production foundry. The core sand is forced into the core box from a sand reservoir with a stream of high velocity air at a pressure of about 6- 8 kg/cm2. The core box has a number of vent holes suitably located so that as the sand is introduced, the air is ejected through these holes. Due to the high velocity air, the sand is passed instantly in the core box.

A core shooter is another version of a core blower in which the core sand is ejected from the shooter head and is made to impinge into the core box cavity under impact (Fig. 2.44). 45

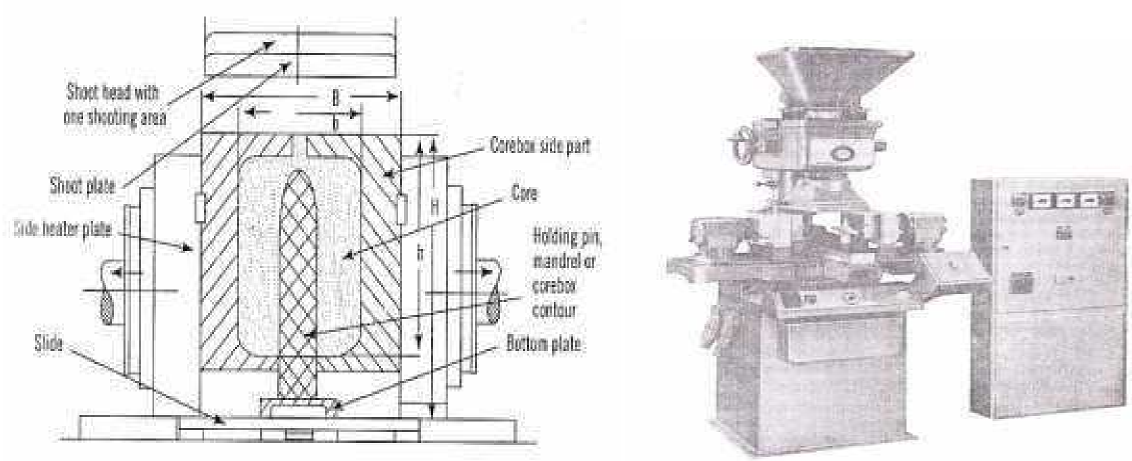


Fig. 2.44 Core shooting and curing machine

b. **Core-drawing Machine**

Core shooting and curing machine: The core-drawing machine facilitates in drawing off the cores from the boxes especially for core boxes having deep draw. The core box, with core sand duly rammed in, is placed on a core plate, which is supported on the machine bed.

From one side, the core box is placed in contact with another vertical plate and this vertical plate is vibrated so as to produce a rapping action on the core box. After rapping the core box is raised leaving the core on the core plate. The ramming of the sand in this case is done by hand either with a hand rammer or a pneumatic rammer.

c. **Continuous Core-Making Machine:**

A continuous core-making machine is used for preparing cylindrical cores of uniform section in various sizes which are called stock cores. Cylindrical cores, which are most commonly used, are prepared in long length on these machines and are kept in stock.

When a core of a certain diameter and length is required, it is taken out of the stock, cut to the desired length, and used after tapering down the ends. For preparing the stock cores, the core sand is filled in the hopper of the core-making machine from where it comes into a cylinder. It is then forced from the cylinder through a die of the size desired by means of a horizontally rotating screw.

d. **Roll-over Core-Box Draw Machine:**

This machine is similar to the roll-over pattern-draw hand moulding machine, except that it is smaller and is used for withdrawing the core box from the core.

e. **Jolt Roll-over or Jolt Pin-lift Core-Box Draw Machine:**

These machines again are similar to the corresponding moulding machines described earlier. In general, these machines are smaller in size and often the various operations such as jolting, roll over, and drawing, are performed manually.

f. **Sand Slinger:**

For medium- and large-sized cores, sometimes a sand slinger, similar to the one used for moulding work, is required. This is usually of the stationary type and smaller than the one used for making moulds.

IV. Metal Melting

Melting and pouring metal are two of the most important processes in the manufacture of castings. During these processes, the chemistry and grain structure of the metal are determined. The metal comes into contact and reacts with the atmosphere, the **furnace** and ladle refractories, and the moulding media. Proper control is necessary to minimize defects such as inclusion, porosity, hot tears, and adhering sand defects. In addition, the final properties of the metal are strongly influenced by the method of melting and pouring.

The type of melting equipment is determined by the requirements of the foundry and the type of product produced. Some important consideration are the ability to accurately control chemistry; the need for refining; selection of row materials; the ease of changing alloy types; pollution control equipment requirements.

A. Melting Furnaces

Electric arc and induction melting are the common method of melting metal. Most materials are tapped into ladles directly from the melting unit, but some specialty melts require further refining.

B. Ladle

Pouring is accomplished by using a refractory lined ladle with the metal being bottom poured, lip poured, or teapot poured.

C. Molten metal handling

Metal handling systems the aim of handling system is to deliver clean liquid metal to the mould at the required temperature. Automatic pouring systems are used increasingly, but manual pouring is still the commonest method of filling moulds.

For efficient energy used, molten metal tapping temperature should be as near as practicable heat losses.

2.2 Inspect Pattern equipment and damaged patterns

1. **Importance of Select and inspect pattern**.

Keeping tools and equipment properly storing, cleaning, and maintaining will save time and money for extending the life of foundry machine.In order to keep tools in good working condition during storage, there are some basic preparatory steps that should be taken. It is important to follow the cleaning and storage instructions, especially for larger tools such as pattern, molds and so on.

2.2.1 Maintenance of casting equipment's

i. Maintenance of patterns

Selecting damage patterns, inspecting damages pattern, replacing pattern, Checking pattern, Entering in to operation.

ii. Maintenance of MOLDS

Identifying damage molds, Selecting damage molds, inspecting damages molds , replacing molds, Checking molds, Entering in to operation.

iii. Maintenance of Grinder

lubricating with cleaned oil, Replacing of worn parts of grinding machine, Cleaning dusts and other materials**,** Changing worn blade

iv. Storing tools and equipment's

Storing of in tool room

Store the different pattern in preferably in status by 5S, Storing the pattern and molds in clear place, Storing of other important casting tools and equipments.

To keep tools tidy, it should be cleaned after use and wiped down with a rag or towel to be sure that they are free of dirt, grease and debris.

After cleaning, damage or defects should be checked. If the tool cannot be repaired, it should be thrown to aways.

v. Storage of plate compactor

Store the plate compactor on dry places

Storing of tools

How to Prepare and Store Tools

Any soil and dirt should be scraped away from the molds surfaces with an approved

Short-handled tools should be stored in a plastic bin or box. All surfaces of Power tools should be cleaned and completely dry before storage and Spraying lubricant

Damaged patterns/ core boxes for repair or replacement

2.2.2 Casting Defects

There are numerous opportunities for things to go wrong in a casting operation, resulting in quality defects in the cast product. In this section, we compile a list of the common defects that occur in casting, and we indicate the inspection procedures to detect them.
Some defects are common to any and all casting processes. These defects are illustrated in

- solution. Before placing in storage it should be dried with a towel or rag.
- The metal parts of the tools should be coated with a lubricant protector spray.
- Tools is does not directly stored on the ground both small hand and power tools should be Placed on shelving.

Figure 4.1 and briefly described in the following

a) Misruns, which are castings that solidify before completely filling the mold cavity.
   Typical causes include
   - ✓ fluidity of the molten metal is insufficient,
   - ✓ pouring temperature is too low
   - ✓ pouring is done too slowly, and/or
   - ✓ cross-section of the
   - ✓ mold cavity is too thin.

b) Cold Shuts, which occur when two portions of the metal flow together but there is a lack of fusion between them due to premature freezing. Its causes are similar to those of a misrun.

C) Cold shots, which result from splattering during pouring, causing the formation of solid globules of metal that become entrapped in the casting. Pouring procedures and gating system designs that avoid splattering can prevent this defect.

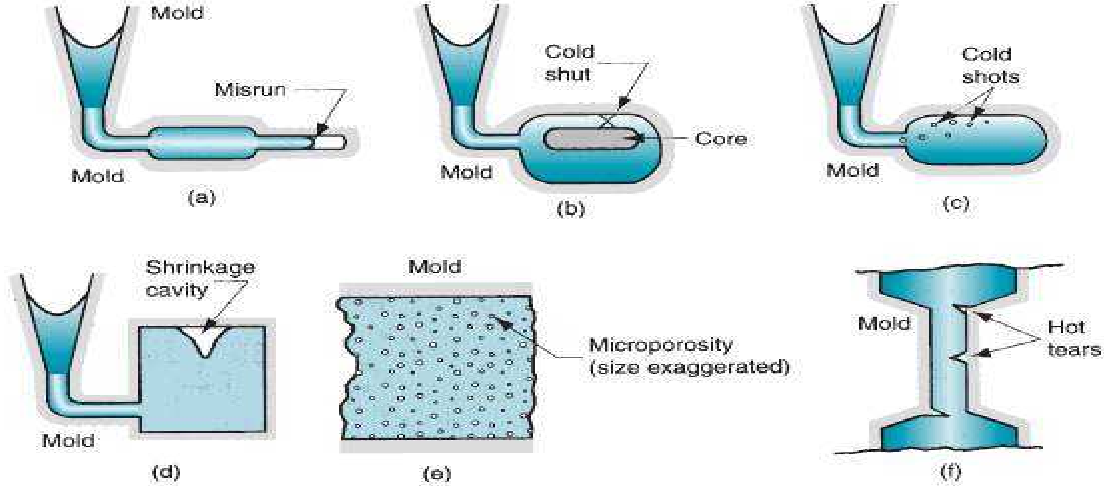


Figure 2.44 some common defects in castings:
(a) misrun, (b) cold shut, (c) cold shot, (d) shrinkage cavity, (e) microporosity, and (f) hot tearing.

d) Shrinkage cavity is a depression in the surface or an internal void in the casting, caused by solidification shrinkage that restricts the amount of molten metal available in the last region to freeze. It often occurs near the top of the casting, in which case it is referred to as a ‘‘pipe.’’
e) Microporosity consists of a network of small voids distributed throughout the casting caused by localized solidification shrinkage of the final molten metal in the dendritic structure. The defect is usually associated with alloys, because of the protracted manner in which freezing occurs in these metals.
f) Hot tearing, also called hot cracking, occurs when the casting is restrained from contraction by an unyielding mold during the final stages of solidification or early stages of cooing after solidification.
    - ✓ The defect is manifested as a separation of the metal (hence, the terms tearing and cracking) at a point of high tensile stress caused by the metal’s inability to shrink naturally.
    - ✓ In sand casting and other expendable-mold processes, it is prevented by compounding the mold to be collapsible.
    - ✓ In permanent-mold processes, hot tearing is reduced by removing the part from the mold immediately after solidification.

- The casting which we make is, of course, never quite perfect in terms of size and shape.
- To allow for this, tolerances are quoted on engineering drawings.

- So long as the casting is within tolerance, it will be acceptable. Some reasons for the casting being out of tolerance include elementary mistakes like the patternmaker planting the boss in the wrong place.
- This leads to an obvious systematic error in the casting, and is easily recognized and dealt with by correcting the pattern.

2.3 Assembling Pattern

A sand casting mould usually consists of two mould pieces, the upper section is named Cope and the lower section is named Drag. Sand core is a preformed sand aggregate inserted in a mould to shape the interior or that part of a casting that cannot be shaped by the pattern. It may have to be broken in order to remove it afterwards. Flask is a frame, normally made by metal or wood, as the main structure to carry the sand and avoid looseness of sand while assembling of the mould halves. Figure shows a typical sand casting mould.

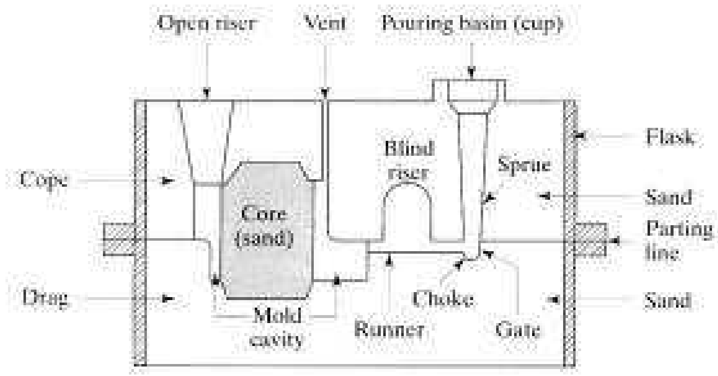


Figure 2.45 Cross section view of a sand mould assembly

2.4 Setting up Pattern equipment

Selection of Pattern Type

The type of pattern or core box used and the pattern or core box material used for a given set of castings depend on the following fundamental factors:

- The number of castings to be produced
- The molding or core making process to be employed
- The casting design
- The dimensional tolerances required

The life and cost of a pattern can both vary dramatically, depending on the pattern material and the type of pattern equipment.

In the developmental stage of a pattern design, only a few prototype castings need to be produced before modifications are made to the pattern dimensions or to the gating and risering. If such revisions are likely, an inexpensive wood pattern is often used first. This will enable engineering changes to be made quickly and inexpensively. After the design and the tolerances of the casting have been approved, a permanent pattern is selected based on production quantity and the molding or core making processes to be used.

Costs that are influenced by pattern equipment selection depend largely on the pattern material and pattern type and are dictated by production quantity. Expensive pattern equipment can often be justified if production quantities are high. The complexity of the pattern and the quality of the material used to make the pattern generally increase with the number of castings to be produced from one set of patterns. For example, an unmounted or loose softwood pattern could be used only for very limited production before it would require repair or replacement. A similar pattern made from a more durable material and mounted on a pattern board would increase the useful life of the pattern dramatically.

2.4.1 Pattern Shops General safety instructions

- ✓ The faculty or staff member in charge of the shop will ensure that all appropriate safety rules are followed.
- ✓ Only trained and approved persons will be permitted to use any piece of powered equipment.
- ✓ For shops that are intended to be used by students:
- ✓ Training is to be done and documented by the designated shop owner (faculty, staff member). Training should consist of both classroom instruction (including reading the Operator's Manual for each piece of equipment) and hands on competency training.
- ✓ Training will be documented and record retention will be the responsibility of the department.
- ✓ Shops are to be kept clean and orderly.
- ✓ Shop safety rules are to be posted.
- ✓ Horseplay is forbidden.
- ✓ .Machines is to be inspected prior to use.
- ✓ Machines should ***never*** be used if all guards are not in place.

- ✓ Machines should be placed out of service if:
- ✓ Guards are missing or damaged
- ✓ Machine is damaged or not operating properly
- ✓ Power cords are damaged or plug is not properly grounded
- ✓ Use the right tool for the job. Do not force a tool or attachment to do a job for which it was not designed.
- ✓ Wear proper attire. Do not wear loose fitting, gloves, jewellery, watches, ties, ID badges or anything else dangling that might get caught in a piece of moving equipment. Long hair should be in a protective head covering such as a hair net
- ✓ No student shall operate a powered piece of equipment in a shop alone.
- ✓ Use a buddy system in the shops.
- ✓ Shops should have designated and posted operating hours.
- ✓ Never use a powered machine when impaired.
- ✓ This includes when you are sick, too tired, stressed or hurried to work carefully or on medication that could make you drowsy.
- ✓ .Never is shy about seeking help.
- ✓ Always ask if you're unsure about the safe operation of a tool or any aspect of a job.
- ✓ Have Shop Staff check the tool or work with which you are unfamiliar.
- ✓ Exercise common sense and clarify before starting work.
- ✓ All injuries should be assessed and appropriate medical treatment or first aid administered immediately.

In general, Use personal protective equipment and follow safe work procedures. Use proper personal protective equipment

2.4.2 Pattern Shops

Set up woodworking machines has to follows

- ✓ Selecting tools/cutters appropriate to task requirements.
- ✓ Sharpening or shaping cutting tools.
- ✓ Installing tools/cutters correctly.
- ✓ Setting or adjusting guards/stops.
- ✓ Setting-up woodworking machines.

Selecting tools/cutters appropriate to task requirements

A. Tools for wood work and metal work

The principle hand tools used in a carpentry workshop can be classified into Marking and measuring tool, Cutting tool, Planning tool, Boring tool, Striking tool, Holding tool.

1. **Cutting tools**

- ✓ **Saws**

Saw is a cutting tool which has teeth on one edge and cutting is affected by reciprocating motion of the edge relative to the work piece. Cutting occurs during the forward motion; such a saw is called push type saw, the cutting occurs during the backward motion.

I. Hand saw- This saw is used for short straight cuts. It has a blade of 25-40cm length 6- 10cm width. The number of teeth per cm length ranges from 3-5.

II. Tenon Saw (Back saw) - It has a parallel blade of 25-40cm length and 6-10cm width. The number of teeth per cm length ranges from 5-8.

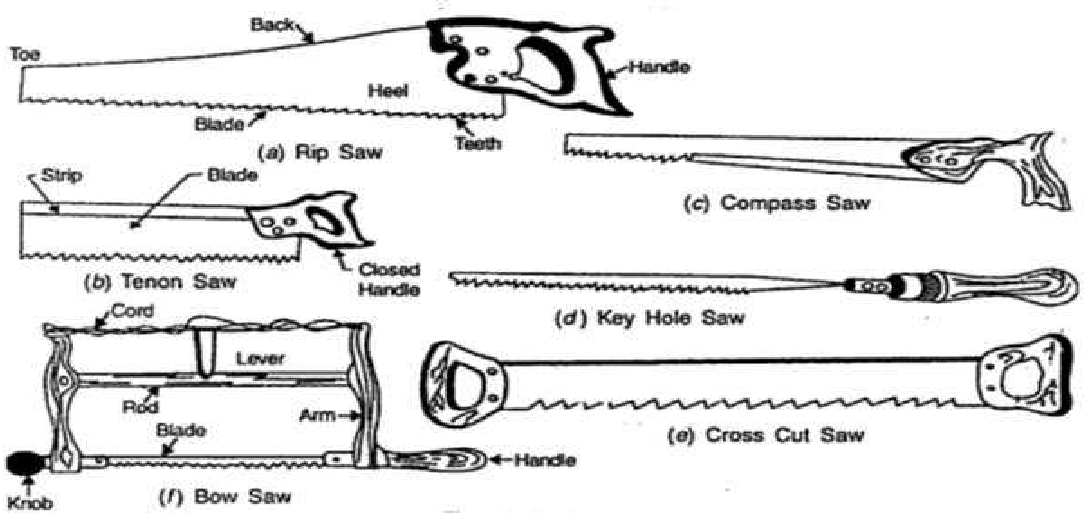


Fig 1.12 Saws

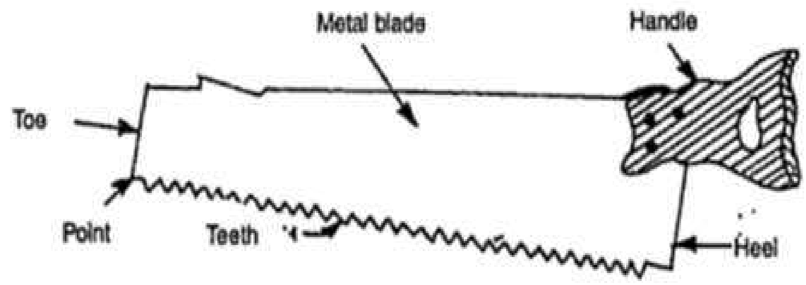


Fig1.13. parts Rip saw

- **Chisels**

The common type of chisels used is briefly explained below.

- **Firmer Chisels**- they are most common and general purpose chisel used by a carpenter. They have flat blade of 15-50mm width and 125mm length.
- **Dove Tail Chisel** (bevelled edge firmer chisel) - These chisels are used for fine and delicate works as well as for cutting corners.
- **Mortise chisel** – These chisels are used for heavy and deep cut to remove large quantity of wood. These chisels have width of about 15mm but the blade thickness may range from 6- 15mm.

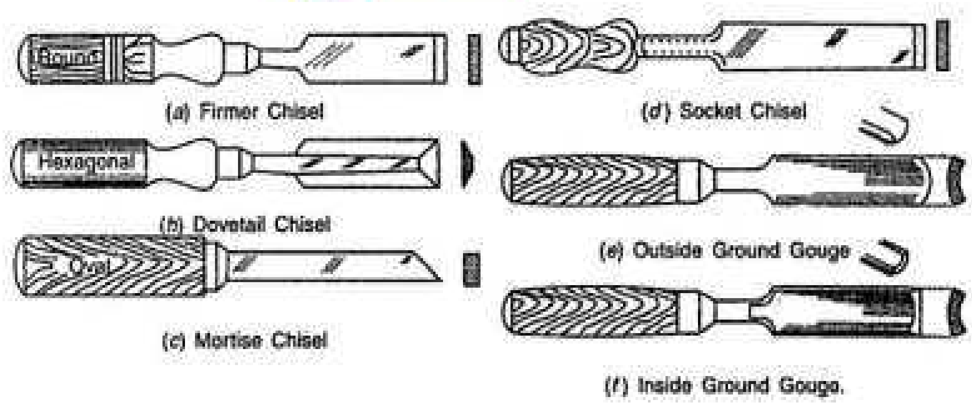


Fig. 2.46 types of chisels

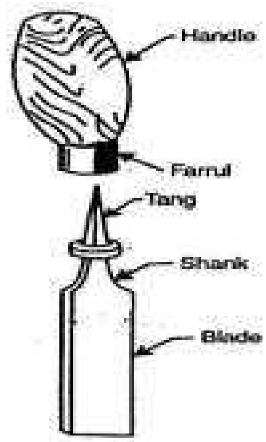


Fig. 2.47 Parts of chisel

- ✓ **Claw Hammer**

This is a hammer having steel head and wooden handle. The flat face of the head is used to drive nails and claw portion for extracting nails out of the wood.

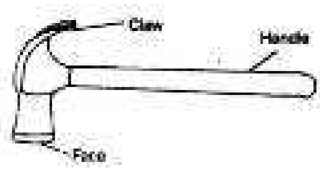


Fig. 2.48 claw hammer

- ✓ **Wood rasp files**

it is a finishing tool used to make the wood surface smooth, remove sharp edges, and finish fillets and other interior surfaces. Sharp cutting teeth are provided on its surface for the purpose. This file is exclusively used in wood work.

Fig.2.49 Rasp file

- ✓ **Common Drill Bits**

Drill bits are available in many shapes and sizes for various functions.

Besides basic hole drilling bits, there are specialized bits such as countersink bits for recessing screw heads or screwdriver bits for driving and removing screws.

The two basic types, based on the back of the bit or shank, are the round- or straight-shank bits and square-shank bits.

The latter have a tapered square tang on the end.

The round-shank bits are used in hand drills and portable electric drills, whereas the square-shank bits are used in braces.

Some of the common bits (auger, expansive, Forstner, spade, and twist drills) are discussed below.

See Figure 2.50 Note that the auger, expansive, Forstner, and spade drill bits are available in both square and round shanks for use in braces and portable power drills.

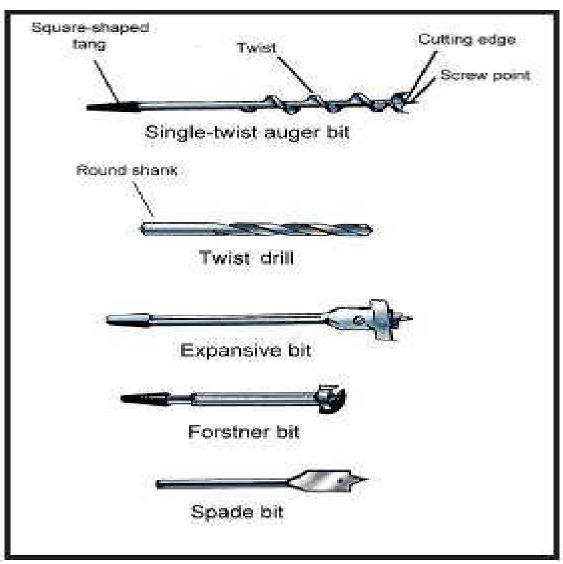


Figure 2.50 - Common Types of Drill Bits

Sharpening or shaping cutting tool

Using a Bench Grinder to Sharpen or Recondition Tool

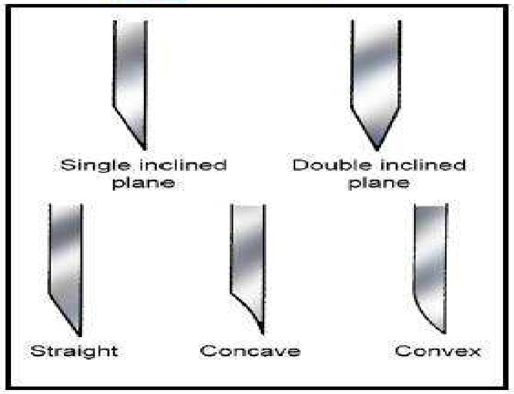


Fig 2.51 - Different Shapes of Tool Edges

Check the edge or shape of the tool for accuracy; a tool sharpening gauge can be used to check the angle of a number of tools. (Figure 2.51).

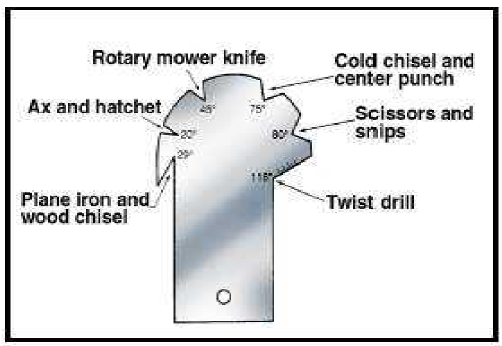


Fig. 2.52 Tool sharpening gauge

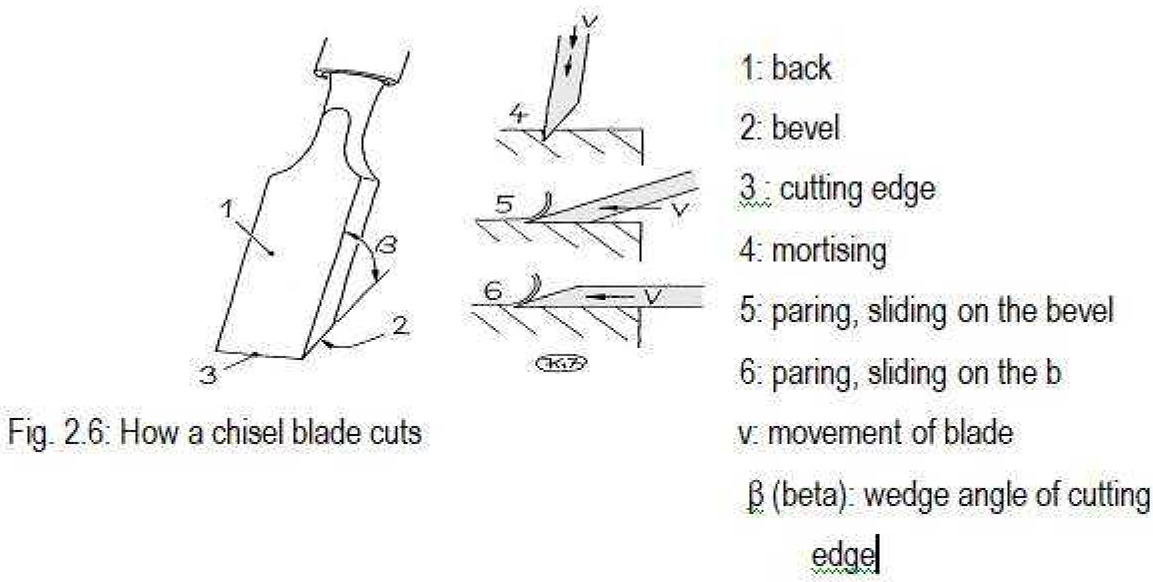


Fig. 2.53

Installing tools/cutters correctly

You have to follows Procedures for installing tools and cutters

- ✓ **Circular table saw**
- ✓ **Fitting a band saw blade**
- ✓ **Wood lathe**
- ✓ **Drive centre**
    - The drive canter is placed in the headstock and rotates with the lathe to drive the wood while turning.
    - The most common type of drive centre is the Spur Centre which consists of a centre point and four spurs that penetrate into the end of the spindle to provide traction.
    - When teaching beginning turners, some instructors prefer to use a Cup Drive instead of a spur drive.
    - The cup drive has a centre point inside a supporting cup, but no spurs. When turning with cup drive, if the tool begins to catch the wood, the cup drive acts similar to a clutch and allows the wood to slip.
    - This stops the rotation o f the wood rather than forcing the tool to dig in and tear the surface

Fig. 2.54 drive center

- ✓ **TAILSTOCK CENTERS**
    - The tailstock centre, which mounts in the tailstock spindle, centres the work and exerts force through itself to the drive centre in the headstock.
    - It also gives radial support to the work, thereby holding it in the lathe.
    - As with drive centres, the tailstock centre has a Morse-taper shaft, but the business end is quite different.
    - There are two types of tailstock centres: dead centres and live centres .

- The simplest dead centre is a 60° point, but the more traditional design-a cup centre-consists of a simple pivot bearing surrounded by a raised ring.

Setting or adjusting guards/stops

Any machine part which can cause injury must be guarded. Machine guards help to eliminate personnel hazards created by points of operation, ingoing nip points, rotating parts and flying chips.

- Types of guards commonly. Fixed guard, Interlocked guard, Adjustable guard, Self adjusting guard, Pull back device and Two-hand control.
- Fixed guard-is kept in place permanently by fasteners that can only be released by the use of a tool

Fig:2.55 guard

Interlocked guard-shuts off or disengages power to the machine and prevents it from starting when the guard is removed/ opened. Adjustable guard-provides a barrier which can be adjusted to suit the varying sizes of the input stock. Self adjusting guard-provides a barrier which moves according to the size of the stock entering the danger area. Two hand controls -concurrent use of both hands is required to operate the machine, preventing the operator from reaching the danger area. Pull back -the device is attached to the wrist of the operator which pulls the operator's hands away from the point of operation or other hazardous areas when the machine operates. hields can be used to provide protection from flying particles, splashing metal working fluids or coolants. Holding tools can be used to place and remove stock. Example, reaching into the danger area of a power press. Holding tools must not be used as a replacement of machine guards Ensure that the guards are in position and in good working condition before operating.

- ✓ Know the location of emergency stop switch.

- ✓ Do not wear loose clothing or jewellery that can be caught in the rotating parts.
- ✓ Confine long hair.

The keys and adjusting wrenches must be removed from the machine before operating it.

2.3. 2 Setting-up woodworking machines

Setting up wood lathe

- ✓ Always check the speed of the lathe before turning it on.
- ✓ Use slower speeds for larger diameters or rough pieces, and higher speeds for smaller diameters and pieces that are balanced.
- ✓ Always start a piece at a slower speed until the work piece is balanced.
- ✓ If the lathe is shaking or vibrating, lower the speed.
- ✓ If the work piece vibrates, always stop the machine to check the reason.
- ✓ Check that all locking devices on the tailstock and tool rest assembly (rest and base) are tight before operating the lathe.
- ✓ Check tool rest position often and as wood is removed, turn off the lathe and re-position the rest.
- ✓ Rotate your work piece by hand to make sure it clears the tool rest and bed before turning the lathe “on.” Be certain that the work piece turns freely and is firmly mounted.
- ✓ A hand wheel on the outboard side of the headstock simplifies this process of spinning the lathe by hand before turning on the switch.
- ✓ Be aware of what turners call the “red zone” or “firing zone.”
- ✓ This is the area directly behind and in front of the work piece — the areas most likely for a piece to travel as it come off the lathe.
- ✓ A good safety habit is to step out of this zone when switching the lathe to the “on” position.
- ✓ When observing others turn stay out of this area.
- ✓ Hold turning tools securely on the tool rest, holding the tool in a controlled and comfortable manner.
- ✓ Always contact the tool rest with the tool before contacting the wood.
- ✓ It is safest to turn the lathe “off” before adjusting the tool rest or tool rest base (banjo).
- ✓ Remove the tool rest before sanding or polishing operations.

- ✓ Never leave the lathe running unattended.
- ✓ Turn the power off. Don’t leave the lathe until it comes to a complete stop.

Before turning on the lathes

A short checklist will assure that students are ready to turn on the lathe: Eye protection on, Blank properly mounted between centres: drive centre point engaged in the end-grain, Tailstock base firmly locked., Tailstock ram not extended too far out, and live centre pressed into the end grain, Tailstock ram locked, Tool rest base locked firmly in position, Tool rest set at proper height and distance from the wood to avoid contact

Fig. 2.56 Exercise blank mounted on lathe

Proper Tool Grip

The simple over-hand grip is the easiest for roughing gouge use: Right hand: grip near the end (butt) of the handle, thumb pointing forward and on the top. Left hand: grasp the steel within the first few inches down from the cutting edge. The left hand should be in contact with the tool rest.

Fig. 2.57 Left hand grip

fig. 2.58 Right hand grip

Self-check-2

Test I: True false item

Directions: write true if the statement is correct and false if the statement is not correct on the space provided

1. Pattern shops should be furnished with ***a mechanical drawing*** or blue print of the part to be made.
2. In the pattern shop only trained and approved persons will be permitted to use any piece of powered equipment.
3. It is no problem wearing of loose fitting, gloves, jewellery, watches, and ties in the process of machining operation.
4. Use the right tool for the job and force a tool or attachment to do a job for which it was not designed
5. The pattern Shop should be equipped with a band saw or at least a jig saw, a pattern lathe and suitable clamps for gluing up material

Test II: multiple choices

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1.The ________________ preparation activities for receiving molten metal.

A, mould B, Casting C, Foundry D, None

2. Too soft ramming will generate ________ mould.

A, Good B, hard C, weak D, Smooth

3. It is the replica of the final object to be made.

A, Casting b, Pattern c, allowances

4. Types of patterns depend upon the factors of _____________.

A, The shape and size of casting

B, No. of castings required

C, Method of moulding employed

D, All

5. Types of machine which is used to produce round symmetrical shape on the work pieces is ;

A. Jointer
B. wood lathe
C. vertical band saw
D. plane

6. Machines which used to achieve a fine, smooth finish on timber surfaces.

A. Bench grinder B. sander C. jointer D. portable drill

7. Which one of the following machine is used for cutting holes on wood surface?

A. Floor drill press B. grinder C. plane D. jointer

8. Cutting fine straight line and curved work, heavy logs to required lengths on wood stock is done by?

A. Bench grinder B. Band Saw C. drill press D. All

9. ______is used to sharpening cutting tools

A. Portable drill B. bench grinder C. floor type drill D. none

Test III: Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

Column A	**Column B**
1. Types of pattern	A. permeability
2. Types allowance in casting	B. loose peces
3. Common pattern material	C. wood

Test IV: writing short Answer

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. Write types of allowance added to the drawing of patterns?
2. Write at list three the common types of patterns?

   1. ____________________ 2. ____________________3.______________

3. Write at list three pattern allowances?

   1. ____________________ 2. ____________________3.______________

Operation sheet-1 set up equipment

Operation Title: perform set up wood lathe

Purpose: to operations

Instruction: Given all the necessary materials the simulation room/ Lab must conducive to perform the demonstration and the trainees must be in right and healthy condition.

- Demonstrate all the principal pattern making processes on the timber by using the wood lathe (if available) with the recommended tools and safety requirements correctly.
- Using the figure below and given data/ information
- You have given 4 Hours for the task.

Required tools and equipment: Hand/power tools, etc.

Precautions: take care during operate of wood lathe machine

- do not forget to use and select appropriate wood lathe equipment
- follow pre/post set up and material preparation activities

Procedures:

Step 1- wear PPE.

Step 2- check that all locking devices on the tail stock and tool rest

Steps 3- position the tool rest cloth to the work

Step 4rotate the work piece by hand to make sure it clears the tool rest and reposition the rest

Step 5adjust the drive center and tail stock center when required

Quality criteria: - you have to follow standard operating procedures

- You have to familiars by short time operations

Operation sheet-2 set up equipment

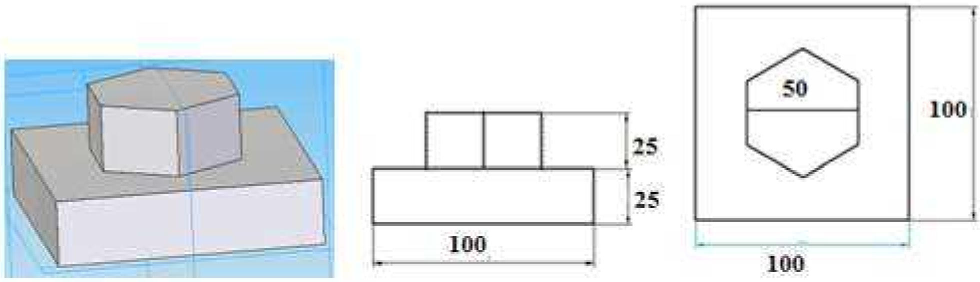
Operation Title: perform set up equipment

Purpose: to make a Solid Pattern

Instruction: Given all the necessary materials the simulation room/ Lab must conducive to perform the demonstration and the trainees must be in right and healthy condition.

- Demonstrate all the principal pattern making processes on the timber by using the wood lathe (if available) with the recommended tools and safety requirements correctly.
- Prepare the following Solid Pattern from wood by using workshop hand tools. All dimensions are given by mm.
- Using the figure below and given data/ information
- You have given 4 Hours for the task.

Operations to be carried out**:** Planning, Marking, Sawing, Finishing.



All dimensions are given by mm.

Required tools and equipment: Steel rule, Try square, Marking guage, Rip saw, Tenon saw, Mallet, Jack plane, Wood rasp file, etc

Precautions: take care during operate of wood lathe machine

- do not forget to use and select appropriate wood lathe tools & equipment
- follow pre/post set up and material preparation activities

Procedures:

1. The wooden pieces are checked for dimensions.
2. One side of pieces is planned with jack plane and for straightness.
3. An adjacent side is planned and checked for squareness with a try square.
4. Marking guage is set and lines are marked hexagonal according to given figure.
5. Using tenon saw, the portions to be removed are cut from the piece.

Quality criteria: 1. Wood should be free from moisture

2. Marking is done without parallax error

3. The Solid Pattern is made success fully.

.

Operation sheet-3 set up equipment

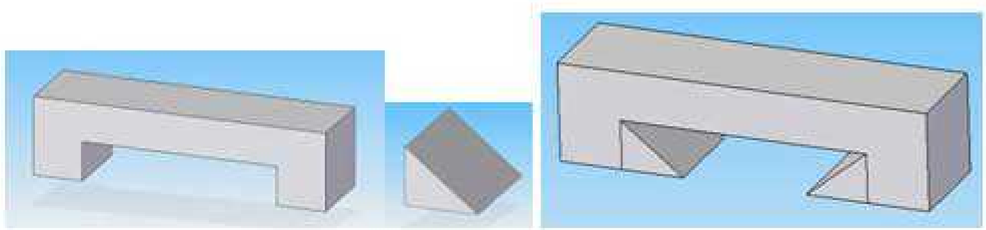
Operation Title: perform set up equipment

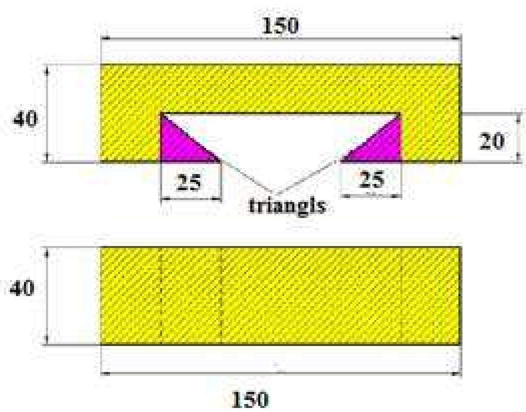
Purpose: To make a Loose Piece Pattern.

Instruction: Given all the necessary materials the simulation room/ Lab must conducive to perform the demonstration and the trainees must be in right and healthy condition.

- Demonstrate all the principal pattern making processes on the timber by using the wood lathe (if available) with the recommended tools and safety requirements correctly.
- Prepare the following Solid Pattern from wood by using workshop hand tools. All dimensions are given by mm.
- Using the figure below and given data/ information
- You have given 4 Hours for the task.

Operations to be carried out**:** Planning, Marking, Sawing, Finishing.





Required tools and equipment: Steel rule, Try square, Marking guage, Rip saw, Tenon saw, Mallet, Jack plane, Wood rasp file, etc

Precautions: take care during operate of wood lathe machine

- do not forget to use and select appropriate wood lathe tools & equipment

- follow pre/post set up and material preparation activities

Procedures:

1. The wooden pieces are checked for dimensions.
2. One side of pieces is planned with jack plane and for straightness.
3. An adjacent side is planned and checked for squareness with a try square.
4. Marking guage is set and lines are marked hexagonal according to given figure.
5. Using tenon saw, the portions to be removed are cut from the piece.

Quality criteria: 1. Wood should be free from moisture

2. Marking is done without parallax error

3. The Loose Piece Pattern is made success fully.

LAP Test	Practical Demonstration

Name: ___________________________ Date: _____________

Time started: ____________________ Time finished: _______________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1: set up equipment

Unit three: Make mould

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Close and check Mould.
- Select and position appropriate molding equipment
- Select appropriate molding media to produce mould.
- Secure mould.
- Select or manufacture pouring basin and positioning.
- Ramming up mould properly and striking off.
- Utilize parting and stripping systems.
- Remove pattern and loose pieces from mould.
- Clean and paint mould and core

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Close and check mould for compliance to component specification in accordance with standard operating procedures
- Select appropriate moulding equipment and positioned according to standard operating procedures
- Select appropriate moulding media to produce mould to specification
- Secure mould according to standard operating procedures
- Select or manufacture pouring basin to specification and positioned in accordance with standard operating procedures
- Ramming mould up properly with joints and strike off as required to standard operating procedures
- Utilise parting and stripping systems in accordance with standard operating procedures
- Position and secure loose pieces, vents, risers and runners as required to standard operating procedures
- Remove Pattern and loose pieces from mould in a safe manner least likely to cause

damage to the pattern and in accordance with standard operating procedures

- Clean and paint mould and core according to specification using standard operating procedures

3.1 Close and check Mould

3.1.1 Mould hardening

Many moulds are hardened before closing and casting, whether by drying or chemical reaction: factors influencing the choice between this and greensand practice were reviewed in previous information sheet. The introduction of high pressure moulding machines enhanced the capabilities of the greensand process, but the use of dry sand, even for heavy castings, became widely replaced by cold setting chemically bonded sands.

The hardening of cold-set sands has been discussed elsewhere. Where moulds do need to be dried the operation may involve complete stoving of the mould parts or may be confined to surface drying with portable equipment.

3.1.2 Clamps and weights

Clamps and weights are used to hold the cope and drag sections of a mold together and to prevent lifting of the cope by the force of the molten metal. It is safe practice to use a weight on small molds, but when the molds are of considerable size, both weights and clamps should be used. The use of insufficient weights is a common cause of defective castings.

1.2. Closing molds

The most important factor in the proper and easy closing of molds is to have flask equipment in good condition. Clean pins and bushings and straight sides on the flasks are the factors that make the closing of molds an easy operation. The opening of a mold after it has been closed is sometimes recommended. This procedure may prove useful. By using an excess of parting compound, the molder can then determine, with a fair degree of certainty, any mismatch or crushing of the mold. Nevertheless, the fewer times a mold is handled, the fewer chances there are to jar it and cause sand to drop

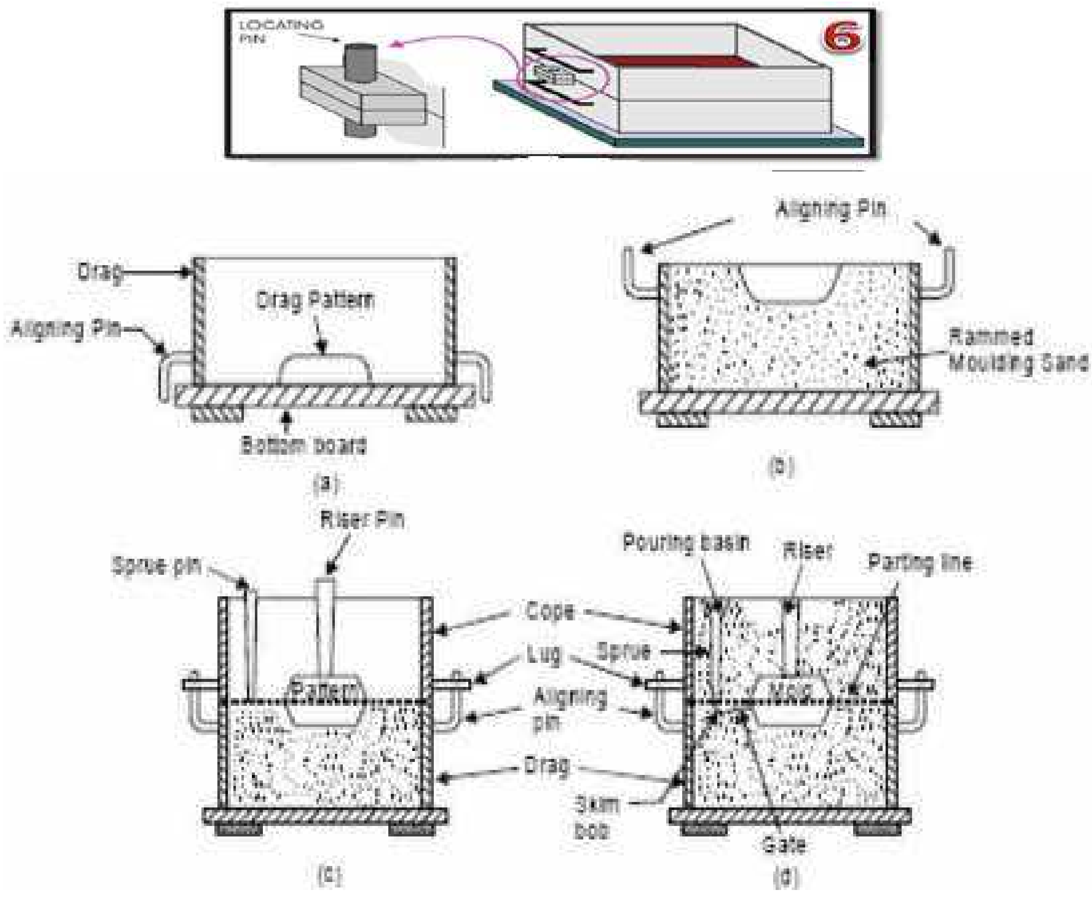


Fig.3.1. Close and check Mould

3.2 Select and position appropriate molding equipment

3.2.1 Moulding boxes (flasks)

Casting flask is also known as moulding flask, sand box or molding box. It is an essential tooling in the production of sand castings. Suitable casting flasks could improve the casting quality, and reduce the consumption of molding sand, so to reduce the production costs.

Casting flasks are normally made by welding steel plates, but could also be made by sand casting process. In other words, sand flasks could be a kind of sand castings either. If the iron foundries do not have suitable casting flasks, then they will have to make some for production. There are many types and sizes of sand boxes. Small sand boxes are suitable for producing small metal castings, large boxes are suitable for large castings. Their shapes include round and square. Sometimes, there are some reinforcing ribs welded inside to hold the molding sand. All designs need to be considered to suit the casting production.

The sand moulds are prepared in specially constructed boxes called flasks, which are open at the top and bottom. They are made in two parts, held alignment by dowel pins. The top part is called the cope and the lower part as drag. If the flask is made in three parts, the intermediate part is called a cheek.

These flasks can be made of either wood or metals. Though the wood is the cheapest material and flasks can be made quickly, but they have the disadvantage of wearing out rapidly and are destroyed by the contact with hot metal. The metal flasks of steel, cast iron, magnesium or aluminum alloys are widely used in production work because of their rigidity. Following two types of flasks are widely used in foundry.

3.2.1 Wooden Moulding Box:

A typical wooden moulding box is shown in Fig. 3.2 (a), (b),(c). The handles are an integral part of the boxes and are provided at the extended sides. The upper part known as cope has cross wooden partition but not the drag. These partitions help in supporting the sand when the cope is lifted. For accurate placing of cope and drag together, steel lugs are provided. The clamps and wedges are used for holding the lugs at their position.

Figure 3.2 moulding box / flasks

The molder's skill is the basic skill of the foundry. He must know how to prepare molds with the following characteristics:

1. Strong enough to hold the weight of the metal.
2. Resistant to the cutting action of the rapidly moving metal during pouring.
3. Generate a minimum amount of gas when filled with molten metal.
4. Constructed so that any gases formed can pass through the body of the mold itself rather than penetrate the metal.
5. Refractory enough to withstand the high temperature of the metal, so it will strip away cleanly from the casting after cooling.
6. Collapsible enough to permit the casting to contract after solidification.

The molding operation aboard ship depends primarily on the molder and his ability to do his job. Skill in this type of molding can be attained only through experience, but a high level of skill can be reached in a shorter length of time by following correct molding techniques. For a beginning molder, it may appear much easier to patch molds that have been made haphazardly (randomly), than to take the time to make them properly. A molding technique based on careful attention to the various details involved in making a mold is by far the best approach to attaining molding skill. As with many other trades, speed in molding comes about by itself, if proper attention is given to the basic techniques.

3.3 Select appropriate molding media to produce mould.

3.3.1 Sources of Molding Sand

Sand used in foundries is available in (i) River beds. (ii) Sea. (iii) Deserts. (iv) Lakes.

✓ **Types of Molding Sand**

The following section introduces three type of sand; include green sand, resin-sand and CO2-sand that are commonly used in casting industry.

1) Green Sand

The most common method used to make metal casting is green sand molding. "Green sand" is a mixture of silica sand / zircon sands, bentonite clay, moisture and other additives. The additives help to harden and hold the mould shape to withstand the pressures of the molten metal. The moisture contents have to control in around 7%, too dry or too wet of sand mixture are also not suitable. The "Green sand" mixture can be compacted by hand or through mechanical force around a pattern to create a mould. It is the least expensive method of making moulds.

2) Resin-Sand

Resin-sand is a mixture of sand and 2.5%-4% of thermoset resin binder. The binder coats the sand particles altogether and it become hard and bond the sand particles together once head applied. Resin-sand mould has better dimensional accuracy than green sand mould but is more expensive. Therefore, it is usually utilized for producing sand core instead of cope and drag.

3) CO2-Sand

CO2-Sand is a mixture of sand and 3-4% sodium silicate (water glass). Molding procedures are similar to that of the green sand process. However, after removal of the pattern, the mould is hardened by blowing of carbon dioxide gas via a tube. Since no heat is involved it is called a cold-setting process.

✓ **Binders used in molding sands**

Binders are added to give cohesion to molding sands. Binders provide strength to the molding sand and enable it to retain its shape as mold cavity. Binders should be added in optimum quantity as they reduce refractoriness and permeability. An optimal quantity of binders is needed, as further increases have no effect on properties of foundry sand.

The following binders are generally added to foundry sand:

(ii) Fireclay, Illite , Bentonite (Sodium montmorillonite, Calcium montmorillonite) , Limonite, Kaolinite.

(i) ***Fireclay:*** It is usually found near coal mines. For use in the foundry, the hard black lumps of fireclay are taken out, weathered and pulverized. Since the size of fireclay particles is nearly 400 times greater than the size of bentonite particles, they give poor bonding strength to foundry sand.

(ii) ***Illite:*** Illite is found in natural molding sands that are formed by the decomposition of micaceous materials due to weathering. Illite possesses moderate shrinkage and poor bonding strength than bentonite.

(iii) ***Bentonite:*** It is the most suitable material used in molding sands. Limonite and Kaolinite are not commonly used as binders as they have comparatively low binding properties.

The main constituents of molding sand involve silica sand, binder, moisture content and additives

3.1.2 Terminology of mould and Definition of core making media

Mould includes the following terms.

1. Pouring cup: This is where the metal is poured into the mold.
2. Sprue: The vertical channel from the top of the mold to the gating and riser system. Also, a generic term used to cover all gates, runners and risers.
3. Runner: The portion of the gate assembly that connects the sprue to the casting in gate or riser.
4. Gate: The end of the runner in a mold where molten metal enters the mold cavity.
5. Riser: A reservoir of molten metal provided to compensate for the contraction of the metal as it solidifies.
6. Mould cavity: The impression in a mold produced by the removal of the pattern. When filled with molten metal it forms a casting.
7. Cope: Upper or top most section of a flask, mold or pattern.
8. Parting line: A line on a pattern or casting corresponding to the separation between the parts of a mold.
9. Drag: Lower or bottom section of a flask, mold or pattern.

May include the following or as appropriate for the particular machine: Shell, Chemically bonded, Green sand, etc.

✓ **Shell-mold casting**

Shell-mold casting yields better surface quality and tolerances. The process is described as follows: The 2-piece pattern is made of metal (e.g. aluminum or steel), it is heated to between 175°C-370°C, and coated with a lubricant, e.g. silicone spray. Each heated half-pattern is covered with a mixture of sand and a thermoset resin/epoxy binder. The binder glues a layer of sand to the pattern, forming a shell. The process may be repeated to get a thicker shell. - The assembly is baked to cure it.

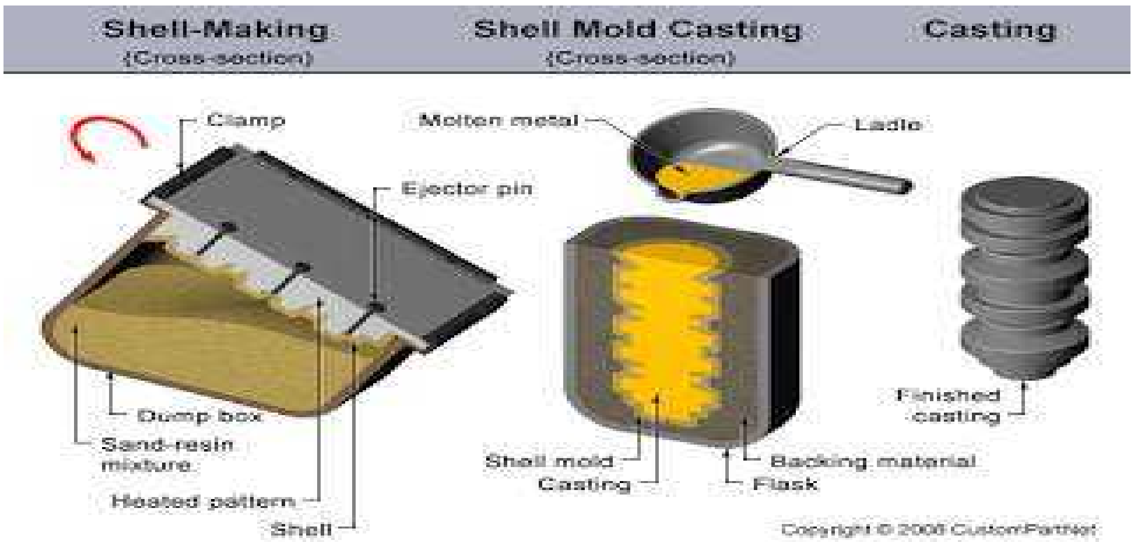


Fig. 3.3 shell- making casting

The patterns are removed, and the two half-shells joined together to form the mold; metal is poured into the mold

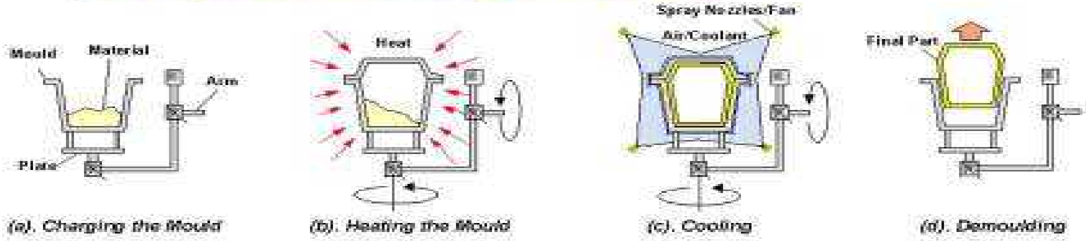


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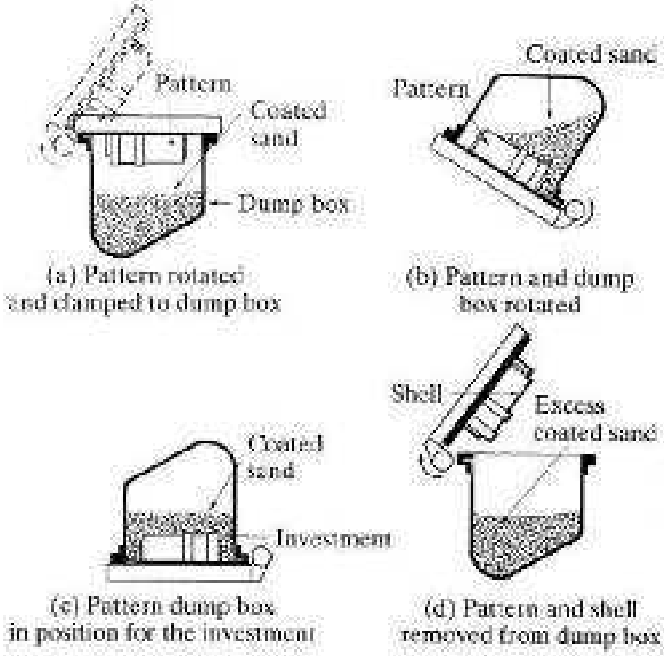
Fig. 3.4 patterns are removed, and the two half-shells joined together to form the mold



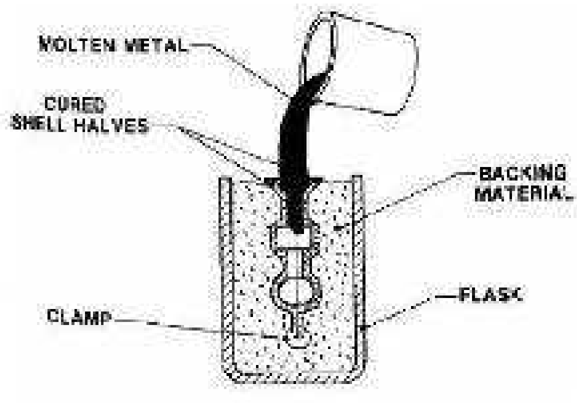


Figure.: Making the shell-mold [Source: Kalpakjian & Schmid]   Figure 6. Shell mold casting

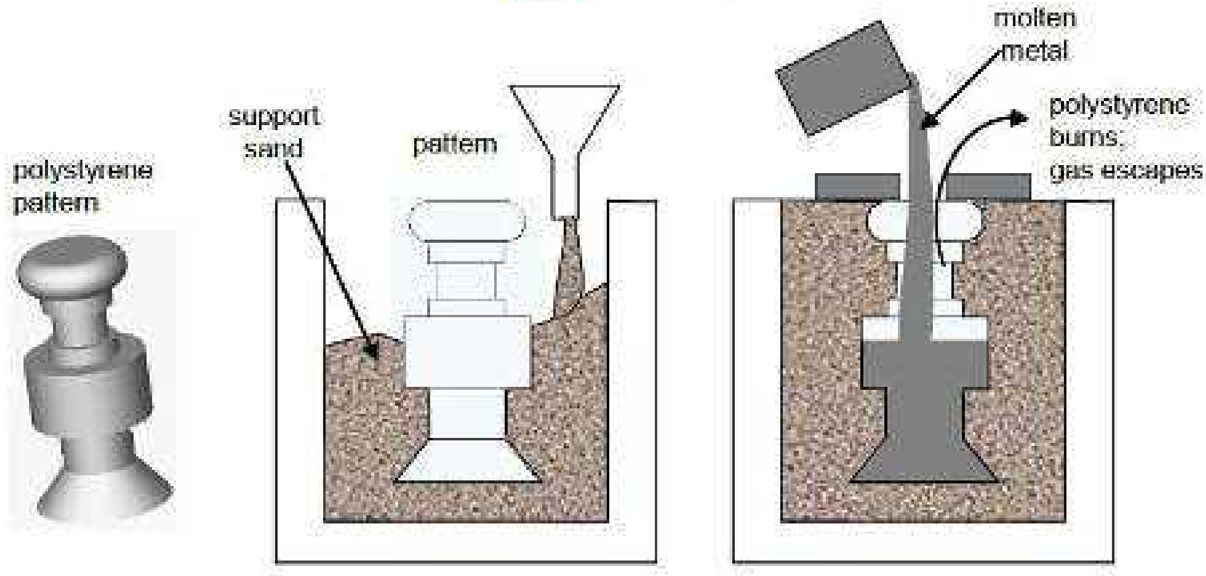
3.1.3 Expendable-pattern casting (lost foam process)

The pattern used in this process is made from polystyrene (this is the light, white packaging material which is used to pack electronics inside the boxes). Polystyrene foam is 95% air bubbles, and the material itself evaporates when the liquid metal is poured on it. The pattern itself is made by molding – the polystyrene beads and pentane are put inside an aluminum mold, and heated; it expands to fill the mold, and takes the shape of the cavity.

The pattern is removed, and used for the casting process, as follows: The pattern is dipped in a slurry of water and clay (or other refractory grains); it is dried to get a hard shell around the pattern. The shell-covered pattern is placed in a container with sand for support, and liquid metal is poured from a hole on top.

The foam evaporates as the metal fills the shell; upon cooling and solidification, the part is removed by breaking the shell.

The process is useful since it is very cheap, and yields good surface finish and complex geometry. There are no runners, risers, gating or parting lines – thus the design process is simplified. The process is used to manufacture crank-shafts for engines, aluminum engine blocks, manifolds etc.



Figures.6 Expendable mold casting

3.1.4 **Plaster-mold casting**

The mold is made by mixing plaster of paris ($CaSO_4$) with talc and silica flour; this is a fine white powder, which, when mixed with water gets a clay-like consistency and can be shaped around the pattern (it is the same material used to make casts for people if they fracture a bone). The plaster cast can be finished to yield very good surface finish and dimensional accuracy. However, it is relatively soft and not strong enough at temperature above 1200°C, so this method is mainly used to make castings from non-ferrous metals, e.g. zinc, copper, aluminum, and magnesium.
Since plaster has lower thermal conductivity, the casting cools slowly, and therefore has more uniform grain structure (i.e. less warpage, less residual stresses).

3.1.5 Centrifugal casting

Centrifugal casting uses a permanent mold that is rotated about its axis at a speed between 300 to 3000 rpm as the molten metal is poured. Centrifugal forces cause the metal to be pushed out towards the mold walls, where it solidifies after cooling. Parts cast in this method have a fine grain microstructure, which is resistant to atmospheric corrosion; hence this method has been used to manufacture pipes. Since metal is heavier than impurities, most of the impurities and inclusions are closer to the inner diameter and can be machined away. surface finish along the inner diameter is also much worse than along the outer surface.

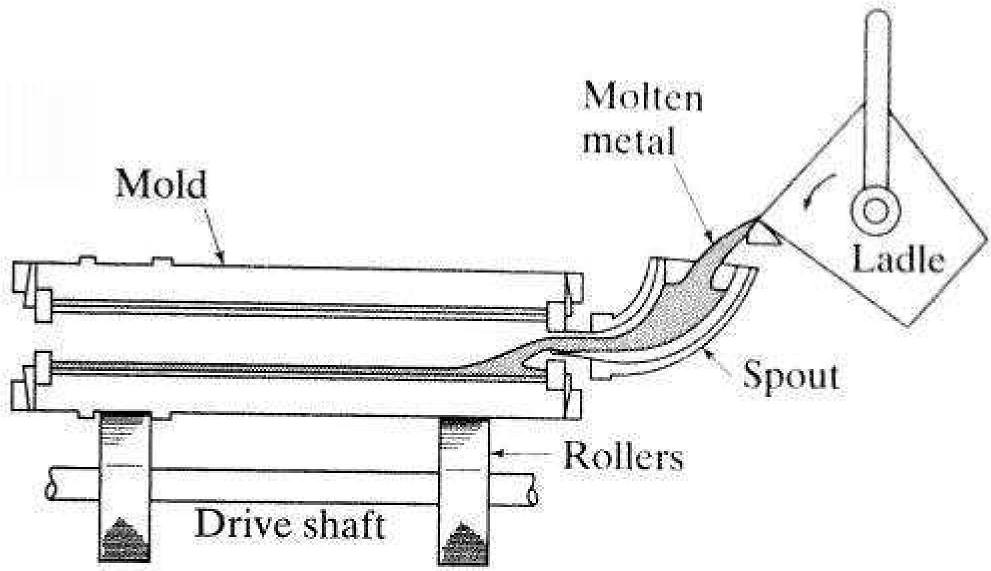


Figure: 3.7 Centrifugal casting schematic [source: Kalpakjian & Schmid]

Generally Cores are used for making interior surfaces of hollow castings and now-a-days it is used for making exterior surfaces and for other purposes. Green sand cores contain ordinary molding sand and dry sand core contains hardened or baked sand. Core mix contains clay free silica sand. This is suitably mixed with binders, water and other ingredients to produce a core mix. Synthetic core binders have some unusual properties like shorter baking times and excellent collapsibilities which reduces the defect castings. Urea formaldehyde binders burn out faster and collapse at lower temperature as compared to phenol formaldehyde binders. Thus urea formaldehyde binders are suitable for use at lower temperature metals like Al, Mg, thin sections of brass, bronze.

3.1.6 Green sand moulding:

Among the sand-casting processes, molding is most often done with greensand. Green molding sand may be defined as a plastic mixture of sand grains, clay,water, and other materials which can be used for molding and casting processes.

The sand is called "green" because of the moisture present and is thus distinguished from dry sand. The basic steps in green-sand molding are as below

✓ **Dry-sand Moulds:**

Dry-sand moulds are actually made with molding sand in the green condition. The sand mixture is modified somewhat to give good strength and other properties after the mould is dried. Dry-sand molding may be done the same way as green-sand molding on smaller sizes of castings.

✓ **Green sand:**

By green sand we denote sand in its natural, more or less moist state. It is a mixture of silica sand with 18 to 30 percent clay, having a total water of from 6 to 8 percent. The clay and water furnish the bond for green sand. It is fine, soft, light and porous. Being damped, it retains the shape, the impression given to it under pressure when squeezed in the hand. Molds prepared in this sand are known as green sand molds.

3.1.7 Foundry Automation

Pouring into Molds, Cleaning, Heat Treatment, Inspection, Automated Guided Vehicles; Automatic Storage, Moving Cores and patterns, Etc

Fig. 3.8 automatic costing picture

3.1.7.1 Reasons for Automation

Increased Manufacturing Efficiency, Reducing Costs, Reliability in Harsh Environments , Release of Skilled Man Power, Maximize Space, Improved Quality.

Fig.3.9. Phenol formaldehyde binders are employed for thick sections of CI, steel castings

3.1.7.2 Semi-Automatic Moulding Machine

Semi-automatic moulding machine uses high static squeeze force and high dynamic squeeze force to make the mould uniformly. It can make full use of sand and maintain the quality of mould. Therefore, the mould preparation costs can be reduced when large production of casting is needed. Figure3.10. Shows a typical semi-automatic moulding machine and a set of core pattern

Fig. 3.10 Left; semi-automatic Machine, Right; core pattern p

3.1.7.3 Objectives of plant layout

Minimum materials handling and minimize waste during handling, Facilitate manufacturing process, Flexibility of arrangement, Maximum utilization of equipment and space, To increase production capacity by smoothing work flow, Efficient utilization of manpower, Care for employee safety and convenience, Better lighting and ventilation of the area, Minimum production delays and minimize overall production time, Better working conditions, Easy supervision, Reduced in-process inventory, Minimum capital investment to improve customer service.

3.1.8 Mould

Mould is a container with cavity whose geometry determines part shape. Actual size and shape of cavity must be slightly oversized to allow for shrink age of metal during solidification and cooling Molds are made of a variety of materials, including sand, plaster, ceramic, and metal
In the foundry processes, for mould making or core making times mould sand will be filled according to organizational procedure or in the form of the following manner. See fig. 3.11 below during making sand mould in box / flasks on parting, pattern placing, core plate, core draying.

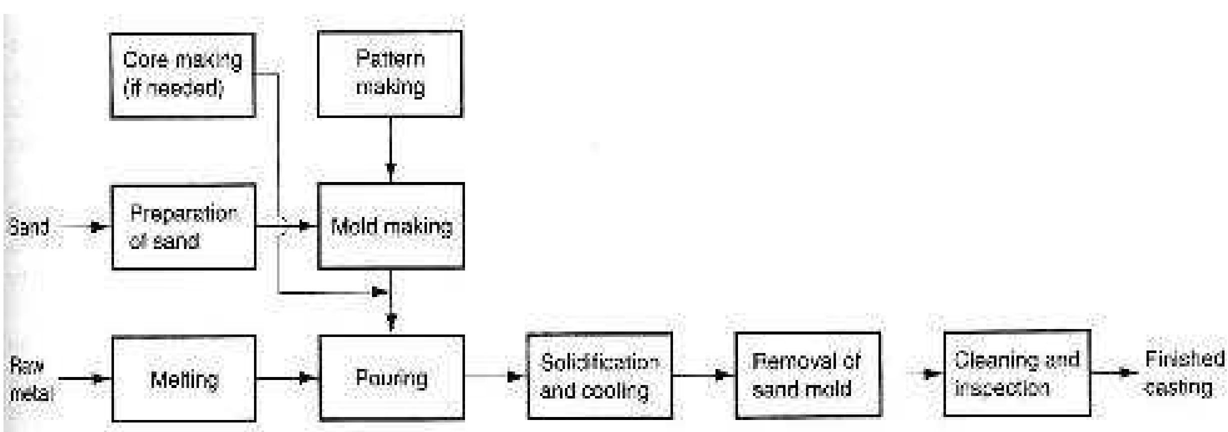


Fig. 3.11 Casting procese

A. Two forms of mold.

i. **Open mold**, simply a container in the shape of the desired part

iii. **Closed mold**, in which the mold geometry is more complex and requires a gating system (passageway) leading into the cavity

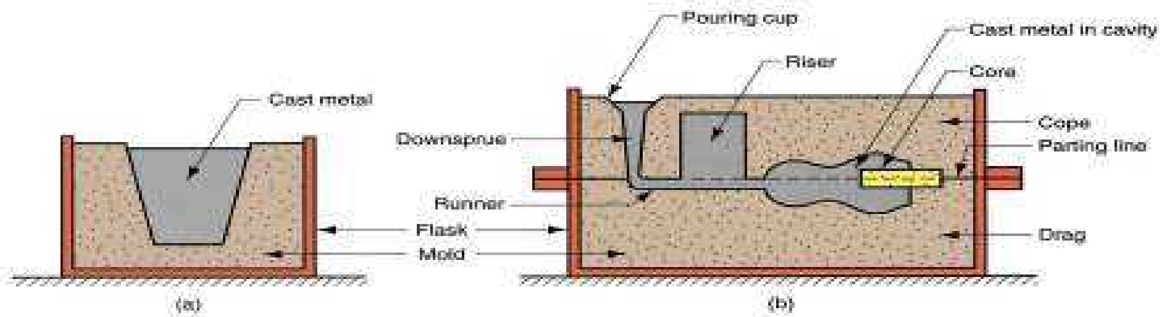


Fig. 3.12 Two forms of mold.

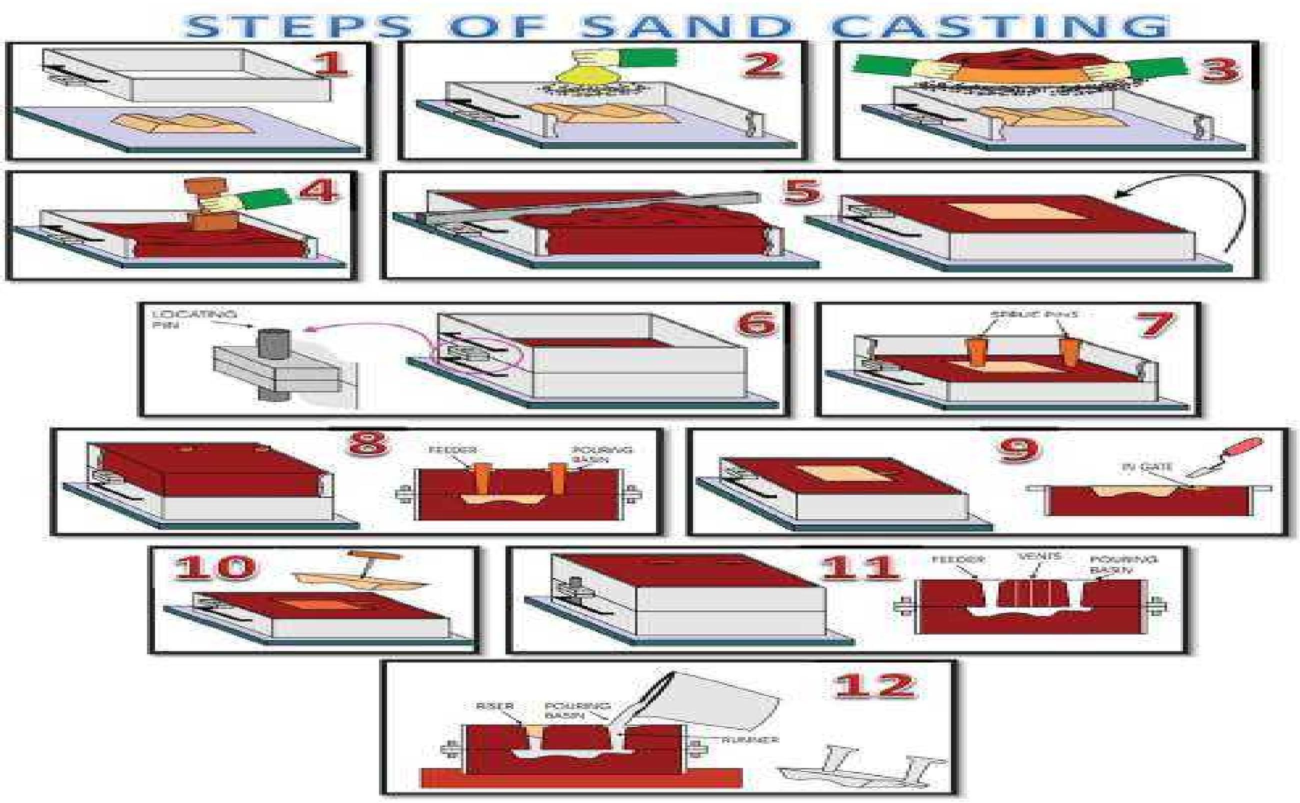


Figure3.13 cast making process

B. Core dryers may be made as metal castings,

Core dryers may be made as metal castings with thin sections in order to absorb minimum heat. They are perforated for easy escape of gases. For large quantity production, many core dryers are required. Loose pieces in core boxes. Loose pieces are required for cores having backdraft on vertical sides. Such a loose piece will form an entire side of the core. The loose piece remains on the core, which will be removed later by horizontal movement. Core wires, rods, arbors. Small core have sufficient strength after baking to withstand the molten metal upward force. For iron castings the lifting force is four times the weight of a core.

Certain cores and slender cores which do not have strength are supported by embedding wires, rods, arbors into the core sections. Wires are meant for small cores, where as arbors are CI or steel based skeleton structures. Removing arbors is an issue here, sometimes arbors are made in parts, bolted together to facilitate easy removal. Hooks are provided in the arbors for easy removal. They sometimes project outside the core prints.

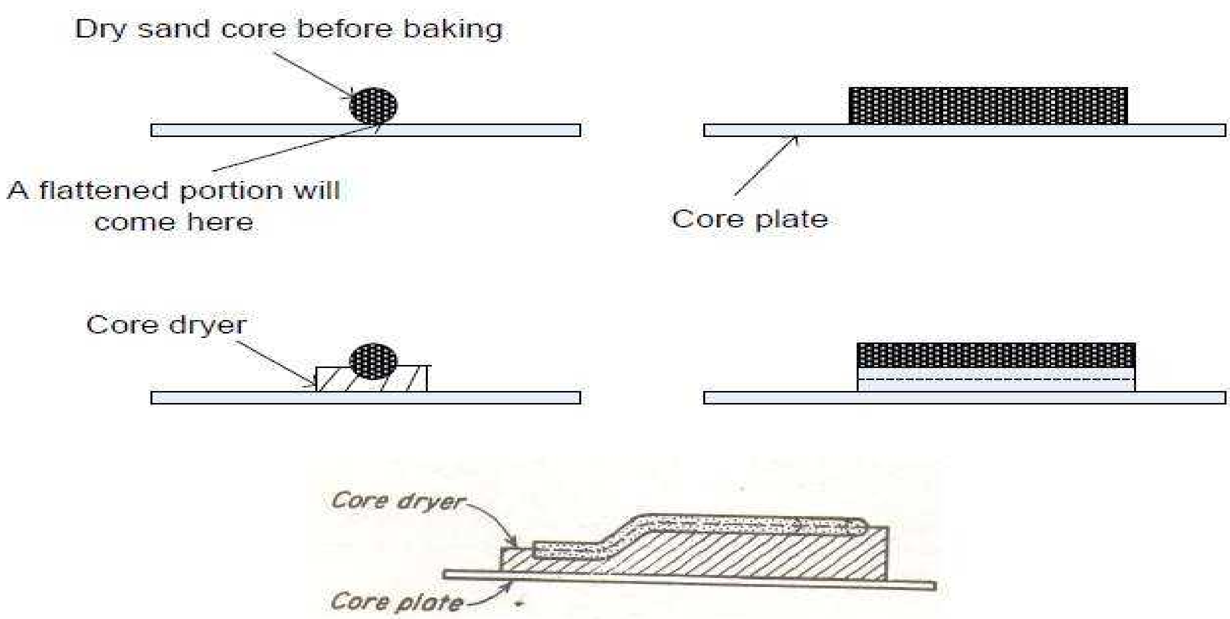


Fig. 3.14 core making and drying

C. *Core venting*

Proper core venting is required especially if the cores are surrounded largely by molten metal. The cores containing binders will produce gases, steam because of the heat generated due to molten metal. These gases should be vented out through core prints so that defects like 'blows' can be avoided. Large cores are sometimes made hollow.

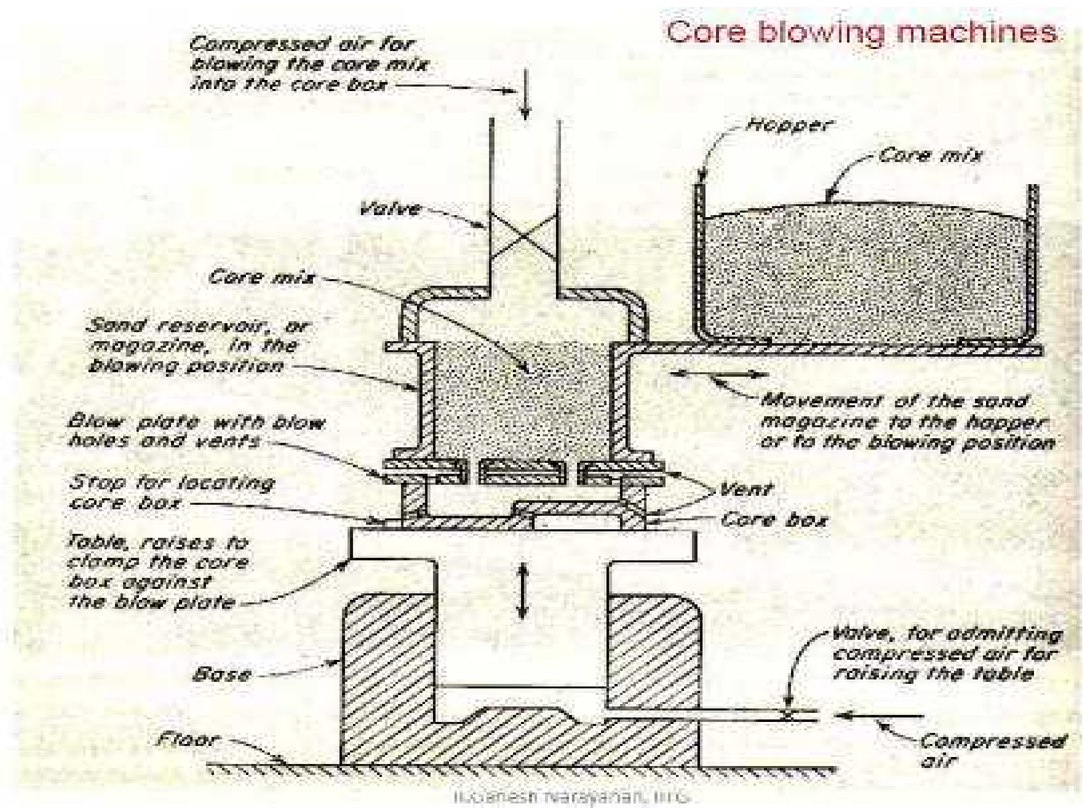


Fig. 3.15 core below machine

D. Core box equipment for core blowing

Core box should be complemented with core dryers for proper support, a blow plate to fasten to the reservoir. The core box contains blowing holes and the number, locations, size of the blowing holes are important in proper filling of the core box. This prevents the presence of soft cores and soft spots. Vent area to blowing hole area is 5:1. Sometimes the sand grains may not be conveyed properly due to the presence of entrapped air channels.

For continuous operation of the machine, many duplicate core boxes should be used. Conveyors are also used to handle the operations properly. The upper half of the core box is sometimes used as the blow plate that is fastened to the sand magazine. Core shooting can also be used to prevent some of the difficulties of core blowing. See fig. 3.15 below.

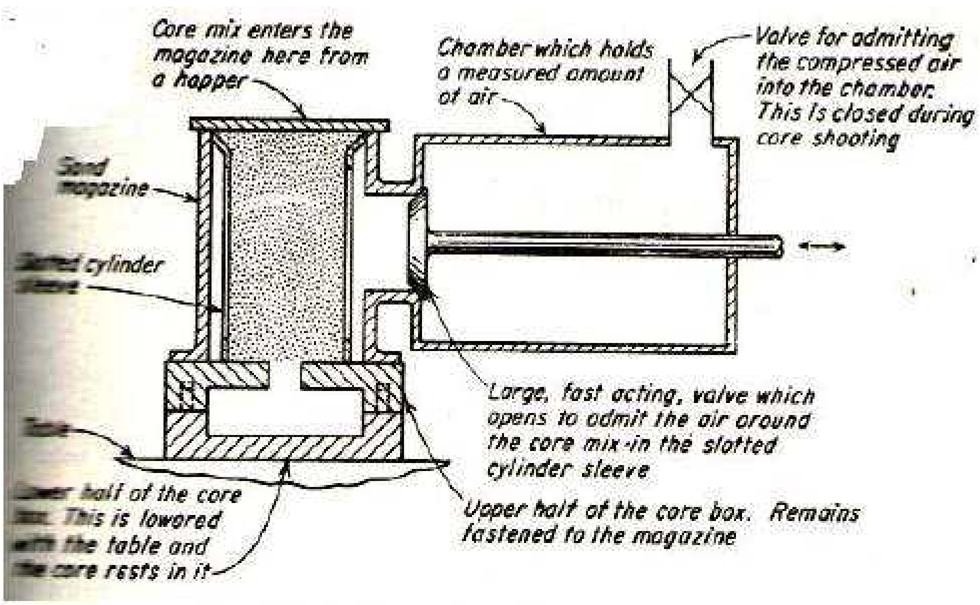


Fig. 3.16 core shooting machine

Compressed air is admitted into the chamber and the chamber is closed during core shooting. Large, fast acting valve is opened to admit the air around sand magazine. This pressurizes the core mix and because of which sand gets filled in the core box.

3.4 Securing mould

3.4.1 Securing mold

After all the above operations are complete, the cope box is again placed on the drag and clamped securely. Now the mould is ready for pouring molten metal.

3.4.2 Clamps

Are used for holding together the cope and drag of the completed mold or for clamping together the mold-board and the bottom-board on either side of the drag when the latter is rolled over. They are of many styles and sizes. Some are adjustable and are tightened on the flask by means of a lever. Other types use wedges to secure them on the flask. The WEDGES are usually of soft wood, but for the heavier works are either of hard wood or iron.

3.4.3 Clamps and Weights

Clamps and weights are used to hold the cope and drag sections of a mold together and to prevent lifting of the cope by the force of the molten metal. It is safe practice to use a weight on small molds, but when the molds are of considerable size, both weights and clamps should be used. The use of insufficient weights is a common cause of defective castings.

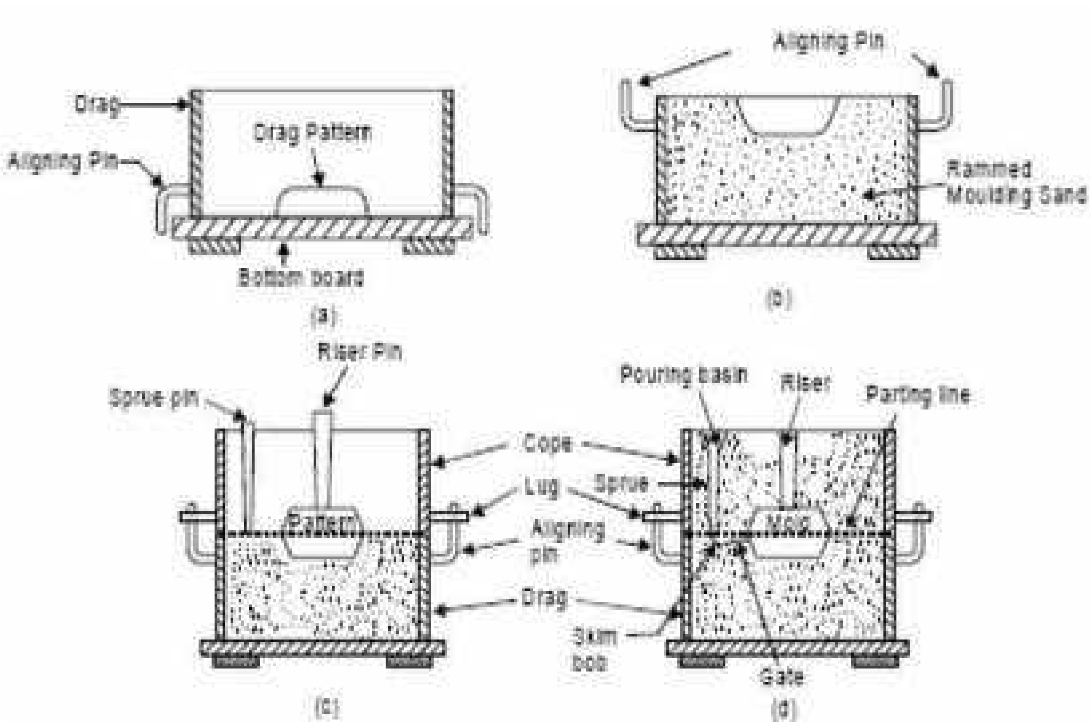


Fig. 3.17 Securing mould

3.5 Select or manufacture pouring basin and positioning.

3.5.1 Gating system

The passage-way which serves to deliver the molten metal into the mould cavity is known as gating system. A gating system, consists of the following parts. Like, pouring cup, sprue, runner. A pouring cup which is funnel shape opening in the upper surface of the cope above the sprue .It minimizes the splash and turbulence and promotes the entry of the clean metal only into the down sprue. In order to prevent the entry of dirt or slag into the down sprue, the pouring basin is provided with a skin core, strainer core, delay screen or a sprue plug. Down gate or sprue: which is a vertical opening (usually tubular) through the cope, a runner also receives the metal from the down sprue and also distributes to several gate passage ways around the mould cavity. A runner may be used in large casting an ingate is an opening (usually horizontal) which carries the metal from the runner to the mould cavity.

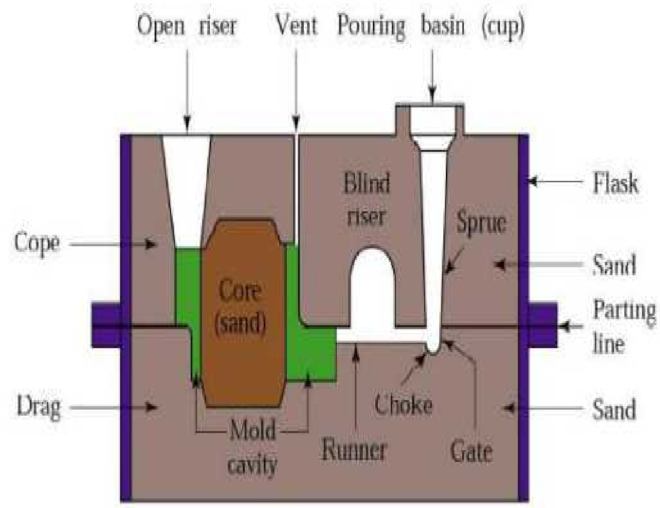


Fig. 3.18 gating system

A. Elements of a Gating System

Gating systems refer to all those elements which are connected with the flow of molten metal from the ladle to the mould cavity. The various elements that are connected with a gating system are: rprue, runner, riser sprue, base well, pouring basin**,** runner extension, and ingrate.

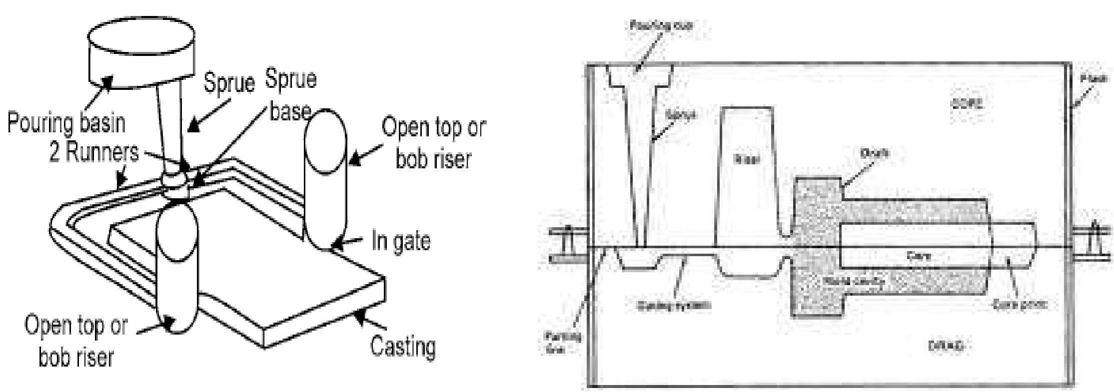


Fig. 3.18 Elements of a Gating System

- ✓ **Pouring basin**

The main function of a pouring basin is to reduce the momentum of the liquid flowing into the mould by settling first into it. In order that the metal enters into the sprue without any turbulence it is necessary that the pouring basin be deep enough, also the entrance into the sprue be a smooth radius of at least 25 mm. The pouring basin depth of 2.5 times the sprue entrance diameter is enough for smooth metal flow and to prevent vortex formation. In order that vortex is not formed during pouring, it is necessary that the pouring basin be kept full and constant conditions of flow are established. This can be achieved by using a delay screen or a strainer core. A delay screen is a small piece of perforated thin tin sheet placed in the pouring basin at the top of the down sprue. This screen usually melts because of the heat from the metal and in the process delays the entrance of metal into the sprue thus filling the pouring basin fully. This ensures a constant flow of metal as also exclude slag and dirt since only metal from below is allowed to go into the sprue. A similar effect is also achieved by a strainer core which is a ceramic coated screen with many holes. The strainer restricts the flow of metal into the sprue and thus helps in quick filling of the pouring basin. Pouring basins are most desirable for alloys which form troublesome oxide skins (aluminium, aluminium bronze, etc.

The molten metal is entered into the pouring basin, which acts as a reservoir from which it moves into the sprue. The pouring basin stops the slag from entering into the mould cavity by the help of skimmer or skim core. It holds the slag and dirt which floats on top and only allows the clean metal. It should be always full during pouring and one wall should be inclined 450 to the horizontal.

Function:-This will reduce the momentum of liquid flowing into mould

Design: - Pouring basin should be deep enough. Entrance into sprue be a smooth radius of 25mm.

Pouring basin depth should be 2.5 times the sprue entrance diameter. A strainer core restricts the flow of metal into the sprue and thus helps in quick filling of the pouring basin. It is a ceramic coated screen with many small holes.

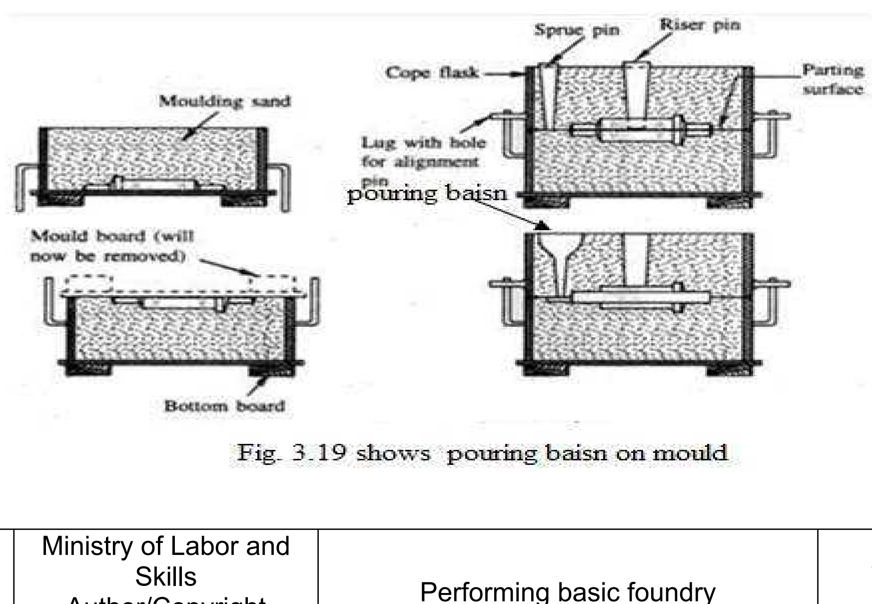


Fig. 3.19 shows pouring baisn on mould

3.6 Ramming up mould properly and striking off

3.6.1 **Ramming up Molds**

Sand is then tightly packed in the drag by means of hand rammers. Peen hammers (used first close to drag pattern) and butt hammers (used for surface ramming) are used.

The ramming must be proper i.e. it must neither be too hard or soft. Too soft ramming will generate weak mould and imprint of the pattern will not be good. Too hard ramming will not allow gases/air to escape and hence bubbles are created in casting resulting in defects called 'blows'. Moreover, the making of runners and gates will be difficult. See below fig.3.20.

Figure 3.20 Ramming the Sand

3.6.2 Striking off

After the ramming is finished, the excess sand is leveled/removed with a straight bar known as strike rod.

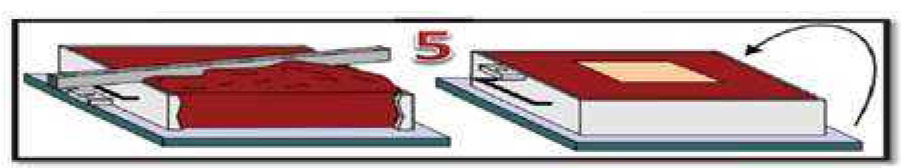


Fig. 3.21striking off

3.7 Utilize Parting and stripping systems.

After the ramming is finished, the excess sand is leveled/removed with a straight bar known as strike rod.

Parting Line, by parting line we mean a line or the plane of a pattern corresponding to the point of separation between the cope and drag portions of a sand mold. Parting lines must be flat or drafted so that the mold can be opened, the pattern removed and then closed for pouring without damage to the sand.

Parting line design

Parting line should be along a flat plane rather than be contoured. Irregular parting lines should be prevented until and unless it is unavoidable. See below fig. 3.22.

1. For less dense material (like Al alloys), parting line should be placed as low as possible
2. For denser metals (like steels), mid-height location is recommended.
3. Parting line greatly influences the total cost of the casting process. It has effects on the total required number of cores, gating system and weight of the final casting.
4. Critical dimensions should not cross parting lines in molds.

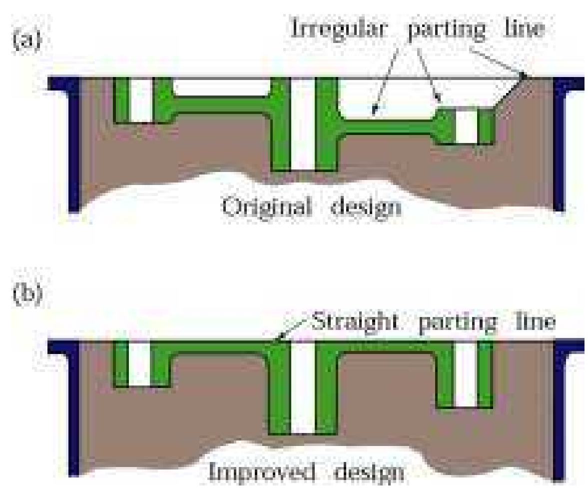


Figure 3.22.Designing for a straight parting line to reduce pattern and casting costs. (a) Irregular parting line is a costly design. (b) Straight parting line is less expensive.

3.8 Position and secure loose pieces, vents, risers and runners.

3.8.1 Positioning core in prints, Utilizing chaplets & chills and venting

Cores are compact mass of core sand that when placed in mould cavity at required location with proper alignment does not allow the molten metal to occupy space for solidification in that portion and hence help to produce hollowness in the casting. The environment in which the core is placed is much different from that of the mold.

There are various functions of cores which are given below.

- Core is used to produce hollowness in castings in form of internal cavities.
- It may form a part of green sand mold
- It may be deployed to improve mold surface
- It may provide external undercut features in casting
- It may be used to strengthen the mold
- It may be used to form gating system of large size mold
- It may be inserted to achieve deep recesses in the casting

✓ **Core in prints**

When a hole blind or through is needed in the casting, a core is placed in the mould cavity to produce the same. The core has to be properly located or positioned in the mould cavity on pre-formed recesses or impressions in the sand. To form these recesses or impressions for generating seat for placement of core, extra projections are added on the pattern surface at proper places.

3.8.2 **Setting cores, chills, and chaplets**

In the setting of cores, it is important to check the size of the core print against the core itself. A core print is a depression or cavity in the cope or drag, or both. The print is used to support a core and, when the core is set, is completely filled by the supporting extensions on the core. An oversize print or an under size core will cause fins on the completed castings, which may lead to cracks or chilled sections in the core area. An oversize core or an under size print may cause the mold to be crushed and result in loose sand in the mold and a dirty casting.

Setting simple cores in the drag should be no problem to a molder. Care should be taken in handling and setting the core. After a core has been properly set, it should be seated by pressing it lightly into the prints. Another item which should be checked is the venting of cores through the mold. Many times, the cores themselves are properly vented but the molder forgets to provide a vent through the mold for the core gases to escape.

Income instances, the cores may have to be tied to the cope. In such a case, they are attached to the cope by wires extending through the cope. The wires are wound around long rods resting on the top of the cope to provide additional support. The rods should rest on the flask to prevent crushing or cracking of the cope.

Such operations should be done with the cope resting on its side or face up. The tieing should be done with as little disturbance as possible to the rammed surface. The core should be drawn up tight to prevent any movement of the core while the mold is being closed. Before closing the mold, the cope should be checked to make sure it is free of any loose sand.

Chills are rammed in place with the mold and are described under "Molding Tools" in this chapter. Again it is emphasized that chills must be clean and dry. Even chills which have just been removed from a newly shaken-out mold should be checked before immediate reuse.

The use of chaplets was described earlier in this chapter under "Molding Tools." It must be remembered that chaplets should be used only when absolutely necessary. Preferably, another method for support (for example, core prints) should be used, if at all possible. The use of chaplets in pressure castings should be completely avoided.

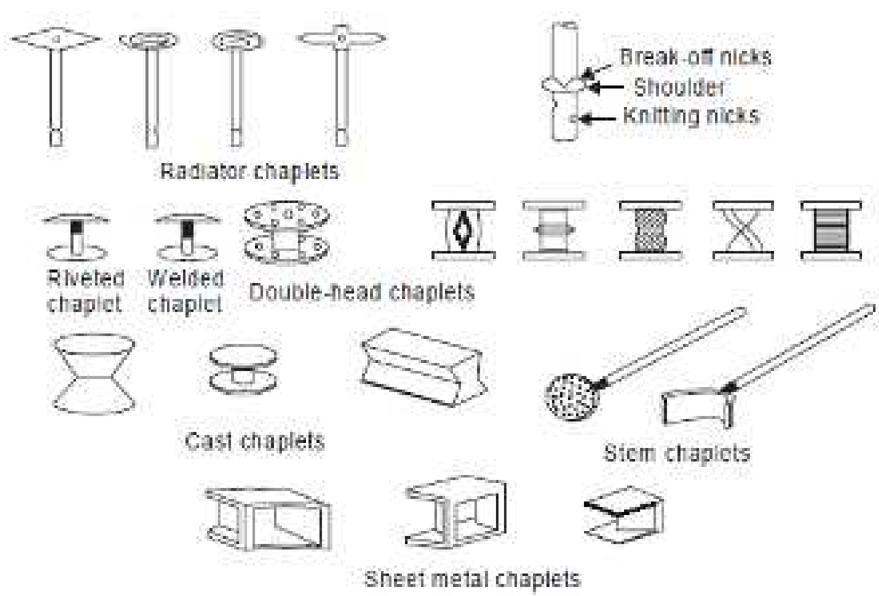


Fig. 3.23 Types of chaplets

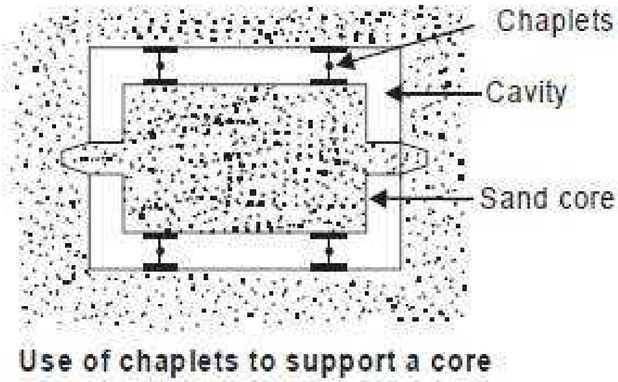


Fig. 3.24 Use of chaplets

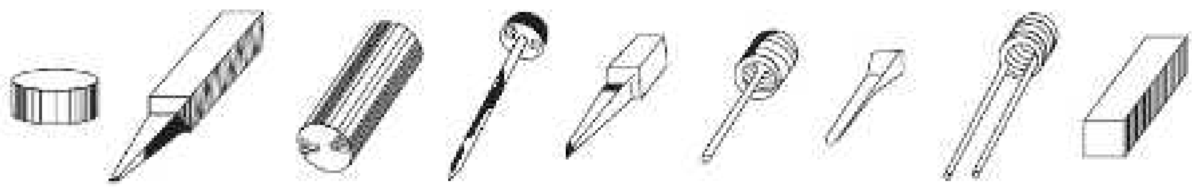


Fig. 3.25 Types of chills

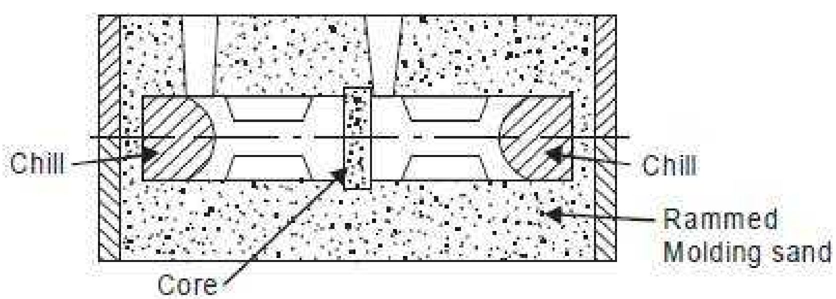


Fig. 3.26 Use of a chill

3.8.4 Secure loose pieces, vents, risers and runners

The passage-way which serves to deliver the molten metal into the mould cavity is known as gating system. A gating system, consists of the following parts. Like, pouring cup, sprue, runner.

Sprue: The passage through which the molten metal, from the pouring basin, reaches the mould cavity. In many cases it controls the flow of metal into the mould.

Runner: The channel through which the molten metal is carried from the sprue to the gate. Gate: A channel through which the molten metal enters the mould cavity.

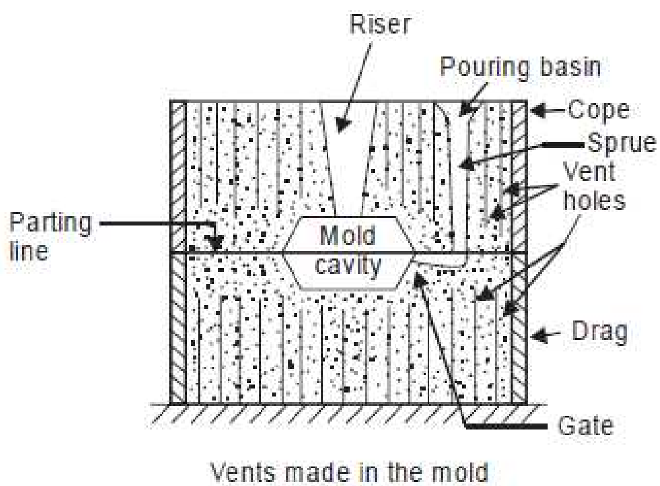
Riser: A column of molten metal placed in the mould to feed the castings as it shrinks and solidifies. Also known as "feed head",

Vent: Small opening in the mould to facilitate escape of air and gases.

It has to prepare the properly in order to minimize the erosion of sand by molten metal has to secure the loose pieces, vent, risers, and runners.

- ✓ **VENTING OF MOLDS**

Vents are very small pin types holes made in the cope portion of the mold using pointed edge of the vent wire all around the mold surface as shown in Fig. 6.1.(b). These holes should reach just near the pattern and hence mold cavity on withdrawal of pattern. The basic purpose of vent holes is to permit the escape of gases generated in the mold cavity when the molten metal is poured. Mold gases generate because of evaporation of free water or steam formation, evolution of combined water (steam formation), decomposition of organic materials such as binders and additives (generation of hydrocarbons, CO and CO2), expansion of air present in the pore spaces of rammed sand. If mold gases are not permitted to escape, they may get trapped in the metal and produce defective castings. They may raise back pressure and resist the inflow of molten metal. They may burst the mold. It is better to make many small vent holes rather than a few large ones to reduce the casting defects.



(a) (b)

Fig. 3.27(a), (b) Venting of holes in mold

Then, the cope is placed on the drag, and Sprue and riser pins are placed in vertically position at suitable locations using support of molding sand. It will help to form suitable sized cavities for pouring molten metal. Talcum powder and sand are again sifted over the pattern, and rammed to fill the cope. The pins are then carefully pulled out of the sand. The critical part of the operation is to separate the cope and drag to remove the pattern.

Vent holes are made in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during pouring and solidification. Done by vent rod, a sprue pin for making the sprue passage is located at some distance from the pattern edge.

Riser pin is placed at an appropriate place. Filling, ramming and venting of the cope is done in the same manner.

Remove sprue and riser pins and create vent holes in the cope with a vent wire. The basic purpose of vent creating vent holes in cope is to permit the escape of gases generated during pouring and solidification of the casting.

Runners and gates are made by cutting the parting surface with a gate cutter. A gate cutter is a piece of sheet metal bent to the desired radius.

3.9 Removing Pattern and loose pieces from mould.

3.9.1. **Remove the pattern from mold**

The first thing to be considered in looking at a pattern is how it will best draw out of the sand. Every complicated form of casting presents a partially new problem to the pattern maker. If a piece will readily draw out of the sand except one or more small projections , they can sometimes be left on a dovetail slide , which will allow the pattern to be drawn , leaving a part in the sand to be removed later on ; or if it be a cavity , it must be cored out .

Pattern draw**,** on completion of ramming the mould is ready for pattern withdrawal. In hand moulding the mould part is usually turned over after ramming, for which a crane, hoist, or simple turnover unit can be used. The pattern is rapped to provide clearance and lifted out by hand or crane: care is needed to avoid dimensional errors from excessive rap. Machine draw systems have already been discussed: the initial clearance is normally provided by low amplitude vibration, giving greater dimensional consistency.

The pattern may be vibrated with a powered vibrator, or the pattern, and maybe the cope and drag flask, will be lightly tapped with a small hammer. The pattern is lifted from the sand. When the pattern is withdrawn, its imprint provides the mould cavity. This cavity is filled with metal to become the casting.

✓ **Inspecting and repairing mold.**

After removing wooden pattern halves, the mould cavities may be repaired in case any corners etc. have been damaged. This is a delicate operation.

Before closing of the mould boxes, graphite powder is sprinkled on the mould surface in both boxes. In the drag box, a gate is cut below the location of the runner (in the cope box). The molten metal poured in the runner will flow through the gate into the mould cavity.

In case, the moulds have been dried, instead of graphite powder, a mould wash containing suspension of graphite in water is lightly spread over the mould surface

3.10 Clean and paint mould and core

3.10.1 Clean mould or core

If any sand has fallen into the mould cavity, it is carefully lifted or blown away by a stream of air.

Cleaning refers to all operations necessary to the removal of sand, and scale, from the mold and core. Excess sand and scale are removed to improve the surface appearance of the mold. Inspection of the molding for Brocken, damages and general quality is performed.

3.10.2 Coating Benefits

Most of the reasons for using coatings center around reducing casting costs by improving sand peel and reducing mold/core reaction, reducing or eliminating metal penetration (burn-in and/or burn-on), and reducing or eliminating veining. These reasons are directly associated with casting cleaning costs. Coatings are also used to reduce machining time and tool wear by having a clean smooth surface, to improve casting appearance, to facilitate handling (especially where low-strength cores may be required because of shakeout conditions), or to promote chill or increase hardness in metal (for which selenium or tellurium paste is used). Coatings should not be used indiscriminately. No coating will compensate for a poor-quality core

i. **Mold and core coatings**

Coatings are frequently applied to cores to enhance the casting surface finish and to reduce casting defects at the mold/metal interface. Coatings accomplish this by having a higher refractory value than the sand and/or by forming an impermeable barrier between the metal and the core. Most coatings are formulated with five major components:

- ✓ Refractory material: - Refractory, usually oxides of many kinds ground to a particle size of 50 mm or less, but for castirons carbonaceous material is common in the form of graphite or ground coke etc.
- ✓ Carrier system: - allows the refractory to be applied evenly to the sand mold or core. After the coating has been applied, the carrier must be removed. When the carrier is water, it can be torched or oven dried. Alcohol carriers are commonly ignited and allowed to burn off. The volatile chlorinated hydrocarbons readily air dry and require neither torching nor oven drying.
- ✓ Suspension system: - The function of the suspension system is to maintain the refractory material uniformly dispersed in solution. With water carriers, sodium bentonite is commonly used, while organic bentonite or bentones are generally used with alcohol and chlorinated hydrocarbon carriers.
- ✓ Binder system: - in a coating is usually an organic resin, and it behaves similarly to the resins used to bond sands. The amount of binder used depends on the density and fineness of the refractory. It is used sparingly to avoid casting surface defects.
- ✓ Chemical modifiers: - including surfactants to improve wettability, antifoaming agents, and bactericides.

ii. Aggregate molds

Although we have dealt at length with reactions that can occur between the metal and the mold, the purpose of a mold coating is to prevent such happenings by keeping the two apart. It has to be admitted that for many formulations, these attempts are of only limited success. Some useful reviews of coatings from which the author has drawn are given by Vingas (1986), Wile and colleagues (1988), and Beeley(2001). Vingas in particular describes techniques for measuring the thickness of coatings in the liquid and solid states. All describe the various ways in which coatings can be applied by **dipping**, **swabbing**, **brushing**, and **flow-over**. An important aspect to bear in mind, as with the provision of feeders, and the best action (if possible) is to avoid coatings.

At this time many coatings are still alcohol (ethanol) based, and so burned off rather than dried. This requires minimal floor space and energy, but does add to the loading of VOCs (volatile organic compounds) in the environment. This approach is likely to be banned under future legislation, forcing the use of water-based coatings. The water-based coatings pose a significantly increased drying problem.

- ✓ **Permanent molds and metal chills**

Permanent molds or chills in gray iron or steel are practically inert, so any mold coat is not required to prevent chemical reactions between the two. A coat will help to:

- ✓ Protect the mold from thermal shock
- ✓ Avoid the premature chilling of the metal that might result in cold lap defects
- ✓ Confer some 'surface permeability' on the impermeable surface to allow the melt to flow better over the surface,and allowing the escape of any volatiles or condensates (particularly from the surface of chills).

- ✓ **Dry coatings**

These dry coating techniques deserve wider use. When correctly applied, the coating simply fills the interstices between the surface grains of the mold, not adding any thickness of deposit. Thus the technique has the advantage of preserving the accuracy of the mold, while improving surface finish with no drying time penalty.

3.10.3 Advantages and Disadvantages of coating

advantages of coatings:

- ✓ Reduction of cleaning costs because of improved surface finish (finer surface, reduced or eliminated veining, reduced penetration and/or burn-on and reduced reactions between metal and mold, for instance between (i) manganese steel and silica sand, and (ii) binder gases such as sulfur compounds from furan binders).
- ✓ Improved shake-out because of improved sand peel.
- ✓ Reduced machining time and tool wear.

Reasons for avoiding coatings / Disadvantages include:

- ✓ Cost of materials, especially those based on expensive minerals such as zircon.
- ✓ Potential loss of accuracy because of difficulty of controlling coat thickness and coating penetration.
- ✓ Possibility of cosmetic defects from runs and drops.
- ✓ Floor space for coating station.
- ✓ Energy cost to dry and possible capital cost and floor space for drying ovens and extraction ducting and fans.
- ✓ Floor space to dry if dried naturally (this might exceed molding space since drying is slow).
- ✓ Drying time can severely reduce productivity.
- ✓ Cores appear to be never fully dried, despite all attempts, after the application of a coating, so that there is enhanced danger of blow defects if the core cannot be vented to the atmosphere.

Self-check-3

Test I: True false item

Directions: write true if the statement is correct and false if the statement is not correct on the space provided

1. Pattern shops should be furnished with ***a mechanical drawing*** or blue print of the part to be made.
2. Care is needed to avoid dimensional errors from excessive rap for Pattern draw.
3. During ramming the mould is ready for pattern withdrawal.

Test II: multiple choices

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. The name intermediate part of molding flask

   A, drag b, cope c, cheek

2. Sand is then tightly packed in the drag by means of __________________.

   A, Strike off bar B, Vent wire C, hand rammers

3. Will not allow gases/air to escape and hence bubbles are created in casting

   A, Too hard ramming B, Too soft ramming C, A and B Answer

4. After the ramming is finished, the excess sand is leveled/removed with a straight bar known as ______________.

   A, Lifter B, Trowels C, strike rod

5. It is a thin steel rod carrying a pointed edge at one end and a wooden handle or a bent loop at the other.

   A, Vent wire B, Strike off bar C, Slicks

Test III: Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

Column A	Column B
1. Types of pattern	A. permeability
2. allowance in casting	B. loose peces
3. Common pattern material	C. wood
4.	D. machine

Test IV: writing short Answer

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. Write types of allowance added to the drawing of patterns?
2. List at least three common sand moulding equipments?
3. List at least three sources of foundries sand used in mould making?
4. List at least three types of molding sand?

Operation sheet-1 Select appropriate molding media to produce mould

Operation Title: To Select appropriate molding media to produce mould

Purpose: To prepare a sand mold, using the given single piece pattern.

Instruction:-Given all the necessary materials the simulation room/ Lab must conducive to perform the demonstration and the trainees must be in right and healthy condition.

- Demonstrate mould making on the sand casting by using recommended tools and safety requirements correctly.

- Prepare the mould using single piece (a solid) pattern

- Using the figure below and given data/ information

-You have given 4 Hours for the task.

- pre/post Sequence of operations**;** Sand preparation, Placing the mould flask (drag) on the moulding board/ moulding platform, Placing the pattern at the centre of the moulding flask, Ramming the drag , Placing runner and riser, Ramming the cope, Removal of the pattern, runner, riser, and Gate cutting.

Required tools and equipment: - Molding board, Drag and cope boxes, Molding sand , Parting sand, Rammer, Strike-off bar, Bellows, Riser and sprue pins, Gate cutter, Vent rod , Draw spike, Wire Brush, etc . Raw material; - Moulding sand, Parting sand, facing sand, baking sand, single piece solid pattern, bottom board, moulding boxes etc.

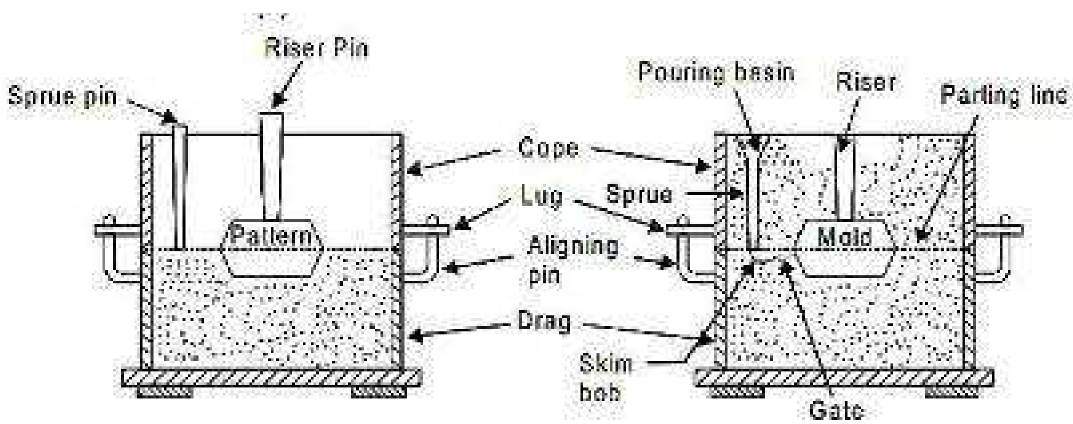
Precautions: - take care during operate of mould making tools and equipments

- do not forget to use and select appropriate mould tools & equipment
- follow pre/post set up and material preparation activities

Procedure: Mould Making

1. First a bottom board is placed either on the molding platform or on the floor, making the surface even.
2. The drag molding flask is kept upside down on the bottom board along with the drag part of the pattern at the centre of the flask on the board.
3. Dry facing sand is sprinkled over the board and pattern to provide a non-sticky layer.
4. Freshly prepared molding sand of requisite quality is now poured into the drag and on the pattern to a thickness of 30 to 50 mm.
5. Rest of the drag flask is completely filled with the backup sand and uniformly rammed to compact the sand.
6. After the ramming is over, the excess sand in the flask is completely scraped using a flat bar to the level of the flask edges.
7. Now with a vent wire which is a wire of 1 to 2 mm diameter with a pointed end, vent holes are in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during casting solidification. This completes the preparation of the drag.
8. Now finished drag flask is rolled over to the bottom board exposing the pattern.
9. Using a slick, the edges of sand around the pattern is repaired
10. The cope flask on the top of the drag is located aligning again with the help of the pins of the drag box.
11. Sprue of the gating system for making the sprue passage is located at a small distance of about 50 mm from the pattern. The sprue base, runners and in-gates are also located as shown risers are also placed. Freshly prepared facing sand is poured around the pattern.
12. The moulding sand is then poured in the cope box. The sand is adequately rammed, excess sand is scraped and vent holes are made all over in the cope as in the drag.
13. The sprue and the riser are carefully withdrawn from the flask
14. Later the pouring basin is cut near the top of the sprue.
15. The cope is separated from the drag any loose sand on the cope and drag interface is blown off with the help of the bellows.

16. Now the cope and the drag pattern halves are withdrawn by using the draw spikes and rapping the pattern all around to slightly enlarge the mould cavity so that the walls are not spoiled by the withdrawing pattern.
17. The runners and gates are to be removed or to be cut in the mould carefully without spoiling the mould.
18. Any excess or loose sand is applied in the runners and mould cavity is blown away using the bellows.
19. Now the facing paste is applied all over the mould cavity and the runners which would give the finished casting a good surface finish.
20. A dry sand core is prepared using a core box. After suitable baking, it is placed in the mould cavity.
21. The cope is placed back on the drag taking care of the alignment of the two by means of the pins.
22. The mould is ready for pouring molten metal. The liquid metal is allowed to cool and become solid which is the casting desired.



Quality criteria: 1. Pattern / mould should be free from moisture, free fouren material

2. You have to test the sand before making mould
3. Making sand mould is done without error
4. The required mould cavity is prepared using the given Single /solid Pattern.

Operation sheet-2: Select appropriate molding media to produce mould

Operation Title: Prepare the mould using A Split pattern.

Purpose: To prepare a sand mold, using the given Split-piece pattern

Instruction:-Given all the necessary materials the simulation room/ Lab must conducive to perform the demonstration and the trainees must be in right and healthy condition.

- Demonstrate mould making on the sand casting by using recommended tools and safety requirements correctly.
- Prepare the mould using Split-piece pattern
- Using the figure below or given data/ information
- You have given 4 Hours for the task.

- Pre/post Sequence of operations**;** Sand preparation, Placing the mould flask (drag) on the moulding board/ moulding platform, Placing the pattern at the centre of the moulding flask, Ramming the drag , Placing runner and riser, Ramming the cope, Removal of the pattern, runner, riser, and Gate cutting.

Required tools and equipment: - Molding board, Drag and cope boxes, Molding sand, Parting sand, Rammer, Strike-off bar, Bellows, Riser and sprue pins, Gate cutter, Vent rod, Draw spike, Wire Brush, etc . Raw material; - Moulding sand, Parting sand, facing sand, baking sand, pattern, bottom board, moulding boxes, etc.

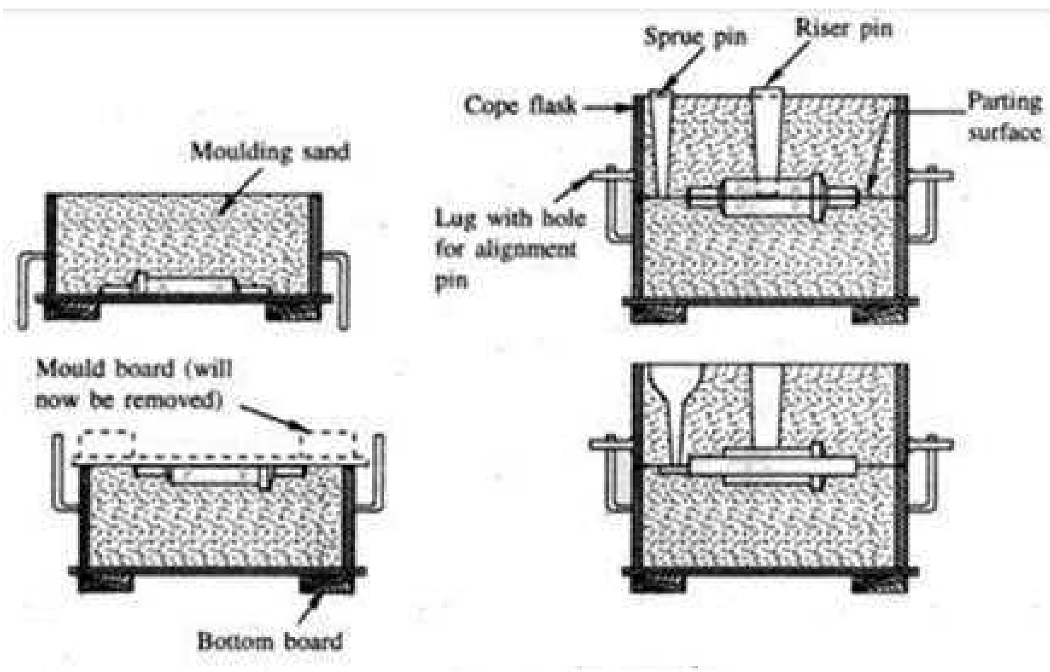
Precautions: - take care during operate of mould making tools and equipments

- do not forget to use and select appropriate mould tools & equipment
- follow pre/post set up and material preparation activities

Procedure: Mould Making

1. First a bottom board is placed either on the molding platform or on the floor, making the surface even.
2. The drag molding flask is kept upside down on the bottom board along with the drag part of the pattern at the centre of the flask on the board.
3. Dry facing sand is sprinkled over the board and pattern to provide a non-sticky layer.
4. Freshly prepared molding sand of requisite quality is now poured into the drag and on the split-pattern to a thickness of 30 to 50 mm.
5. Rest of the drag flask is completely filled with the backup sand and uniformly rammed to compact the sand.
6. After the ramming is over, the excess sand in the flask is completely scraped using a flat bar to the level of the flask edges.
7. Now with a vent wire which is a wire of 1 to 2 mm diameter with a pointed end, vent holes are in the drag to the full depth of the flask as well as to the pattern to facilitate the removal of gases during casting solidification. This completes the preparation of the drag.
8. Now finished drag flask is rolled over to the bottom board exposing the pattern.
9. Using a slick, the edges of sand around the pattern is repaired and cope half of the pattern is placed over the drag pattern, aligning it with the help of dowel pins
10. The cope flask on the top of the drag is located aligning again with the help of the pins of the drag box.
11. Dry parting sand is sprinkled all over the drag surface and on the pattern
12. Sprue of the gating system for making the sprue passage is located at a small distance of about 50 mm from the pattern. The sprue base, runners and ingates are also located as shown risers are also placed. Freshly prepared facing sand is poured around the pattern.
13. The moulding sand is then poured in the cope box. The sand is adequately rammed, excess sand is scraped and vent holes are made all over in the cope as in the drag.
14. The sprue and the riser are carefully withdrawn from the flask
15. Later the pouring basin is cut near the top of the sprue.
16. The cope is separated from the drag any loose sand on the cope and drag interface is blown off with the help of the bellows.

17. Now the cope and the drag pattern halves are withdrawn by using the draw spikes and rapping the pattern all around to slightly enlarge the mould cavity so that the walls are not spoiled by the withdrawing pattern.
18. The runners and gates are to be removed or to be cut in the mould carefully without spoiling the mould.
19. Any excess or loose sand is applied in the runners and mould cavity is blown away using the bellows.
20. Now the facing paste is applied all over the mould cavity and the runners which would give the finished casting a good surface finish.
21. A dry sand core is prepared using a core box. After suitable baking, it is placed in the mould cavity.
22. The cope is placed back on the drag taking care of the alignment of the two by means of the pins.



Quality criteria: 1. Pattern / mould should be free from moisture, free fouren material

2. You have to test the sand before making mould

3. Making sand mould is done without error

4. The required mould cavity is prepared using the given Single /solid Pattern.

LAP Test	Practical Demonstration

Name: ___________________________ Date: _____________

Time started: _____________________ Time finished: ________________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1: Select appropriate molding media to produce mould; by single pieces (soild) pattern

Task 2: Select appropriate molding media to produce mould; prepare the mould using a Split pattern

Unit four: Clean and restore work area

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Clear all materials/debris and clean work site.
- Dispose unwanted treated sand

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Clear all materials/debris and clean work site and left in a safe state
- Dispose unwanted treated sand of according to standard operating procedures.

4.1 Clear all materials/debris and clean work site.

Clearing all materials/debris and work site in a safe state. Dusts, solvents, and other materials present a health hazard in foundries. Dust is generated in many foundry processes and presents a twofold problem: Cleaning to remove deposits, and Control at the point of origin to prevent further dispersion and accumulation; Vacuum cleaning is the best way to remove dust in foundries. Once dust has been removed, prevent further accumulation by using local exhaust systems (LEV) that remove it at the point of origin.

- ✓ **Personnel Facilities**

Encourage frequent washing with soap and water, and install adequate facilities. Core room workers whose hands and arms may be exposed to sand and core oil mixtures are candidates for dermatitis. Prolonged contact with oil, grease, acids, alkalis, and dirt can produce dermatitis. References do it industrial sanitation standards. Sanitary food preparation and service is especially important in nonferrous foundries. Prohibit eating in work areas.

✓ **Work Environment in Foundries**

Good housekeeping, ventilation, and light help maintain a safe and healthy work environment. Proper inspections, maintenance, and fire protection increase workers' safety in foundries.

- Housekeeping
- Clean machines and equipment after each shift, and keep them reasonably clean during the shift.
- Place all trash in the proper trash bins.
- Keep the floors and aisles in the work area unobstructed.
- Properly stack and store materials.

Remove the dust /unwanted sand from the surrounding area with a brush/broom, never by hand. Clean the equipments upon completion of the task. Use a rag to clean the bench. Sweep the floor surrounding the moulding bench area.

✓ **Cleaning tools and equipment**

Tools and equipment shall be kept in proper operating condition and used only for the purpose for which they were designed. If proper and safe tools are unavailable, this should be reported to the trainer/instructor.

All tools should be inspected at regular intervals, and any tool that develops defects while in use shall be taken from service, tagged and not used again until restored to proper working condition. The care of hand tools should follow the same pattern as for personal articles; that is, always keep clean tools and equipments after each use and free from dirt, dust, burrs, and foreign matter. After use, return tools promptly to their proper place in the toolbox. Improve your own efficiency by organizing your tools so that those used most frequently can be reached easily without digging through the entire contents of the box. Avoid accumulating unnecessary junk.

4.2 Dispose unwanted treat sand

4.2.1 Reclamation of Foundry Sand

Reclamation of foundry sand means “to make like new”. As a result of the processes encountered by foundry sand before, during, and after the casting operation, many of the sand grains (both in the cores and the molds) are no longer as they were before the process began. As is true of most materials in service, sand experiences thermal, chemical, and mechanical inputs during its lifetime. Some of the specific examples of each of these are illustrated below:

Thermal Stress - A sand grain close to the molten metal can experience severe thermal gradients from one side of the sand grain to another. The low thermal conductivity of this material means that fracture of the sand grain can occur due to the mismatch created when one side of the sand grain expands (hot side) while the cold side does not want to expand. Fractured sand grains mean that smaller particles are created, so-called fines, which are not desirable in a molding sand aggregate primarily because of the negative effect that fines have on the permeability of the sand. With silica sand, these problems of expansion and contraction are exaggerated because of the phase changes which silica sand goes through as it is heated to high temperatures.

Chemical Change - The binders used to create aggregates that are bonded together before and after making castings can react with the sand grain or under the influence of heat be changed chemically so that the particular grain could be in a situation where it could no longer be readily bonded to other sand grains. The effectiveness of the binder would then be reduced. There are many specific examples of these kinds of situations between the clay binders used in green sands and the organic binders used to produce cores.

Mechanical Stresses - The sand handling system provides a challenge for sand grains which are subjected to abrasion and impact by other sand grains. This happens primarily when the sand is being transported from one station to another within the foundry. This rough treatment can result in grain fracture or spalling which creates fines, and the problems the fines generate. The worst treatment comes in pneumatic systems where the grains are transported through tubes at high velocities, rubbing into and colliding with each other and the container. Transport on conveyors or in buckets minimizes this type of rough contact.

An ideal sand handling system would, after the castings are produced, remove all of the fine particles in the system, scrub the unwanted chemical layers of those grains that have been so affected, and take new sand into the system so that the proper sand size distribution is maintained.

Unfortunately there are no ideal handling systems and each foundry must determine the quantity of new sand necessary to add to maintain the desirable properties of the sand. The effects of the above conditions on grain are shown below

4.2.2 Sand Life Cycle

A typical life cycle of foundry sand in a green sand foundry involves sand being transported through the process in the following way:

1. Enter as new sand for core making
2. Binder is combusted either completely or partially, freeing the sand grains to enter the green sand system to be reused over and over.
3. Finally through attrition the sand grain leaves the system through the dust collector, or is purposely removed to make room in the system.

The "shaken out" sand contains sand in a variety of conditions depending upon the severity of the interactions (chemical, mechanical, thermal) within the sand handling and processing system. This is illustrated in the following schematic

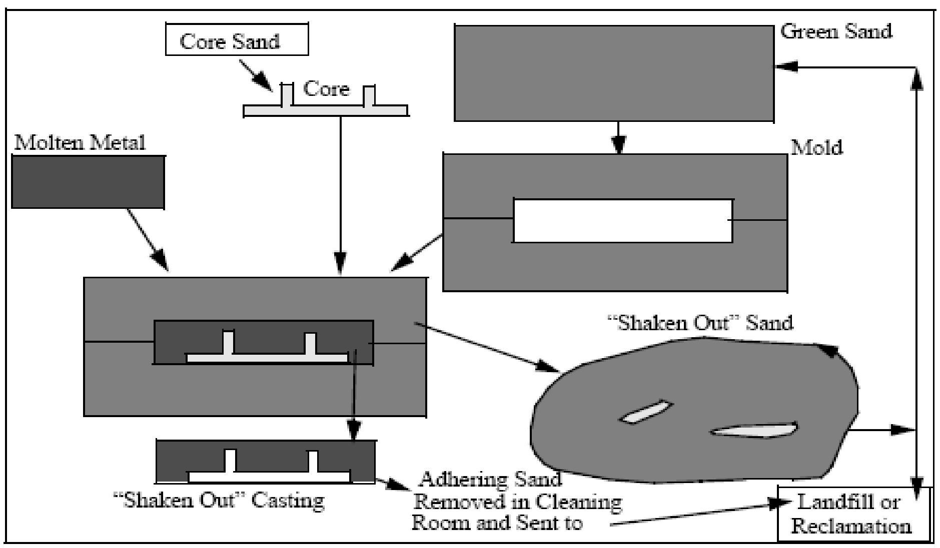


Fig.4.1 reclamation of foundry sand places

These various components include:

1. **Green sand unaffected by the heat of the casting process.** This component would likely be the largest component and would include the warm wet sand.
2. **Core sand in which the binder has been combusted to the extent that the sand grain is no longer bonded to its neigh bors.** This component will contain all degrees of combustion from sand which has been made "like new" by the heat of the process to grains which are still covered with partially combusted binder, or un combusted binder

which has fractured in handling or at shakeout. This component is likely to be the second largest component of the "shaken out's and.

3. **Green sand in the immediate vicinity of the casting, the "heat affected sand".** This clay bonded sand will to a large extent have had its binder destroyed by the heat from the casting process. This component will also likely be quite large, again depending upon the casting size and shape.
4. **Core butts, those parts of the cores which have not been affected enough by the heat or mechanical handling during and after shakout to disintegrate.** These chunks can make up a significant part of the shaken out sand, again depending upon the size of the cores, and especially upon the temperature of the metal poured (iron is much hotter than aluminum and therefore would be expected to better break down the cores in the casting).
5. **Dust and fines resulting from thermal and mechanical stresses of the process.** This would make up a small fraction of the weight of the shakeout sand and would be removed in the dust collection system.

4.2.3 Reclamation Systems

At this point in time most foundries continue to landfill large quantities of sand, but because of the ever rising costs to landfill are seriously considering reclamation to make their throw away sand "like new", to be used in the production of cores. This desire on the part of foundries has spawned a large number of companies which build reclamation systems. The bulk of these systems rely on **thermal** and **mechanical** methods to scrub or clean the sand grain surfaces.

Chemical methods involve liquids, and handling large quantities of liquids simply generates a new environmental problem. As a result there are no foundries that anticipate cleaning sand grains chemically.

Mechanical systems currently available involve vibrating screens, rapidly rotating impellers which throw sand against metal or rubber surfaces, and pneumatic systems which scrub sand grains against one another in a series of tubes. The objective in all of these processes is to separate one sand grain from another, to remove the spent binder from the surface of the grains, and to return the sand grain to the system ready for another coat of new binder.

Thermal systems are designed to combust the sand grain surface layers (especially effective with partially or uncombusted organic core and mold binders), removing them to the atmosphere or a scrubber system to capture obnoxious combustion gases.

Combinations of **mechanical** and **thermal** systems can be used to maximize the recovery of sand. These systems are designed to handle that portion of the sand system which was formerly thrown away, which includes core butts and the excess sand removed from the system to maintain sand quality. Unfortunately this latter component contains a significant quantity of sand which does not need reclamation, and a good fraction which does need reclamation goes merrily on its way to green sand processing. This dilemma results from the current shakeout practice which is designed to mix all of the above sand components together at the point of shakeout. Clearly a better way in principle would be to separate and segregate these components at shakeout.

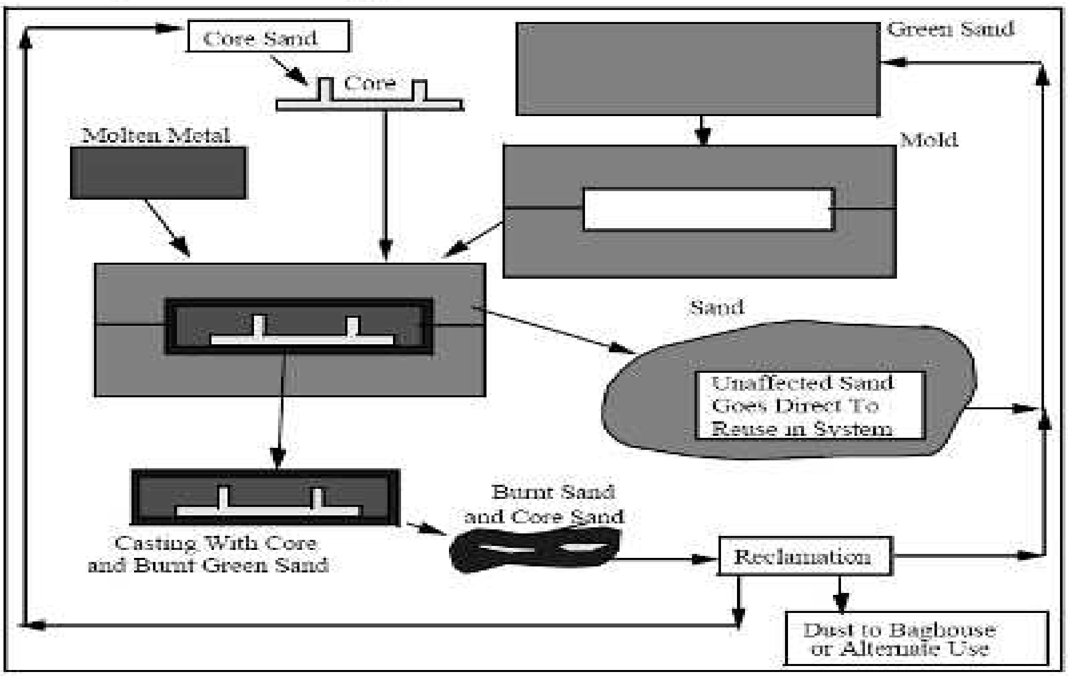


Fig.4.2 separate and segregate sand for reclamation

Foundries should not deliberately promote a reuse option if they know that the waste stream contains contaminants that might at any time present a risk to human health or the environment. If not characterised and managed appropriately.

Sand reclamation is the process of cleaning previously used sand so it can be reused.

There are some reasons of sand reclamation:

- Due to environmental regulations, the disposal of waste foundry sand has become one of the most pressing problems for the foundry.
- In recent years because of the high disposal costs encountered and difficulty in finding disposal sites.

Flow diagram for typical moulding sand system

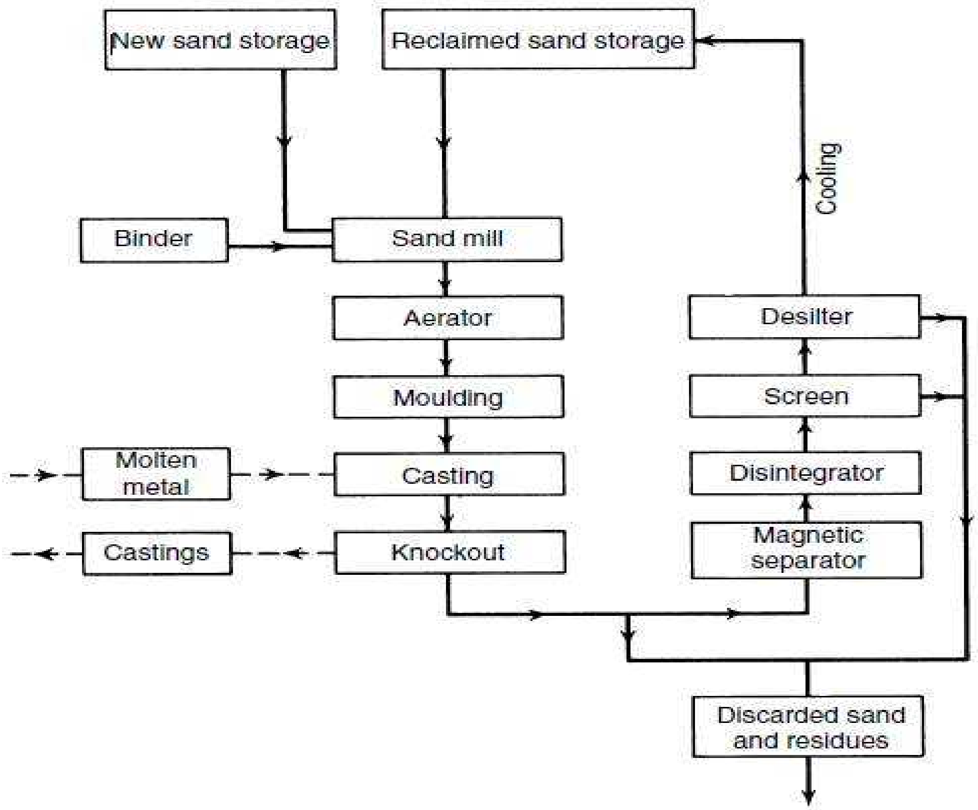


Fig.4.1 Flow diagram for typical moulding sand system

Sand reclamation of sand in foundries, such as Primary reclamation and Secondary reclamation

- ✓ **Primary reclamation of sand in foundries**

Primary reclamation is used by virtually all UK greensand foundries, though the degree of sophistication of the reclamation plant varies widely from a simple manual operation to fully automatic computer-controlled equipment. A proportion of sand is discarded from the system on each cycle to allow for the addition of new sand, replacement clay and other materials

- ✓ **Secondary reclamation**

Greens and foundries currently treat the discarded sand proportion as a waste material for disposal. This sand could, however, be treated by secondary reclamation techniques to render it fit for use in place of new sand. This would reduce sand purchase and disposal costs, and lead to a reduction in waste to landfill.

A. Mould and core preparation

Mould release agents can contain organic solvents and binders and chlorinated substances. The use of these agents should be reviewed against less harmful alternatives and their continued use justified to the satisfaction of the EPA. Green sand moulding methods release dust during mixing. This should be extracted and collected and then treated in a suitable air-cleaning unit. Resin bonded processes use a variety of resins and catalysts. The cold box method uses a gaseous catalyst, such as amine or sulfur dioxide, which must be collected in a suitable scrubbing unit. Where wet scrubbing is used, a suitable discharge route must be used for the underflow liquor.

Emissions of VOCs from solvents in chemical resins are generally of a sufficiently low level to render scrubbing unnecessary. However, emissions should be prevented or minimized by careful selection of sand binding agents.

4.2.2 Recycling /storing excess materials.

Green sand can be reused after adjusting its composition to replenish the lost moisture and additives. The pattern itself can be reused indefinitely to produce new sand molds.

Once the snow melts and the ice disappears, the sand is generally unusable for reuse as it contains contaminants such as salt, litter, dirt, and hydrocarbons, such as oil from vehicles. However, we can now recycle sand through separation using one of two methods: sieving or solubility.

✓ **Foundry Sand Recycling**

Foundry's casting processes require large volumes of sand, which is continually used, reconditioned and reused. ... More than 800,000 tons of sand is re-used each year. Sand that can no longer be used for creating quality iron castings does not have to end up in a landfill.

Foundry sand is the material that has been used in moulds for the hot casting of metals which is no longer suitable to be used for that purpose. Much of this sand produced by foundries is not hazardous and can be used for other purposes. Reuse options however may be limited due to the presence of chemical binders (which may include phenols, formaldehyde or Triethylamine (TEA)), residual metal, or fluoride (which may be naturally occurring in the sand). High concentrations of contaminants may pose a risk to the environment or human health.

using foundry sand may cause environmental harm including contamination of surface water, groundwater and land, as well as potentially posing a health risk. Best practice environmental management must be considered and implemented wherever possible.

A review of the best practice approach to dealing with non-organic regulated waste (including foundry sand) in the composting process was conducted by GHD and findings published in a report in 20144 . This review identified the potential benefits of using foundry sand in compost manufacturing and recommended measures to appropriately manage the risks. These recommended measures have been used in developing the conditions of this approval.

In general, disposing of used sand and debris according to standard operating procedures and regulations

Self-check-4

Test I: True false item

Directions: write true if the statement is correct and false if the statement is not correct on the space provided

1. The **sand** is generally unusable for reuse as it contains contaminants such as salt, litter, dirt, and hydrocarbons. Clean the equipments upon completion of the daily task.
2. Use a broom to clean the bench.
3. After finish the work sweep the floor surrounding the moulding bench area.
4. Tools and equipment shall be kept in proper operating condition and used only for the purpose for which they were designed.
5. Always keep clean tools and equipments after each use and free from dirt, dust, burrs, and foreign matter.

Test II: multiple choices

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

1. Recycle sand through separation using __________ method/s

   a, sieving b, solubility. C, none d, a and b answer

2. Which one is true about reasons of sand reclamation?

   A. Due to environmental regulations

   B. high disposal costs encountered and difficulty in finding disposal sites

   C. A & B

3. _______ reduces sand purchase and disposal costs, and lead to a reduction in waste to landfill.

   A. Primary reclamation B. Secondary reclamation C. A and B.

Test III: Matching

Instruction: select the correct answer for the give choice. You have given 1 Minute for each question. Each question carries 2 Point.

Column A	**Column B**
1. Disposal of sand	A. Sieving
2. types of sand reclamation	B. waste foundry sand
3. Recycle sand	C. Primary reclamation

Test IV: writing short Answer

Instruction: write short answer for the given question. You are provided 3 minute for each question and each point has 5Points.

1. What it mean sand reclamation?
2. Explain the primary reclamation of foundries?

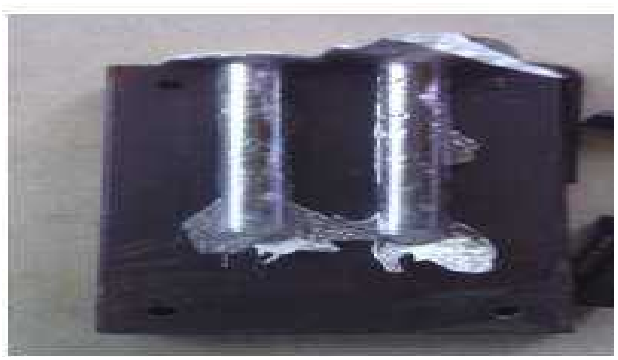
Operation sheet-1 Clear all materials/debris and clean work site

Operation Title: perform clear all materials/debris and clean work site

Purpose: To trimming castings / clear all materials / debris and clean work site

Instruction:-Given all the necessary materials the simulation room/ Lab must conducive to perform the demonstration and the trainees must be in right and healthy condition.

- Demonstrate trimming castings / clear materials / debris and clean work site on the sand casting by using recommended tools and safety requirements correctly.
- Prepare the mould using single piece (a solid) pattern
- Using the figure below and given data/ information
- You have given 4 Hours for the task.



Required tools and equipment: - Molding board, Drag and cope boxes, Molding sand , Parting sand, Rammer, Strike-off bar, Bellows, Riser and sprue pins, Gate cutter, Vent rod , Draw spike, Wire Brush, etc . Raw material; - Moulding sand, Parting sand, facing sand, baking sand, single piece solid pattern, bottom board, moulding boxes etc.

Precautions: - take care during Clear all materials/debris and clean work site of tools and equipments

- do not forget to use and select appropriate tools & equipment
- follow pre/post clear all materials/debris and clean work site preparation activities

Procedure:

Step 1- Identifying / interpreting work / job sheet requirements.

Step 2- Selecting tool and equipment and use PPE.

Step 3- foundry shop inspecting, and clear all materials / debris and clean work site

Step4- foundry shop tools and equipment has to ready for next operation according to manufactures recommended or organization polices.

Step5- you have to follow waste segregation, clear all materials / debris and clean work site system as requirement

Quality criteria: 1. Foundry shop should be free from foreign material

2. Before clear all materials / debris and clean work site, you have to follow the standard or organizational rules.

3. Foundry shop has to organized properly

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LAP Test	Practical Demonstration

Name: ___________________________ Date: _____________

Time started: ____________________ Time finished: _______________

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 10 hours.

Task 1: Clear all materials/debris and clean work site

Task 1: Dispose unwanted treat sand