Government Polytechnic College
Bargarh

PRODUCTION TECHNOLOGY

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Metal forming process

Dt. 18.07.2019

Extrusion

Extrusion is a metal forming process that produces continuous length of uniform, non-uniform crossectional area from a metal billet (molten metal), solid or hollow, by causing the matter to flow under high pressure through a restricted opening called die, which is so shaped as to import the required form to the product.

→ Extrusion is a mainly hot working process

Components of extrusion:

Major components:-

(i) containers

(ii) Die

(iii) Ram

Process:

A heated cylindrical billet is placed in a container and forced out through a steel die by a Ram or plunger. The metals takes in crossection the shape of the die.

Eg:

When pressed from the back, the toothpaste comes out of the front. Small portion comes out of the toothpaste tube, this is an extrusion process.

Different types of extrusion:

(i) Direct extrusion (ii) In-direct extrusion

(iii) Impact/cold ex. (iv) Backward extrusion

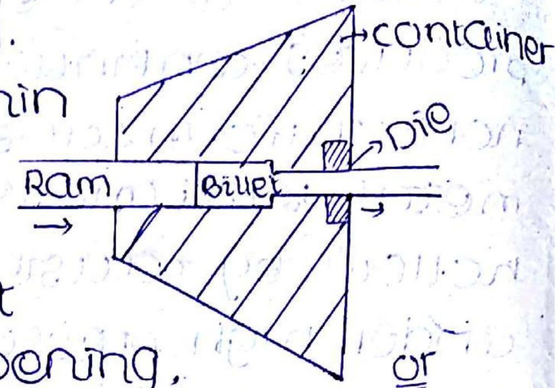
(v) Hydrostatic. (vi) combined ex. (vii) hot ex.

Direct Extrusion process:

→"In which the flow of metal through the die is in the same direction as the movement of the ram. Ram is solid.

→ A hot billet is placed within the container that has a die at one end.

→ A ram forces that hot billet through the die opening, producing the extruded product.



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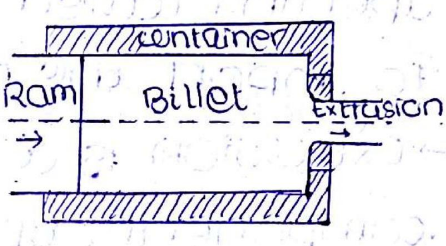


So that the oxides etc. that exist on the exterior walls of the billet do not get mixed into the final extrusion. as the billet is pushed through the die. direct sleeve extrusion method is used. A dummy block which is a little smaller than the billet chamber diameter and, therefore. does not touch the chamber walls is employed for the purpose.

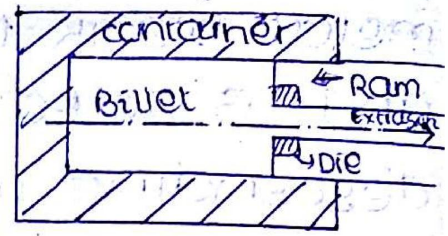
As the punch moves forward, the exterior (contaminated) surface of the billet remains stationary, whereas the interior (uncontaminated) metal is forced through the die for making the extruded product.

Indirect extrusion:

The ram used is hollow and the die is mounted over the bore of the ram. The metal flows in the opposite direction to the movement of the ram.

→ In indirect extrusion, the billet remains stationary while the die is pushed into billet by the hollow ram (or punch), through which the extrusion takes place.

→ Indirect extrusion does not require as much force as direct extrusion because no force is required to move the hot billet inside the chamber walls.



→ The length of the billet in indirect extrusion is limited only by the column strength of the ram, because there is no relative motion between the billet surface and the container (billet chamber) wall.

Backward extrusion:

→ In direct & Indirect extrusion methods the ram is of the same diameter as the bore of the container, whereas in backward extrusion the ram is smaller in diameter than the container and the metal flows up the annulus formed by the ram and the container.

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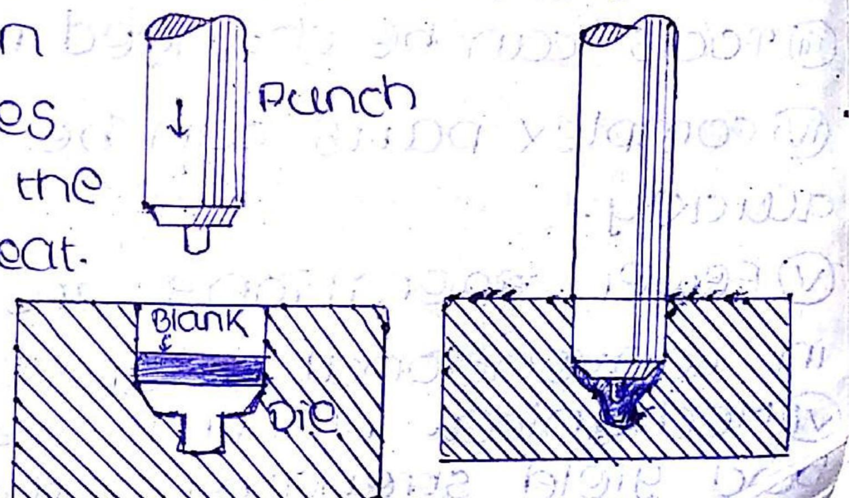
Dt. 22.03.2019

Impact / cold extrusion:

↳ cold extrusion is also known as cold forming or impact extrusion process.

→ cold extruction process extrudes metal without the application of heat.

→ The purpose cold extruction is producing finished product.



★ **Process:**

→ In impact extrusion process an unheated metal blank is placed in the die cavity and is acted upon by the rapidly descending punch which transmits a very high pressure to the metal blank with immediatly fills the cavity.

→ Since all the metal can not be accomodated in the die cavity, some metal travels along the sides of the punch, thereby forming a tube-shaped component.

→ Collapsible tubes of lead, tin and aluminium which are used as containers for shaving cream, tooth paste, medicine, greases, shoe polish etc. are produced with the help of impact extrusion process.

★ **Advantages of cold extrusions:**

(i) Very little scap is there in the process.

(ii) Little trimming or final machining is required because of the fine finish and close tolerances obtained on the finished part.

(iii) Tools can be changed rapidly.

(iv) Complex parts can be produced quickly.

(v) Fewer operations are required than in conventional shaping methods.

(vi) Mechanical properties (tensile strength and yield strength) of the extruded parts are improved without the need for heat-treating.

★ **Disadvantages of cold extrusion:**

(i) Tools being expensive, the method is practical only for mass production.

(ii) Metal blank should be free from internal or external defects, which makes the stock somewhat more expensive.

★ **Application of cold extrusion:**

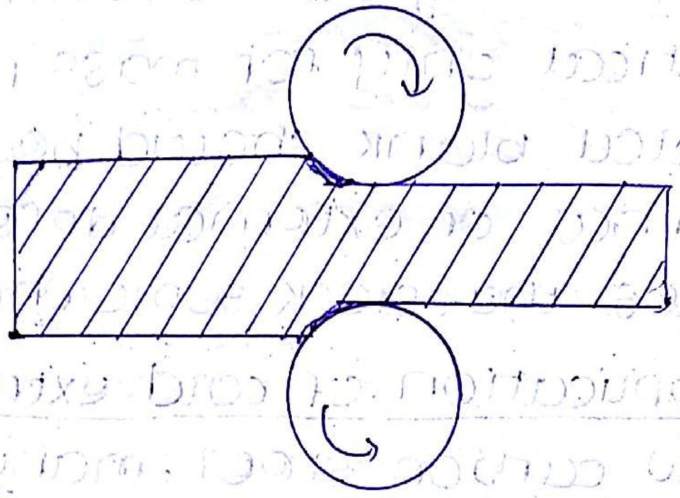
(i) Low carbon steel, many alloy steel, stainless steel, lead, tin, zinc, aluminium copper and its alloys etc. can be cold extruded.

(ii) Gear blanks, bearing races, housing or caps, copper fittings, the walled collapsible tubes, catridge cases, radiator tubes etc. can be produced by cold extrusion.

★ **Rolling:**

→ Rolling is a metal forming process in which stuck of materials passed between one or more pairs of roller to reduce and maintance the uniform thickness.

→ Rolling was the first metal sharping process to depart from the pure handicraft process and as such as a significant advance both from a production and technological standpoint.



☆ There are 2 types of rolling of metals:

① Hot Rolling:

→ Metal is fed to the rolls after being heated above the recrystallization temperature.

→ In general, rolled metal does not show work hardening effect.

→ Co-efficient of friction between the rolls and the stock is higher. It may even cause shearing of metal in contact with rolls.

→ Yield stress various with the temperature; it varies with each pass, therefore, hot rolling presents more problems in formulating a theory than does cold rolling.

→ Experimental measurements are difficult to make.

→ Heavy reductions in area of the workpiece can be obtained.

→ Mechanical properties are improved by breaking cast structure and refining grain size. Blow-holes and other similar defects present in the ingot (get welded) are removed. The strength and toughness of the metal increases. A fibre-like structure results.

→ Roll radius is generally larger than that used in cold rolling.

→ Very thin sections are not obtained by hot rolling. Hot rolling of sheets less than 1.25 mm in thickness is not economical.

→ The hot rolled surface has scale (metal oxide) on it, the surface finish is not good.

→ Close tolerances on dimentions can not be attained.

→ Hot rolling is widely used in ferrous as well as non-ferrous industry for steels, aluminium, copper, brass, bronze, magnesium, nickel and zinc alloys to change ingots into billets, slabs, sheets, bars, rods, wires and tubular shapes.

→ Hot rolling is the father of cold rolling.

ii) Cold Rolling:

→ Metals is fed to the rolls when it is heated below its recrystallization temperature.

→ The metal shows the work hardening effect after being cold rolled.

→ Co-efficient of friction between the rolls and the stock is comparatively lower.

→ Theoretical analysis can be easily carried out and extensively developed theory is available.

→ Experimental measurements can be easily carried out in cold rolling.

→ Heavy reduction is not possible.

→ Hardness increases. Excessive cold working generates cracks. Ductility of the metal reduces. Cold rolling increases the tensile strength and yield strength of steel.

→ Roll radius is smaller.

→ Aluminium foils as thin as 0.020 mm can be made.

→ The cold rolled surface is smooth and oxide-free.

→ Section dimensions can be finished to close tolerances (within 0.002 mm/mm).

→ Cold rolling is equally applicable to both plain and alloy steels and

non-ferrous metals and their alloys.
→ cold rolling follows hot rolling. Hot rolled objects are thoroughly cleaned of their surface scale by pickling in an acid solution and then cold rolled on a four-high or cluster rolling mill.

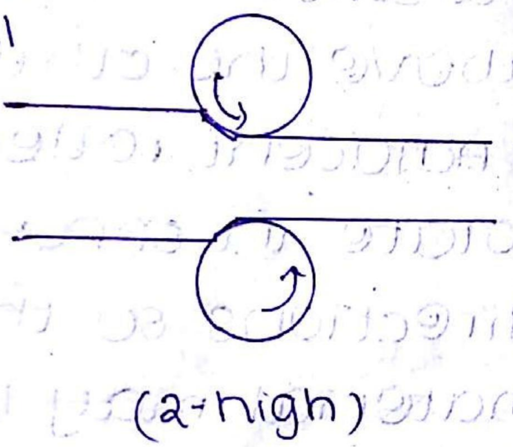
★ **Types of rolling mills:**

Rolling mills may be classified according to the number and arrangement of the rolls.

ⓐ Two-high rolling mill
ⓑ Three-high rolling mill } Generally used for hot rolling of metals.

ⓒ Four-high rolling mill
ⓓ A Tandem mill of three four high stands
ⓔ cluster rolling mills } Generally used for cold rolling of metals.

ⓐ **Two-high rolling mill:**



→ A two-high rolling mill may further be classified as a reversing mill and a non-reversing mill.
→ A two-high rolling mill has two rolls only.
→ In a two-high reversing mill the rolls rotate first in one direction and then in the other so that the rolled metal

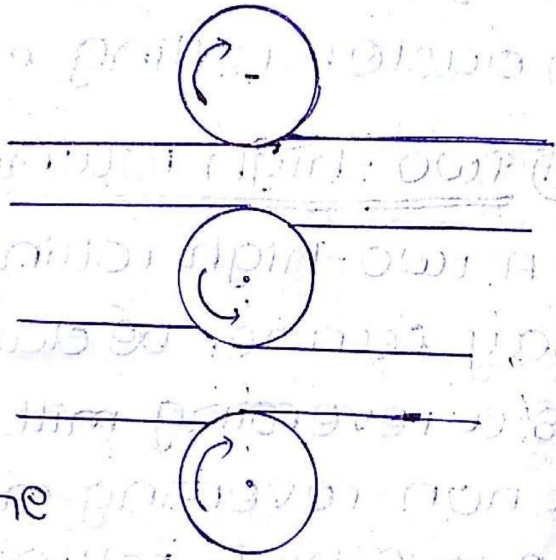
may pass back and forth through the rolls several times. This type is used in blooming and slabbing mills and for roughing work in plate, rail, structural and other mills.

→ A two high non-reversing mill has two rolls which revolve continuously in the same direction. Therefore, smaller and less costly motive power can be used. However, every time, material is to be carried back over the top of the mill for again passing it through the rolls. Such an arrangement is used in mills through which the bar passes once and in open-train plate mills.

(b) Three-high rolling mills:

→ It consists of a roll stand with three parallel rolls one above the other.

→ Adjacent rollers rotate in opposite directions so that the material may be passed between the top and middle rolls in one direction and the bottom and middle rolls in the opposite one.


(3-high)

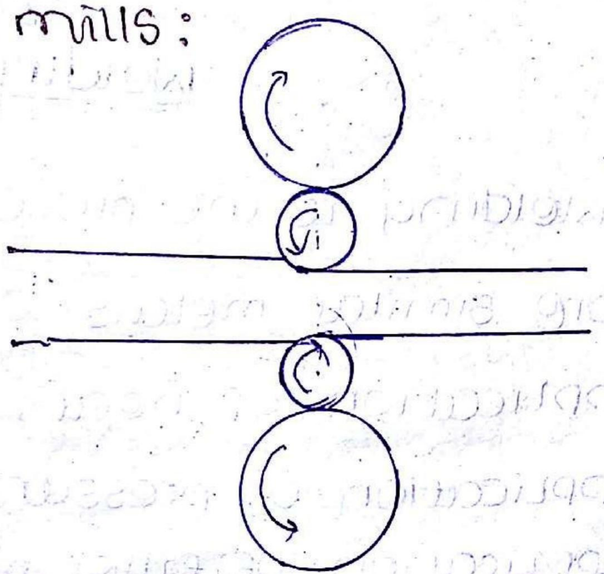
→ In a three-high rolling mill the workpiece is rolled on both the forward and return passes. First of all the workpiece passes through the bottom and the middle rolls and then returning between the middle and top rolls so that thickness is reduced at each pass. Mechanically operated lifting tables are used which move vertically on either side of the stand, so that the workpiece is fed automatically into the roll gap.

→ Since the rolls run in one direction only, a much less powerful motor and transmission system is required.

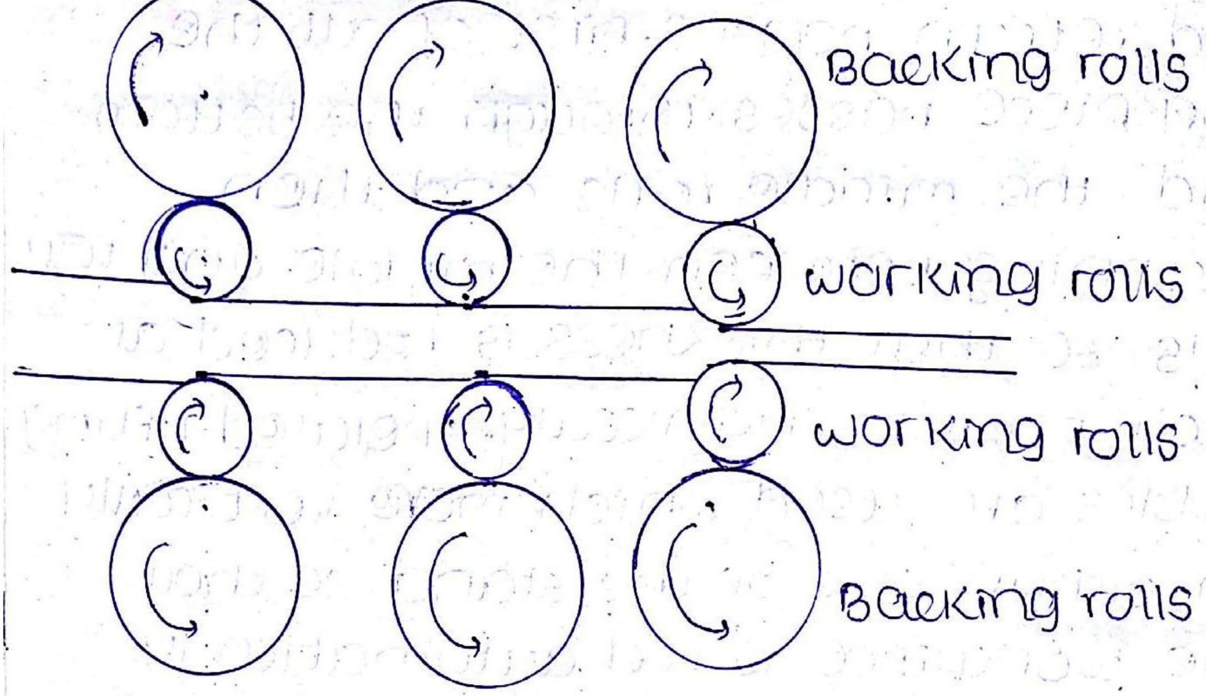
→ The rolls of a three-high rolling mill may be either plain or grooved to produce plate or section respectively.

→ Three-high rolling mills may be used as blooming mills or for subsequent rolling operations, such as billet rolling and finish rolling.

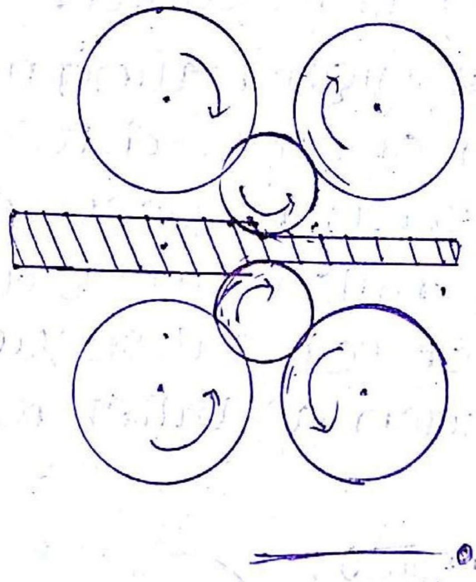
(iii) Four-high Rolling mills:



(iv) Tandem rolling mills:



(v) cluster rolling mills:



Welding

Dt. 02.08.2019

→ Welding is the process of joining two or more similar metals with or without the application of heat, with or without the application of pressure, with or without the application of filler metal.

Classification of welding process:

There are 35 different welding and brazing processes and several soldering methods in use by industry today.

★ Brazing:

It is a metal joining process in which 2 or more metal items are joined together by melting and flowing a filler metal into the joints.

→ The filler metal having a lower melting point than the adjusting metal.

Types

① Gas welding:

ⓐ Air Acetylene welding

ⓑ oxyacetylene welding

ⓒ oxyhydrogen welding

ⓓ pressure gas welding

② Arc welding:

ⓐ carbon Arc welding

ⓑ shielded Metal Arc welding

ⓒ Flux cored Arc welding

ⓓ submerged Arc welding

ⓔ TIG (or GTAW) welding

ⓕ MIG (or GMAW) welding

ⓖ plasma Arc welding

(h) Electroslag welding & Electro gas welding

(i) Stud Arc welding

(3) Resistance welding:

(a) Spot welding

(b) Seam welding

(c) Projection welding

(d) Resistance Butt welding

(e) Flash Butt welding

(f) Percussion welding

(g) High frequency Resistance welding

(4) Solid state welding:

(a) Cold welding

(b) Diffusion welding

(c) Explosive welding

(d) Forge welding

(e) Friction welding

(f) Ultrasonic welding

(g) Roll welding

(5) Thermo-chemical welding process:

(a) Thermit welding

(b) Atomic hydrogen welding

(6) Radiant Energy welding process:

(a) Electron Beam welding

(b) Laser Beam welding

good

Dt. 03.08.2019

✰ Coalescence:

→ It is the process by which 2 or more droplets, bubbles or particles merge during contact to form a single doughters dropless, bubbles or particles.

✰ Brazing:

→ It is a metal joining process in which two or more metal items are joined together by melting and flowing a filler metal into the joints.

→ The filler metal having a lower melting point than the adjusting metal.

✰ FLUXES:

→ During welding, if the metal is heated / melted in air, oxygen from the air combines with the metal to form oxides which result in poor quality, low strength welds or, in some cases, may even make welding impossible. In order to avoid this difficulty, a flux is employed during welding.

→ A flux is a material used to prevent, dissolve or facilitate removal of oxides and other undesirable substances. A flux prevents the oxidation of molten metal.

→ The flux (material) is fusible and non-metallic.

→ During welding, flux chemically reacts with the oxides and a slag is formed that floats to and covers the top of the molten puddle of metal and thus helps keep out atmospheric oxygen and other gases.

→ Fluxes are available as powders, pastes or liquids.

→ No flux is used in the gas welding of steel.

☆ Fluxes are used in the gas welding of cast iron, stainless steel and most non-ferrous metals other than lead, zinc and some precious metals.

☆ Flux for welding cast iron:

The use of a suitable flux is essential when gas welding cast iron. The flux increases the fluidity of the fusible iron-silicate slag, as well as aids in the removal of the slag.

Fluxes for gray iron rods are usually composed of borates or boric acid, soda ash etc.

☆ Flux for welding stainless steel:

→ A flux is needed to ensure better control of the molten metal and to make possible a sound, clean, good-appearing weld.

→ Flux should be applied at the underside of the seam also to prevent oxidation.

★ Flux for welding Aluminium & its Alloys:

→ A flux is necessary for welding aluminium because of the formation of oxide film on the metal. This film of aluminium oxide will prevent the formation of a sound weld. A flux when used breaks down the oxides & changes them into a fusible slag. The fusible slag being lighter than the base metal, floats to the surface of the weld puddle.

→ The flux may be applied on the base metal by brushing and on the filler rod end by dipping the same into the flux paste just before welding.

→ Flux employed for welding aluminium and its alloys are compounds of lithium, sodium and potassium and are obtainable in either paste or powder form.

→ Flux may contain potassium chloride, lithium chloride, etc.

→ After welding, the flux must be thoroughly cleaned off from the job because of its liability to corrode the metal. Washing in warm water and hard scrubbing with a wire brush are effective.

★ Fluxes for welding copper and its alloys:

→ Flux is not necessary for gas welding pure copper, however for alloys, borax based fluxes may be used. Flux for copper alloys may contain: Borax (fused), Di-sod., phosphate, Magnesium silicate, Lime, etc.

① Gas welding :-

Defn → Gas welding is a fusion-welding process. It joins metals, using the heat of combustion of an oxygen/air and fuel gas (i.e. acetylene, hydrogen, propane or butane) mixture. The intense heat (flame) thus produced melts and fuses together the edges of the parts to be welded, generally with the addition of a filler metal.

☆ Oxy-acetylene welding:

Defn → It is a gas welding process. It is the combination of oxygen, air and fuel gas like acetylene, hydrogen, propane & butane.

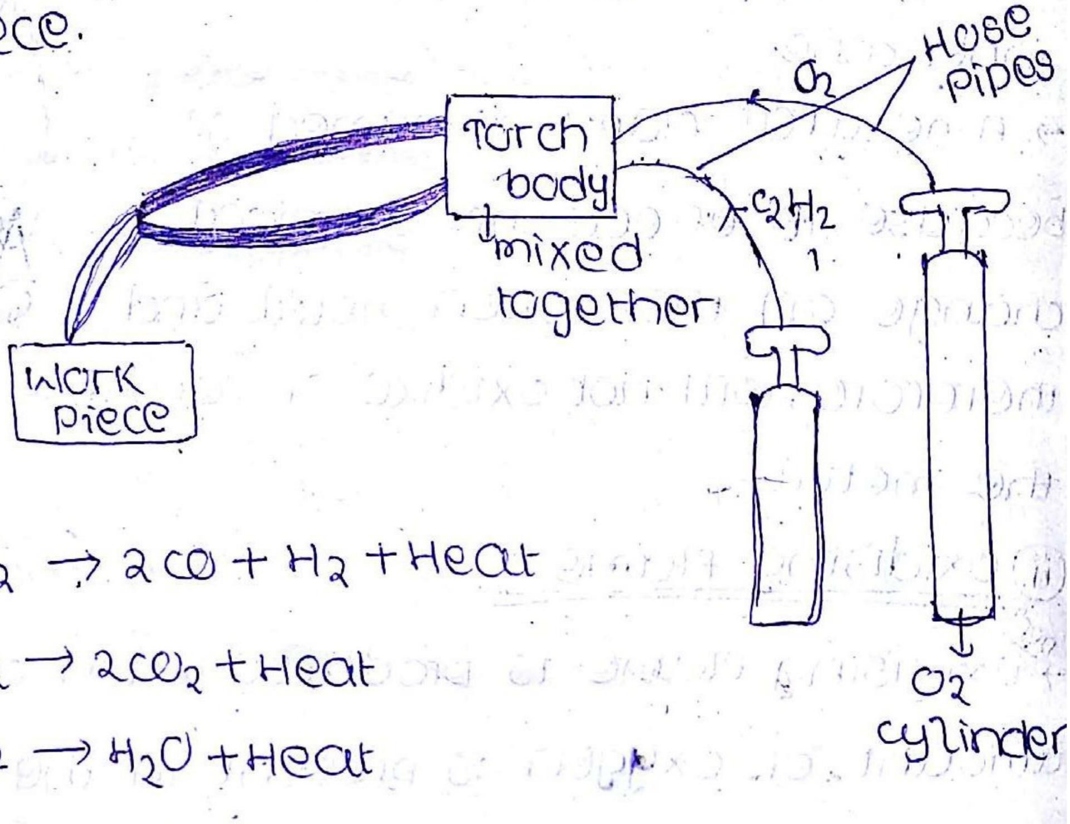
☆ Principle of operation :

→ In this case heat is required for melting the plate is obtained by burning of oxy-acetylene gas mixture.

→ Oxygen and acetylene are drawn from respective cylinder by flexible hose pipes into torch bar.

→ Both the gases are mixed together in the torch body. So that the mixture is possesing sudden high pressure. When the high pressure mixture is passed through the converyect and nozzle the pressure energy gets converted into velocity energy and the mixture is coming out from the nozzle at very high velocity.

→ Then the mixture is given initiation for burning, the continious flame will be produce. so the heat is available in this mixture is used for melting to the workpiece.



$$C_2H_2 + O_2 \rightarrow 2CO + H_2 + Heat$$

$$2CO + O_2 \rightarrow 2CO_2 + Heat$$

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O + Heat$$

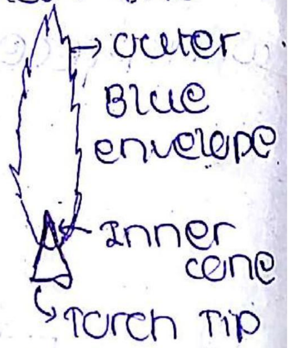
★ **Types of welding flames used in oxy-acetylene welding process:**

① **Neutral flame:**

Def^n → A neutral flame is produced when approximately equal volumes of oxygen and acetylene are mixed in the welding torch and burnt at the torch tip.

→ The temperature of the neutral flame is of the order of about 5900°F (3260°C).

→ The flame has a nicely defined inner cone which is light blue in colour. It is surrounded by an order flame envelope, produced by the combination of oxygen in the air and superheated carbon monoxide and hydrogen gases from the inner cone (flame). This envelop is usually a much darker blue than the inner cone.



→ A neutral flame is named so because it effects no chemical change on the molten metal and, therefore, will not oxidize or carburize the metal.

(ii) Oxidising flame:

Def → Oxidising flame is produced when excess amount of oxygen is present in the welding torch and burnt.

or,

→ If, after the neutral flame has been established, the supply of oxygen is further increased, the result will be an oxidising flame.

→ An oxidising flame can be recognised by the small cone which is shorter, much bluer in colour and more pointed than that of the neutral flame.

→ An oxidising flame burns with a decided loud roar.

→ An oxidising flame tends to be hotter than the neutral flame. This is because of excess oxygen and which causes the temperature to rise as high as 6300°F.

→ The high temperature of an oxidising flame ($O_2 : C_2H_2 = 1.5 : 1$) would be an advantage if it were not for the fact that the excess oxygen, especially at high temperature, tends to combine with many metals to form hard, brittle, low strength oxides.

→ A slightly oxidising flame is helpful when welding most-
(i) copper-base metals (ii) zinc-base metals, and (iii) A few types of ferrous metals, such as manganese steel and cast iron.

→ It is not used in the welding of steel.

(iii) Reducing flame:

Defn
→ It is produced when excess amount of acetylene is present in the welding torch and burnt.

or,

If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburising or reducing flame, i.e, rich in acetylene.

→ A reducing flame can be reconized by acetylene feather which exists between the inner cone and the outer envelope. The outer flame envelope is longer than that of the neutral flame and is usually much brighter in colour.

→ A reducing flame does not completely consume the available carbon; therefore, its burning temperature is lower and the leftover carbon is forced into the molten metal. With iron and steel it produces very hard, brittle substance known as iron carbide. This chemical change makes the metal unfit for many applications in which the weld may need to be bent or skretched. Metals that tend to absorb carbon should not be welded with reducing flame.

→ A reducing flame has an approximate temperature of 5500°F (3038°C).

→ A reducing flame may be distinguished from carburizing (surface hardening) flame by the fact that a carburizing flame contains more acetylene than a reducing flame.

→A reducing flame, on the other hand, does not carburize the metal, rather it ensures the absence of the oxidising condition. It is used for welding with low alloy steel rods and for welding those metals (e.g. non-ferrous) that do not tend to absorb carbon. This flame is very well used for welding high carbon steel.

To include, for most welding operations, the neutral flame is correct, but the other types of flames are sometimes needed for special welds, e.g.. non-ferrous alloys and high carbon steels may require a reducing flame, while zinc-bearing alloys may need an oxidising flame for welding purposes.

Advantages of gas welding:

(i) It is probably the most versatile (flexible) process. It can be applied to a wide variety of manufacturing and maintenance situation.

(ii) The rate of heating and cooling is relatively slow. In some cases, this is an advantage.

(iii) The cost and maintenance of the gas welding equipment is low when compared to that of some other welding processes.

(iv) It is mostly used welding process.

(v) The equipment is low cost, self-sufficient and portable.

✫ Disadvantages :

(i) Heavy sections cannot be joined economically.

(ii) Flame temperature is less than the temperature of the arc.

(iii) Fluxes used in certain welding and brazing operation fumes that irritating to the eyes, nose, throat and lungs.

(iv) Refractory metals (e.g., tungsten, molybdenum, tantalum, etc.) and reactive metals (e.g. titanium and zirconium) cannot be gas welded.

(v) Gas flame takes place a long time to heat up the metal than an arc.

(vi) More safety problems are associated with the handling and storing of gases.

(vii) Acetylene and oxygen gases are rather expensive.

✫ Application of gas welding:

→ For joining thin metals.

→ For joining materials in whose case excessively high temperatures or rapid heating and cooling of the job would produce unwanted or harmful changes in the metal.

→ For joining materials in whose case extremely high temperatures would cause certain elements in the metal to escape into the atmosphere.

→ For joining most ferrous and non-ferrous metals, e.g., carbon steels, cast iron, aluminium, copper, nickel, magnesium and its alloys etc.

→ In automotive and aircraft industries. In sheet metal fabricating plants etc.

✯ Filler metal:

Filler metal is the material that is added to the weld pool to assist in filling the gap.

✯ Gas welding equipment:

The basic equipments used to carry out gas welding are:

(i) Oxygen gas cylinder

(ii) Acetylene gas cylinder

(iii) Oxygen pressure regulator

(iv) Acetylene pressure regulator

(v) Oxygen gas hole (Blue).

(vi) Acetylene gas hole (Red).

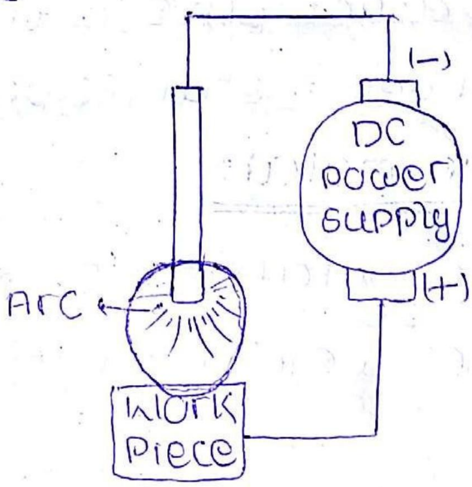
(vii) Welding torch or blowpipe with a set of nozzles and gas lighter.

(viii) Trolleys for the transportation of oxygen and acetylene cylinder.

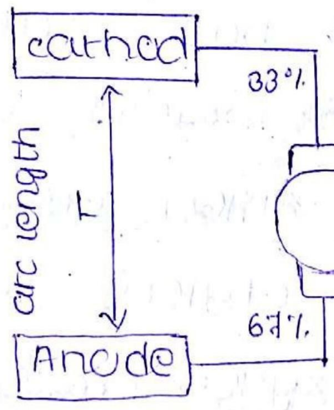
(ix) A set of keys and spanners.

☆ Arc welding process:

Defn → In arc welding process whatever heat is required for melting and joining of plates is obtained due to electric arc and it is called as arc welding.



☆ Principle:



→ When the power supply is given and a optimum gape is maintain below cathod and anode, the high velocity negative charge electrons are generated at the cathod, and attracted by the anode and moving towards the anode.

→ When the high velocity electrons are obtain on the anode the kinetic energy of electrons converted into heat energy.

→ Hence, heat is generated at electrod.

Alternatly a small amount of heat is generated at the cathod.

☆ Arc welding electrods:

The consumable electrods may be of the following types:

☆ Bare electrods:

They consist of a metal or alloys wire without any flux coating on them.

☆ Lightly coated electrodes:

Electrodes with a coating factor approximately 1.25 are termed as lightly coated electrodes.

Example: Citobest electrode of Advani Oerlikon (AO)

☆ Midium coated electrods:

They are the electrods with a coating factor about 1.45.

Example: Overcord-C, (A.O.).

☆ Heavily coated electrods:

The coating factor is between 1.6 and 2.2 for heavily coated electrods.

Example: Citofine, (A.O.).

$$\text{☆ coating factor} = \frac{\text{Dia. of the electrods}}{\text{Dia. of core wire}}$$

☆ Types of arc welding process:

① Tungsten inert gas (TIG) or Gas tungsten arc welding (GTAW):

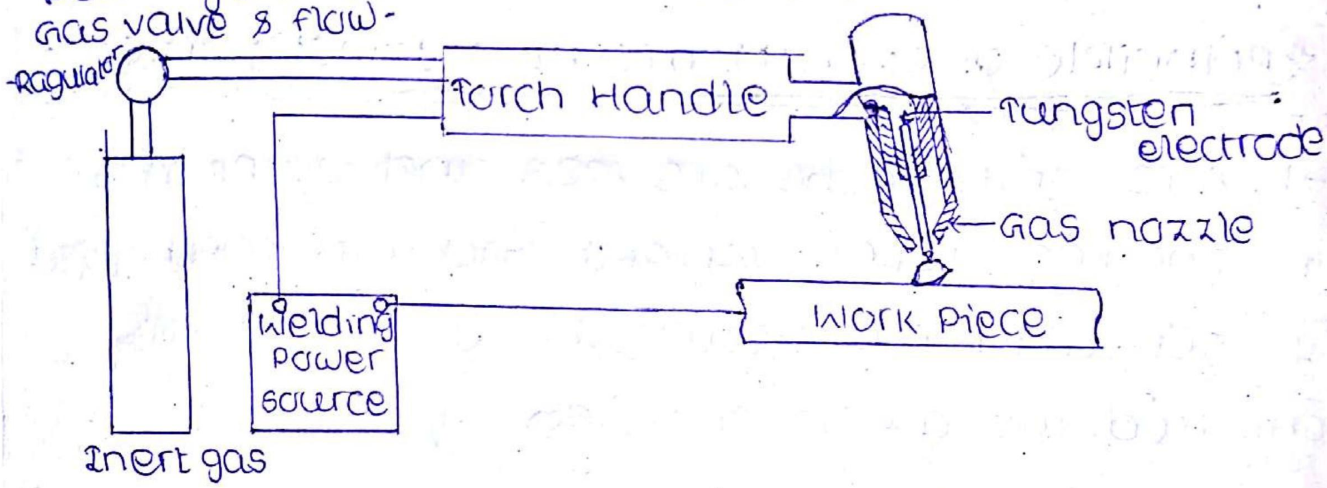
Defn - It is an arc welding process where in coalescence is produce by heating the job with an electric arc struck between a tungsten electrod and the job. A shielding gas (argon, helium, nitrogen, etc.) is used to avoid atmospheric contamination of the molten weld pool. A filler metal may be added, if required.

Extra ☆ coalescence:

It is the process by which two or more droplets, bubbles or particles merge during contact to form a single daughter droplet, bubble or particle.

☆ Principle of operation:

Welding current, water and inert gas supply are turned on. The arc is struck either by touching the electrod with a scrap tungsten piece or using a high frequency unit. In the first method arc is initially struck on a scrap tungsten piece and then broken by increasing the arc length. This procedure repeated twice or thrice warms up the tungsten electrode. The arc is then struck between the electrode and precleaned job to be welded. This method avoids breaking electrode tip, job contamination and tungsten loss. In the second method, a high frequency current is superimposed on the welding current. The welding torch (holding the electrode) is brought nearer to the job. When electrode tip reaches within a distance of 3 to 2 mm from the job, a spark jumps across the air gap between the electrode and the job. The air path gets ionized and arc is established.



Equipment :

ⓐ Welding torch, tungsten electrode and filler metal.

ⓑ Welding power source, high frequency unit, DC suppressor unit and cables.

ⓒ Inert gas cylinder, pressure regulator and flow meter.

ⓓ cooling water supply.

ⓔ Water and gas solenoid valves.

(ii) Metal inert gas (MIG) or Gas metal arc welding (GMAW):

Defn: It is an arc welding welding process where in coalescence is produced by the heating the job with an electric arc established between a continuously fed metal electrode and the job.

→ No flux is used but the arc and molten metal are shielded by an inert gas, which may be argon (Ar), helium (He), carbon dioxide (CO_2) or a gas mixture.

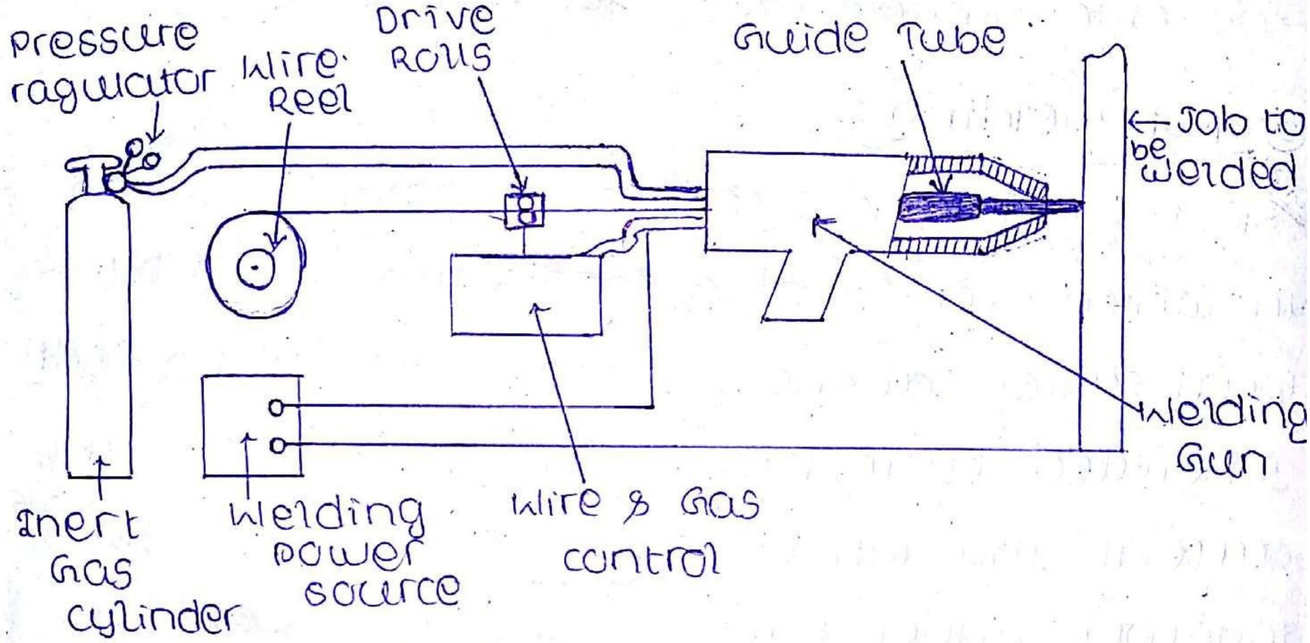
☆ **Principle of operation (semi-automatic process):**

→ Before igniting the arc, gas and water flow is checked. proper current and wire feed speed is set and the electrical connections are ensured. The arc is strucked by any one of the two method.

→ In the first method, current and shielding gas flow is switched on and the electrod is scratched against the job usual practice for striking the arc.

→ In the second method, electrod is made to touch the job, is retracted and then moved forward to carry out welding; but before striking the arc, shielding gas, water and current is switched on. About 15 mm length of the electrode is projected from the torch before striking the arc.

→ During welding, torch remains about 10-12 mm away from the job and arc length is kept between 1.5 to 4 mm. Arc length is maintained constant by using the principles of self-adjusted arc, and self controlled arc in semi-automatic (manually operated) and automatic welding sets respectively.



(a) MIG Welding set up

☆ **Equipment:**

(a) Welding power source and cables

(b) Welding torch and wire electrode coiled on a spool.

(c) Wire feed mechanism and controls consisting of a pair of driving rolls, electric motor, etc.

(d) Shielding gas cylinder, pressure regulator & flow meter.

(c) controls for switching on and off the current, electrode wire and inert gas.

Resistance welding:

Defn

Resistane welding is a group of welding processes where in coalscence is produced by the heat obtained from resistance of the work to the flow of electric current in a circuit of which the work is a part and by the application of pressure.

→ No filler ~~needed~~ metal is needed.

(a) Spot welding:

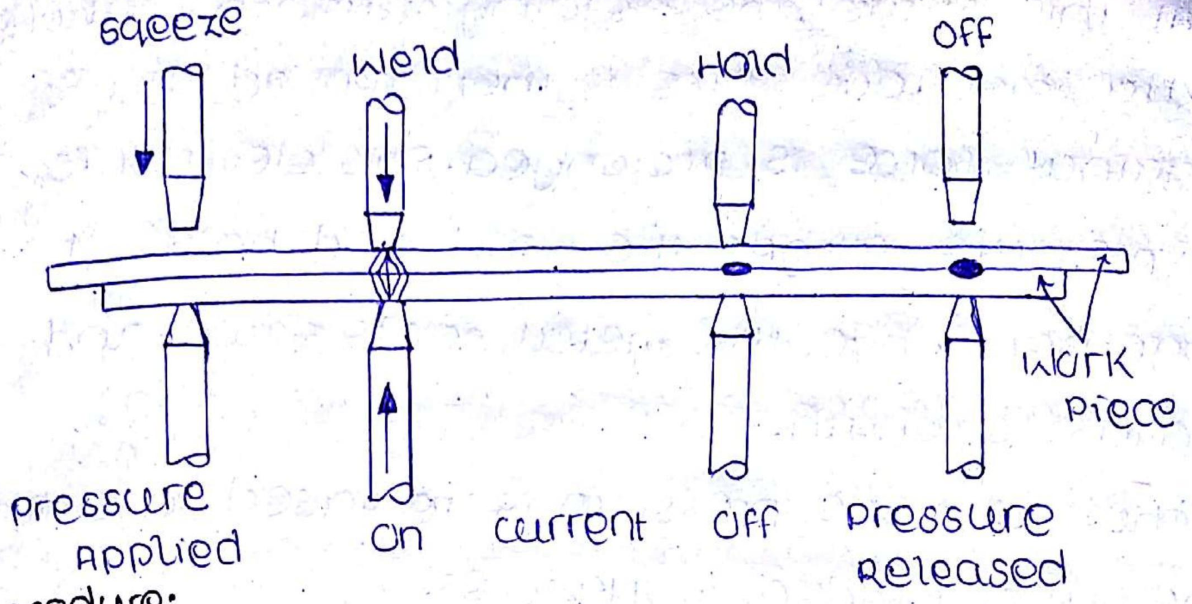
Defn

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

→ It is the most widely used of resistance welding processes.

→ Spot welding is used for joining relatively light gauge parts (upto about 3mm thick) superimposed on one another (as a lap joint).

→ Spot welding is employed for joining sheet, sheet to rolled sections or extrusions, wire to wire, etc.



Procedure:

→ Electrods are brought together against the overlapping workpieces and pressure applied so that the surfaces of the two workpieces under the electrodes come in physical contact after breaking any unwanted film existing on the workpieces.

→ Welding current is switched on for a definite time. The current may be of the order of 3000 to 1,00,000 A for a fraction of second to a few seconds depending upon the nature of material and its thickness.

As the current passes through one electrode & the workpieces to the other electrods, a small area where is workpieces are in contact is heated. The temperature of this weld zone is approximately 815°C to 930°C.

To achieve a satisfactory spot weld, the nugget of coalesced metal should from with no melting of the material between the faying surfaces.

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

→ The electrode pressure is released to remove the spot welded workpieces.

☆ Advantages of spot welding:

(i) Low cost

(ii) High speed of welding

(iii) Dependability

(iv) Less skilled worker will do

(v) More general elimination of warping or distortion of parts.

(vi) High uniformity of products

(vii) Operation may be made automatic or semi-automatic.

(viii) No edge preparation is needed.

☆ Applications of spot welding:

→ Spot welding of 2(two) 12.5 mm thick steel plates has been done satisfactory as a replacement for riveting.

→ Many assemblies of two or more sheet metal stamping that do not require gas tight or liquid tight joints can be more economically joined by spot welding than by mechanical methods.

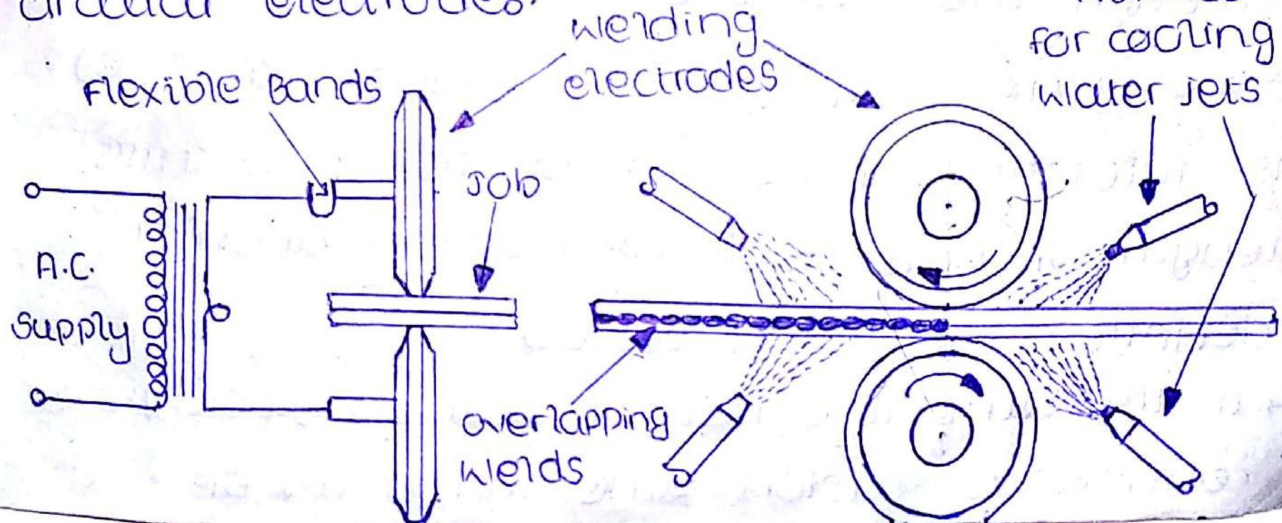
→ containers such as receptacles and tote boxes frequently are spot welded.

→ The attachment of braces, brackets, pads or clips to formed sheet-metal parts such as cases, covers, bases or trays is another application of spot welding.

→ spot welding finds applications in automobile and aircraft industries.

(b) Seam welding:

Def: Seam welding is a resistance welding process where in coalescence at the faying surfaces is produced by the heat obtained from resistance to electric current flow through the work parts held together under pressure by electrodes. The resulting weld is a series of overlapping resistance-spots welds made progressively along a joint by rotating the circular electrodes.



★ Principle of operations:

→ The seam welding is similar to spot welding, except the circular rolling electrods are used to produce a continues air-tight seam of overlapping welds. overlapping (spot) welds are produced by the rotating electrodes and a regularly interrupted current.

→ The workpieces to be seam-welded are cleaned. overlapped suitably and placed between the two circular electrodes which clamp the workpieces together by the electrode force.

→ A current impulse is applied through the rollers to the material in contact with them. The heat generated thus makes the metal plastic and the pressure from the electrodes completes the weld.

→ As the first current impulse is applied, the power driven circular electrodes are set in rotation and the workpieces steadily move forward. Throughout the welding period, the electrodes revolve and the work passes through them at a specific speed.

→ The current applied to welding electrodes is intermittent i.e., it is on for a definite length of time and then off for another definite and short period.

→ If the current is put off and on quickly, a continuous fusion zone made up of overlapping nuggets is obtained and the process is known as stitch welding.

→On the other hand, if individual spot welds (or nuggets) are obtained by constant and regularly timed interruptions of the welding current, the process is known as Roll (spot) welding. Roll welding simply joins two workpieces whereas stitch welding produces gas tight and liquid tight joints.

→There are two seam welding methods. One involves continuous motion and the other intermittent motion during welding operation.

→In continuous motion method, the electrodes rotate at a constant speed and the current flows continuosly or is interrupted.

→In intermittent motion welding, the electrodes travel the distance necessary for each successive weld and then stop. The current is then switched on and the weld made, the whole process being controlled automatically. Continuous motion is used for welding workpieces less than 4.5 mm thick and intermittent motion, above 4.5 mm thick.

→The rotating welding electrodes are cooled to prevent over-heating with consequent wheel dressing and replacement problems reduced to a minimum. Moreover, employing water-cooling jets immediately before and after the electrodes reduces warping of the material being joined.

© ☆ **Projection welding:**

Defn Projection welding is a resistance welding process where in coalscence is produced by the heat obtained from resistance to electric current flow through the work parts held together under pressure by electrodes. The resulting welds are localized at predetermined points by projections, embossments or intersections.

☆ **Principle of operations:**

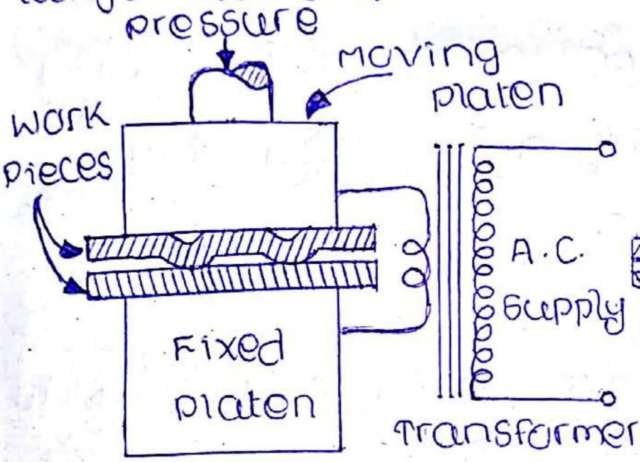
→ Projection welding is similar to spot welding except that-

(i) The electrods, instead of being tips as in spot welding, are flat and relatively large in surface area. Electrods are cooled as in spot welding.

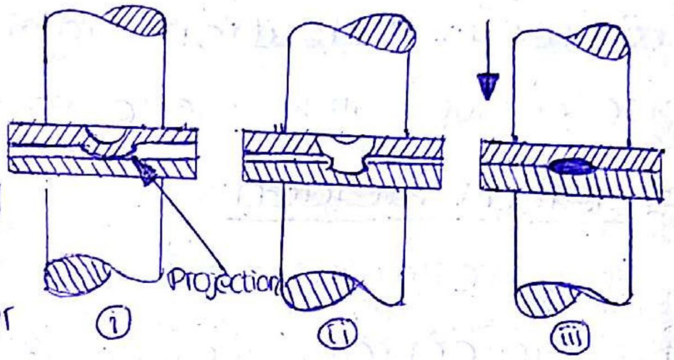
(ii) Since a number of welds are made at each operation, both the electrical power (KVA) and mechanical pressure must be correspondingly greater, as compared with a spot welder.

→ The success of projection welding depends on the surface preparation of the work-pieces to be welded. Projections, small deformations that will touch the surface of the material to be welded are formed on the weld areas by embossing, stamping, casting or machining.

These projections serve to concentrate (localize) the welding heat at these areas and facilitate fusion without the necessity of employing a large current.



(principle of projection welding)



(stages in projection welding)

Stages:

(i) The projection in the upper piece is held in contact with the lower piece under electrode pressure.

(ii) The current flows and being localized to the region around the projection, heats the metal in that area to the plastic state.

(iii) The heated and softened projection collapses under the pressure of the electrodes thereby forming the weld.

★ Projection welding Equipment:

→ Projection welding employs a press-type machine and with a single-phase or three-phase transformer.

→ The welding head is guided by bearing or ways and moves in a straight line. Platens with T-slots are used for mounting the electrodes.

→ The welding head is actuated by air, spring or hydraulically.

→ Welding machine controls are usually of the synchronous type. Phase shift and pulsation timing are often included to regulate welding current. Pulsation timing are helpful when welding thick materials.

✿ Metals welded:

The following metals are satisfactorily welded by projection welding:

(i) Low carbon (0.20%C max) steels.

(ii) Coated metals such as galvanized steel, terne plate, tin plate, etc. considerable electrode maintanance is usually needed when welding coated metals because coating stricks to the face of the electrode.

(iii) Naval brass, Monel (Ni-Cu) alloys.

(iv) Stainless steel.

(v) Titanium alloys.

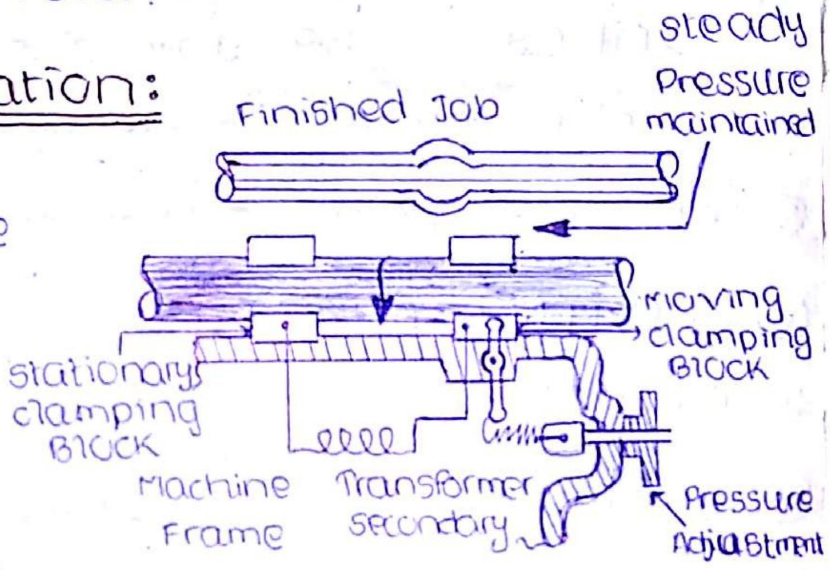
(d) Resistance (Upset) Butt welding:

Defn

Upset butt welding is a resistance welding process where in coalescence is produced simultaneously over the entire area of abutting surfaces by the heat obtained from the resistance to electric current flow through the area of contact of these surfaces.

→ Pressure is applied before heating is started and is maintained throughout the heating period. This pressure or force is later on increased to give a forging sqeeze when the welding temperature (1600 to 1700°F) has been reached. When sufficient upset has been produced, the welding current is cut off and the force is removed.

Principle of operation:



(Resistance butt-welder)

① The two pieces to be butt-welded are gripped firmly, one in each clamp & are correctly aligned so that when brought into contact one with the other by sliding the movable clamp to the fixed one, they fit together exactly.

② Force is applied so that the faces of two pieces touch together and remain under pressure.

③ A heavy current is then passed from one piece to another. The resistance to the electrical current flow heats the faces to fusion temperature.

④ Both pressure and current are applied

throughout the weld cycle and when the faces (or ends) of the pieces become plastic, they are pressed together more firmly, upsetting the metal pieces to form a dense joint.

→ Upsetting takes place while the current is flowing and continues until after the current is shut off.

→ The upsetting action mixes the two metals homogeneously and pushes out many of the impurities of the atmosphere. It also reduces the heat-affected zone to a minimum.

(v) The welding current is cut off.

(vi) Upsetting force is released as the welded joint has cooled to the desired temperature.

(vii) Workpieces are unclamped.

☆ Good butt welding is obtained if

(a) Faces to be butt welded are clean, parallel and reasonably smooth.

(b) The two workpieces are equal in cross-sectional area and/or equal specific resistance.

(c) To facilitate heating at the abutting surfaces, the areas are sometimes restricted by bevelling the ends.

☆ Metals welded:

The following materials are butt-welded

s in wire, bar (up to 30 mm dia.) strip or tube form.

(i) copper alloys (ii) Low & high carbon steels.

(iii) stainless steels (iv) Aluminium (v) Nickel alloys

(vi) Resistance alloys

Equipment used:

→ A butt welder consist of a couple of clamps suitably mounted on a horizontal slide, one being fixed rigidly and the other movable. Both clamps are made of conducting material (cu-alloy) and are connected to the secondary of a transformer.

→ A step-down transformer provides the electrical current for heating. control of secondary current is achieved by transformer tap switches or electronic phase-shift devices.

→ Each butt-welding machine has an activating device to start the welding process, such as a foot pedal or clamp release lever.

→ pressure for butt-welding is obtained by mechanical spring, pneumatic or hydraulic systems.

Application of Butt welding:

(i) For welding of small ferrous and non-ferrous strips and rods.

(ii) For welding of longitudinal butt joints in tubing and pipe and transverse-butt joints in heavy steel rings.

(iii) In wire drawing industries, where wire drawing would be impossible without the upset butt welding process.

Resistance butt welding has been largely replaced by flash butt welding.

(e) Flash Butt Welding:

Defn

Flash welding is a resistance welding process wherein coalescence is produce simultaneously over the entire area of abutting surfaces, by the heat obtained from resistance to electric current flow between the two surfaces, by the application of pressure after heating is substantially completed. Flashing and upsetting are accompanied by expulsion of metal from the joint.

Introduction:

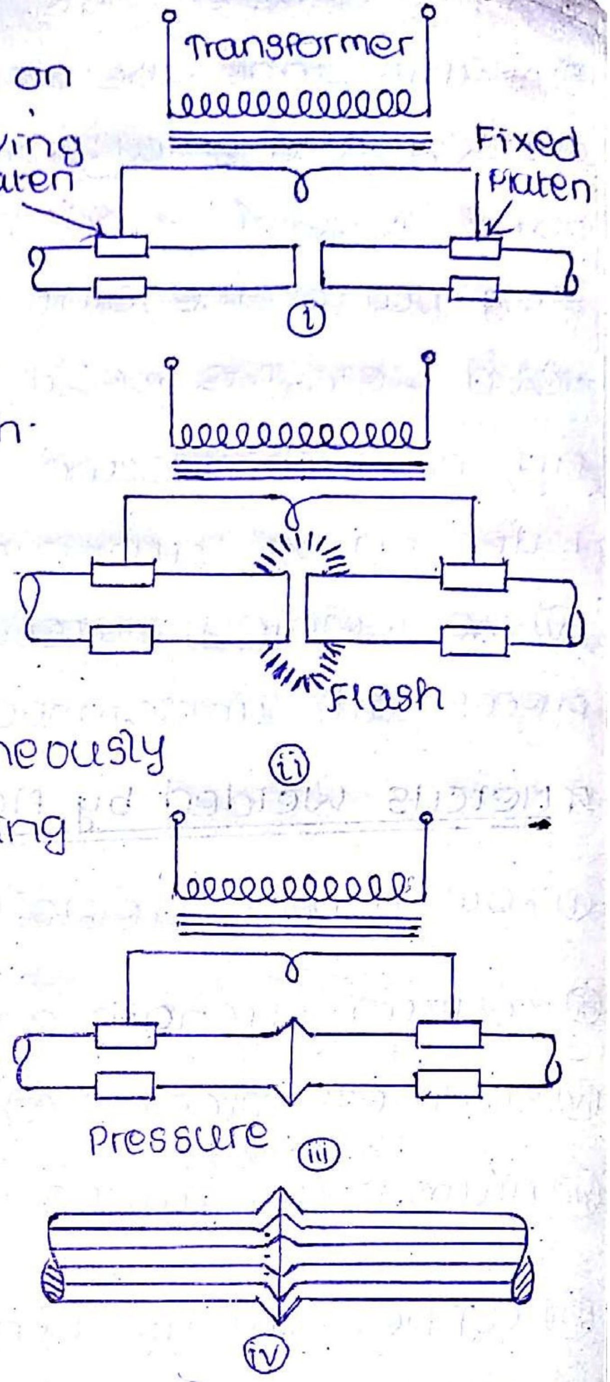
→ The term flash welding derives its name from the flash produce during the process.

→ Probably, flash welding process was developed from resistance butt welding by accident in attempts to increase the capacity of the butt-welding machine by raising the voltage and applying pressure intermittently.

Principle of operation:

① Flash-butt welds are made on a machine having one stationary and one opposing movable platen, on which are mounted the flash-welding dies or clamps.

These clamps securely hold the two workpieces to be welded while simultaneously serving to conduct the welding current through these work-pieces.



(Flash butt welding)

⑪ The workpiece held in the movable platen is brought towards the one gripped in the stationary platen until the two come in light contact, and as the welding current (with voltage sufficiently high) is turned on, flashing is established. While incandescent metal particles are being expelled by flashing, the movable platen keeps on moving constantly toward the stationary one at a carefully controlled and accelerated rate.

→ As the flashing continues, the ends of the two workpieces burn off as they reach a higher and higher temperature until finally they attain the welding temperature.

(iii) At this stage, the pressure of the moving clamp is quickly and greatly increased to (upset) forge the parts together and expel the molten metal and slag out of the joint thereby making a good solid weld. The metal expelled forms a ragged fin or flash around the joint which is removed later on by cutting or grinding.

(iv) The welding current is cut off and the work-pieces are unclamped as the fusion weld cools.

Metals welded by flash welding:

(i) Low carbon steels. (ii) Tool steels

(iii) Medium strength and high strength low alloys steels

(iv) Stainless steels (v) Magnesium alloys.

(vi) Aluminium alloys (with thickness greater than 1.25 mm)

(vii) Copper alloys (with high zinc content)

(viii) Molybdenum alloys

(ix) Nickel alloys

(x) Titanium alloys.

Casting

casting is a manufacturing process in which liquid material is usually poured into a molt, which contains a hollow cavity of the desire shape and then allow to solidify. The solidified process is known as casting.

→ casting materials are usually materials of various time setting materials that are cured after mixing to or more components together.

Ex: concreat plaster & clay.

→ casting is most upon used for making complex shapes that could be otherwise difficult or uneconomical to make by other methods.

★ casting process:

casting is one of the oldest manufacturing process, and is one the first step in manufacturing product.

→ In this process the materials are first liquidify by properly heating it in a suitable furnace & then poured into a previously prepared mould cavity where it is allowed to solidify.

→ Finally the product is taken of the mould cavity, trimmed and cleaned to shape.

✪ Types of casting:

① sand mould casting

② precision investment casting

③ perment mould casting

④ Die casting

⑤ centrifugal casting

① sand mould casting:

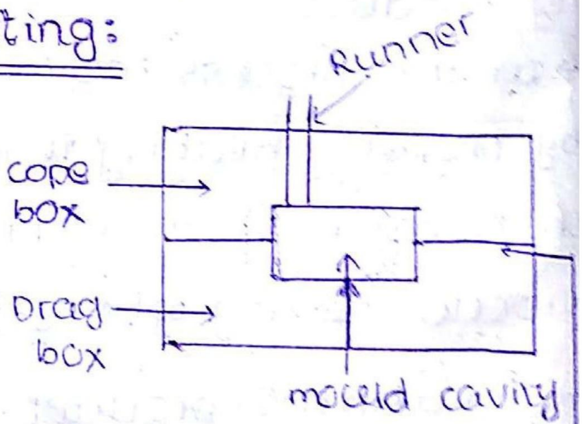
→ sand casting is the most widely used casting process in manufacturing.

→ The advantage of using sand to manufacture products of metals is that sand is very resistance to elevated temperature.

→ Almost all metal casting material can be sand cast.

→ Some examples of items manufacture in modern industries by sand casting process are :- Engine blocks, machine tool bases, cylinder heads, pump housing and valves.

Procedure of sand casting:



→ First of all on a clean floor we will set the inverted dragbox.

→ Then we will place the pattern inside the box & poured the moulding

sand into the box.
After that sand is rammed and level up.

→ The packed dragbox is then turned over and cop box is placed over it.

→ After that, the second half of the pattern is placed exactly over the first half of pattern.

→ Then the sand is filled and rammed tightly.

→ Now two boxes are opened and pattern is removed with the help of screw.

→ Boxes are again placed into position & clamped with reverse to prevent uper box of floating.

→ Gats and spour are form to poured the molten metal.

→ Now the molten metal is poured into the mould then it is allow to cool down for solidification.

→ After cooling the final cast is taken out.

Types of moulding sand:

1. Green sand
2. Dry sand
3. Loam sand
4. Facing sand
5. Backing sand
6. System sand
7. Parting sand
8. Core sand.

1. Green sand:

→ 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 & water furnish the bond of green sand. It is fine, soft, light and porous. Being damp, when squeezed in the hand, it retains the shape, the impression given to its under pressure. Mould prepared in this sand are known as green sand moulds.

2. Dry sand:

Gree sand that has been dried or baked after the mould is made is called dry sand. They are suitable for larger castings.

→ Moulds prepared in this sand are known as dry sand moulds.

Loam sand is high in clay, as much as 50 percent or so, and dries hard. This is particularly employed for loam moulding usually for large castings.

④ **Facing sand:**

Facing sand forms the face of the mould. It is used directly next to the surface of the pattern and it comes into contact with the molten metal when the mould is poured.

→ It is made of silica and clay.

→ The layer of facing sand in mould usually ranges from 20 to 30 mm

⑤ **Backing sand:**

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

→ It is also called as black sand.

⑥ **System sand:**

In mechanical foundries where machine moulding is employed a so-called system sand is used to fill the whole flask.

→ In mechanical sand preparation and handling units, no facing sand is used. The used sand is cleaned and reactivated by the addition of water binders and special additives. This is known as system sand.

⑦ **Parting sand:**

Parting sand is used to keep the green sand from sticking to the pattern and also to allow the sand on the parting surface of the cope and drag to separate without clinging.

This is clean clay-free silica sand which serves the same purpose as parting dust.

⑧ **Core sand:**

The sand used for making cores is called core sand/oil sand.

→ This is silica sand mixed with core oil which is composed of moulding linseed oil, resin, light mineral oil and other binding materials.

✯ **Patterns:**

A pattern is a replica of the object to be made by the casting process, with some modifications. The main modification are:

ⓐ The addition of pattern allowances

ⓑ The provision of core prints and

ⓒ The elimination of fine details, which cannot be obtained by casting and hence, are to be obtained by further processing.

✩ Pattern allowances:

The dimensions of the pattern are different from the final dimensions of the casting required. This is required because of the various reasons. These are details below:

① Srinkage:

All metals shrink when cooling except perhaps bismuth. This is because of inter-atomic vibrations which are amplified by an increase in temperature. However, there is a distinction to be made between liquid shrinkage and solid shrinkage.

✩ Liquid shrinkage:

It refers to the reduction in volume when the metal changes from liquid to solid state at the solidus temperature.

✩ Solid shrinkage:

It is the reduction in volume caused, when metal losses temperature in solid state. The shrinkage allowance is provided to take care of this reduction.

→ The rate of contraction with temperature is dependent on the material. For example, steel contracts to a higher degree compared to aluminium.

2) Finish or Machine allowances:

The finish and accuracy achieved in sandcasting are generally poor and, therefore, when the casting is functionally required to be of good surface finish or dimensionally accurate, it is generally achieved by subsequent machining. Also ferrous materials would have scales on the skin, which are to be removed by cleaning. Hence, extra material is to be provided which is to be subsequently removed by the machining or cleaning process.

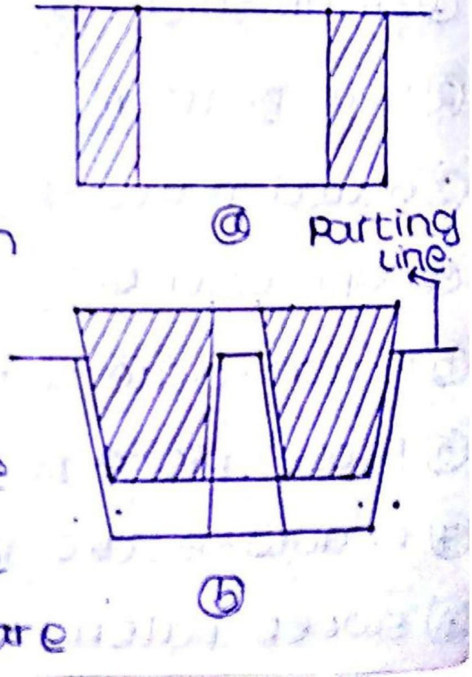
→ This depends on dimensions, the type of casting material and the finish required. This may range from 2 to 20 mm.

→ General guidelines for machining allowances are provided.

→ The machining allowance provided would ultimately have to be removed by machining.

3) Draft allowances:

→ At the time of withdrawing the pattern from the sand mould, the vertical faces of the pattern are in continual contact with the sand, which may damage the mould cavity. To reduce the chances of this happening, the vertical faces of the pattern are



always tapered from the parting line. This provision is called draft allowance.

④ Shake allowances:

→ Before withdrawl from the sand mould, the pattern is wrapped all round 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 allowances, since it is highly dependent on the foundry personnel and practies involved.

Types of Patterns:

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

① single-piece pattern

② split pattern or two-piece pattern

③ Gated pattern

④ cope and drag pattern

⑤ Match-plate pattern

⑥ Loose-piece pattern

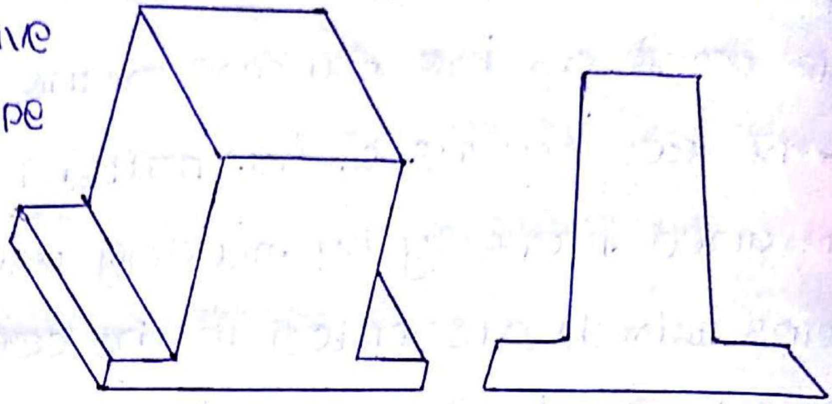
⑦ Follow-Board pattern

⑧ sweep patern

(9) skeleton pattern.

(1) single-piece pattern:

→ These are inexpensive and the simplest type of patterns. As the name indicates, they are made of a single piece.



(a) casting (b) Pattern

→ This type of pattern is used only in cases where the job is very simple and does not creat any withdrawl problems.

→ It is also used for applications in very small-scale production or in prototype development. This pattern is expected to be entirely in the drag.

→ One of the surfaces is expected to be flat which is used as the parting plane. If no such flat surface exists, the moulding may become complicated with the necessity of a follow board as explained later.

(2) split pattern or two-piece pattern:

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

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

③ Gated pattern:

This is an improvement over the simple pattern where the gating and runner system are integral with the pattern.

→ This would eliminate handcutting of the runners and gates and help in improving the productivity of a moulder.

④ Cope and Drag pattern:

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

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

⑤ **Match-plate pattern:**

These are extensions of the previous type. Here, the cope-and-drag patterns along with the gating and the risering are mounted on a single matching metal or wooden plate on either side.

→ On one side of the match plate, the cope flask is prepared and on the other, the drag flask. After moulding when the match plate is removed, a complete mould with gating is obtained by joining the cope and the drag together.

→ The complete pattern with match plate is enitirely made of metal, usually aluminium, for its light weight and machinability.

→ These are used generally used for small castings with higher dimensional accuracy and large production.

⑥ **Loose-piece pattern:**

This type of pattern is used when the contour of the part is such that, withdrawing the pattern from the mould is not possible.

Hence, during moulding, the obstructing part of the contour is held as a loose piece by a wire.

→ After moulding is over, first the main pattern is removed and then the loose pieces is a highly skilled job and is generally expensive and, therefore, should be avoided where possible.

⑥⑦ Follow-Board pattern:

This type of pattern adopted for those castings where there are some portions, which are structurally weak and if not supported properly are likely to break under the force of ramming.

→ Hence, the bottom board is modified as a follow board to closely fit the contour of the weak pattern and thus support it during the ramming of the drag.

→ During the preparation of the cope, no follow board is necessary because the sand that is already compacted in the drag will support the fragile pattern.

⑧ Sweep pattern:

It is used to sweep the complete casting by means of a plane sweep. These are used for generating large shapes, which are axi-symmetrical or prismatic in nature such as bell shaped or cylindrical. The greatly reduces the cost of a 3-D pattern.

(g) Skeleton pattern:

→ A skeleton of the pattern made of strips of wood is used for building the final pattern by packing sand around the skeleton. After packing the sand, the desired form is obtained with the help of a strickle.

→ The type of skeleton to be made is dependent upon the geometry of the workpiece. This type of pattern is useful generally for very large castings, required in small quantities where large expense on the complete wood pattern is not justified.

★ Cores:

Cores are materials used for making cavities and hollow projections, which cannot be normally produced by the pattern alone. Any complicated contour or cavity can be made by means of cores so that really intricate shapes can be easily obtained.

→ The normal characteristics desired of a core are the following.

(a) Green strength:

A core made of green sand should be strong enough to retain the shape till it goes for baking.

(b) Dry strength:

It should have adequate dry strength so that when the core is placed in the mould, it should be able to resist the metal pressure acting on it.

ⓒ **Refractoriness:**

Since in most cases the core is surrounded all round, it is desirable that the core material should have ~~earlier~~ higher refractoriness.

ⓓ **Permiability:**

Some of the gases envolving from the molten metal and generated from the mould may have to go through the core to escape out of the mould. Hence, cores are required to have higher permiability.

ⓔ **Collapsibility:**

As the casting cools, it shrinks, and unless the core has good collapsibility (ability to decrease in size) it is likely to provide resistance against shrinkage and thus can cause hot tears.

ⓕ **Friability:**

After the casting is completely cooled, the core should be removed from the casting before is processed further.

→ Hence, the friability (the ability to crumble) should also be a very important consideration.

ⓖ **Smoothness:**

The surface of the core should be smooth so as to provide a good finish to the casting.

ⓗ **Low-gases emission:**

Because of the high temperatures to which a core is subjected to, it should the only a minimal amount of gases to be evolved, such that voids in the casting can be eliminated.

---

cupola furnace:

→ It is used to melt cast iron.

Important part of cupola:

(i) shell
(ii) foundation
(iii) tuyers
(iv) wind belt
(v) Blower
(vi) slag hole
(vii) charging door
(viii) chimney or stack

(i) shell:

→ shell is a vertical and cylindrical in shape.
→ It is made of steel shell of thickness 6-12 and lined inside with refractories, bricks and clay.
→ Refractory, bricks and clay used for cupola lining consist of silica (SiO_2) and alumina (Al_2O_2).
→ cupola diameter varies from 1-2 meter and the height of cupola is 4-6 times of diameter.

(ii) Foundation:

The steel shell is mountained entire on a bricks works foundation or a steel columns.

→ The bottom of the shell consist of drop bottom doors.

→ Through which we can discharge coke, slag etc.

(iii) **Tuyeres:**

→ Air for combustion of fuel is delivered through tuyers.

→ Tuyers are provided at the height of between 0.6 - 1.2 meters above the working bottom.

(iv) **Wind belt:**

Air is developed to the tuyers from a wind belt which is a steel plate.

→ Wind box is mountained on the outer box of the cupola.

(v) **Blower:**

A high pressure fan or blower supplies, the air to the wind belt through the blast pipe or wind box.

(vi) **Slag hole:**

→ It is located at a level about 250 mm below the centre of the tuyers.

→ It is used to remove the slag from the cupola furnace.

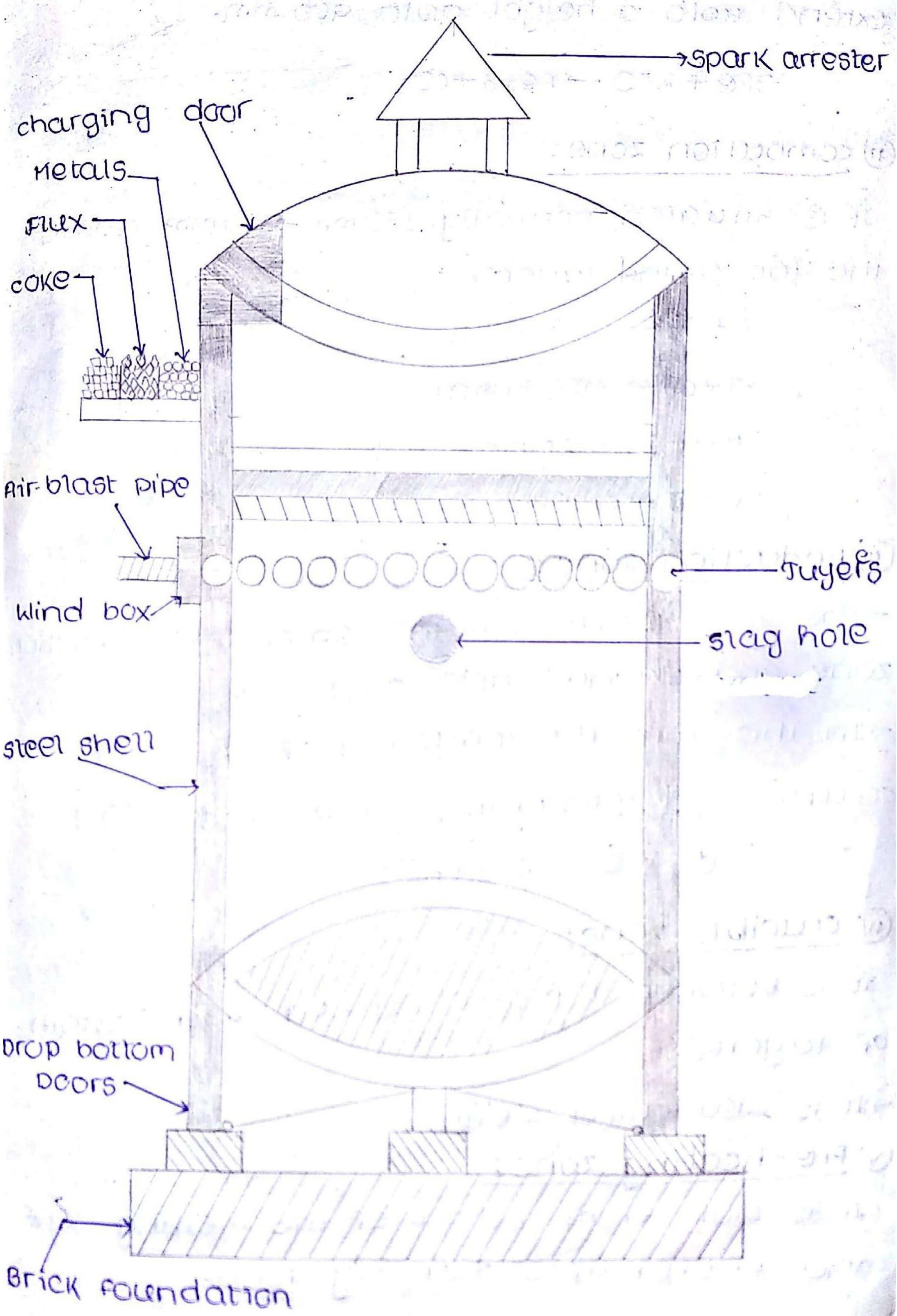
(vii) **Charging door:**

→ It is situated at 3-4 meters above the tuyers.

→ Through the charging door metal coke and flux are filled into the furnace.

(viii) chimney or stack:

→ The shell is usually continued for 4-5 m. above the changing door to form a chimney.



Different zones of cupola:

(i) Melting zone:

The zone starts from the top of the coke bed & extend upto a height upto 900 mm.

$$3Fe + 2CO \rightarrow Fe_3 3 + CO_2$$

(ii) Combustion zone:

It is situated normally 150 mm–300 mm above the top of the tuyers.

$$C + O_2 \rightarrow CO_2 + Heat$$

$$Si + O_2 \rightarrow SiO_2 + Heat$$

$$2Mn + O_2 \rightarrow 2MnO + Heat.$$

$$Fe + O \rightarrow FeO + Heat$$

(iii) Reduction zone:

→ The zone starts from the top of the combustion zone and extends upto coke bed.

→ In this zone the reduction of CO_2 to CO occurs and temperature drop about 1200°C.

$$CO_2 + C \rightarrow 2CO + Heat$$

(iv) Crucible zone:

It is between top of sand bed and bottom of tuyeres.

→ It is also called well.

(v) Pre-heating zone:

It is start from the top of the melting zone and extend upto charging doors.

→ It is also called charging zone, where the materials are re-heated.

(vi) stack zone:

→ It start from charging zone and extend upto the cupola.

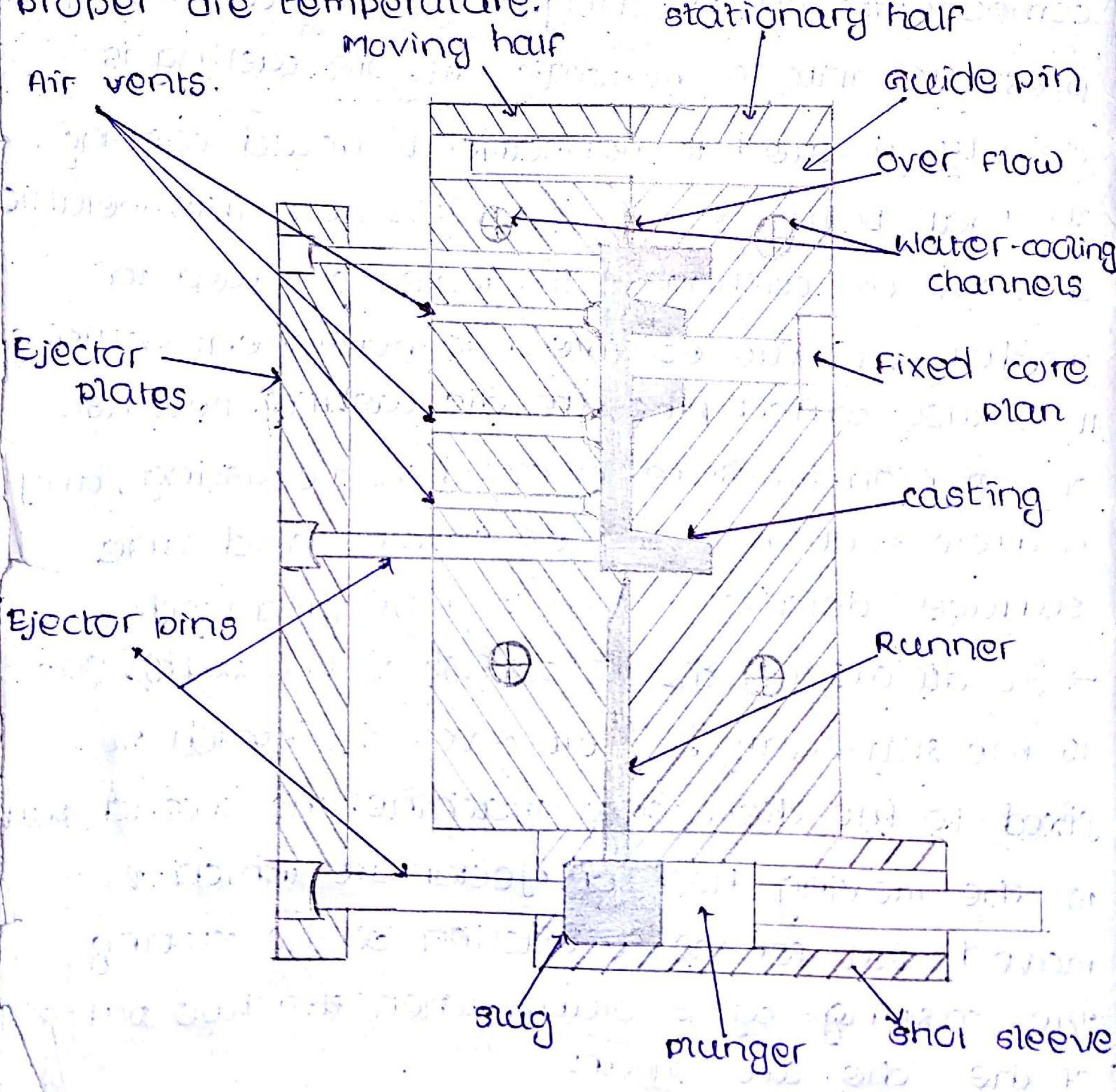
→ The gases generated within the furnace are carried out to the atmosphere by the stack zone.

☆ Die casting:

Die casting involves the preparation of components by injecting molten metal at high pressure into a metallic die. Die casting is closely related to permanent mould casting, in that both the processes use reusable metallic dies. In die casting, as the metal is forced in under pressure compared to permanent moulding it is also called pressure die casting. Because of the high pressure involved in diecasting, any narrow sections, complex shapes and fine surface details can easily be produced.

→ In die casting, the die consist of two parts. One is the stationary half or cover die which is fixed to the die-casting machine. The second part is the moving half or ejector die which is moved out for the extraction of the casting. The casting cycle starts when the two parts of the die are apart.

The lubricant is sprayed on the die cavity manually or by the autolubrication system so that the casting will not stick to the die. The two die halves are closed and clamped. The required amount of metal is injected into the die. After the casting is solidified under pressure, the die is opened and the casting is ejected. The die-casting die needs to have the provision of ejectors to push the casting after it gets solidified. It will also have cooling channels to extract the heat of the molten metal to maintain proper die temperature.



→ The die casting machines are of 2 types:

(i) Hot-chamber die casting

(ii) cold-chamber die casting

→ The main difference between these 2 types is that in the hot chamber, the holding furnace for the liquid metal is integral with the die-casting machine, whereas in the cold-chamber machine, the metal is melted in a separate furnace and then poured into the die-casting machine with a ladle for each cycle which is also called shot.

(i) <u>Hot-chamber die casting:</u>

A typical hot-chamber die-casting machine is shown in the figure. In this, a gooseneck is used for pumping the liquid metal into the die cavity. The gooseneck is submerged in the holding furnace containing the molten metal. The gooseneck is made of grey alloy or ductile iron, or of cast steel. A plunger made of alloy cast iron, and which is hydraulically operated, moves up in the gooseneck to uncover the entry port for the entry of liquid metal into the gooseneck. The plunger can then develop the necessary pressure for forcing the metal into the die cavity. A nozzle at the end of the gooseneck is kept in close contact with the sprue located in the cover die.

The operating sequence of the hot-chamber process. Cycle starts with the closing of the die, when the plunger is in the highest position in gooseneck, thus facilitating the filling of the gooseneck by the liquid metal. The plunger then starts moving down to force the metal in the gooseneck to be injected into the die cavity. The metal is then held at the same pressure till it is solidified. The die is opened, and any cores, if present, are also retracted. The plunger then moves back returning the unused liquid metal to the gooseneck.

(ii) **Cold-chamber process:**

The hot-chamber process is used for most of the low-melting temperature alloys such as zinc, lead and tin. For materials such as aluminium and brass, their high melting temperatures make it difficult to cast them by the hot-chamber process, because the gooseneck of the hot-chamber machine is continuously in contact with the molten metal. Also, liquid aluminium would attack the gooseneck material and thus hot-chamber process is not used with aluminium alloys. In the cold-chamber process, the molten metal is poured with a ladle into the shot chamber for every shot. This process reduces the contact time between the liquid metal & the shot chamber.

→ The operation starts with the spraying of die lubricants throughout the die cavity and closing of the die when molten metal is ladled into the shot chamber of the machine either manually by a hand ladle or by means of an autoladle. An autoladle is a form of a robotic device which automatically scoops molten aluminium from the holding furnace and pours into the die at the exact instant required in the casting cycle. The metal volume and pouring temperature can be precisely controlled with an autoladle and hence the desired casting quality can be had. Then the plunger forces the metal into the die cavity and maintains the pressure till it solidifies. In the next step, the die opens. The casting is ejected. At the same time, the plunger returns to its original position completing the operation.

❀ Centrifugal casting:

This is process where the mould is rotated rapidly about its central axis as the metal is poured into it. Because of the centrifugal force, a continuous pressure will be acting on the metal as ~~poured into~~ it solidifies. The slag, oxides and other inclusions being lighter, get separated from the metal and segregates toward the centre.

→ There are 3 main types of centrifugal casting:

① True centrifugal casting:

This is normally used for the making of hollow pipes, tubes, hollow bushes, etc. which are axi-symmetric with a concentric hole. Since the metal is always pushed outward because of the centrifugal force, no core needs to be used for making the concentric hole. The axis of rotation can be either horizontal or vertical or any angle in between. Very long pipes are normally cast with horizontal axis, whereas short pieces are more conveniently cast with a vertical axis.

Process:

First, the moulding flask is properly rammed with sand to confirm to the outer contour of the pipe to be made. Any end details, such as spigot ends or flanged ends are obtained with the help of dry sand cores located in the ends. Then the flask is dynamically balance so as to reduce the occurance of undesirable vibrations during the casting process. The finished flask is mounted in between the rollers and the mould is rotated slowly. Now the molten metal in requisite quantity is poured into the mould through the movable pouring basin. The amount of metal poured determines the thickness of the pipe to be cast. After the pouring is complete, the mould is rotated as its operational speed till it solidifies, to form the requisite tubing. Then the mould is replaced by a new mould machine and the process is continued.

→ Metal mould can also be used in the true centrifugal casting process for large quantity production. A water jacket is provided around the mould for cooling it. The casting machine is mounted on wheels, with the pouring ~~ladder~~ ladle with has a long spout extending till the other end of the piple is made. To start, the mould is rotated with the metal being delivered at the extreme end of the pipe. The casting machine is slowly moved down the track allowing the metal to be deposited all along the length of the pipe. The machine is continously rotated till the pipe completely solidified. Afterwards, the pipe is extracted from the mould and the cycle repeated.

Advantages

1. The mechanical properties of centrifugally cast jobs are better compared to other processes, because the inclusions such as

Slag and oxides get segregated towards the centre and can be easily removed by machining. Also, the pressure acting on the metal throughout the solidification causes the porosity to be eliminated giving rise to dense metal.

2. Up to a certain thickness of objects, proper directional solidification can be obtained starting from the mould surface to the centre.

3. No cores are required for making concentric holes in the case of true centrifugal casting.

4. There is no need for gates and runners, which increases the casting yield, reaching almost 100%.

__Limitations:__

① Only certain shapes which are axi-symmetric and having concentric holes are suitable for true centrifugal casting.

② The equipment is expensive and thus is suitable only for large quantity production.

(ii) __Semicentrifugal casting:__

Semicentrifugal casting is used for jobs which are more complicated than those possible in true centrifugal casting, but are axi-symmetric in nature. It is not necessary that these should have a central hole, which is to be obtained with the help of a core. The moulds made of sand or metal are rotated about a vertical axis and the metal enters the mould through the central pouring basin. For larger production rates, the moulds can be stacked one over the other, all feeding from the same central pouring basin. The rotating speeds used in this process are not as high as in the case of true-centrifugal casting.

(iii) **Centrifuging:**

In order to obtain higher metal pressures during solidification, when casting shapes are not axis-symmetrical, the centrifuging process is used. This is suitable only for small jobs of any shape. A number of such small jobs are joined together by means of radial runners with a central sprue on a revolving.
The jobs are uniformly placed on the table around the periphery so that their masses are properly balanced.

★ **Investment casting:**

This is the process where the mould is prepared around an expendable pattern.

The various steps in the process are shown in the figure. The first step in this process is the preparation of the pattern for every casting to be made. To do this, molten wax, which is used as the pattern material is injected under pressure of about 2.5 MPa into a metallic die, which has the cavity of the casting to be made. The wax is then allowed to solidify would produce the pattern. The pattern is ejected from the die.

→ Then the cluster of wax patterns are attached to the getting system by applying heat.

→ To make the mould, the prepared pattern is dipped into a slurry made by suspending fine ceramic materials in a liquid, such as ethyl sillicate or sodium sillicate.

→ The excess liquid is allowed to drain off from the pattern. Dry refractory grains such as fused silica or zircon are "stuccoed" on the liquid on this ceramic coating. Thus a small shell is formed around the wax pattern. The shell is cured and then the process of dipping and stuccoing is continued with ceramic slurries of gradually increasing grain sizes.

Finally when a shell thickness of 6 to 15 mm is reached, the mould is ready for further processing. The shell thickness required depends on the casting shape and mass, type of ceramic and the binder used.

→ The next step in the process is to remove the pattern from the mould, which is done by heating the mould to melt the pattern. The melted wax is completely drained through the sprue by inverting the mould. Any wax remnants in the mould are dissolve with the help of the hot vapour of a solvent, such as trichloro-ethylene

Advantages:

(i) complex shapes, which are difficult to produce by another method are possible since the pattern is withdrawn by melting it.

(ii) No machining required.

(iii) very fine details and thin sections can be produced by this.

Limitations:

→ This process is normally limited by the size and mass of the casting.

→ This is a more expensive process because of larger manual labour involved in the preparation of the pattern and the mould.

Applications:

This process was used in the olden days for the preparation of artefacts, jewellery and surgical instruments. Presently, the products made by this process are blades for gas turbines, shuttle eyes for weaving.

Casting defects

→ Any irregularity in the moulding process causes defects in casting which may sometimes tolerated, sometimes eliminated with proper moulding practice or repaired using methods such as welding and metallisation.

(i) Gas defect

(ii) Shrinkage defect

(iii) Moulding-material defects

(iv) Pouring metal defects

(v) Metallurgical defects.

(i) Gas defects:

The defects in this category can be classified into blow holes and open blows, air inclusion and pin-hole porosity.

(a) Blowholes and open blows:

These are the spherical, flattened or

elongated cavities present inside the casting or on the surface.

→ on the surface they are called open blows and inside, they are called blowholes.

→ These are caused by the moisture left in the mould and the core. The main reason for this is low permeability of the sand mould.

ⓑ Air-inclusion:

The atmospheric and other gases absorbed by the molten metal in the furnace, in the ladle, and during the flow in the mould, when not allowed to escape, would be trapped inside the casting and weaken it.

→ The remedies would be choose the appropriate pouring temperature and improving gating practice by reducing the turbulence.

ⓒ Pinhole porosity:

This is caused by hydrogen in the molten metal. The main reason for this is the high pouring temperature with increases the gas pick-up. This is particularly severe in aluminium alloys or steels and iron having aluminium.

ⓘ Shrinkage cavity:

These are caused by the liquid shrinkage occuring during the solidification of the casting

To compensate this, proper feeding of liquid metal is required as also proper casting design.

(iv) <u>Moulding material defects:</u>

The defects that can be put in this category are cuts and washes, metal penetration, fusion, run out, rat tails and buckles, swell and drop.

(a) <u>Cuts and washes:</u>

These appears as rough spots and areas of excess metal, and are caused by erosion of moulding sand by the flowing molten metal. This may be caused by the moulding sand not having enough strength or the molten metal flowing at high velocity.

(b) <u>Metal penetration:</u>

When the molten metal enters the gaps between the sand grains, the result would be a rough casting surface. The main reason for this that the grain size of the sand is too coarse, or no mould wash has been applied to the mould cavity. This can also be caused by higher pouring temperatures. Choosing appropriate grain size, together with a proper mould wash should be able to eliminate this defect.

3. FUSION

This is caused by the fusion of sand grains with the molten metal, giving a brittle, glassy appearance on the casting surface. The main reason for this defect is that the clay in the moulding sand is of lower refractoriness, or that the pouring temperature is too high. The choice of an appropriate type and amount of bentonite would cure this defect.

4. RUNOUT

A run out is caused when the molten metal leaks out of the mould. This may be caused either due to faulty mould making or because of the faulty moulding flask.

5. RAT TAILS BUCKLES

Rat tail is caused by the compression failure of the skin of the mould cavity because of the excessive heat in the molten metal under the influence of the axes heat, the sand expands, thereby moving the mould wall backwards and in the process when the wall gives away the casting surface may have this marked as a small line, with a no. of such failures the casting surface may have a no. of criss-crossing small lines. Buckles are the rat tails which are severe.

The main causes for these defects are the moulding sand has got poor expansion properties and hot strength or the heat in the pouring metal is too high.

6. Swell

under the influence of the metallostatic forces, the mould wall may move back causing a swell in the dimensions of the casting. The main cause of this is the faulty mould making procedure adopted.

7. DROP

The dropping of loose moulding sand or lumps normally from the cope surface into the mould cavity is responsible for this defect.

IV. POURING METAL DEFECTS

a. Misruns and cold shuts

Misrun is caused when the metal is unable to fill the mould cavity completely and thus living ~~ca~~ unfilled cavities.

A cold shut is caused when two metal streams while meeting in the mould cavity, do not fuse together properly, thus causing a discontinuity or weak spot in the casting as shown in Fig 5.11. This defect can also be caused when the heat-removal capacity is increased such as in case of green sand moulds. The casting with large surface area to volume ratio are more likely to be prone to these defects. This defect is also caused in moulds which are not properly vented because of the back pressure of the gases. The remedies are basically improving the mould design.

b. Slag Inclusions

During the melting process, flux is added to remove the undesirable oxides and impurities present in the metal. At the time of tapping, the slag should be properly removed from the ladle, before the metal is poured into the mould. This can be eliminated by some of the slag-trapping methods discussed in chapter 4 such as pouring basin screens or runner extensions.

Metallurgical Defects

The defects that can be grouped under this category are hot tears and hot spots.

A

1. Hot spots

These are caused by the chilling of the casting. For example, with grey cast iron having small amounts of silicon, very hard white cast iron may result at the chilled surface. This hot spot will interface with the subsequent machining of this region. Proper metallurgical control and chilling practices are essential for eliminating the hotspots.

As seen from earlier paragraph, the remedies of some defects are also the cause of others, Therefore, the foundry engineer has to analyse the casting from the viewpoint of its final application and thus arrive at a proper moulding procedure to eliminate or minimise the most undesirable the casting defects.

Powder metallurgy

→ Powder metallurgy is an art and science of producing fine metal powders and then making objects from individul, mixed or alloyed metal powders with or without the inclusion of non-metallic constituents.

→ For making a component by powder metallurgy,

(i) The metal in the powder form must be able to respond to solid phase welding.

(ii) The metal powder form must be capable of sufficiently close packing under pressure to permit welding to take place and, in case of alloying, be capable of being sufficiently intimately mixed.

Applications of powder metallurgy:

(i) Porous products, e.g., bearings and filters.

(ii) Refractory parts, e.g., components made out of Tungsten, Tantalum and Molybdenum, and used in electric bulbs, radio valves, oscillator valves, x-ray tubes in the form of filament, cathode, anode, control grids etc.

(iii) Products of complex shapes that require considerable machining when made by other processes, e.g., toothed components such as gears.

(iv) Automotive components such as electrical contacts, crankshaft drive or camshaft sprocket, piston rings and rocker shaft brackets, door machanisms, connecting rods etc.

(v) products made from materials that are very difficult to machine, e.g., tungsten carbide etc.

Advantages of powder metallurgy:

→ The dimensional accuracy and surface finish obtainable are such that for many applications all machining can be eliminated.

→ cleaner and quieter operation and longer life of the components.

→ High production rates.

→ No material is wasted as scrap.

→ structure and properties can be controlled.

→ Highly qualified or skilled labour is not required.

→ Impossible parts can be produced.

Disadvantages of powder metallurgy:

→ complicated shapes, such as produced by casting, cannot be made by powder metallurgy.

→ Do not have as good physical properties as wrought or cast parts.

→ Relatively high tool and die cost is associated with the process.

→ powdered metals are considerably more expensive than those in wrought forms.

→ powder metallurgy is not economical for small scale production.

powder metallurgy process:

The principal steps in a powder metallurgy process include:

ⓐ obtaining / producing metal powders in a suitable degree of fineness and purity.

ⓑ weighing and mixing of the necessary powders and lubricants to arrive at a composition which processes satisfactorily and which produces desired properties in the fabricated part.

ⓒ pressing the powder in a suitable mold of required shape and size to cause cohesion to occur between the powder particle.

ⓓ presintering the powder compact by heating and holding it at a moderate temperature. Presintering develops additional green strength and drives off mixing lubricants or moisture.

ⓔ sintering the compacted mass at a temperature high enough to cause diffusion and integranular crystal growth to occur.

ⓕ Finishing and sizing the final product. In addition to above, one or more of the

Following treatments may also be required for metal components.

(g) Annealing

(h) Repressing for greater density or closer dimensional control.

(i) Machining

(j) Polishing

(k) Rolling, forging or drawing.

(l) Surface treatments to protect against corrosion.

☆ Presintering and sintering :

Presintering :

Frequently, powder metallurgy is used to make parts from materials that are very difficult to machine. When some machining is required on such parts, one goes for pre-sintering before the actual sintering operation.

→ After presintering operation, the compacted part acquires sufficient strength to be handled and machined without difficulty. Moreover, very little dimensional change takes place, then, in the final sintering, therefore, machining after final sintering may be eliminated.

→ For presintering, the compacted parts are heated for a short time at a temperature considerably below the final sintering temperature.

→ presintering is necessary when holes are to be drilled in hard to machine parts.

→ presintering, in addition, removes lubricants and binders added to the powders during the blending operation.

→ presintering can be eliminated if no machining of the final products is required.

Sintering:

→ After being compressed into a briquette of the shape required in the finished component, the agglomerated metals are sintered.

→ sintering is done to achieve all possible final strength and hardness needed in the finished product.

→ sintering consists of heating pressed metal or cermet compacts in batch or continuous furnaces to a temperature below the melting point of the major constituent in an inert or reducing atmosphere, where time, temperature, heating rate and cooling rate are automatically controlled.

→ Most metals are sintered at 70 to 80% of the melting temperature, e.g., porous bronze bearings require treatment for only a few minutes at 800°c, iron base compacts and cemented carbides require treatment for up to 2 hours at 1200-1250°c etc.

Press work

Presswork may be defined as a manufacturing process by which various components are made from sheetmetals. This process is also called as cold stamping. The machine used for press work is called press.

A frame which support a ram or a slide and a bed, a source of mechanism for operating the ram in line with an normal to bed. The ram is equiped with suitable punch or punches and a die block assembly is generally called a die ster or simply a die.

☆ Press working Dies:

The major classification of press working die is given below:

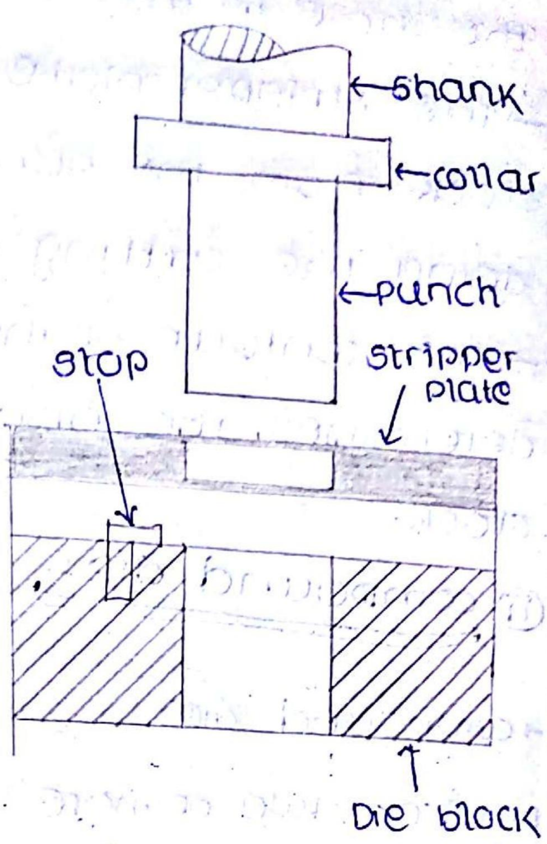
(i) single operation dies
(ii) compound dies
(iii) combination dies
(iv) Gang and follow dies

(v) progressive dies

(vi) transfer dies

(vii) forming dies.

(i) single operation dies:



→ single operation dies are used when there are only piercing or simple trimming and cutting operations. A simple forming die might also be considered a single-operation die.

→ A single operation die may be a

(i) Blanking die (ii) piercing die (iii) shaping dies such as bending die, curling die, wiring die and bulging die.

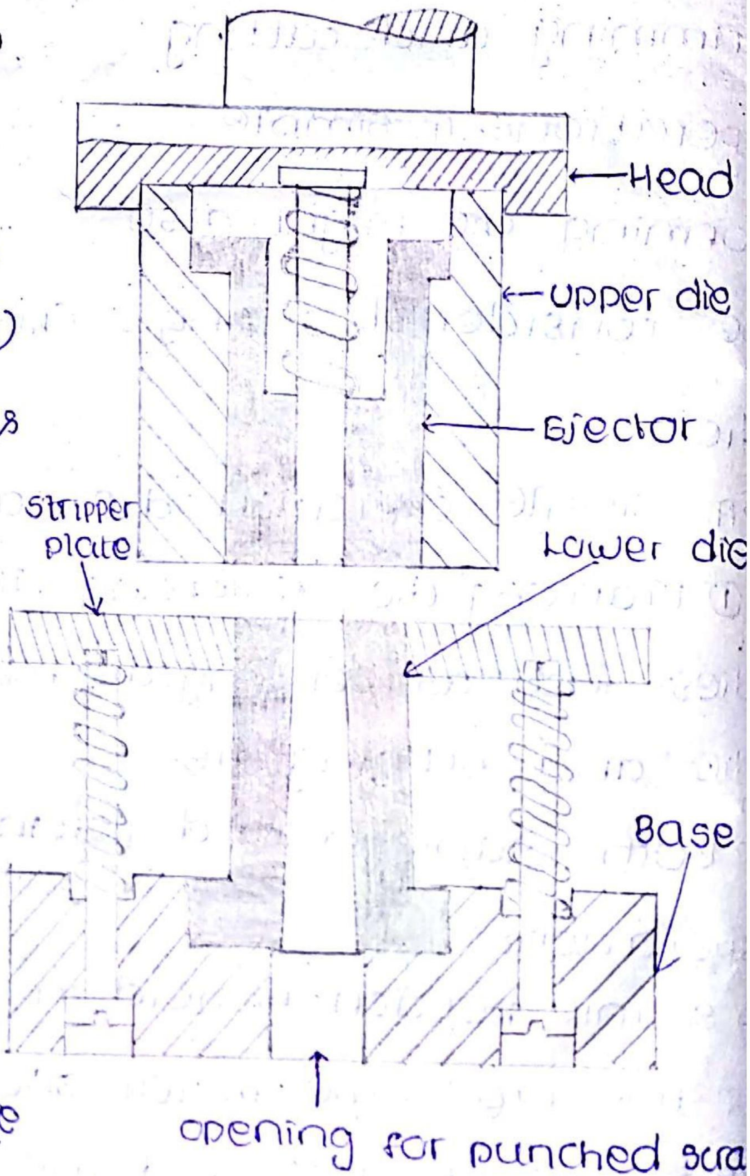
→ Both blanking and piercing are cutting operations.

→ shank portion is held in the ram or slide of the press. The metal sheet is held between the striper plate and the die block, resting against the stop so that same amount of sheet stocks is fed every time for the cutting operation. As the punch descends it cuts the metal sheets. The punch fits into the hole in the die block.

→ The stripper plate helps to removal of the stock from the punch as it moves up after doing the cutting operation.

→ The contour of the punch and die determines the final shape of the sheet metal stock.

(ii) compound die:



→ compound dies perform two or more operations (at a time) in a single stage & assure that greatest accuracy of the product, but are limited to relatively simple processes such as blanking punching etc. A compound die does not only cutting operations.

→ The metal sheets is placed between the upper die and the lower. Both blanking & piercing is carried out during the same stroke of the press.

→ The blanking operation on the metal sheet is carried out by the telescopic action of the upper and lower dies (the lower die acting as a punch) as the upper die descends. At the same time that the blank is cut, the punch pieces a hole in the centre of the blank.

~~→~~

(iii) **Progressive Dies:**

→ Many parts are of a geometry that can not be directly formed, either because the depth to diameter ratio is too large or because the shape has steps, conical portions etc., requiring several successive draws. A compound die for such jobs is often inadequate and progressive or transfer dies are required.

→ A progressive die is a multiple-station die.

→ It performs a number of sheet metal operations at two or more stations during each stroke of the press. The aim is to develop the workpiece as the (metal) strip stocks moves through the die.

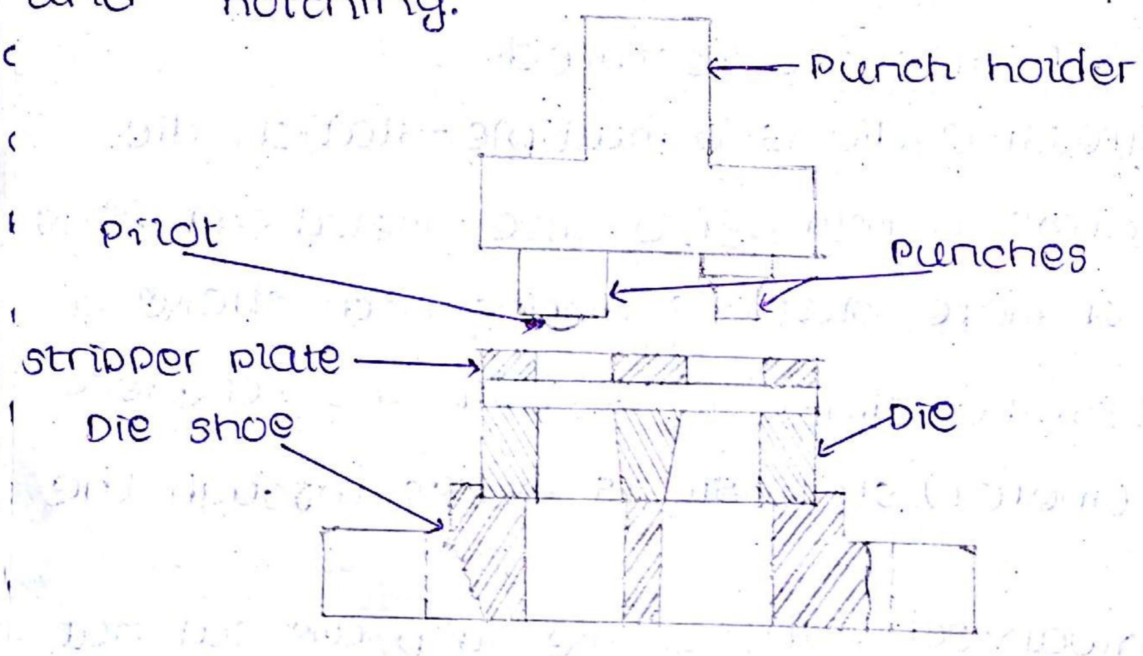
→ The unwanted parts of the strip are cut out as it advances through the die and one or more tabs are left connected to each partially completed part to carry it through the station of the die.

→ The metal strip to be operated upon is fed between the die and the stripper plate. A stop provided for locating the leading end of the strip and during this first stroke only the slot is punched.

→ The strip is next advanced the distance between adjacent stages to another stop. During the next stroke, 2 operations are performed on the strip stock, one at each stage.

→ For proper operation, the strip stock must be positioned accurately in each stage or station. A commonly used method of stock positioning is the incorporation of pilots in the system.

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



(A progressive die)

☆ Blanking:

→ Blanking is the operation of cutting a shape from a metal strip. The piece detached from the strip is known as blank and is used for further operations. The remaining metal strip is scrap.

→ Blanking is nearly always the first operation and may be the only necessary, or it may be followed successively by many others.

→ Blanking is often combined with other operations in one tool, all the work being performed at one stroke of the press.

→ A blanking die must have clearance, otherwise the blank would not fall freely, it might remain struck in the die block.

☆ Piercing:

→ Piercing is a punching operation. However piercing is a distinct hole making process characterized by the lack of scrap from the hole. In piercing, a pointed, bullet-shapped punch is forced through the sheet metal to produce a hole with a rough flange around the hole.

☆ Trimming:

→ During any press working operation, in which the part must be held in place by the press, the outer edge of the part, which is the area usually gripped, becomes marked and scored. Trimming is the cutting off this excess metal edge.

→ Trimming dies are similar to blanking dies and the part is forced through the die by a suitable punch to carry out trimming operation.

→ Trimming may be the last operation in a progressive die to separate the parts from the strip.

→ Trimming may be performed horizontally or vertically depending upon the configuration of the part.

Jigs and Fixtures

→ The jigs and fixtures are the economical means to produce repetitive type of work by incorporating special work holding and tool guiding devices.

Jigs

A jig may be defined as a device which holds and locates a workpiece and guides and controls one or more cutting tools. In construction, a jig comprises a plate, structure or box made of metal or in some cases of non-metal having provision for holding the components in identical position one after the other, and then guiding the tool in correct position on the work in accordance with the drawing, specification, or operation layout.

Fixture:

A fixture may be defined as a device which holds and locates a workpiece during an inaspection or for a manufacturing operation. The fixture does not guide the tool. In construction, the fixtures comprise different standard o specially designed work holding devices, which are clamped on the machine table to hold the work in position.

Advantages of using Jigs and Fixtures:

(i) It eliminates the marking out, measuring, and other setting methods before machining.

(ii) It increases the machineing accuracy, because the workpiece is automatically located and the tool is guided without making any manual adjustment.

(iii) It enables production of identical parts which are interchangeable. This facilitates the assembly operation.

(iv) It increases the production capacity by enabling a number of workpieces to be machined in the single set up, and in some cases a number of tools may be made to operate simultaneously. The handling time is also greatly reduced due to quick setting and locating of the work. The speed, feed and depth of cut for machining can be increased due to high clamping rigidity of jigs and fixtures.

(v) It reduces the operator's labour and consequent fatigue as the handling operations are minimized and simplified.

(vi) It reaches semi-skilled operator to perform the operations ~~as~~ as the setting operations of the tool and the work are mechanized. This saves labour cost.

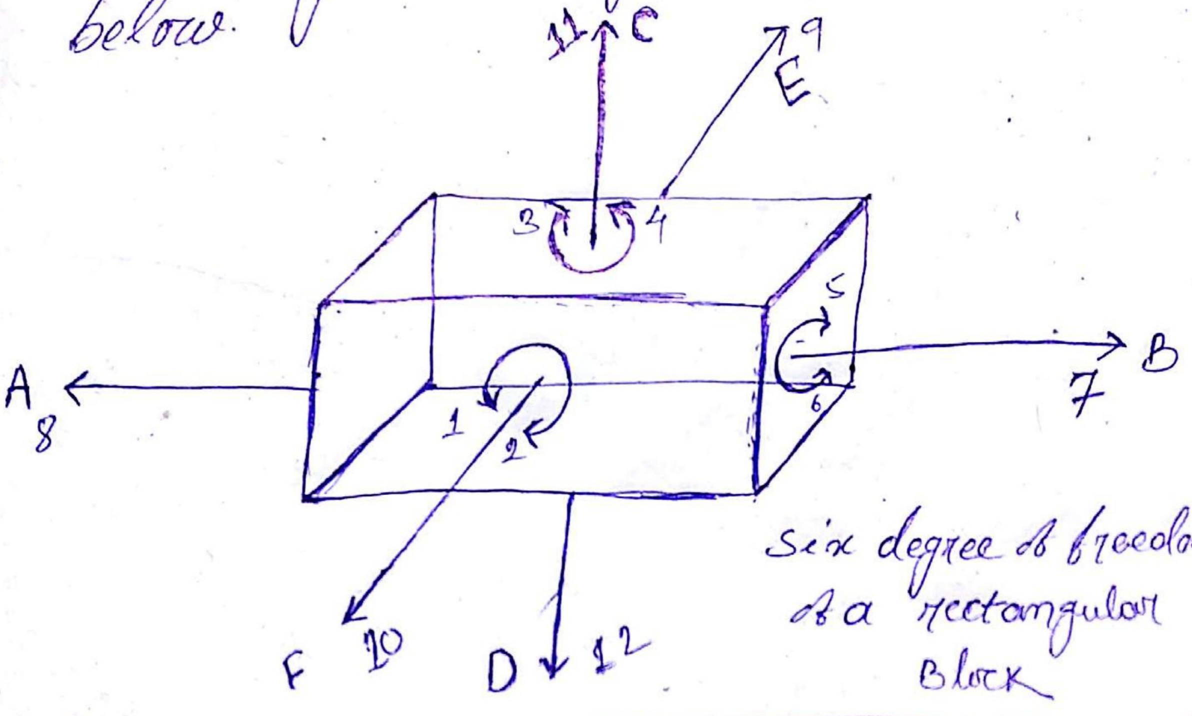
(vii) It reduces the expenditure on the quality control of the finished products.

(viii) It reduces the overall cost of machining by fully or partly automatising the processes.

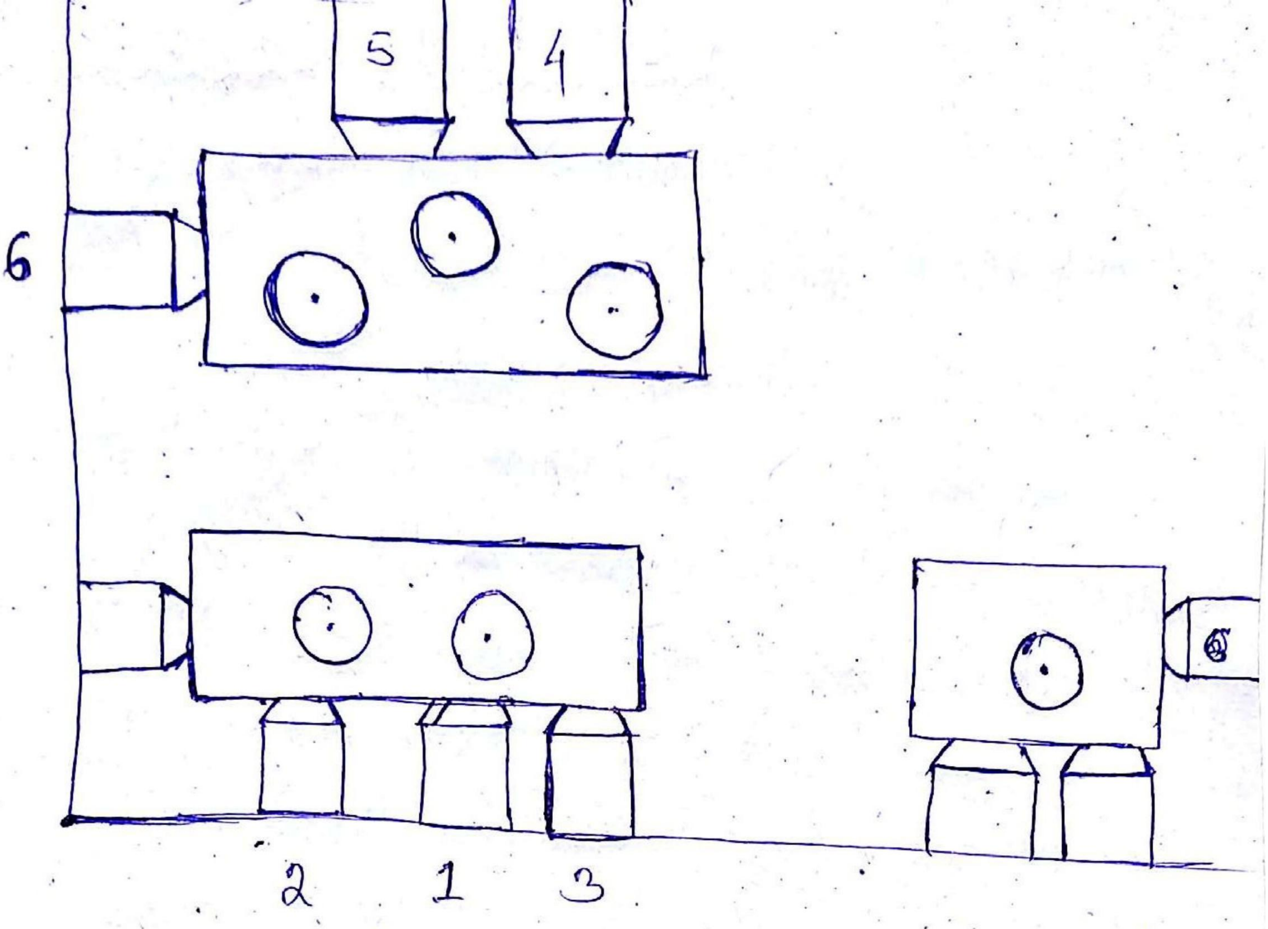
Principle of location:

Principle of Location

As illustrated in the figure a rectangular block is free to move along the axis, AB, CD, and EF. The body can also rotate about these axis, and thus the total degrees of freedom of a body along which it can move in six. In order to locate the block correctly within a jig, all these six movements must be restrained by arranging suitable ~~location~~ locating points and then clamping the block in position. The principle of determining locationg point of certain typical objects are describe below.



Six degree of freedom of a rectangular Block



6 point location of a rectangular block

→ It is assumed that the block in the figure is made to rest on several point on the jig body as shown in the figure. The bottom of the block is supported.

→ The bottom of the block is supported againts 3 points. The rear face of the block bears againts 2 point and the side of the block rest againts a single point

→ All projecting from the jig body it will be now clear that the downward moment of the block along CD is restricted by the 3 supporting ~~points~~ pins which have the capacity of supporting even a rough casting

→ The movement along EF and AB axis are restricted by the double and the single point restruct.

→ The six points thus serve to locate a block correctly while resting all the movements.

→ The locating points for uneven objects can be determined by different arrangement but the guiding principle remain same.

Type of jig and fixture.

1) Template jig
2) plate jig
3) channel jig
4) Diameter jig
5) Leaf jig.
6) Ring jig.
7) Box jig.

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