PRODUCTION TECHNOLOGY

(Diploma 3rd SEM)

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Foundry (or) Casting is the process of forming metallic products by melting the metal, pouring it into a cavity known as mould and allowing it to solidify. In this way the molten metal takes ~~place~~ a shape of the mould. The molten metal will chill rapidly on making contact with the mould surface. The casting of all sizes are produced in sand moulds.

~~Foundry~~:-

Foundry:- Foundry is the place where castings are produced.

Casting:- Casting is a process of forming metallic products by melting the metal, pouring it into a cavity known as the mould and allowing it to solidify. The solidified object is called casting.

Terms of Casting:-

Flask — A moulding flask is one which holds the sand mould intact.

(a) Drag - ~~Upper~~ lower moulding flask.
(b) Cope - Upper moulding flask.
(c) Cheek - Intermediate moulding flask (in three piece mould)

Pattern:- Pattern is a replica of the final object to be made.

Parting Line:- It is the dividing line between the two moulding flasks.

Moulding Sand:- It is a mixture of silica, clay, moisture and other additives in appropriate proportions to get desired result.

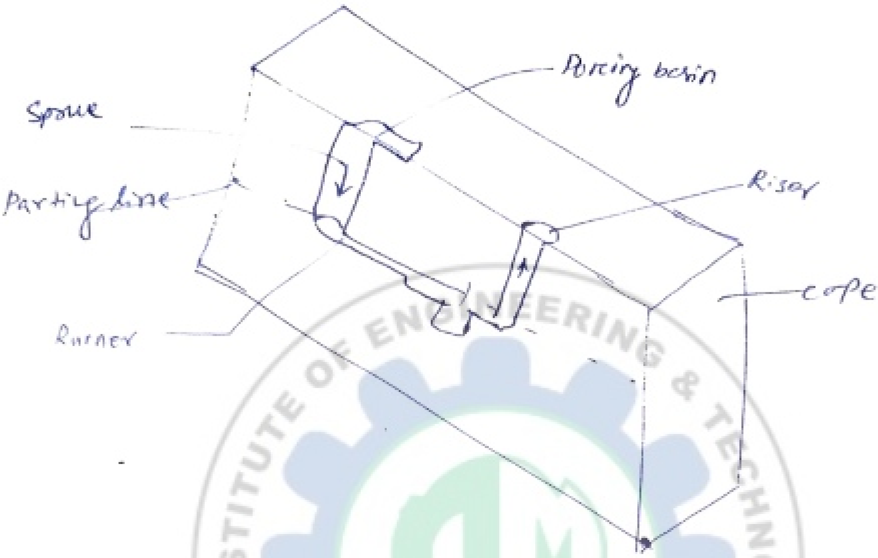
Core:- It is used for making hollow cavities in casting.

Sprue:- It is the passage through which the molten metal from the pouring basin reaches the mould cavity.

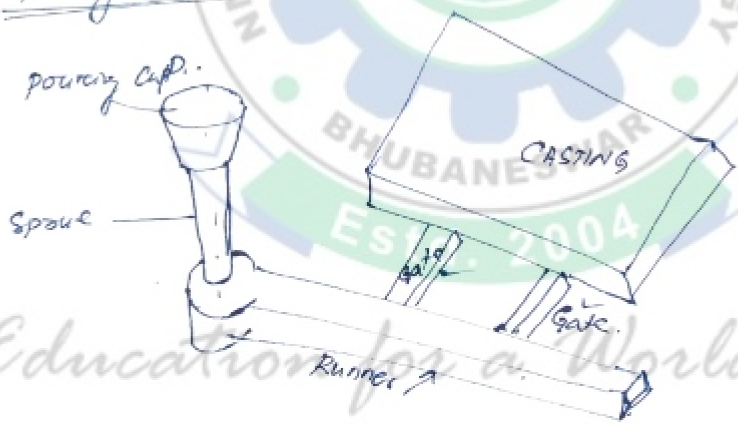
Runner:- The passage way in the parting plane through

Gate:- the ~~actul~~ actual entry point through which molten metal enters.

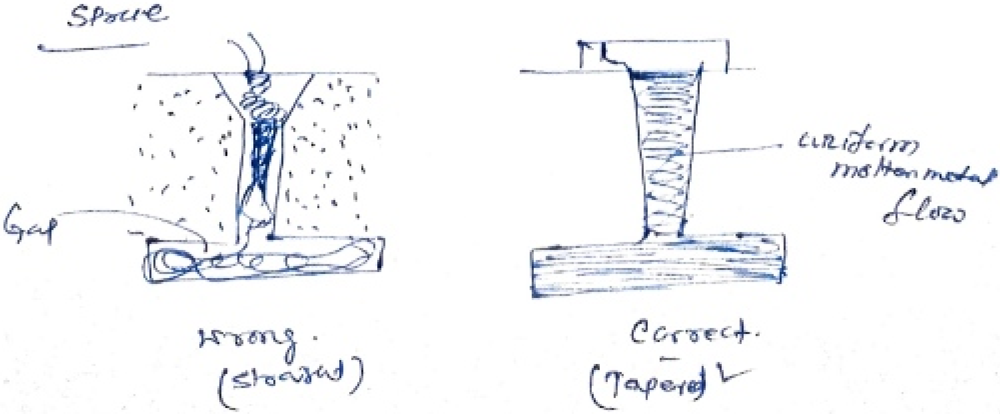
Riser :- It's the reservoir of molten metal provided in casting so that the hot metal can flow back into the mould cavity when there is a reduction in volume of metal due to solidification.



Gating System:-



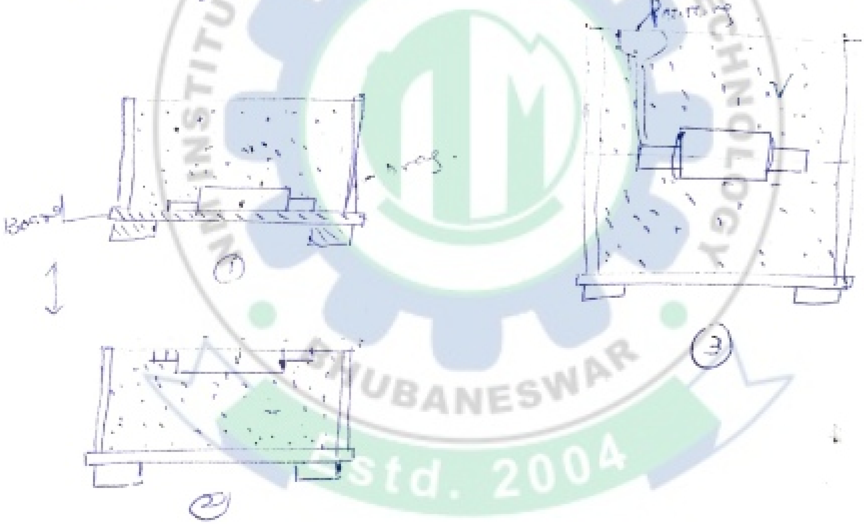
Sprue



Sand Casting Process

Sand moulding :-

First the bottom board is placed even surface of floor. The drag 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. There should be enough clearance b/n the pattern and wall of flask (appx. 50 to 100 mm). The sand is sprinkled over the pattern & board completely filled. The ramming of sand should be done properly.



The basic steps in making a casting process :-

- Pattern making.
- Mould & core making
- Melting & casting or pouring
- Fettling
- Testing & inspection.

1> Pattern making:-

According to the casting desired pattern is made. Soft wood pattern are used when a small no. of casting is to be produced. While for large no. of production Hardwood (or) metal pattern may be employed.

2> Mould & Core making:-

Moulding sand is one of the most important matereial in production of sand casting. Sand is formed by breaking up of rocks due to natural forces such as frost, wind, rain, action of water.

3>

Once mould is made. It is ready to receive the molten metal. At this stage ~~melt~~ metal of required composition is melted in a suitable furnace & the molten metal is tapped in a suitable ladle & then poured into the cavity & allowed to cool down for solidification.

Pouring must be carefully controlled. It should be done continously & uniform rate until the mould gates & risers are full.

4> Fetteling.

Castings, when taken out are not in same condition due to riser, gates etc. Also not free from sand particles. The process of cutting off the unwanted parts, cleaning & finishing the casting is known as fetteling.

- Removal of fins (unwanted) & other projections.
- " " scale from the surface

(Generally by the help of grinding wheel)

5) Testing & Inspection :-

Pneumatic or hydraulic pressure tests on castings such as valves, cylinders, where pressure tightness is important.

Small casting can be tested with air pressure or submerged under water to indicate the leaks.

Inspection is an act of checking the acceptability of a casting, the cleaned castings are inspected to check blowholes, cracks and other such defects.

- Visual inspection.
- Dimensional "
- Mechanical testing
- Crack detection etc.

Pattern Allowances:-

In the construction of pattern due - allowance must be made for the behaviour of a casting during solidification. metals shrink during solidification. ~~& further construction of the~~ Therefore the size of the pattern, be larger than the required than the resultant casting, inorder to avoid the necessity of making due allowance by calculation either by the blue print stage or on the production of pattern.

Hence the size of the pattern is never kept the same that of the desired casting.

Allowances

✓ - Shrinkage allowance
x - machining "
- Draft "
✓ - Distortion allowane
✓ - shake "

shrinkage allowance(or) contraction allowance.

the. metals shrink when cooling.

Liquid shrinkage:- refers to reduction in volume - when the metal changes from liquid to solid state at the solidus temp.

Solid shrinkage is reduction in vol. caused, when metal ~~changes~~ loses temperature in solid state

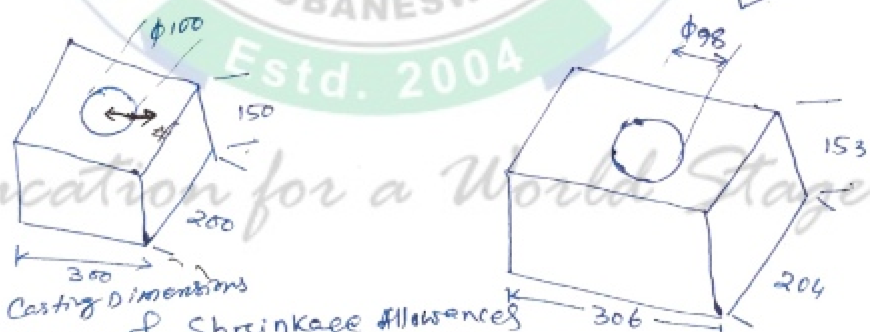
The rate of contraction with temperature is dependent on the meterial.

ex. cast iron - shrinks by 21.0 mm/m.

Shrinkage Allowances for various metals

Metals/Alloys	Shrinkage Allowance (mm/m)
Grey C.I	10.5
White C.I	20.0
Aluminium	17.0
Brass	15.5
Copper	16.0
Zinc	24.0

Calculation of pattern



Casting Dimensions

Provision of Shrinkage Allowances

Pb. Calculate the dimension of patterns for the casting of white cast iron.

From Table. White cast Iron = 20 mm/m $= \frac{20}{100} = 0.02$ mm.

Allowance on Dimension 300 = 300 × 0.02 = 6 mm
⇒ 300 + 6 = 306 mm

" " " 200 × 0.02 = 4 mm
⇒ 204 mm.

" " " 150 × 0.02 = 3 mm
⇒ 153 mm.

" " " 100 × 0.02 = 2 mm

All dimensions of wall thickness will be reduced, Then this allowances should be substracted from actual 100 − 2 mm = 98 mm

Draft Allowances (or) Taper Allowances

When withdrawing the pattern from the sand mould. The vertical faces of pattern are in contact with the sand, which may damage the edge of the mould cavity around the pattern.

To reduce the chances of this happening the vertical faces of pattern are always tapered from the ~~patter~~ parting line. This provision is called draft allowance.

Shake allowence or Rapping Allowance

Before withdrawn from the sand mould the pattern is ~~to~~ rapped all around the vertical faces to enlarge the mould cavity slightly which facilitates its removal. Since it enlarges the final casting made it is desirable that the original pattern dimensions should be reduced to account for this increase. ~~There is~~

FINISHING (or) MACHINING ALLOWANCE:-

The finish of the casting obtained in sand casting is generally poor. To bring the casting to the desired level of quality, it has to be machined. For this some extra material has to be provided on the pattern. This is known as machining allowance. Therefore the size of the pattern increases due to machining allowance. this allowance depends on casting metal, size & shape of casting, method of machining & the degree of finish required.

Standard finishing allowance for metals is 3mm to 1.5mm / mt.

PATTERNS

The first step in the production of a casting is the manufacture of a suitable pattern. Soft patterns are used when a small no. of casting is to be produced, while for large production; hard wood or metal patterns are used.

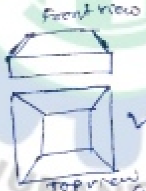
Patterns should be impermeable to moisture, & for this reason wood patterns are usually coated with several layers of paints. It should have good surface finish to ensure that they can be with drawn form the mould easily.

Types of patterns

1. Single piece pattern (Solid)
2. Split pattern (or) two piece pattern
3. Gated pattern
4. Cope & Drag pattern.
5. Match plate pattern.
6. Loose piece pattern. (multipiece pattern)
7. Follow board pattern.
8. Sweep pattern
9. Skeleton pattern
10. Segmental "

1) Single piece pattern :-

This is the simplest type of patterns. The name single itself indicates a single piece pattern. For simple ^shape large casting^ job this type of pattern is used. This type of pattern can be cast in drag only, because one surface is expected to be flat. Single pattern is made with out joints. It is also known as solid pattern.

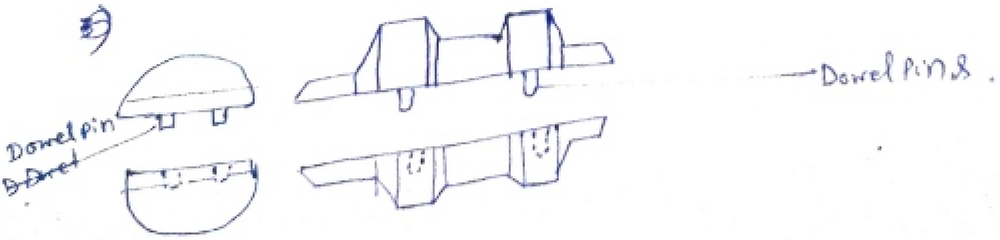


2) Split

When the depth of the casting is too high, then the pattern is split into two parts so that one piece is in drag and another piece in the cope.

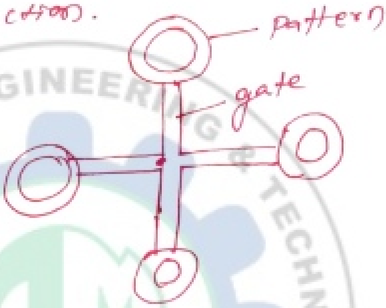
The split surface of the pattern is lying on the parting line. In this case the two pieces of the ~~partee~~ pattern should be aligned properly by the help of ~~two~~ ~~dire~~ dowel pins

3)



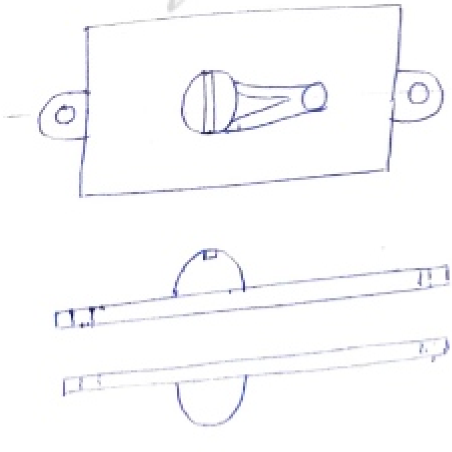
Gated pattern:-

It is an improved type of simple pattern, where the gating & runner system are integral with the pattern. These are suitable for small quantity production.



Cope & drag pattern:-

This type of pattern are similar to split pattern. In this pattern two piece or the cope & drag halves of pattern along with the gating and risering system are attached ~~separ~~ separately to the metal or wooden plate ~~along~~ with the dowel pin (or) alignment pins. These are used for very large casting.



Match plate pattern

The pattern in two halves ~~are mounty~~ are mounted on the opposite sides of the wooden or metallic plate known as match plate.

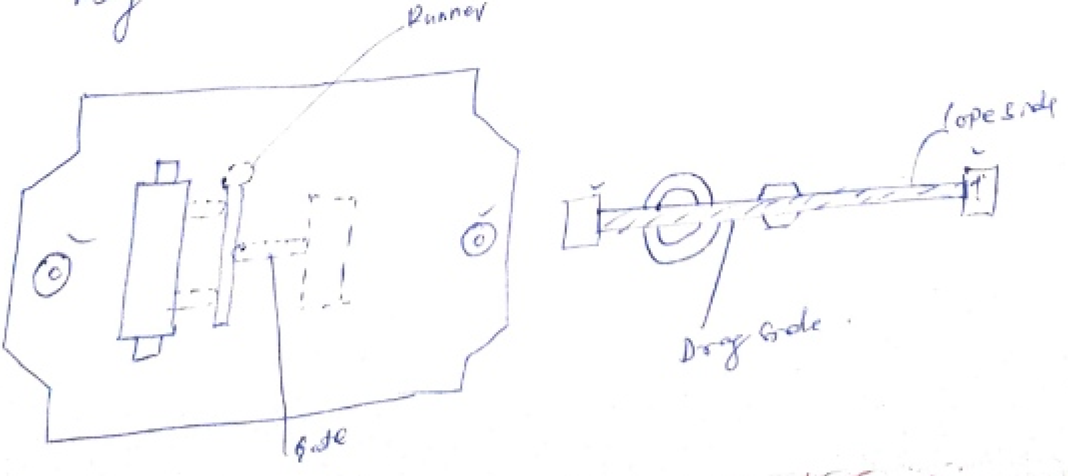
This model or patterns are extension of cope & drag pattern.

Here the pattern (cope & drag) along with the gating & risering are mounted on a single matching plate of metal or wooden plate with <u>either side</u>.

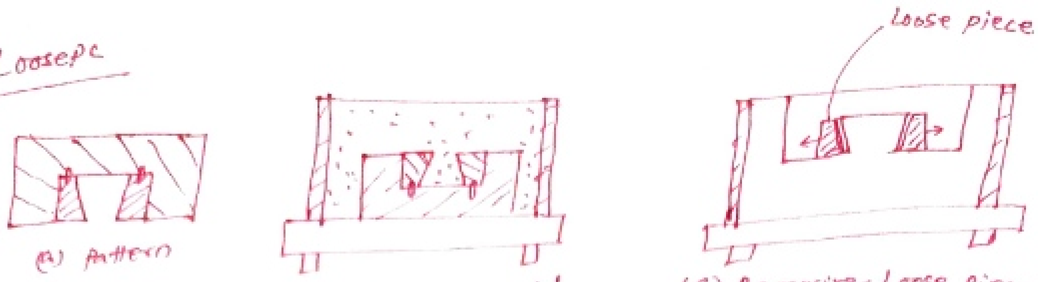
One side of match plate is attached with drag flask & other side with cope flask. In this case after removal of pattern, obtained a complete mould with ~~gatting~~ gating by joing cope & drag.

Generally it is made up of aluminium, metal or any light weight metal. Also the gating system are either screwed to the match plate or integral made.

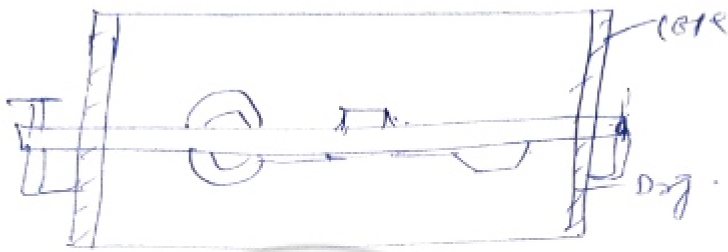
This is used for a small castings with higher accuracy & large production. Here moulding process may be sand moulds or plaster moulds.



Loosepc



(a) Pattern (b) making the mould (c) Removing Loose pieces



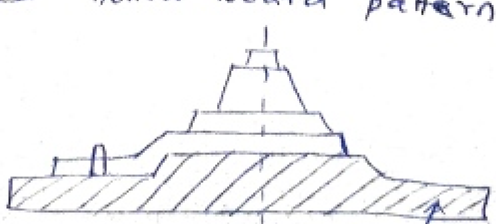
Loose piece pattern:- (multipiece pattern)

Many pattern which are complicated in shape, cannot be made in one or two pieces because of difficulty in withdrawing the pattern. A complicating casting may required three or more pieces to make the difficult pattern. ~~In such cases the pattern is made~~. This type of pattern is called Loose piece pattern. This pattern is required when it is not possible to withdraw the pattern as such from the moulding sand. In this case main patter is removed first then the loose pieces.

Follow board pattern:-

This type of pattern is adopted for those castings, where there are some portions structurally weak. If the weak portions are not supported properly it will break due to ramming force.

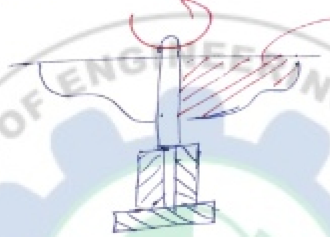
Hence for these weak or hanging portion a follow board is closely fitted to avoid breakage. This type of pattern is called follow board pattern.



Follow Board.

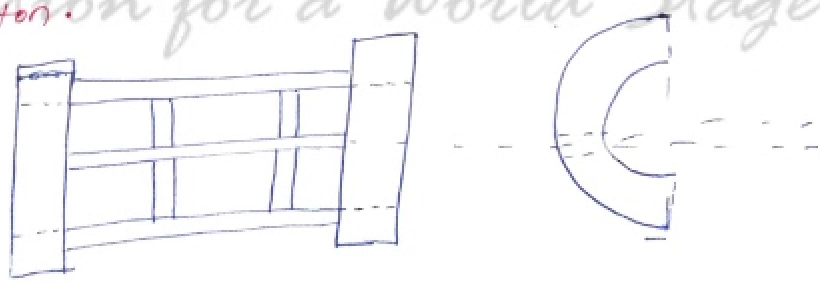
Sweep pattern :- It is not a true pattern.

Sweep pattern are used for forming large circular moulds by revolving a sweep attached to a spindle. Actually a sweep is a template of ~~wood~~ or metal & is attached to the spindle at one edge and other end depend upon the desired shape. It is used for large casting of symmetrical section such as bells etc.



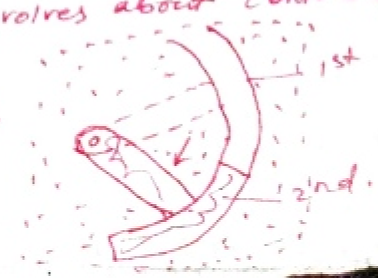
Skeleton Pattern:-

This pattern made of ribs of wood used for building the final pattern by packing sand around the skeleton. This type of pattern is useful generally for very large castings required in small numbers, where large ~~number~~ expense on complete wooden pattern is justified. This frame work of ribs is called skelton.



Segmental pattern

It is also known as 'part patterns'. These are used for producing a large circular casting such as rings, wheel of rims & gear. This pattern revolves about centre after ramming one section it moves to another section to complete the moulds.



Pattern Matereial:-

Before selecting a particular matereial for pattern making the following factors must be considered

- Choice of matereial & no. of casting desired
- mould matereial used.
- Thickness, degree of accuracy & finishing.
- Type of production of castings.
- Possibility of design changes.

The most important characteristics:-

- Easily available at low cost.
- Easily washed, ~~shaped, joined~~
- Easily shaped & joined
- Lightness.
- Strong, hard & durable so that it may be resistant to wear, to corrision & chemical action.
- Repairable & re-usable.

Commonly used matereials in pattern making:-

(A) — wood.

(B) — metal & alloys.

(C) — plasters

(D) — plastics & Rubbers

(E) — Wax Pattern.

~~[illegible]~~

e) **Wax patterns** → Wax pattern provide high degree of surface finish & dimensional accuracy to castings. After being moulded the wax pattern is not taken out of the mould like other patterns, rather the mould is inverted & heated the molten wax comes out of the mould.

Patterns are made in water cooled moulds (or) dies.
Commonly used wax s are — Paraffin wax, Carnauba wax, shellac wax, bees wax, ceresin wax.

(A) Wood :- Usually wood is the most popular material for pattern making. The main reason is that it is easily available & low weight. Also it can be easily fabricated with low cost. However, for large no. of production hard wood may be employed.

The commonly used wood for pattern making are —

- Teak wood
- Mohagony wood
- Deodar wood.
- Kali Cherry wood.
- Wal nut wood.
- Shisam wood.

Adv (wood)
- ~~Readily~~ Readily & plentyfly available.
- Cheapness
- Easily workable
- Lightness
- Making smooth surface easily.
- wood can be cut & fabricated into many forms

Dis adv (wood)
1) Readly affected by moisture. Due to absorption of moisture distortion & dimension changes.
2) — If not store properly it may warp.
3) — Less durability.
4) Its strength is low & tends to break on rough uses.

Generally wood pattern should be properly dried before it is used.

(B) Metal :-

metallic Patterns are used when a large number of castings are desired. For better result like durability, smooth surface finish, metal Patterns are used.

The following metals - - Cast iron
- Aluminium
- Steel
- Brass etc.

adv

* Cast iron is cheaper, stronger & also gives a smooth surface but heavy & easily break.

* Among all metallic patterns, Aluminium patterns are more popular because of their lightness, soft & easy to work & also got resistance to corrosion & abrasion by sand and with stand chemical action.

disadv

- High cost
- Heavier than wood
- Tendency for rusting (except Alluminium).

(C) PLASTICS :- (Epoxy resign, Phenolic resign)

Plastic materials are lighter, stronger wear resistent and are not affected to moisture of the moulding sand. Because of its smooth surface it's dimensionally stable & canbe cleaned easily.

Adv
- Durable
- Corrosion Resistance
- Easy to make
- Better adhesive qualities.

Rubber — Generally silicon Rubber is used for forming the pattern.

(d) Plaster :- Gypsum cement known as "plaster of paris" is also used for making patterns.

Moulding Sand

The ~~important~~ Principal ingredients of sand moulding are silica grains, clay (as binder materials), and moisture to activate the clay & miscellaneous materials like zircon sand, additives etc.

* Silica sand in the form of granular quantity is the chief constituent of moulding sand (approximately 80 – 90% of silica). It is a product of breaking of quartz rocks or decomposition of granite.

Silica sand gives refractoriness, chemical resistivity etc. Along with ~~silica~~ a small amount of iron-oxide, alluminium, limestone, magnesia, soda, potash are present as impurities.

Clay :- (5 to 18%) Clays are used as a binder agent mixed with moulding sand to provide the strength.

ex.- Bentonite, Kaolinite.

(water) Moisture :- (2 to 8%) so that it Clay is activated by moisture. The develops the plasticity & strength. The amount of moisture used should be properly controlled, the bonding action considered best, if the moisture added in the exact quantity.

Ⓧ Excess of moisture will reduce the bonding & strength & weaken the mould. For better result the %age of water used are 2 to 8%.

Special additive (or) miscellaneous materials

sea coal (improve surface finish)
Ash "
Graphite & silica. (improve refractoriness)
Fuel oil (Improve mouldability)
molasses (" strength & edge hardness)

Type of moulding sand:-

For better casting, moulds are required to have ~~so~~ some properties.

→ It must be strong enough to withstand the temperature.

→ It must resist the flowing hot metal.

~~→~~

Moulding sands may be classified according to their use —

1) Green sand.
2) Dry sand.
3) Loam sand.
4) Facing sand.
5) parting sand
6) Core sand.

Green Sand:-

Green sand is the mixture of silica sand with 18 to 30 % of clay and 6 to 8% water. The clay & water furnish the bond for green sand. moulds prepared in this sand are known as green sand mould.

Dry Sand:-

Green sand that has been dried or baked ~~baked~~ after the mould is made is called Dry sand.

When clay & silica are mixed in equal proportions with little or no special additives is called loam sand. (It's used for large castings).

Facing Sand:-

Facing sand is made of silica & clay without the addition of used sand. Facing sand forms the face of the mould. It is used directly next to the surface of the pattern & it comes in contact with the molten metal when it's poured. Around 10 to 15% of facing sand is ~~used~~ used in the whole amount of moulding.

Parting Sand:-

Parting sand is clean clay-free silica sand which serves for the purpose of parting. Parting sand is used to sprinkle on the pattern before ramming for easy withdrawal of pattern after ramming.

Core Sand:-

It's also called oil sand. It's the mixture of silica sand & core oil like linseed oil, ~~light mineral~~ light mineral oil & other binding materials. ~~used~~ ~~powder~~ It improve the collapsibility.

Properties of Sand:-

A good mouldy sand must have the following important properties -

- Porosity (Permeability)
- Cohesiveness (or) Strength
- Flowability
- Adhesiveness
- Refractoriness
- Thermal stability
- Collapsibility

Porosity ~~Per~~ - molten metal always contains certain amount of gases & water vapour. These gases and water vapour evolve by moulding sand. The sand must have sufficiently porous to allow the gases & moisture present. ~~within~~ ~~the moulds to be removed~~ molten. This property of sand is known as porosity (or) permeability.

Cohesiveness (Strength):-

The ability of sand particles to stick together is known as cohesiveness. Due to insufficient strength, it may lead to collapse.

Flowability:-

This property of a sand refers to its ability to behave like a fluid so that, when rammed it will flow to all portions of mould & pack all round the pattern and take up the required shape. The sand must flow smoothly while preparing mould.

Adhesiveness:-

This property of sand helps the sand to retaining the mould cavity & stay in box. In other word the particles cling or adhere to mould box surfaces & also adhere to neighbouring sand particles.

Refractoriness:- (withstand temperature)

This property implies that the sand must not fuse when it comes in contact with molten metal. That is why it must have good refractoriness.

Thermal stability:-

It means that a foundry sand must retain its dimensions under high temperature conditions, otherwise the mould cavity may disturb.

Collapsibility :

This means that after the molten metal on the mould gets solidified, the sand mould must be collapsible, so that free - contraction of metal occurs & this mould naturally avoid the tearing or cracking of contracting metal.

This helps easy removal of the casting.

Casting Defects

- Any irregularities in the moulding process, causes defects in casting.
- The major defects, which are likely to occur in casting are

1. – Gas Defects.
2. – Shrinkage defects.
3. – Moulding Material defects.
4. – Pouring metal defects.
5. – Metallurgical defects.

Gas Defects

All these defects are caused by the lower gas passing tendency of the mould which may be due to lower venting or lower permeability of the mould.

(a) Blow holes (or) open blows

- These are the spherical cavity present inside the casting (or) on surface.
- The defects on the surface is called open blows.
  " " inside the casting " " blow holes.
- This is due to "The moisture present / left in the mould."

Because the heat of the molten metal converts moisture into steams

- Air

Also the atmospheric (air) gases absorbed by the molten metal during the flow in the mould is not escape out. This is also known as inclusion.

-

pin hole porosity:

This is caused due to present of hydrogen in the molten metal.

The hydrogen, while leaving form a small diameter pin holes.

Shrinkage Cavity

These are caused by the liquid shrinkage occurring during the solidification of casting.

To compensate this defect, proper feeding of different metal is required.

Moulding Matererial Defects

these are the defects, which are caused due to the characteristic of moulding materials.

(a) Cuts & washes

It appears as a rough spots caused by erosion of moulding sand by the flowing molten metal

(b) Metal Penetration

- When the molten metals enters the gap b/n the sand grains.
- The result would be rough casting surface.
- Also some times fuse of moulding sand.
- Choosing appropriate grain size to eliminate the defects.

(c) fusion:-

- This is due to fusion of sand grains with molten metal.
- The main reasons is the lower quality of refractoriness of clay used in moulding sand

Run out :-

- When the molten metal leaks out of the mould due to faulty mould making or defective moulding flask.

Buckles

It is the expansion of thin layer of sand at mould face, when obstructed by the flask, the mould face tends to bulge out, forming the V-shape. If ~~Additives~~ additives are proper than the buckles to be avoided.

Rat tail

A thin long shallow angular depression.

Scab :-

Drop

Swell

Dross

Dirt

Poureing metal Defect.

This defects occur due to lower fluidity of motten metal -

The defects are

1> Mis run

2> Cold Shut

3> Slag Inclusion.

(1) This is due to insufficient superheat, start freezing/chilling before reaching the farthest point of mould cavity

(2) For casting with gates at its two sides The misrun may slow up at the centre of casting due to non fusion of two streams of metal resulting in a discontinuty.

(3) Due to slag
If slag is not removed before tapping It will moves to the mould cavity.

Die Casting Method

- Die casting is best suited for mass production at low cost.
- Die casting again two types
  1. Gravity Die Casting
  2. Pressure " "

Gravity Die Casting -

- It is also known as permanent mould casting
- The mould made of metals like steel, grey cast iron etc.
- This mould is called "DIES"
- In this process, the molten metal is gravity poured into the die cavity.

Adv

- Better mechanical properties
- Gives better surface finish.
- Dimensional accuracy
- Defects free
- Production rate is faster
- Longer life.

Dis

- Not economical
- Heavy casting can not be casted.
- Very thin section is not possible.

Pressure die casting:

- In this Process, the molten metal is forced into the metallic moulds under pressure.
- Hence molten metal flows very quickly & solidify reapidly.
- This Process is suitable for low melting metals & alloys. like
  - Aluminium
  - Lead
  - TiN
  - Magnesium
  - Zinc etc.

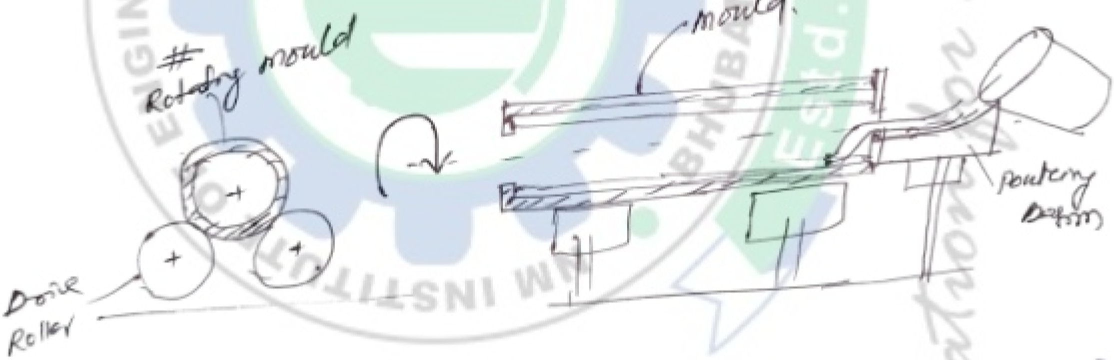
Centrifugal Casting:

It is the introduction of liquid metal into a rotating mould.

Centrifugal force plays a major role in shaping & feeding of casting.

Centrifugal force is utilised to distribute liquid metal over the outer surfaces of mold.

Hollow cylinder and Annular shapes are formed in this process.



- The molten metal is poured into rotating mould or die due to which, ~~fre~~ freezing/chilling of casting.
- In this method/process, each layer of metal is subjected to a pressure gradient across its radial thickness, such as max – at outermost layer
  min – " inner " " .

This Pr. gradient assists the removal of gases & also make the casting more dense & sound.

- It is commonly used for casting of
  - Hollow cylindrical shape
  - Water pipes
  - Gun barrels
  - Pulleys etc.

Method :

① True centrifugal casting .

② Semi centrifugal casting

③ Centrifuging.

TRUE CENTRIFUGAL CASTING:-

- It is used for making cylindrical parts.
    - pipes
    - Gun barrels
    - Hollow bushes
    - axi symmetric
- molten metal is poured in rotating mould.
- Axis of rotation is Horizontal (Vt for small pc)
- molds are made of steel, iron, graphite coated with refractories materials / refractory lining.
- Inner surface of casting remain cylindrical because of molten metal is uniformly distributed by centrifugal force.
- No core is required.
- Mold is rotated slowly.
- molten metal in required quantity is poured into the mould through the movable pouring basin.

- Amount of molten metal determines the thickness of pipe to be casted.
- A water jacket is provided around the mould for cooling.
-

Adv

- Dense & fine grained metal casting are produced.
- Proper directional solidification obtained.
- There is no need of core.
- No gating system is required.
- Useful for mass production.

dis

- Limit upto certain shapes.
- Cost of equipments is very high.
- Skilled workers are required for operⁿ.

Application

- Gun pipe
- Bearings for electrical motor.
- Cast iron pipe
- Tubing.
- Liners for I.C Engine
- Rings, Long pots . etc.

Semi Centrifugal Casting:

- It is also known as Profiled centrifugal castin
- Gear blanks, wheels are produced.
- molds may be made of sand or metal.
- The axis of rotation is always vertical.
- Metal enters the mould through central pouring basin.
- Speed of rotation is less as compared to true centrifugal casting.
-

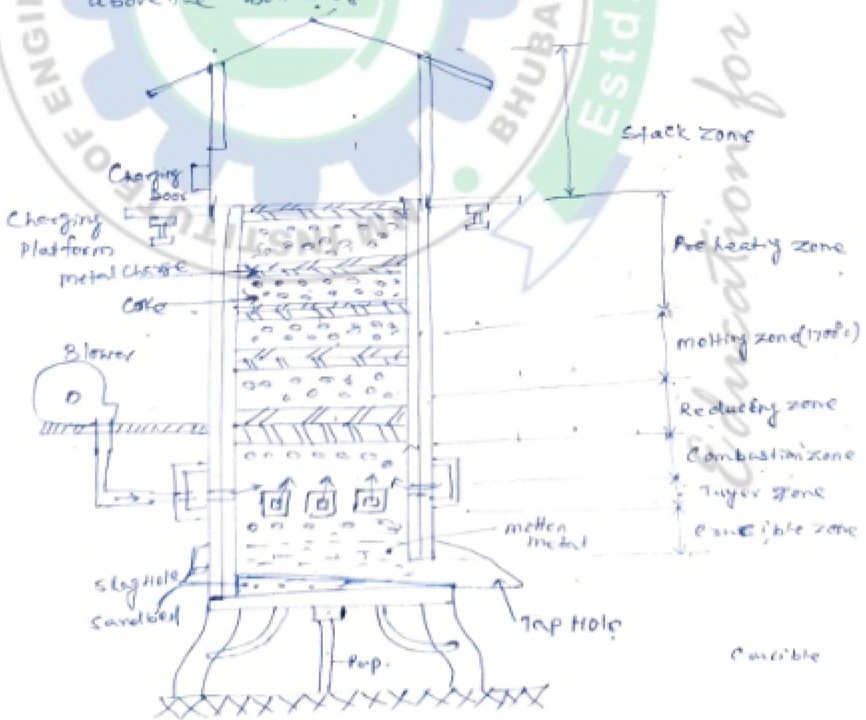
Centrifuging:-

- Centrifuging method is used to obtain higher metal pressure.
- Bearing Caps can be made.
- It is suitable for small jobs of any shape.
- A numbers of small jobs are joined together by radial runners.
- The casting is possible only in vertical direction.
-

Melting furnaces (Cupola)

After moulding, the molten metal is poured into the mould to get the casting.

The cupola is a shaft type furnace for producing molten cast iron. It is a vertical cylindrical shell made of 6 to 12 mm thickness boiler plate rivetted & lined inside with acid refractory bricks. Diameter varies from 1 to 2 meters. The whole shell is mounted on brick work foundation or on steel columns. The bottom of the cupola is provided with drop bottom door, through which debris consists of slag, coke etc. can be removed at the end of melt. Towards the top there is an opening (charging door) through which the charge is fed. Air for combustion is blown through the tuyers located at a height of 0.6 to 1.2 meters above the bottom of the furnace.



Zones

Crucible Zone → It is b/n the top of the sand & the bottom of the tuyers. The molten metal comes here.

Tuyers Zone → It is b/n the bottom of tuyers to the top of tuyers.

Combustion Zone → The zone is located above the tuyers where the combustion of the fuel occur by oxygen of the air blast and produces lot of heat in the cupola.

Reduction Zone → This zone extends from the top of the combustion zone to the top of the coke bed. CO_2 produced in combustion zone comes in contact with hot coke and is reduced to CO. In this zone iron & other elements are protected from oxidizing influence.

Melting Zone → It is the first layer of iron above the coke bed. The temperature in this zone is as high as 1700°C. Iron is melted in this zone.

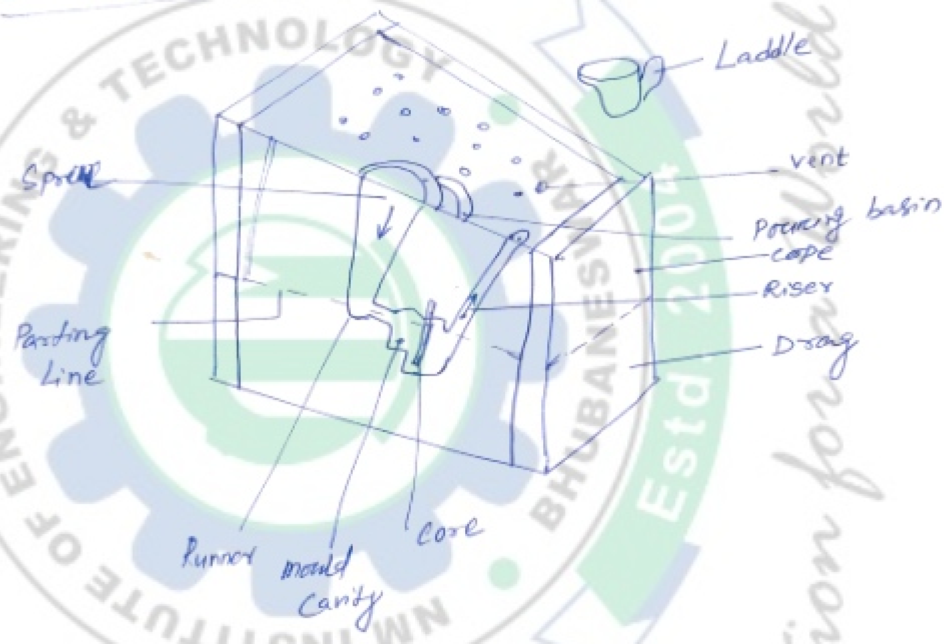
Preheating Zone → It is located above melting zone to the charging door. Iron & coke are preheated to this zone.

Stack :- Carries gases from preheating zone to atmosphere.

Refractory Matereial:

Matereials that donot melt at high temp.

Crosssection of sand mould read for Poureing:



Casting Terms

Flask :—

Moulding flask is one, which holds the sand mould intect depending upon the position of flask, it is reffored by various names such as

drag
cope
cheek

Drag:-

Lower moulding flask.

Cope - Upper moulding flask.

Cheek - Intermediate moulding flask, used in 3-piece moulding.

Mould:- Sand.

Casting (process) - solidified product

Pattern:- Impression giving substance for mould.

- It is a replica of the final object to be made with some modification.
- The mould cavity is made with the help of pattern.

Parting Line:-

This is the dividing line b/n the two moulding flasks that makes the sand mould.

Pouring Basin:-

A small funnel shaped cavity at the top of the mould into which a molten metal is poured.

Sprue:-

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

Runner:-

The passage way in the parting plane through which molten metal flow is regulated before they reach the mould cavity.

Gate:-

The actual entry point through which molten metal enters the mould cavity.

Riser:- It is the reservoir of molten metal provided in the casting, so that hot metal can flow back into the mould cavity when there is reduction in volume of metal due to solidification.

Pattern Material

a) <u>No. of casting to be produced</u>

Metal patterns are preffered, when the production quantity is large.

b) Dimensional accuracy & surface finish.

<c> <u>WOOD</u>.

The most common material for making pattern for sand casting is wood.

<u>Adv (wood)</u>

- Inexpensive
- Easyly available in large quantity
- Easy to machine
- To make & shape diff. configuration
- Easy to join (complex shape)
- Light weight
- Easyly obtain surface finish
- Easyly reparable
- strong also

Limitations (wood) Pattern

1. - Wooden patterns are affected by shrinkage & swelling
2. - They poses poor resistance.
3. - They can't withstand rough handeling.
4. - They are weak as compared to metal pattern.

Application (wood pattern)

- Wooden pattern are used, where the no. of casting to be produced is small and size is large.

- White Pine
- Teak
- Shisham
- Maple
- Cherry
- [illegible]

Pattern (Metal)

Generally Aluminium.

The diff. metals & alloys used for making metal pattern are

- Aluminium & its alloy
- Steel
- Cast Iron
- Brass

Adv (metal pattern)

- Do not absorb moisture (as compared to wood)
- Most accurate & more strong (")
- They can withstand rough handling
- " " stable under diff. environment
- Poses excellent wear resistance.
- Excellent resistance to swelling & dimensional tolerances.

Limitations

- Expensive
- No easily repairable
- Heavier then wooden
- Can't be machined easily.
- Corrosive

Application (Metal Pattern)

Metal pattern are employed, where large no. of casting have to be produced.

Plastic Pattern

Plastic pattern may not work well when subject to a condition of severe shocks as in moulding / jolting / ramming.

POP

It may be made of POP or Gypsum cement

Adv

- Intricate shape can be cast without difficulty.
- It has high compressive strength 285 kg/cm³

Application:-

Small & integrate pattern.

WAX

- It provide very good surface finish.
- High accuracy
- Reusable

Application — Investment Casting

Procedure of Sand Mould Casting:-

First the bottom board is placed on the hz. Surface.

The drag 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.

There should be some clearance between the pattern and the wall of flask.

The sand is sprinkling over the pattern & board completely filled.

Then, ramming of sand should be proper.


①


②


③

The basic steps in making sand mould casting

- pattern making
- mould & core making
- melting & casting & pouring
- Fettling
- Testing & inspection.

① Pattern making

- According to the casting desired, pattern is made
- Soft wood pattern is used for small nos. of casting.
- Hard " or metal pattern " " Large " " "

② Mould & Core Making

- The important material is moulding sand.
- Silica sand is used for the same.

③ Melting, Casting & Pouring

- Once mould is ready.
- It is ready to receive molten metal.
- Melt the suitable metal in a furnace.
- Molten metal is tapped through Ladle
- Poured into the cavity
- Allowed to solidify (cool)
- Pouring should be uniform & continuous.

④ Fettling:-

- After solidified
- Casting is ready
- It is (casting) not free from sand particles.
- The process of cutting/removing sand particles/fins projections/cleaning/finishing the casting is called FETTELING.

⑤ Testing & Inspection

Pneumatic/hydraulic pressure tests on casting
Inspection is an act of checking the acceptability of casting - by
- Visual inspection
- Dimensional "
- Mechanical "
- Crack detection.

Chills

In a casting, metallic chills are used in order to provide progressive solidification or to avoid the shrinkage cavities. Chills are essentially a large heat sink. When ever it is not possible to provide a riser for a part of the casting, which is heavy, a chill is placed close to it. So that more heat is quickly absorbed by the chill from the larger mass making the cooling rate equal to that of the thin sections. Thus this does not permit the formation of a shrinkage cavity. But use of chills means essentially providing higher cooling rate which is also likely to form a hard spot at the contact area with the chill.

CHAPLETS

Chaplets are used to support cores inside the mould cavity to take care of its own weight and overcome the metallostatic forces.

This is related with core setting & core shifting.

Due to the upward thrust of the molten metal, the long thin cores tend to float more easily than short cores. If the molten metal for a long time, the core has greater opportunity to float, shift, or crack. If the core gets shifted from its position in the mould, it will result in a displaced cavity & hence a defective casting is produced. In order to overcome the vertical movement of core due to upward thrust of the molten metal, chaplets are used. The chaplets are metal forms placed between the mould and core surfaces. These are of the same composition as that of the pouring metal so that the molten metal would provide enough heat to completely melt them and thus fuse with it during solidification. The various types of chaplets are normally used...

FIG →

— Though the chaplets is supposed to fuse with parent metal, normally it forms a weak joint in the casting and causes blow holes. This is due to oil, grease & dirt on the surface of chaplets. So generally the chaplets before placed in the mould should be throughly cleaned.

Copula operation :-

Preperation of Cupola :- After each heat, the slag and refractories are cleaned as soon as the patching of the lining is completed, the bottom doors are raised and held in position by metal props. The sand bottom is made such that it slopes towards the tap hole.

FIRING of Cupola

Small pieces of woods are ignited on the sand bottom, when the wood burns well, coke is added. Air necessary for coke combustion from tuyers. Coke is added until the desired height is reached. Instead of placing wooden pieces, the initial coke may be ignited by gas burners or electric spark ignitors.

CHARGING :- After coke bed is properly ignited, coke & pig iron are charged in alternative layers until the cupola is full from charging door.

In addition of iron & coke, a certain amount of limestone is added to the first metal charge.

Besides lime stone, fluorspar (CaF_2) & soda ash (Na_2CO_3) also used as fluxing material. A flux removes the impurities in the iron & protects the iron from oxidation. Limestone reduces the melting point of slag & increases fluidity.

Opening the Air blast :- At the end of this, the blast is opened. As the melting proceeds, the molten metal appears at the tap hole.

Pouring the molten metal :-

When sufficient molten metal is collected the slag hole is opened & slag is run off. Then the tap hole is opened. Molten metal is collected in ladles & carried to moulds for pouring.

Welding

Define welding

Its the process of joining of two similar or dissimilar metal by application of heat with or without application of pressure or addition of filler metal.

Classification of welding Processes

Welding processes may be classified as.

(1) Fusion welding

(2) Electric arc welding

- a) Shielded metal arc welding
- b) Carbon arc welding
- c) Gas metal arc "
- d) Gas tungsten arc welding
- e) Submerged arc welding
- f) Plasma " "

(3) Resistance welding

- a) Spot welding
- b) Seam "
- c) Projection "
- d) Resistance welding
- e) Flash "
- f) Percussion "

4) Solid State welding

- cold welding
- Diffusion "
- Ultrasonic "
- Friction "
- Explosive "
- Forge "

5) Thermochemical welding

- Thermit welding
- ~~Automatic~~ Atomic hydrogen welding

6) Radiant welding

- Laser beam welding
- Electron beam welding

7) Allied Process

- soldering
- Brazing.

Gas Welding :-

Gas welding is a method of fusion welding in which a flame produced by combustion of gases to heat & melt the parent metal and filler rod of joint.

The filler metal may be added to the molten metal to fill up the cavity.

The most commonly used gases are

- Oxygen gas.
- Acetylene gas.

The gases are mixed in proper proportions in a welding blowpipe (Torch).

The intense heat (flame) melts & fuses together the edges of parts to be welded. Generally filler metal is used. ~~as fill~~

Oxy-Acetylene Welding Process

This welding process is the combination of oxygen & acetylene, which gives heat (i.e large amount of temp). The flame reaches a temp. of about 3000°C to 3200°C.

The chemical reaction involved in burning of Acetylene is

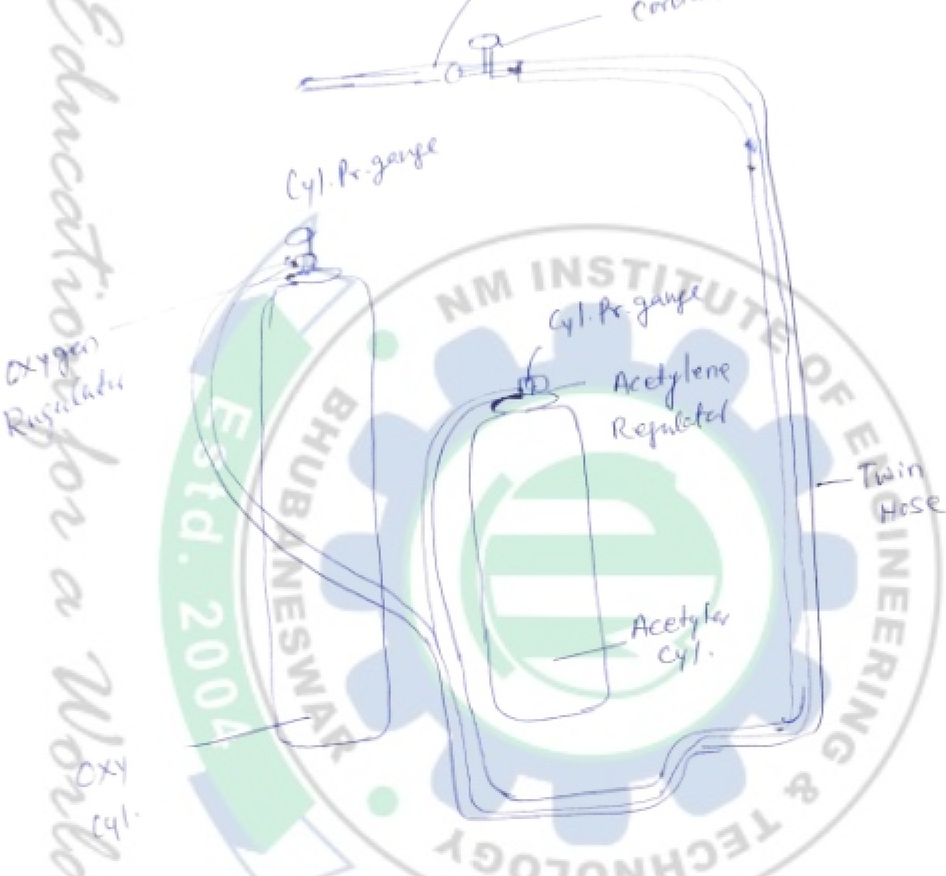
$$2C_2H_2 + 5O_2 = 4CO_2 + 2H_2O + \text{Heat}$$

Gas welding is suitable for joining sheets and plates of 2mm to 50 mm.

Principle

- The flame is obtained by ignition of oxygen & Acetylene gases, mixed in blow pipe
- The flame is applied to edge of the joint.
- As the melting point of Steel appx 1400°C

Figure :



Gas Flame

The correct adjustment of the flame is important for reliable works by varying the proportions of oxygen & acetylene supplied to the blowpipe or torch.

Explain various types of flame: W(4)

(1) Neutral Flame

(2) Carburising "

(3) Oxidising "

Neutral flame:

When the ratio of oxygen and acetylene is equal.

- This types of flames has max temp (3100°c)

- A white colour & has sharply central cone with reddish purple envelope.

- This flame is used to weld mild steel, stainless steel, cast iron, copper, Aluminium.

Neutral

Carburising Flame

- It occurs when Acetylene is more that oxygen

- It consist of three zone
  - Luminious zone
  - Intermediate cone
  - Outer envelope

- It is also known as reducing flame.
- The max. Temp is 2900°C
- Carburising flame is used to weld
  - High carbon steel
  - Alloy steel

Oxidising flame

- It occurs when the oxygen content is more than Acetylene.
- The max temp is 3300°C
- It is used to weld alloy such as
  - Copper
  - Brass
  - Bronze
  - Zinc Alloys

Weldibility:

It is defined as the capacity of being welded into inseparable joints having specified properties such as definite weld strength.

Actually a metal has good weldability means it has various factors affecting:-

- composition of metal
- Brittleness of metal & strength
- Thermal properties.
- welding materials.
- Filler material.
- proper heat treatment before & after deposition of metal.

Resistance Welding :-

Resistance welding process is a fusion welding process where both heat & pressure are applied on the joint but no filler metal or flux is added.

In resistance welding, a heavy electric arc current is passed through the metal pieces to be jointed over a limited area, causing them to be locally heated to plastic state & the weld is completed by the application of pressure. In this process two copper electrodes are used. The pressure on the joint is continuously maintained and the metal fuses together under this pressure.

~~The loc~~

The amount of heat (H) generated is given by the relation :-

$$H = KI^2RT$$

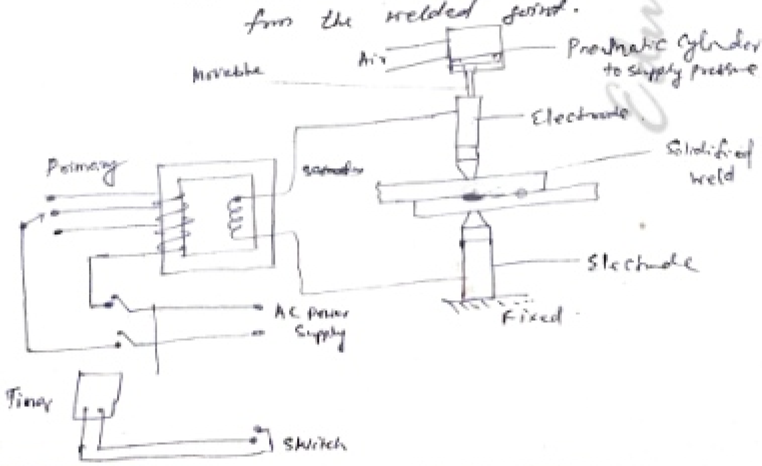
where H = Heat generated of in the work . in joules.

I = Electric current in amperes.

R = Resistance of the joint in ohms.

T = Time of current flow in seconds.

K = a constant to account for the heat loss from the welded joint.



The main requirement of this Process is the low voltage & high current power supply. This is obtained by means of a transformer with a provision to have different tapping on Primary Side as required for different materials. The Secondary ~~electrode~~ windings are connected to the electrodes. An electronic timer is used to control the electric supply.

The force required can be provided either mechanically, hydraulically, Pneumatically

Types of resistance welding:

a) Spot welding
b) Seam welding
c) Projection welding
d) Butt welding

Spot welding

It is the simplest & most commonly used method of overlap welding of strips, sheets or plates of metal at small area.

In this method, sheets of metal to be welded are held b/n copper electrode by applying pressure through foot pedal lever. A current of low voltage & sufficient amperage is passed between electrodes causing the parts to be brought to welding temperature. The metal under electrodes pressure is squeezed & welded.

After this, the current is turned off, while the pressure is still acting. The pressure is applied till the weld cools & produce a solid bond.

Now the pressure is released and the work is removed from the machine.

Correct combination of Pr. Pr, Current, time.

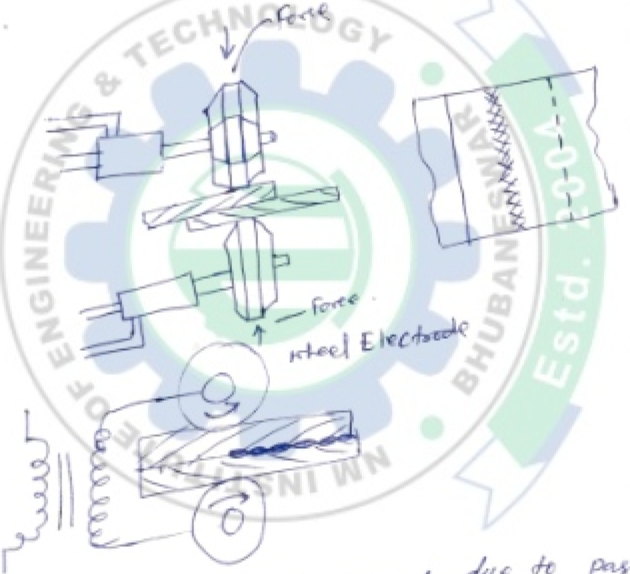
Adv — No edge preparation is needed.
— Low cost.
— High speed of welding.

Application — This technique is used mostly in thin sheet work.

Seam Welding:-

Seam welding is similar to spot welding, except that the electrodes in spot welding are replaced by copper rollers or wheels. The workpieces to be welded are ~~[illegible]~~ pressed between the rollers.

~~A current~~



The heat is produced due to passing of the current through the resistance in the welding circuit. The heat generated can be controlled by either varying the current (or) pressure between the sheets - which varies the contact resistance. Seam welding is used on many types of pressure tight (or) leak proof tanks for various purposes.

Projection Welding :-

Projection welding is another variation of spot welding. Small projections are raised on one side of the sheet (or) plate, where it is to be welded to another. The projections are generally very small such as 0.8 mm appx.

The projections serves to concentrate (localize) the welding heat at these areas & facilitate fusion without the necessity of employing a large current.

During large welding process, the heated and softed projections collapses under the pressure of the electrodes there by forming the weld.

<u>Adv</u> – This method of welding gives longer electrode life.

–

Butt Welding:-

Butt welding is used to join the pieces end to end. This process is best suited to rods, pipes & many other parts of uniform cross-section.

— Upset Welding.
— Flash Welding.

Upset welding:

In upset welding the pieces to be joined are brought together to mate with each other on butt joint. The two pieces are held tightly together and current is applied, so the heat is generated through the contact area between the two plates.

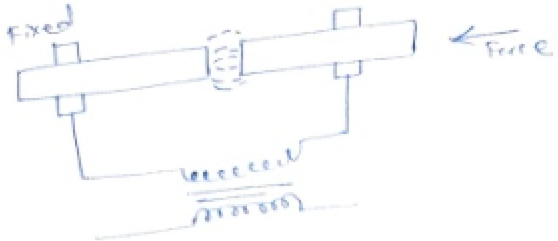
Because of the joint being under pressure, the ends of the two pieces get slightly upset.

Flash Welding Joint

Flash welding is similar to upset welding except that the heat is obtained by means of an arc.

The two parts are brought together & power supply is switched on. As the parts are moved closer, flashing (or) arcing raises the temperature of the parts to a welding temperature. Now the parts are forced together to form a weld.

It consist of two platens, one is fixed and another one is movable.



Forge Welding:

It is the oldest method of all the welding processes. The metal parts to be welded are heated in black smith's furnace to a plastic state and then pressed together by hand (or) power hammer. The force can be applied in repeated blows manually (or) by a M/c.

Though the process is very slow, yet it is conveniently used for joining parts of mild steel, wrought iron, and low carbon steels.

When wrought iron (or) steel at high temperature is exposed to the air, it oxides and is covered with a film of scale (i.e oxide). If the film scale & ashes from the fire are allowed to remain on the surfaces to be welded, the result will be failure. In order to avoid this, the fluxes are used.

In case of wrought iron, sand in the form of flux is sprinkled on the work piece surface, while for mild steel calcined borax is used as flux.

Friction Welding :- (Also it is called Solid State welding)

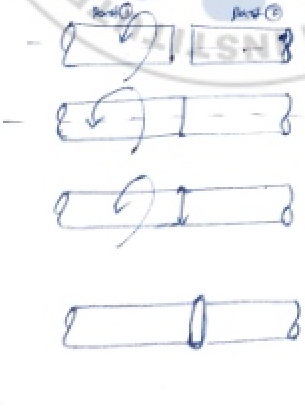
The heat required for welding in this process is obtained by the friction between the ends of the two parts to be joined. One of the parts to be joined is rotated at a high speed - around 3000 rpm & other parts is axially aligned with the second one an pressed tightly against it. The friction between two parts raises the temperature of both ends.

Then the rotation ~~of the~~ part is stopped & ~~the~~ pressure on the fixed part is increased so that the ~~joined~~ joining takes place. This is called friction welding.

Friction welding is mostly used for butt welding of ~~[illegible]~~ tubes, circular cross section.

The axial pressure applied depends on the strength & hardness of the metals being joined. The pr. range from 40 MPa to 450 MPa. The total time that is taken in the friction welding is b/n 2 to 30 secs.

Sequence of a Friction welding Process



Part ① rotated.

← Part ② advances to contact part ①

← Pressure
Slight pressure is applied.

← Pressure
Rotation stopped, pressure increased finished welding.

Defects in welding:-

- Incomplete fusion
- Porosity
- Slag inclusion.
- Cracks.
- Over penetration.

I.F. This will be seen as a discontinuity in the weld zone. The main cause for this defect are improper penetration of the joint, wrong design of joint, & incorrect welding technique & wrong choice of welding parameter.

The main parameter is welding current (if lower than the required would not sufficiently heat all the faces of joint).

Porosity:- Porosity in welding is caused by the presence of gases entrapped during the solidification. ~~The gas is released during the~~ The main gases that causes porosity ~~welding~~ are ~~hydrogen~~, oxygen & nitrogen.

- Oxygen generally reaches the weld pool as oxide of base metal (or) filler metal (or) in some compounds of fluxes present on the electrode coatings.
- Nitrogen generally enters the weld pool through atmospheric nitrogen (or) the contaminated shielding gases.

Porosity if present in large quantity would reduce the strength of the joint.

Slag Inclusions:-

Slag is formed by the reaction with the fluxes and it is lighter.

Due to low density, it will float on top of the weld pool & and would be chipped off after solidification by chipping hammer. Due to arc force, the slag goes into the weld pool & if there is not enough time for it to float the slag ~~solidified on the previous pass is~~ inside the fusion zone and forms slag inclusion.

Cause of slag inclusion

- Rapid solidification.
- ~~Insuf~~ Insufficient welding heat.

It is also reduce the strength of the joint.

Crack:-

Welding cracks may be hot or cold cracks.

Hot – It generally occurs at high temperature. It can be prevented by preheating the base metal.

Cold – Cold cracking generally occurs at room temperature after the weld is completely cooled. This can be seen in the heat-affected zone. (Cause – rapid cooling)

Soldering & Brazing

In welding processes, the joint of the base metal is melted & a joint is prepared. But soldering & brazing processes, where the base metal is not melted, the joint is obtained by means of a filler metal.

The filler metal having a melting point below that of a base metal.

Soldering:

It is a method of joining similar (or) dissimilar metals by means of a filler metal whose (filler metal) melting point is below 420°C. The solder is usually an alloy of lead (38%) and Tin (62%). A suitable flux is used in soldering to prevent oxidation of joint. Fluxes are available in the form of powder, paste or liquid.

The joint design of soldering & brazing are similar, but soldered joint is weaker compared to brazed joint, mechanical fastening etc.

In soldering joint, the surface of the base metal is cleaned by acid cleaning or mechanical cleaning before soldering.

The most commonly used soldering methods are – hand soldering (Electrically heated (or) Flame)
- Dip soldering.
- Wave soldering.

- A soldering iron is a copper rod with a thin tip, which can be used for flattening the soldering material. The soldering iron is heated by keeping in a furnace or by means of electrically. In the joint the solder (filler) is applied, which melts & flows around the joint by capillary action.

- In dip soldering, a large amount of solder is melted in a tank, which is closed. The parts to be soldered are first cleaned & dipped in the flux bath & finally dipped in the molten solder bath and lifted after the soldering is completed.

- In ~~dip soldering~~ the wave soldering, the parts are not dipped into the solder tank, but a wave is generated in the tank so that the solder comes up & makes necessary joint. This is used in electronic printed circuit board PCB.

Also other method of soldering

- torch soldering.
- oven "
- Resistance soldering.
- Infrared soldering.

Brazing :-

It is a process of joining two pieces of metals in which a non-ferrous filler metal (or) alloy is introduced between the pieces to be joined. The melting point of the filler metal is above the melting temperature 420°C, but lower than the melting of parent metal.

The copper base alloys and silver base alloys are commonly used as filler metal in brazing. The suitable flux such as borax powder is used.

In brazing, the two metal pieces to be joined are first of all cleaned to remove all grease & oxide. The parts are fitted together along the line of joint and held in that position by some clamp.

PW (1)(M)

Powdere Metallurgy:-

It is defined as "the art of making objects by the heat treatment of - compressed metallic powders.

"Powder Metallurgy" includes the blending & mixing of powders, pressing or compacting powder into desired shape & size, sintering the pressed - powder compact & finishing of product to meet specified dimension.

Advantages

- It is suitable for mass production.
- Machining oper^n's are eliminated.
- Metals & alloys canbe mixed - together in any proportions.
- Better control of composition.
- Process is very economical.
- Loss is less as compared to other process.

Dis Adv

- High compacting pressure required.
- Costly equipments are required.
- Low melting powders like, tin, zinc cadmium, some times thermal difficulties appear.
- Intricate shapes can not be produced
- Some metal powder are explosive.

Applications

- Rotors of gear pump
- Tungsten wire
- motor brushes.
- metallic filter.
- complex shape components
- Refractory metal composites.
- Auto motive components

PW ② (m)

Sintering:

- Sintering means, Heating of pressed compact below the melting temp. of any constituent
- The sintering temp used vary with the compressive load type of powder.
- Aluminium copper alloys can be sintered at temps. from 350°C to 500°C for 24 hrs.
- copper & copper alloys can be sintered at 700°C
- compact of Iron powder are usually sintered at temp of 1200°C for appx ½ hrs.

Press Tool

3.11. TYPES OF DIES

3.11.1. Classification of Dies

The dies may be classified as follows :

1. Simple dies
2. Compound dies
3. Progressive dies
4. Transfer dies
5. Fluid-activated diaphragm dies
6. Multi-action dies.

1. Simple dies :

- The die sets which are made to perform a single press-working operation, such as punching or bending, that is accomplished in one stroke of the press, are called *simple dies*.
- A single operation die may be a bending die, curlie die, wiring die and buldging die.

2. Compound dies :

- Compound dies make close tolerance and concentric parts, as all work is done in one stroke.
- Fig. 3.48 shows a compound blank and draw die. The metal enters as a flat sheet, is cut to the right length, and is then formed over a reverse-type punch. Spring action on a pressure plate strips the part off the punch. The knockout pin, shown at the top, pushes the part out of the upper die if it stays on that side when the die opens.

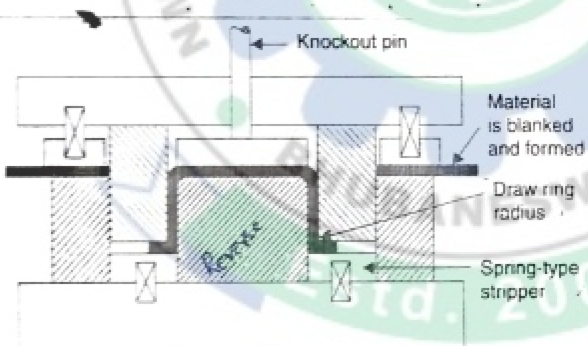


Fig. 3.48. Compound blank and draw die.

3. Progressive dies :

— These dies are made to *cut and form a part in successive stages or stations of the die*. The parts are held together by the strip skelton or tabs until the last station or cut off. Force or movement comes from the strip feeder attached to the press.

— A progressive die can perform very complex work, doing piercing, blanking, forming, lancing and notching.

- The *advantage* of this type of die is that the tooling can be spread out.
- The *cost of progressive dies is high* and therefore they are usually limited to high production operations.

4. Transfer dies :

- Transfer dies, like progressive dies, are also multistation dies and are constructed on the same principle, but unlike progressive dies, the blanks are cut out first from the strip stock and then mechanically moved through successive stages, sometimes arrang circle. An example of the type of part that would require a transfer die is sho Fig. 3.49.

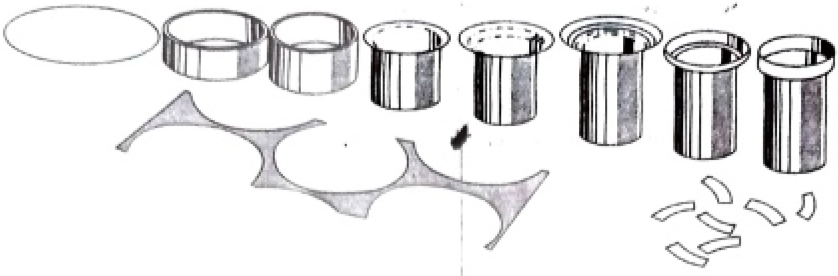


Fig. 3.49. Deep drawn part formed in a transfer die.

Comparison between Transfer dies and Progressive dies :

Transfer dies :

- Both are *multiple station operation dies.*

(*i*) The main advantage of transfer die over progressive die is a reduced liability to dam due to scrap metal getting into the dies as already cut blanks are fed to the dies.

(*ii*) The elimination of a great deal of scrap loss is the greatest advantage of transfer ope tions.

(*iii*) Transfer blanks can also be cut to take advantage of the grain direction of the me stock.

(*iv*) Transfer mechanisms generally have a *higher initial cost than progressive die setu*

Progressive dies :

(*i*) In progressive dies continuous strip from a coil is fed into the dies whereas in trans dies previously cut blanks are fed into the dies.

(*ii*) Progressive operations can usually be run at higher speeds and with shorter press strok than comparable transfer operations.

5. Fluid-activated diaphragm dies :

- Drawing of sheet-metal parts may be accomplished by the use of fluids and a diaphrag
- The process has the *advantage of closer control of the drawing operation so that par that usually require two drawing operations can be done in one.*

6. Multi-action dies :

- Multi-action dies are used to perform multistep forming in one operation. The *punc and die segments are operated in a sequence that is coordinated with the press strok*
- In this setup (Fig 3.50) the entire sheet is held between tooling plates at all time Unsupported metal does not flow with the punch as it does in conventional tooling. The multiple, matched dies are made so that segments can be timed to move for an optimum forming sequence. The tools are mounted in a conventional hydraulic press, which is programmed to activate independent, external hydraulic circuits.

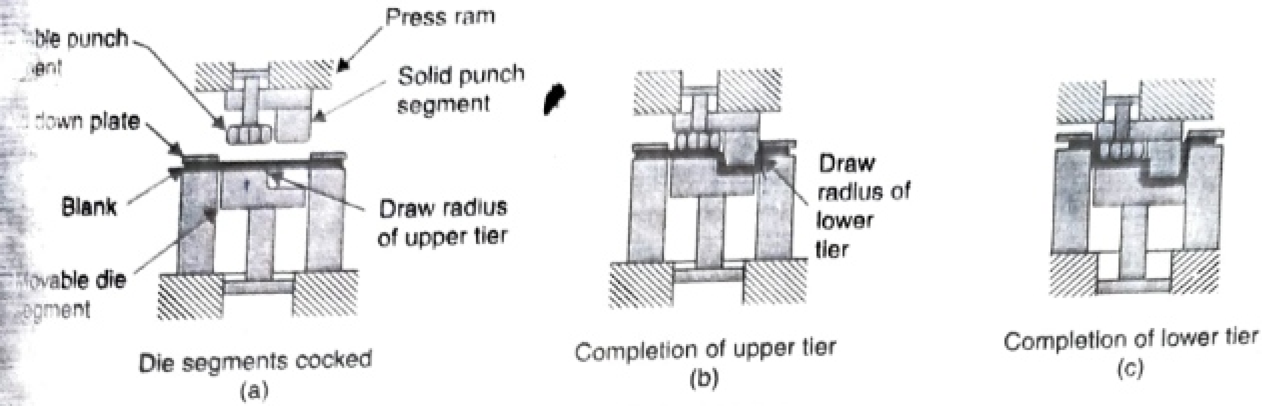


Fig. 3.50. Multi-action dies.

Note : Though both the fluid-activated diaphragm and the multi-action dies have good control over metal hich is necessary to avoid excessive thinning and buckling, it appears that multi-action dies provides *more ility.*

3.11.2. Causes of Failure of Dies in Metal Working Operations

In metal working operations, failure of dies generally results from one or more of the follow- *uses :*

1. Excessive wear.
2. Improper installation, assembly, and alignment.
3. Overloading, misuse and improper handling.
4. Improper dies design.
5. Defective die materials.
6. Improper heat treatment and finishing operations.
7. Overheating and heat checking *i.e.*, cracking caused by thermal cycling.

PRESSES

3.12.1. Classification of Presses

Presses are employed to provide power to operate dies for blanking, forming, and shearing. may be *classified as* follows :

1. According to type of frame :

(i) Open frame presses.

(ii) Closed frame presses.

Open frame press :

This press is also known as 'Gap frame' or 'C' frame press.

The most common type press is 'open back inclinable C-type frame press', commonly known as OBI press. Its frame is inclined backward which facilitates the removal of scrap or parts by gravity through the open back. It ranges from small 1 tonne bench press to floor presses rated upto 150 tonnes.

Owing to their construction, open frame presses are *less rigid and strong* and are useful mainly for operations on *smaller work.*

These presses are available upto 200-tonne capacity with strokes of 90 to 120 per minute.

3.	*Drawing*	(*i*) Good surface finish and dimensional accuracy. (*ii*) Low equipment and tooling cost. (*iii*) High production rate. (*iv*) Long lengths of rounds, tubings, square and angles can be produced.	(*i*) Production of constant cross-sections only. (*ii*) Deformation limited to small reductions. (*iii*) Lubrication is necessary.
4.	*Deep drawing*	(*i*) Moderate equipment and tooling cost. (*ii*) High production rate. (*iii*) Good surface finish.	(*i*) Forming of shallow or deep parts of simple shapes only. (*ii*) Limited to forming of thin sheets. (*iii*) Finishing required.
5.	*Hot extrusion*	(*i*) Suitable for large reduction. (*ii*) Moderate cost of equipment and toolings. (*iii*) Complex sections and long products can be produced.	(*i*) Componente with thin walls are difficult to produce. (*ii*) Only constant cross-section can be produced. (*iii*) Lubrication is necessary. (*iv*) Dimensional accuracy and finish achieved are not good.
6.	*Impact extrusion*	(*i*) Good finish and dimensional accuracy. (*ii*) High production rate. (*iii*) Generally no finishing is required. (*iv*) Suitable for production of thin sections.	(*i*) Deformation limited to small reductions. (*ii*) Suitable for production of light components from softer materials.
7.	*Punching and blanking*	(*i*) Low cost of labour. (*ii*) High production rate. (*iii*) Almost any shape can be obtained. (*iv*) Moderate equipment cost.	(*i*) Cost of tooling can be high. (*ii*) Limited to thin sheet applications.
8.	*Open-die forging*	(*i*) Simple to operate. (*ii*) Inexpensive tooling and equipment. (*iii*) Wide range of workpiece sizes can be used. (*iv*) Suitable for low production volume.	(*i*) Fairly skilled operators are required. (*ii*) Can be used for simple shapes only. (*iii*) Production rate is low. (*iv*) Dimensional accuracy and surface finish achieved are poorer. (*v*) Finishing required for achieving final shape.
9.	*Closed-die forging*	(*i*) Can be used for production of complex shapes. (*ii*) Suitable for high production rate. (*iii*) Good dimensional accuracy and reproducibility.	(*i*) Appropriate die set for production of each component. (*ii*) High equipment and tooling cost. (*iii*) More than one step required for each forging. (*iv*) Finishing required for achieving final shape.