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	PRODUCTION TECHNOLOGY (TH1)	
	PRITY ANIVA XESS	

Lecture :-

A forming processes is a particular process in which you make use of suitable stresses (compression, tension, shear or combined stresses) to cause plastic deformation of the materials to produce required shapes. The mass remains unchanged.

Plastic deformation is the deformation which is permanent and beyond the elastic range of the material.

Extrusion -

Extrusion is the process of confining the metal in a closed cavity and then allowing it to flow from only one opening so that the metal will take the shape of the opening.

eg: squeezing of tooth paste out of the tooth paste tube.

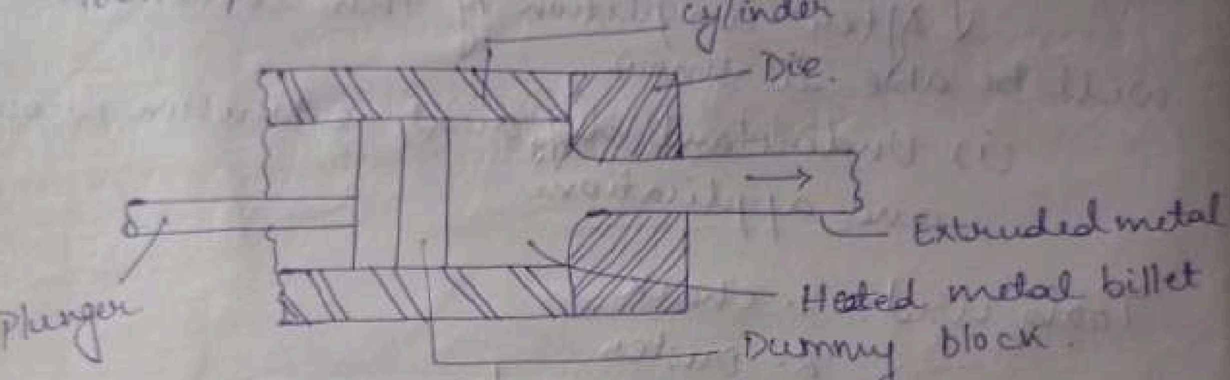


Fig: Typical Extrusion setup

A dummy block which is a steel disc of about 40 mm thick with a diameter slightly less than the container is kept between the hot billet and the ram or plunger to protect it from the heat and pressure.

Extrusion is a single-pass process. The amount of reduction that is possible in extrusion is large. Generally, brittle materials can also be very easily extruded. It is possible to produce sharp corners and angles.

The extrusion ratio is defined as the ratio of cross-sectional area of the billet to that of the extruded section. The value of the extrusion ratio are 20 to 50.

Since hot extrusion involves temperatures in the range of 500 to 1200°c depending on the work material extruded, the cylinder and ram are severely affected by the temperature as well as the therm. The pressure applied may range from 35 to 1000 MPa. The extrusion pressure for a given material depends on the extrusion temperature, the reduction in area and the extrusion speed. The extrusion speed depends on the work material. Too high an extrusion speed would cause excessive heat generation in the extruded metal causing lateral cracks.

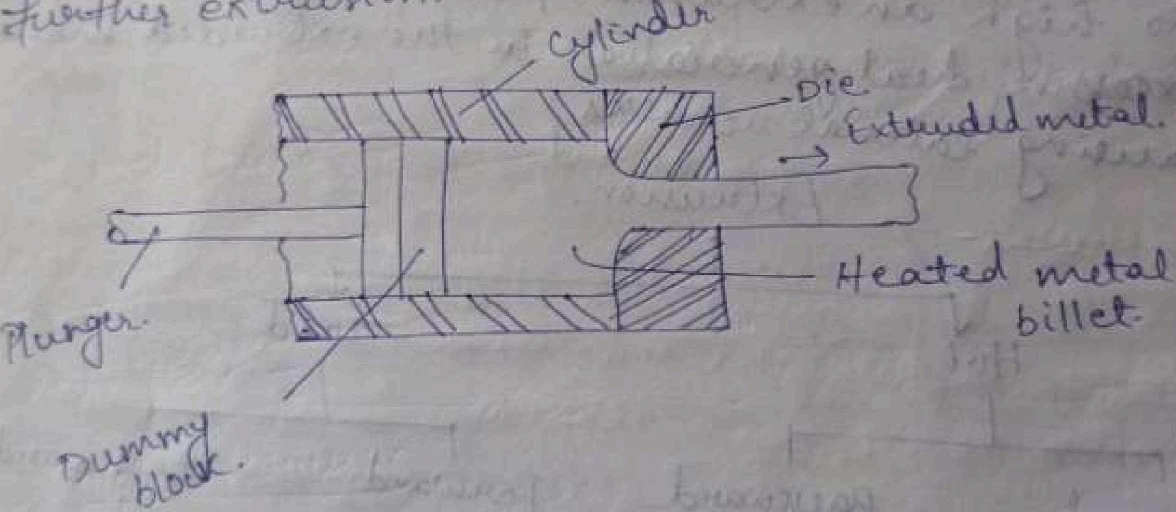
Extrusion.

- Hot
  - Forward
  - Backward
- Cold
  - Forward
    - Hydrostatic extrusion.
  - Backward
    - Cold extrusion forging
    - Impact extrusion

Hot Extrusion Processes.

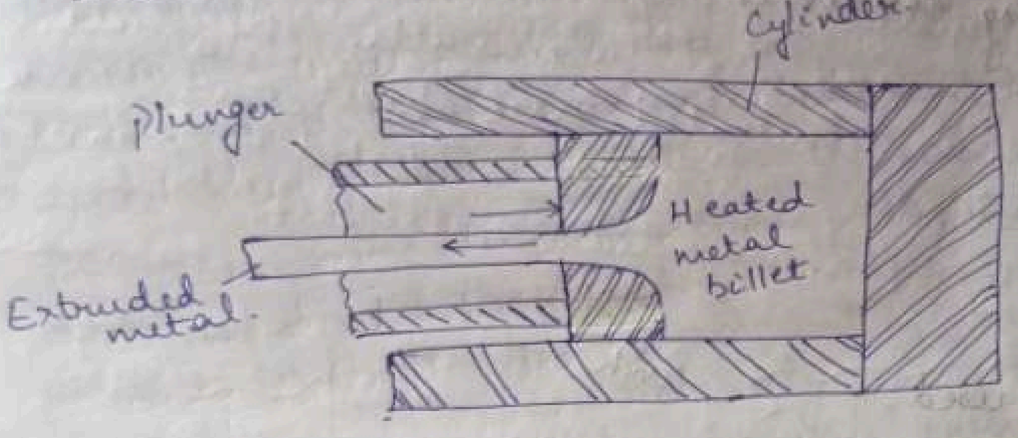
1. Forward Hot Extrusion.

It signifies the flow of metal in the forward direction, i.e the same as that of the ram. In this, the friction problem arises. Due to the relative motion between the heated metal billet and the cylinder walls. To reduce this friction, lubricants are to be used. At lower temperatures, a mixture of oil and graphite is generally used. To reduce the damage to equipment, extrusion is finished quickly and the cylinder is cooled before further extrusion.



Backward Hot Extrusion

In order to completely overcome, the friction the backward hot extrusion is used. In this the metal is confined fully by the cylinder. The ram which houses the die, also compresses the metal against the container, forcing it to flow backwards through the die in the hollow plunger or ram. It is termed backward because of the opposite direction of the flow of metal to that of ram movement. Thus the billet in the container remains stationary and hence no friction. The surface quality achieved is generally good since there is no heat cracking due to the friction between the billet and the extrusion cylinder interface.



Backward hot extrusion process.

Model Questions

1. Define Extrusion process.
2. Differentiate forward and backward hot extrusion process.
3. Name an Extrusion process by which a toothpaste tube can be produced?

References:

1.

Cold Extrusion.

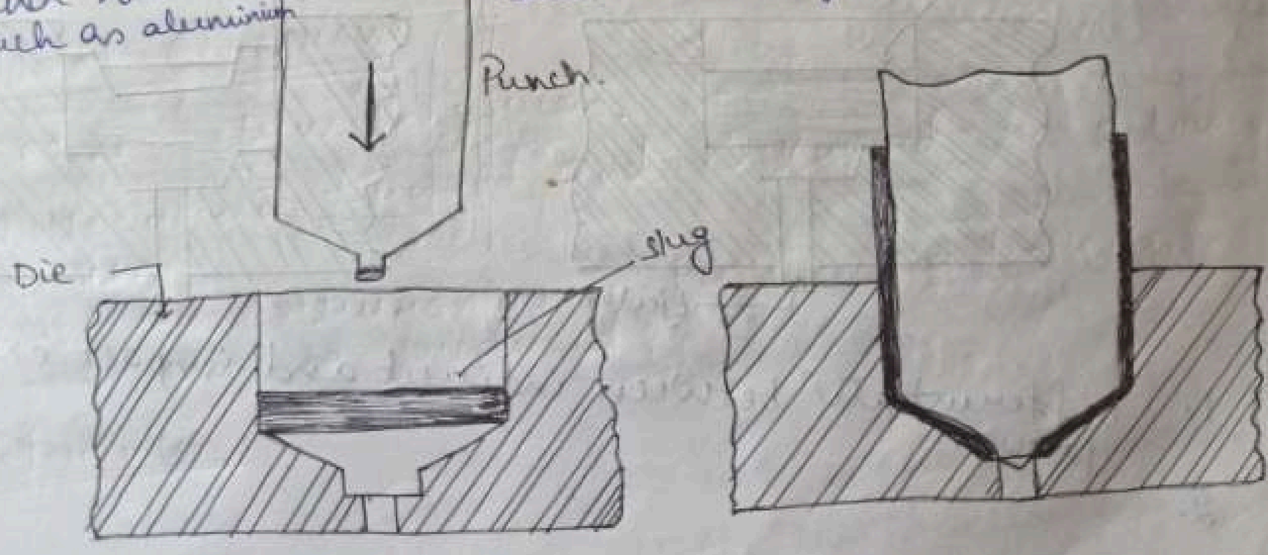
Forward cold Extrusion

The forward cold extrusion is similar to that of forward hot extrusion. In this the extrusion ratio are lower and extrusion pressures are higher than that of hot extrusion. It is normally used for simple shapes requiring

better finish and to improve mechanical properties
Ex: Cans, aluminium brackets, shock absorber cylinders
rocket motors and heads etc.

Impact Extrusion

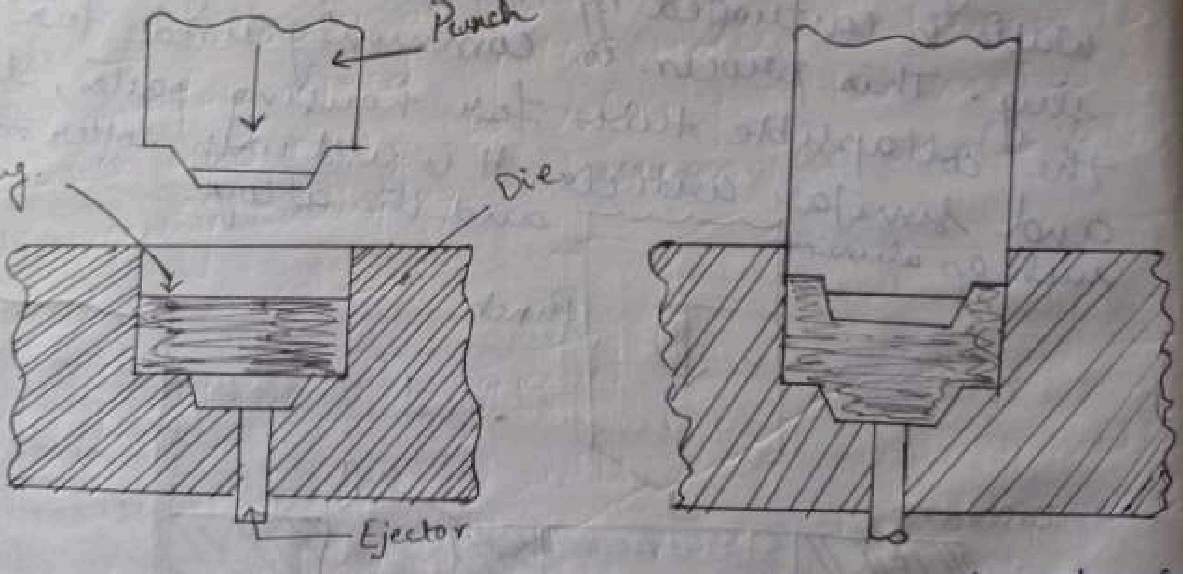
The backward cold extrusion is also called the impact extrusion. The set up consists of a die and a punch. The slug for making the component is kept on the die and the punch strikes the slug against the die. The metal is then extruded through the gap between the punch and die opposite to the punch movement. Because of the impact force, the side walls go straight along the punch. The height of the side walls is controlled by the amount of metal in the slug. This process is commonly used for making the collapsible tubes for housing pastes, liquid and similar articles. It is used with softer materials such as aluminium and its alloys.



Impact Extension.

Cold Extrusion Forging

The cold extrusion forging is similar to impact extrusion but with the main difference that the side walls are much thicker and their height is smaller. This also contains a die and punch set. The punch slowly descends over the slug kept on the die, thus forging some metal between the punch and the die and the rest being extruded through the clearance between the punch and die side walls. The side walls thus generated are short and thick. Afterwards, the component is ejected by means of the ejector pin provided in the die.



1. Differentiate between indirect and impact extrusion process.

2.

Rolling

Rolling is a process where the metal is compressed between two rotating rolls for reducing its cross-sectional area. It is one of the most widely used of all the metal working processes, because of its higher productivity and low cost. Rolling would be able to produce components having constant cross-section throughout its length. Many shapes such as I, T, L and channel sections are possible. It is also possible to produce special sections such as railway wagon wheels by rolling individual pieces.

Rolling is normally a hot working process. The metal is taken into rolls by friction and subsequently compressed to obtain the final shape.

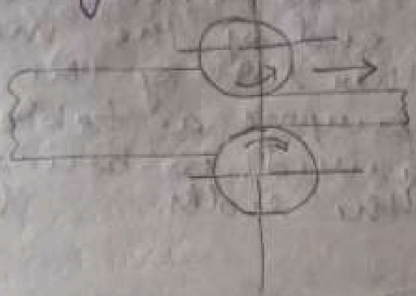
The thickness of the metal that can be drawn into ~~the~~ rolls depend on the roughness of the roll surface. Rougher rolls would be able to achieve greater reduction than smoother rolls. The volume of the metal that enters the rolling stand should be same as that leaving it except in initial passes, where there might be some loss due to filling of voids and cavities in the ingots. Since the area of the cross section gets decreased, the metal leaving the rolls would be at a higher velocity than when it entered. Initially, when the metal enters the rolls, the surface speed of rolls is higher than that of the incoming metal, whereas the metal velocity at the exit is higher than that of the surface speed of the rolls. Between the entrance and exit, the velocity of the metal is continuously changing, whereas the roll velocity remains constant.

Rolling - Stand Arrangement

The arrangement of rolls in a rolling mill, also called rolling stand, varies depending on the application.

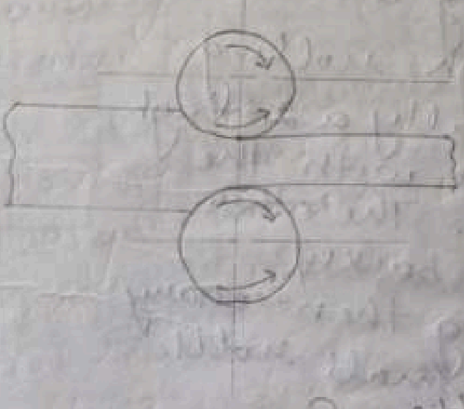
(i) 2- High rolling stand

The 2 high rolling stand arrangement is the most common arrangement. In this, the rolls always move in only one direction.



(ii) 2- High Reversible rolling stand

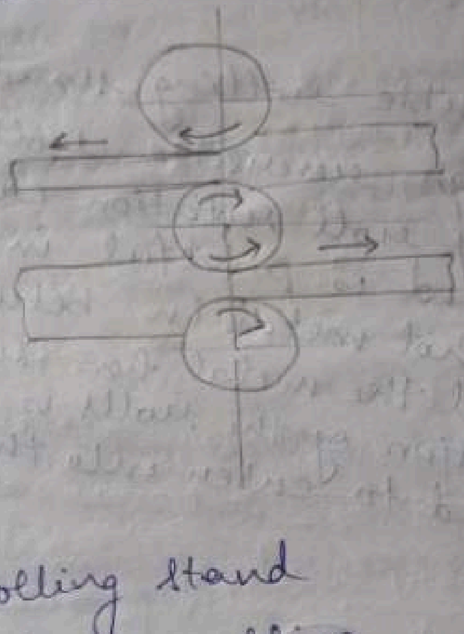
A 2- high reversible rolling stand, where the direction of roll rotation can be reversed. This type of stand is useful in reducing the handling of the hot metal in between the rolling passes. When all the metal has reached the right side, the direction of the rolls is reversed and the metal is allowed to enter into the next pass.



2- high Reversible

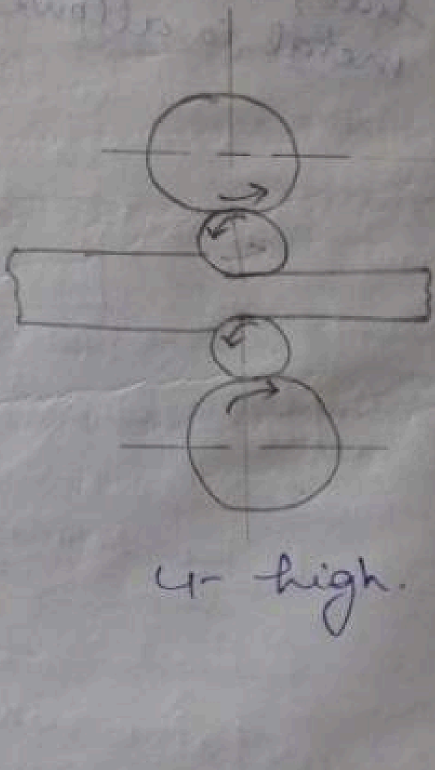
(iii) 3- high rolling stand

The 3- high rolling stand arrangement is used for rolling of two continous passes in a rolling sequence without reversing the drive. After all the metal has passed through the bottom roll set, the end of the metal is entered into the other set of the rolls for the next pass. For this purpose a table - tilting arrangement is required to bring the metal to the level with the rolls.



(iv) 4- high rolling stand

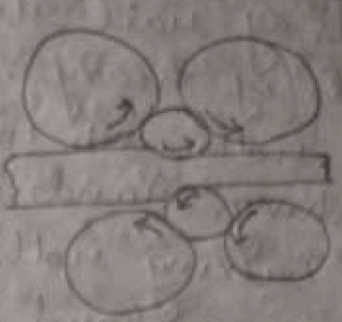
A 4- high rolling stand is essentially a 2- high rolling mill, but with the small sized rolls. The other two rolls are the backup rolls for providing the necessary rigidity to the small rolls.



4- high.

(v) Cluster

A better backup can be provided to the small rolls with a cluster arrangement of rolls.



Cluster

The steel coming out of a blast furnace or a remelting shop is in the form of an ingot which has a cross section of the order of 600 x 600 mm. These ingots are further processed in rolling mills to produce the intermediate shapes such as blooms, slabs and billets.

Blooms are generally square cross section varying from 150 x 150 mm to 400 x 400 mm. Slabs are rectangular cross section with widths varying from 500 to 1800 mm and thickness varying from 50 to 300 mm. Billets are rectangular cross sections with sizes varying from 40 x 40 mm to 150 x 150 mm.

The ingot obtained by casting would normally have defects such as shrinkage cavities, blow holes and slag inclusions. When the ingot is rolled, the shrinkage cavity is towards the end, which is then cropped after a few initial passes to reduce the defects in the finished products.

The rolls are generally manufactured of chilled cast iron, carbon steel and alloy steels. The soft rolls with hardness range of 150 to 250 BHN are used in roughing stands of the heavy section mills and billet mills. The semi-hard rolls with 250 to 400 BHN are used in roughing stands of rail structure mills, and finishing stands of heavy section mills and billet mills. Hard rolls with 400 to 600 BHN are used to make finishing stands of sheets, railway structures and backing rolls for small-diameter rolls. The extra hard rolls with 600 to 800 BHN are used for cold rolling.

Welding is the fabrication process that joins materials, usually metals or thermoplastics by causing fusion which is distinct from lower temperature metal joining techniques such as soldering or brazing which donot melt the base metal.

Welding is a process of joining metallic components with or without application of heat with or without pressure and with or without filler metal. Common examples are aircraft and ship bodies, bridges, building trusses, welded machine frames, sheet-metal parts etc. The fabrication is often the most economical method, and relies on raw material obtained from one of the primary manufacturing processes such as rolling and extrusion. Hence, it may be called as secondary manufacturing process. The various fabrication processes can be classified as follows.

→ Mechanical joining by means of bolts, screws and rivets
→ Adhesive bonding by employing synthetic glues such as epoxy resins.
→ Welding, brazing and soldering.

The choice of a particular fabrication method depends on a number of factors pertaining to the joint such as.

→ type of assembly permanent, semi-permanent or temporary
→ materials being joined, steels, cast irons, aluminium, similar or dissimilar metals,
→ economy achieved, and
→ the type of service required, such as assembly subjected to heavy loading, impact loading, high temperatures etc.

Welding is a metallurgical fusion process. The interface of the two parts to be joined is brought to a temperature above the melting point and then allowed to solidify, so that a permanent joining takes place.

The welding broadly divided into two groups.

1. Forge or Pressure welding (under pressure without additional filler metal)
2. Fusion or non-pressure welding (with additional filler metal)

Forge or pressure welding

- Heat created by
  - Blacksmith's fire
    - Blacksmith forge welding.
  - Electric current
    - Resistance welding
      - Spot welding
      - Seam welding
      - Projection welding
      - Upset butt welding
      - Flash butt Welding
      - Percussion Welding
  - Friction.
    - Friction welding
- cold pressure welding

Fusion or non-pressure welding

- Heat created by
  - Electric arc
    - Atomic hydrogen welding.
    - Carbon arc welding
    - Metal arc welding
    - Submerged arc welding
    - Inert gas welding
      - Tungsten inert gas welding.
      - Metallic inert gas welding
    - Stud arc welding.
  - Gas
    - Oxy-acetylene welding
  - Chemical reaction
    - Thermit welding

Flux

A flux is a substance used to prevent the formation of oxides and the other unwanted contaminations, or to dissolve them and facilitate removal. During welding the flux melts and becomes a liquid slag, covering the operation and protecting the molten weld metal. The slag hardens upon cooling and must be removed later by chipping or brushing.

Types of Fluxes:

1. Halide Fluxes ($CaF_2 - NaF$)
2. Oxide Fluxes ($MnO - SiO_2$, $FeO - MnO - SiO_2$)
3. Halide - Oxide Fluxes ($CaF_2 - CaO - Al_2O_3$)

Functions of Flux in Welding.

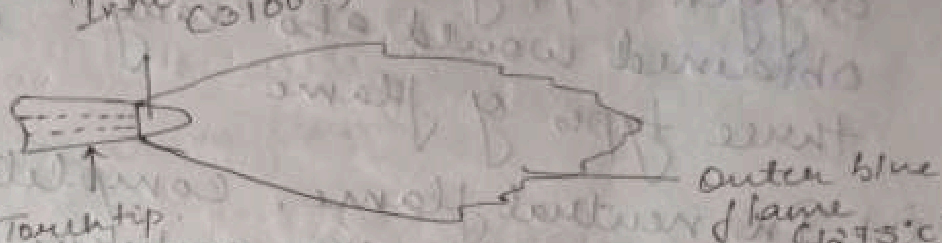
1. Provide protective atmosphere for welding.
2. Stabilize the arc and control arc resistivity.
3. Reduce spattering
4. Permit use of different types of current and polarity.
5. Promote slag detachability.

Oxy - Acetylene Welding Process.

Gas welding is also called Oxy - Fuel gas welding (OFW), derives the heat from the combustion of a fuel gas such as acetylene in combination with oxygen. The process is a fusion - welding process wherein the joint is completely melted to obtain the fusion. The heat produced by the combustion of gas is sufficient to melt any metal..

The fuel gas generally used is acetylene because of the high temperature generated in the flame. This process is called Oxy-Acetylene Welding (OAW).

In all the oxy-fuel gas welding process the combustion takes place in two stages. The first reaction takes place when the fuel gas such as acetylene and oxygen mixture burn releasing intense heat. This is present as a small white cone.



Schematic of an oxy-acetylene gas welding flame (neutral flame)

For the oxy-acetylene welding, the following reaction takes place in this zone.

$$C_2H_2 + O_2 \rightarrow 2CO + H_2 + 448 \text{ KJ/mol}$$

The carbon monoxide (CO) and hydrogen produced in the first stage further combine with the atmospheric oxygen and give rise to the outer bluish flame,

$$4CO + 2H_2 + 3O_2 \rightarrow 4CO_2 + 2H_2O + 812 \text{ KJ/mol}$$

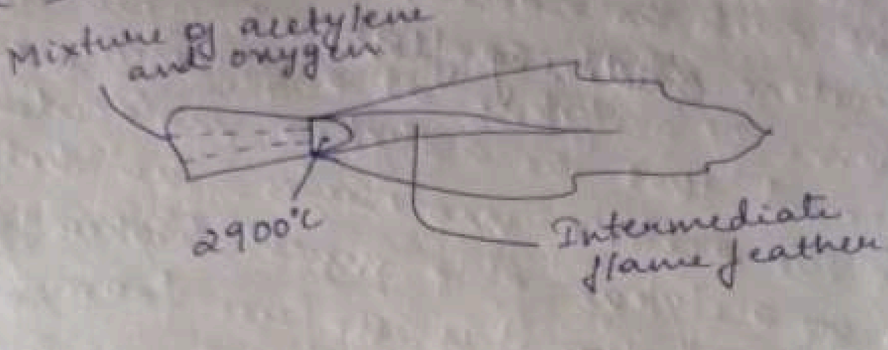
Though higher amount of heat is produced in the second stage, since it is distributed over a larger area, the temperature achieved is small (of the order of 1200 to 2000°c) in the flame, which may be used for preheating the steels. The inner white cone temperature is of the order of 3100°c, which is used for directly melting the steel joint

A certain amount of oxygen is required for complete combustion of fuel gases. When the oxygen supply varies, the flame appearance obtained would also vary. There are three types of flame.

(i) In neutral flame, complete combustion takes place. All the acetylene present is completely burned and thus all the available heat in the acetylene is released. Thus, this is the most desirable flame to be used in oxy-acetylene welding.

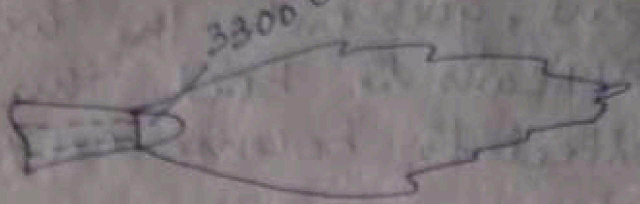
(ii) Carburizing flame - When less oxygen is provided part of the combustible matter is left as it is and it results in a reducing or carburising flame. This flame is similar to the neutral flame, only with the addition of a third phase in between the outer blue flame and the inner white cone. It is called 'intermediate flame ~~the~~ feather' which is reddish in colour.

The length of the flame feather is an indication of the excess acetylene present. Since unburned carbon present, goes into the weld metal pool, the metal appears to boil. This excess carbon causes the steel to become extremely hard and brittle.



Carburising flame.

(iii) Oxidizing flame - When oxygen is in excess, it is called the oxidising flame. The flame is similar to the neutral flame with the exception that the inner white cone is some what small, giving rise to higher tip temperature (3300°C). There is an excess amount of oxygen present in the flame, which badly oxidises the weld metal. Because of the burning of the metal, the weld pool foams and sparks. This also produces a loud noise. This flame would be useful for welding some non-ferrous alloys such as copper-base alloys and zinc base alloys.



Oxidising flame.

Lectures:-

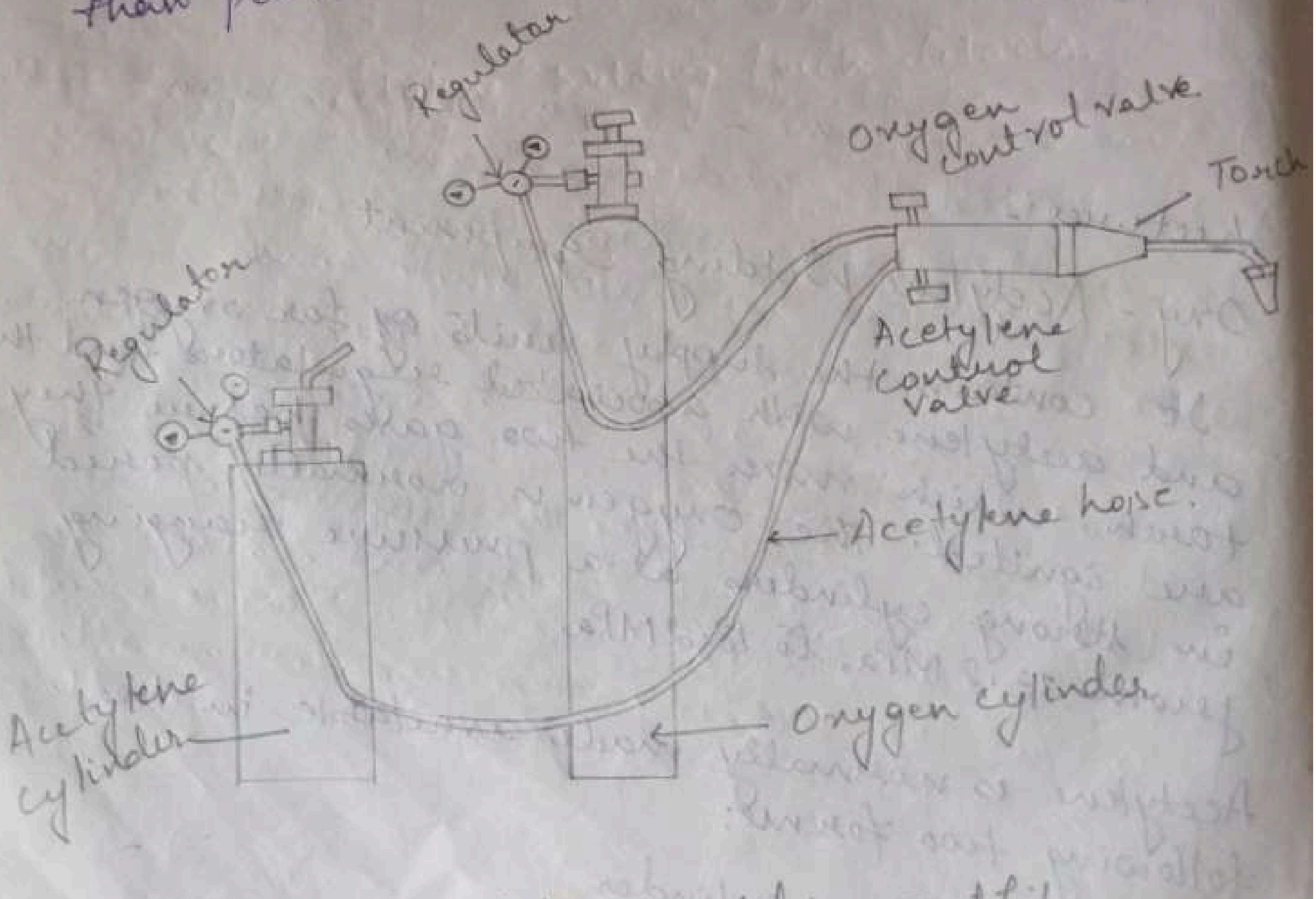
Oxy - Acetylene Welding Equipment

It contains the supply units of for oxygen and acetylene with associated regulators and the torch, which mixes the two gases before they are ignited. The oxygen is normally stored in strong cylinders at a pressure ranging from 13.8 MPa to 18.2 MPa.

Acetylene is normally made available in the following two forms:

1. Acetylene storage cylinder.
2. Acetylene generator.

Free acetylene is highly explosive, if stored at a pressure more than 200KPa, where it becomes very unstable and is likely to explode. Hence acetylene needs to be carefully stored in a strong cylinder, filled with 80 to 85% porous material such as calcium silicate and then filled with acetone which can absorb upto 420 times its volume of acetylene at a pressure of 1.75MPa. It is expected that the acetylene molecules fit in between the acetone molecules. This helps in storing ~~of~~ acetylene at a much higher pressure than permitted when it is in free form.



Oxy- acetylene welding outfit

Acetylene would be released from acetone at a slow rate and thus would not form any pockets of high pressure acetylene. The rate of release depends on the temperature of the gas.

Acetylene generator

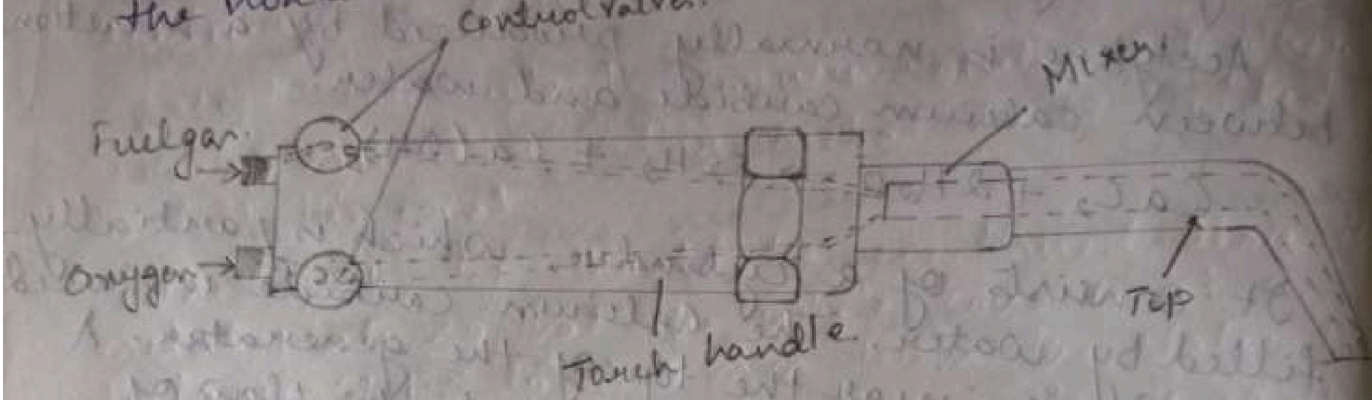
Acetylene is normally produced by a reaction between calcium carbide and water.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$

It consists of a cylinder, which is partially filled by water. The calcium carbide is stored in a hopper near the top of the generator. A pressure regulated valve controls the flow of calcium carbide into water, depending on the pressure of the acetylene in the generator. The acetylene is taken out through a gas pipe. The acetylene generator would be permitted to produce acetylene to a safe pressure of 100 KPa.

Acetylene generator

The oxygen and acetylene from the two cylinders are brought through separate ho pipes to the welding torch. In the torch, the tw gases are mixed and then flowed out through the nozzle at the torch tip.



Oxy-acetylene welding torch details.

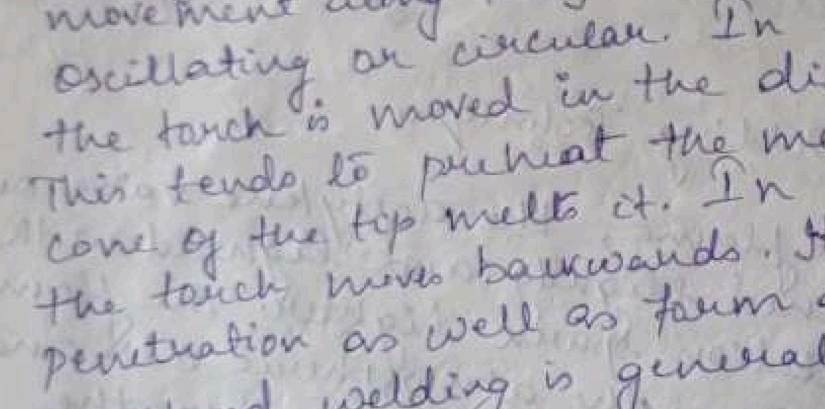
Oxy - Acetylene Welding Technique

To light the flame, the acetylene valve on the torch is opened slightly and lighted with the help of a friction spark lighter. The flame draws the oxygen from the atmospheric air and thus results in a reducing flame. Then the acetylene valve is opened to get the required flow of acetylene. The oxygen valve is then slowly opened till the intermediate flame feather of the reducing flame recedes into the inner white cone.

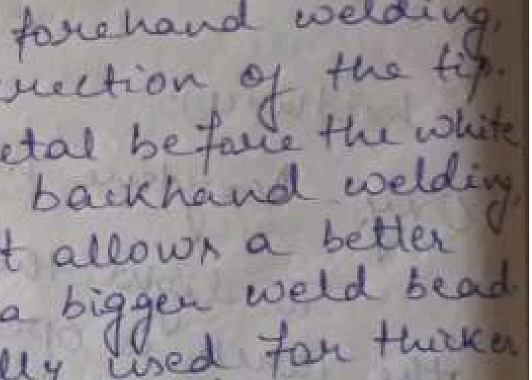
The choice of the torch size depends on the thickness of the metal to be joined. Larger torch tip sizes causes higher amount of oxygen and fuel to flow out, causing the release of more heat. Thus, for thicker metals, larger tip radii are to be used.

Except for outside corner joints, all other joint require a filler metal to be added to fill the joint.

The torch tip should be positioned above the metal plate so that the white cone is at a distance of 1.5 to 3.0 mm from the plate. The torch should be held at an angle of 30 to 45 degrees from the horizontal plane. The torch movement along the joint should be either oscillating or circular. In forehand welding, the torch is moved in the direction of the tip. This tends to preheat the metal before the white cone of the tip melts it. In backhand welding, the torch moves backwards. It allows a better penetration as well as form a bigger weld bead. Backhand welding is generally used for thicker materials.



Fore hand welding



Back hand welding.

When the welding rod is used to provide filler material, it is necessary to hold it at a distance of 10mm from the flame and 1.5 to 3.0 mm from the surface of the puddle (weld metal pool). This way the rod gets preheated and when dipped into the puddle would readily get melted. So, as and when filler metal is required, the welder dips the preheated welding rod into the puddle.

Resistance welding.

Resistance welding process is a fusion welding process where both heat and pressure are applied on the joint but no filler metal or flux is added. The heat necessary for the melting of the joint is obtained by the heating effect of the electrical resistance of the joint and hence the name is resistance welding.

In Resistance welding, a low voltage and high current is passed through the joint for a very short time ($\approx 0.25s$). The high amperage heats the joint, due to the contact resistance at the joint and melts it. The pressure on the joint is continously maintained and the metal fuses together under this pressure.

The heat generated in resistance welding can be expressed as:

$$H = K I^2 R t$$

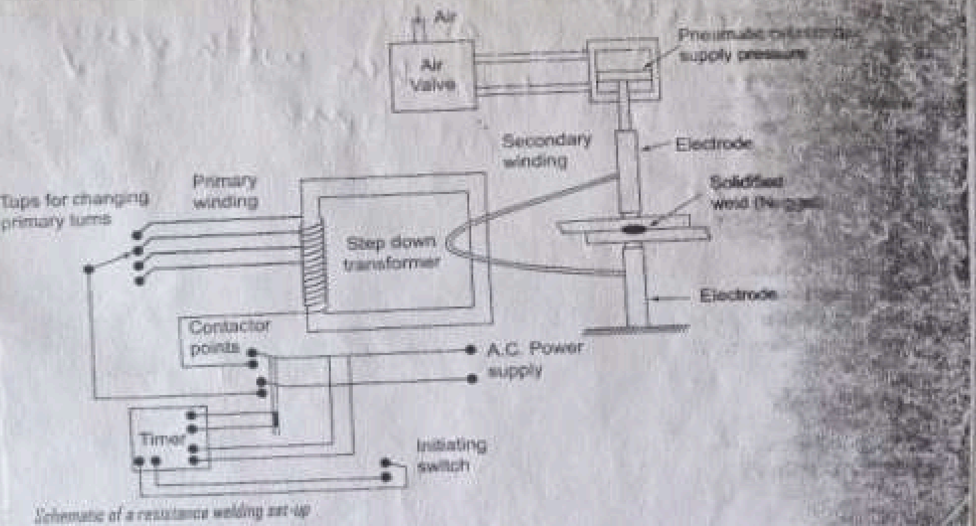
H = Total heat generated in the work, J

I = Electric current, A

t = Time for which the electric current is passing through the joint, s

R = Resistance of the joint, ohm.

K = constant.



Schematic of a resistance welding set-up

The main requirement of the process is the low voltage and high current power supply. This is obtained by means of a stepdown transformer. The secondary windings are connected to the electrodes which are made of copper to reduce their electrical resistance. The time of the electric supply needs to be closely controlled so that the heat released is just enough to melt the joint and the subsequent fusion takes place due to the force on the joint. The force required can be provided either mechanically, hydraulically or pneumatically.

One of the important characteristics of the resistance welding is the transfer of heat to the two parts being joined differently so that proper fusion obtained even when the plates are dissimilar from the stand point of material or thickness. The proper fusion can be obtained only if there is proper heat balance. This is taken care by providing an electrode with a smaller contact area at the thinner sheet and a thicker electrode at the thicker sheet together with very high current densities for short times.

Advantages of the Resistance Welding.

→ Very little skill is req. to operate the resistance welding machine.
→ These are very well suited for mass production as they give a high production rate.
→ There are no consumables used in this process
→ Heating of the work piece is confined to a very small part, which results in less distortion.
→ It is possible to weld dissimilar metals as well as metal plates of different thickness.

Disadvantages

→ The resistance welding machine is highly complex with various elements such as a heavy transformer, electrodes and heavy conductors for carrying the high currents.
→ Certain resistance welding processes are limited only to lap joints.

The various resistance welding processes are:-

→ Resistance spot welding.
→ Resistance seam welding
→ Projection welding.
→ Upset welding
→ Flash welding.

Resistance Spot Welding

The resistance spot welding is also called spot welding. This is the most common resistance welding process. This is done to join two sheet metal jobs in lap joint forming a small nugget at the interface of the two plates.

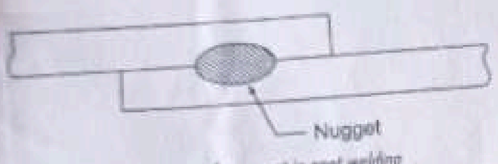
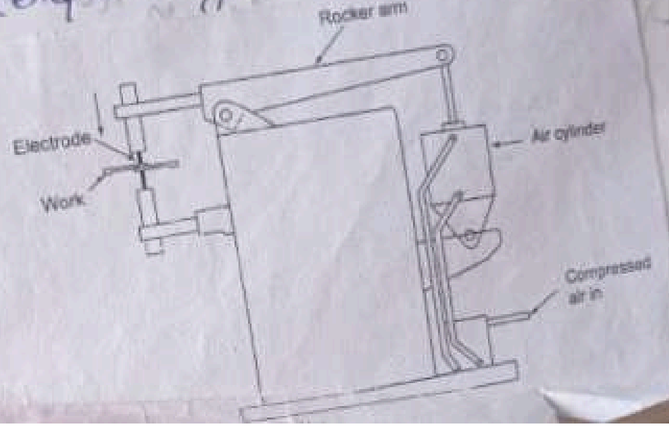
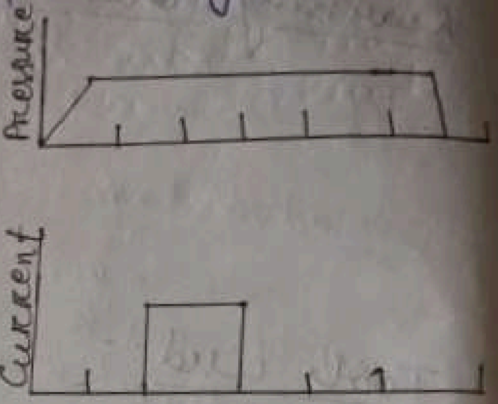


Fig. 9.61 *Formation of a nugget in spot welding*



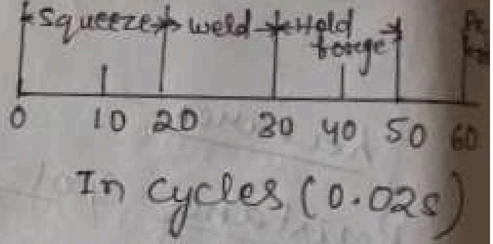
A resistance spot welding machine consists of two electrodes, out of which one is fixed. The other electrode is fixed to a rocker arm for transmitting the mechanical force from a pneumatic cylinder.

A resistance welding schedule is the sequence of events that normally take place in each of the welds. The events are the following.



→ The squeeze time is the time required for the electrodes to align and clamp the two workpieces together under them and provide the necessary electrical contact.

→ The weld time is the time of the current flow through the workpieces till they are heated to the melting temperature

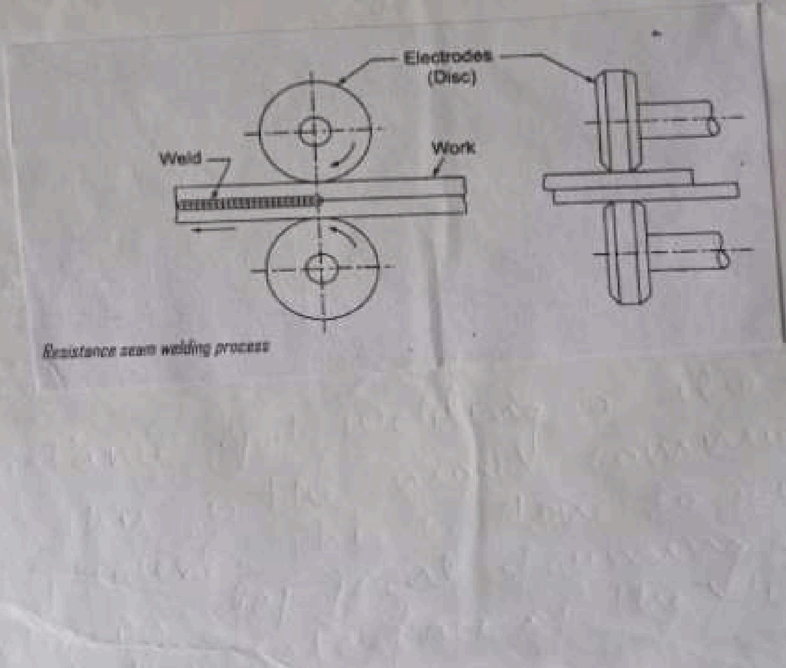


→ The hold time is the time when the pressure is the maintained on the molten metal without the electric current. During this time, the pieces are expected to be forge welded.

→ The off time is time during which, the pressure on the electrode is taken off so that the plates can be positioned for the next spot.

Resistance Seam Welding (RSEW)

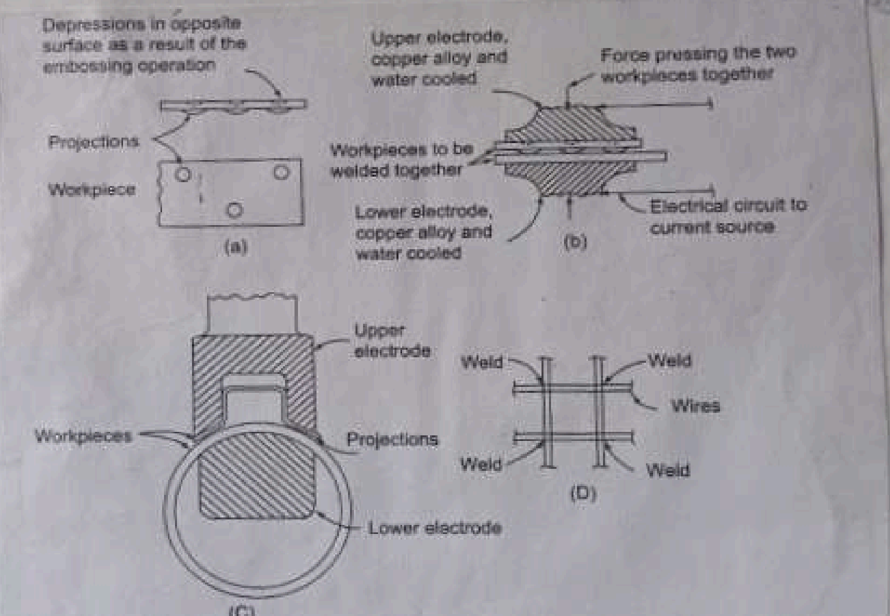
The resistance seam welding (RSEW) is a specialised process of spot welding. Here the cylindrical electrodes are replaced by disc electrodes. The disc electrodes are continously rotated so that the work pieces gets advanced underneath them while at the same time the pressure on the joint is maintained. The current is applied through the heavy copper electrodes in a series of pulses at proper intervals. The timing is adjusted so that the pulses overlap each other and thus form a continous seam joint. If the timing of the pulses is increased, then each of the welds formed would not overlap giving an intermittent seam.



Resistance seam welding process

Projection Welding:)

Projection welding is another variation of spot welding, where one of the sheets to be joined is provided with a number of projections to help localise the current at a predetermined spot. The projects are generally very small of the order of 0.8mm and are obtained by means of embossing. As the welding currents passes through these projections, they soften, get melted and a fusion joint is made under the pressure applied from the electrode.



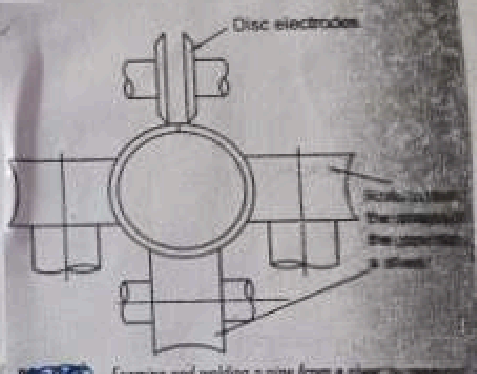
Features of projection welding: (a) Projections on the workpiece (b) Projection welding process (c) Special electrodes to serve as assembly fixtures (d) Cross-wire welding (courtesy Campbell op cit, p 410, McGraw-Hill, New York)

Upset Welding

In upset welding, the pieces to be joined are brought together to mate with each other in a butt joint. The two pieces are held tightly together and current is applied, so that the heat is generated through the contact area between the two plates. Because of the joint being under pressure, the ends of the two pieces get slightly upset and hence its name This is useful for joining the two ends of rods or similar pieces.

In this the plate is first formed into the shape of the pipe with the help of the three roll set. The ends of the plate would then be forming the butt joint. The two rotating copper disc electrodes are made to contact the two ends of the plate through which the current is passed. The ends get heated and then forged welded under the pressure of the rolls.

The ends of the pieces to be upset welded must be perfectly parallel. Any high spots if present on the ends would get melted first before the two ends are completely melted for proper joining.

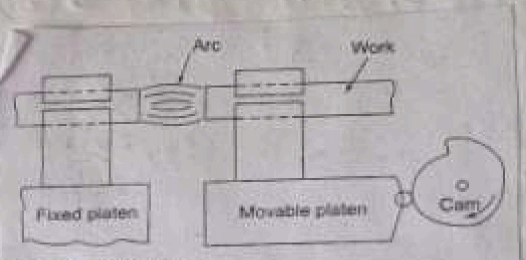


Forming and welding a pipe from a [illegible] upset butt welding process

Flash Welding

Flash welding is similar to upset welding except that the heat required for melting is obtained by means of an arc rather than the simple resistance heating.

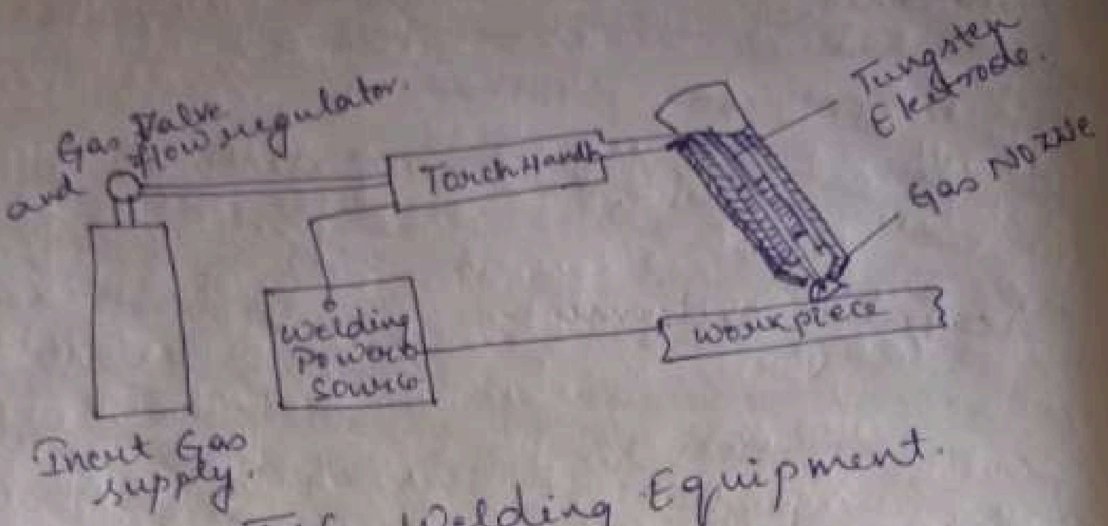
The flash welding equipment consists of essentially two platens, to which the two pieces to be joined are clamped. One of the platens is fixed while the other is movable, the movement being controlled by means of a cam. The ends of the two pieces need not be parallel. The two pieces are brought together and the power supply is switched on. The two pieces are separated to created the arc to melt the ends of the two pieces. These again the pieces are brought together and the power switched off while the two ends are fused under pressure.



Flash welding

Tungsten Inert Gas Welding (TIG)

Tungsten Inert Gas (TIG) welding or Gas Tungsten Arc welding (GTAW) is an inert gas shielded arc welding process using non consumable electrode. The electrodes may contain 1 to 2% thoria (thorium oxide) mixed along with the core tungsten or tungsten with 0.15 to 0.40% zirconia (zirconium oxide). The pure tungsten electrodes are less expensive but will carry less current. The thoriated tungsten electrodes carry high currents and are more desirable because they can strike and maintain a stable arc with relative ease. The zirconia added tungsten electrodes are better than pure tungsten but inferior to thoriated tungsten electrodes.



TIG Welding Equipment.

It consists of a welding torch at the centre of which is the tungsten electrode. The inert gas is supplied to the welding zone through the annular path surrounding the tungsten electrode to effectively displace the atmosphere around the weld puddle. The smaller weld torches may not be provided with any cooling devices for the electrodes, but larger ones are provided with circulating cooling water.

In this power sources used are always the constant current type. Both direct current (dc) and alternating current (ac) power supplies can be used for TIG welding. When dc is used, the electrode can be negative

(DCEN) or positive (DCEP). With DCEN more heat is generated near the workpiece and consequently the electrode does not get heated to a great extent. But when DCEP is used, a large amount of heat is liberated at the electrode itself thereby limiting the maximum current that can be carried by an electrode. The current carrying capacity of a DCEN electrode is about 10 times as high as that of a DCEP electrode.

When alternating current (ac) is used for TIG welding, the current continuously changes its direction. It changes its direction 50 times every second such that, half the time it is operating as DCEN and rest, as DCEP.

Electrodes: The tungsten electrodes used for welding should be clean and completely free from any kind of contamination such as molten filler metal.

If the arc is started by first touching the base metal and withdrawn, the electrode tip may pick up the base metal which causes the subsequent sputtering and loss of metal in the electrode tip. Also, the electrode may get consumed quickly if it is allowed to get oxidised, since tungsten oxide has a lower melting temperature. The oxidation occurs when the electrode is allowed to cool in the atmosphere after welding. Hence, the shielding gas flow should be maintained for sometime after extinguishing the arc so that the electrode gets sufficiently cooled in a protective atmosphere rather than in the oxidising normal atmosphere.

In this no fluxes are required because of the use of shielding gases. However, for thicker sections, it may be desirable to protect the root side of the joint by providing a flux or preferably a shroud of inert gas.

Inert gases used in TIG welding are:
(i) Argon (ii) Helium (iii) Argon-helium mixtures
(iv) Argon-oxygen mixtures (v) Argon-hydrogen mixtures

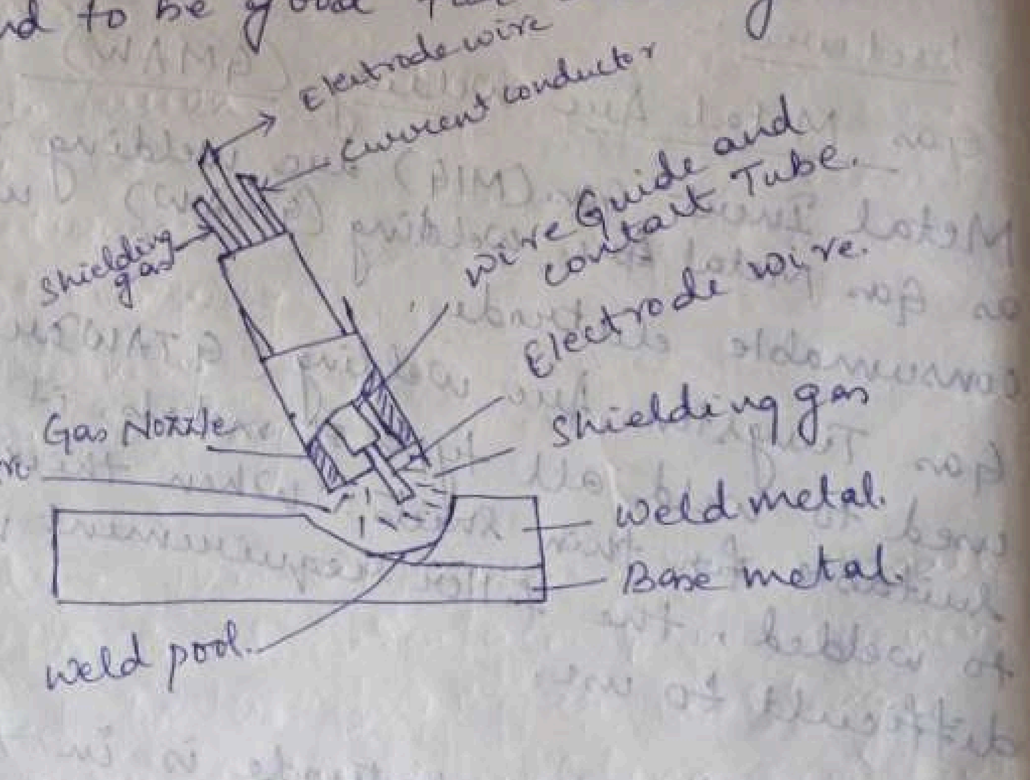
Gas Metal Arc Welding (GMAW)

Metal Inert Gas (MIG) arc welding is also called as Gas Metal Arc welding (GMAW) utilises a consumable electrode.

Gas Tungsten Arc welding (GTAW or TIG) can be used to weld all types of metals, it is more suitable for thin sheets. When thicker sheets are to welded, the filler requirement makes GTAW difficult to use.

The consumable electrode is in the form of a wire reel, which is fed at a constant rate through the feed rollers. The welding torch is connected to the gas supply cylinder, which provides the necessary inert gas. The electrode and the workpiece are connected to the welding power supply. The power supplies are always of the constant-voltage type only. The current from the welding machine is changed by the rate of feeding of the electrode wire.

Normally, dc arc welding machines are used for GMAW with electrode positive (DCEP). The DCEP increases the metal-deposition rate and also provides for a stable arc and smooth electrode metal transfer. With DCEN, the arc becomes highly unstable and also results in a large spatter. But special electrodes having calcium and titanium oxide mixtures as coatings are found to be good for welding steel with DCEN.



In the GMAW process, the filler metal is transferred from the electrode to the joint. Depending upon the current and voltage used for a given electrode, the metal transfer is done in different ways. They are

→ short circuit or dip transfer
→ globular transfer
→ spray transfer
→ pulsed - spray transfer and
→ rotating - spray transfer.

The gases that can be used for GMAW are argon, helium, nitrogen, oxygen, carbon dioxide and a mixture of the above gases in various proportions.

Argon reduces the spatter and concentrates the arc. As a result, it gives deep penetration welds and is the most widely used of all the shielding gases. Also, argon ionises easily requiring smaller arc voltages. It also has lower thermal conductivity and hence conducts heat very slowly from the arc to the weld zone. Thus it is good for welding thin sheets.

Helium is the most expensive of all the shielding gases. Helium has a better thermal conductivity and hence, it is useful for thicker sheets as well as for metals having higher thermal conductivity.

such as copper and aluminium.

The arc in carbon dioxide shielding gas is unstable and therefore a very short arc is to be used to reduce the metal spatter. This is the least expensive of all the shielding gases.

The electrode wire comes generally in the form of coils. Various wire compositions are available depending on the base metal composition. Wires of very small diameter are more expensive. The normal sizes may be of the order of 0.5 to 3.2mm. The electrode wires to be used for steels generally have the deoxidisers added to it.

Defects in Welding

The defects are

- Undercut
- Incomplete fusion
- Porosity
- Slag inclusion
- ~~Cold~~ Hot cracking
- Cold cracking
- Lamellar tearing.

Undercut - This appears like a small notch in the weld interface. This is generally attributed to the improper welding technique or excessive welding current. This is mainly caused by the incorrect manipulation of the electrode while.

depositing the bead.
Remedies → Use proper current, maintain proper arc travel sp

<u>Incomplete fusion</u> — This will be seen as a discontinuity in the weld zone. The main causes for this defect are, improper penetration of the joint, wrong design of the joint or incorrect welding technique including the wrong choice of the welding parameters. The main parameter that controls is the welding current, if lower than required would not sufficiently heat all the faces of the joint to promote proper fusion. Also the improper cleaning of the joint hinder the fusion of the metal in the joint.

<u>Porosity</u> → Porosity in welding is caused by the presence of gases which get entrapped during the solidification process. The main gases that cause porosity are hydrogen, Oxygen and Nitrogen. Though there are other gases such as argon, helium, carbon dioxide, that are also present in the weld pool, in view of their insolubility would not cause porosity.

Hydrogen is the main cause of porosity in the weld pool. The sources of hydrogen could be the electrode coatings such as cellulose, dissociation of water, which is present as moisture pick up of electrodes.

Oxygen generally reaches the weld pool as oxide of base metal or filler metal or in some compounds of fluxes present in the electrode coatings.
Nitrogen generally enters the weld pool through atmospheric nitrogen or the contaminated shielding gases. Remedies → . Reduce welding speed, to allow time gases to escape. Clean the base metal properly.

Slag inclusion :- Slag is formed by the reaction with the fluxes and is generally lighter. It will float on top of the weld pool and would be chipped off after solidification. Some of the factors that cause slag inclusion are:

→ High viscosity of weld metal
→ Rapid solidification.
→ Insufficient welding heat
→ Improper manipulation of the electrode.
→ Undercut

Slag inclusions like porosity, weakens the metal by providing discontinuities.

Remedies → Use correct joint preparation, Use correct type of flux coated electrode, Remove them using a diamond point chisel, Remove it by grinding and reweld that area.

Hot Cracking

Generally occurs at high temperature and the size can be very small to visible. They are more likely to form during the root pass when the mass of the base metal is very large compared to the weld metal deposited. It can be prevented by preheating the base metal, increase the cross-sectional area of the root bead

Cold cracking :- Cold cracking generally occurs at room temperature after the weld is completely cooled. This can be generally seen in the heat affected zone.

Lamellar Tearing. — It is generally seen at the edge of the heat affected zone. It appears as a long and continous visual separation line between the base metal and the heat affected zone. This is caused by the presence of the elongated inclusions such as Mn, Fe and S in the base metal.

Arc Welding.

An arc is generated between two conductors of electricity, cathode and anode when they are touched to establish the flow of current and then separated by a small distance. An arc is a sustained electric discharge through the ionised gas column called plasma between the two electrodes.

It is generally believed that electrons liberated from the cathode move towards the anode and are accelerated in their movement.

When they strike the anode at high velocity, a large amount of heat is generated. When the electrons are moving through the air gap between the electrodes, also called the arc column, they collide with the ions in the ionized gas column between the electrodes. The positively charged ions, moving from the anode and would be impinging on the cathode, thus liberating heat.

In order to produce the arc, the potential difference between the two electrodes (voltage) should be sufficient to allow them to move across the air gap. The larger air gap requires higher potential differences. If the air gap becomes too large for the voltage, the arc may be extinguished.

The electrodes used for providing heat input in arc welding are of two types: the consumable and the non-consumable electrodes.

When the arc is obtained with a consumable electrode, the weld metal under the arc melts as also the tip of the electrode. The molten metal from the electrode and that obtained from the base metal gets intimately mixed under the arc and provides the necessary joint after solidification. So in this process, once the arc is initiated, the electrode is continously consumed and hence, the electrode should be moved continously towards the workpiece to maintain the constant arc length.

Since the electrode continuously melts, it also acts as the filler rod to provide the filler metal into the joint.

Non consumable electrodes made of carbon, graphite or tungsten. The carbon and graphite electrodes are used only in dc welding, whereas tungsten electrodes are used for both ac and dc welding. The filler metal required has to be deposited through a separate filler rod.

When consumable electrodes are ~~used, the welding process is called~~

A consumable electrode used in welding can be either bare or coated. The coated electrode also called stick electrode, is used for the manual arc welding process.

The coatings give off inert gases such as carbon dioxide under the arc heat, which shields the molten metal pool and protects it from the atmospheric oxygen, hydrogen, and nitrogen pick up thus reducing contamination of the weld metal

The coatings provide flux to the molten metal pool, which mixed with the oxides and other impurities present in the puddle forms a slag. The slag being lighter, floats on the top of the puddle and protects it against the surrounding air during the weld bead solidification. The slag covering also helps the metal to cool slowly, preventing the formation of a brittle weld.

Some elements that are required for stabilisation of the arc also added in these coatings.

Casting

Casting is probably one of the most ancient processes of manufacturing metallic components. It is the first step in the manufacture of metallic components. The process involves the following basic steps:

1. Melting the metal.
2. Pouring it into a previously made mould or cavity which confirms to the shape of the desired component.
3. Allowing the molten metal to cool and solidify in the mould.
4. Removing the solidified component from the mould, cleaning it and subjecting it to further treatment.

The solidified pieces of metal, which is taken out of the mould is called as casting. A plant where the castings are made is called a foundry. The casting process is called as of "Founding".

Casting Terms

1. Flask – A moulding flask is one which holds the sand mould intact. Depending upon the position of the flask in the mould structure It is referred by various names as drag lower moulding flask, cope upper moulding flask and Cheek- intermediate moulding.

2. Drag – Lower- moulding flask

3. Cope – Upper- moulding flask.

4. Cheek – Intermediate moulding flask used in three- piece moulding.

5. Pattern – Pattern is a replica of the final object to be made with some modifications. The mould Cavity is made with the help of the pattern

6. Parting Line – This is the dividing line between the two moulding flasks that makes up the sand mould. In split pattern, it is also the dividing line between the two halves of the pattern

7. Bottom Board:- This is a board normally made of wood, which is used at the start of the mould making. The pattern is first kept on the bottom board, sand is sprinkled on it, and then the ramming is done in the drag.

8. Facing Sand:- The small amount of carbonaceous material sprinkled on the inner surface of the moulding cavity to give better surface finish to the castings.

9. Moulding Sand:- It is the freshly prepared refractory material used for making the mould cavity. It is a mixture of silica, clay and moisture in appropriate proportions to get the desired results and it surrounds the pattern while making the mould.

10. Baking Sand: It is what constitutes most of the refractory material found in the mould. This is made up of used and burnt sand.

11. Core: It is used for making hollow cavities in the castings.

12. Pouring Basin: A small funnel shaped cavity at the top of the mould into which the molten metal is poured.

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

flow of metal into the mould.

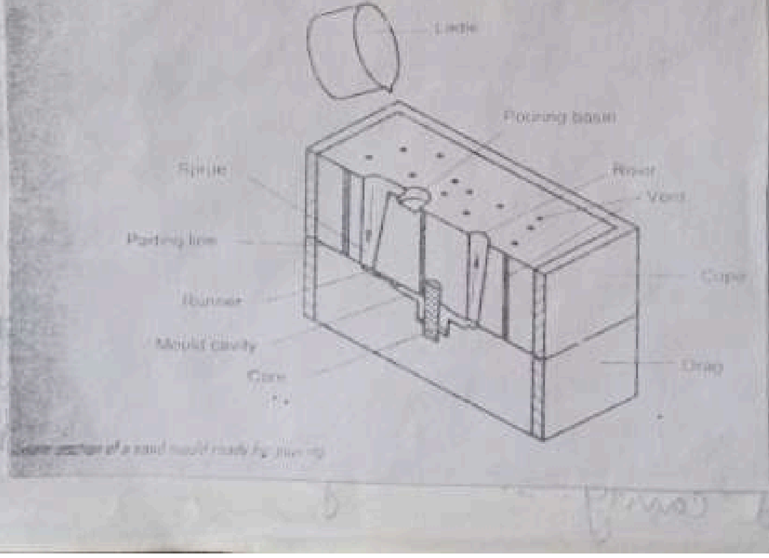
14. <u>Runner</u> - The passageways in the parting line plane through which the molten metal flow is regulated before they reach the mould cavity.

15. <u>Gate</u>: The actual entry point through which molten metal enters the mould cavity.

16. <u>Chaplet</u> - Chaplets are used to support cores inside the mould cavity to take care of its own weight and overcome the metallostatic forces.

17. <u>Chill</u>: Chills are metallic objects, which are placed in the mould to increase the cooling rate of castings, to provide uniform or desired cooling rate.

18. <u>Riser</u>: It is a reservoir of molten metal provided in the casting, so that hot metal can flow back into the mould cavity, where there is a reduction in volume of metal due to solidification.



Patterns

Patterns is a replica of the object to be made by the casting process, with some modifications.

The main modifications are

(i) the addition of pattern allowances,

(ii) the provision of core prints, and

(iii) the elimination of fine details.

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.

1. Shrinkage – All metals shrink when cooling except perhaps bismuth. Two types of shrinkage takes place

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

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

2. Finish of or Machining Allowance : Machining allowance or finish allowance indicates how much larger the rough casting should be over the finished casting to allow sufficient material to ensure that machining will clean up the surfaces.

The amount of finish allowance depends on the material of the casting, its size, volume of production, method of moulding, configuration of the casting, the position of the wall surface occupying in the mould and during pouring.

3. Pattern draft or Taper:
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.

called draft allowance.

4. Shake Allowance: Before withdrawal from the sand mould, the pattern is wrapped all around the vertical faces to enlarge the mould cavity slightly, which facilitates its removal.

5. Distortion Allowance: A metal when it has just solidified is very weak and therefore, is likely to be distortion prone. This is particularly so for weaker sections such as long flat portions, V, U sections.

Pattern Materials.

The usual pattern materials are wood, metal and plastics. The most commonly used pattern material is wood. The main reason being the easy availability and low weight. Also, it can be easily shaped and is relatively cheap. But the main disadvantage of wood is its absorption of moisture as a result of which distortion dimensional changes occur.

The usual varieties of wood commonly used for making patterns are pine, mahogany, teak walnut and deodar.
Choice of the pattern material depends essentially on the size of the casting, the number of castings to be made from the pattern and the dimensional accuracy.
Because of their durability and smooth surface finish, metal patterns are extensively used for large scale casting production and for closer dimensional tolerances. Many materials such as castiron, Brass etc can be used as pattern material most commonly aluminium and white metal are most commonly used. These are light can be easily worked and are corrosion resistant.

Plastics are also used as pattern materials because of their low weight, easier formability, smooth surfaces and durability. They donot absorb moisture and are, therefore, dimentionally stable and can be cleaned easily.

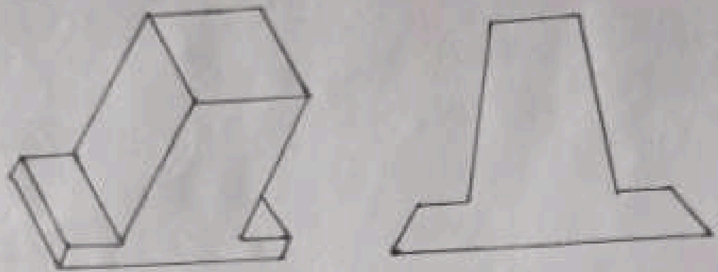
Polyurethane foam is also used as pattern material. It is very light and can be easily formed into any shape required.

Types of Patterns.

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

1. Single - Piece Pattern

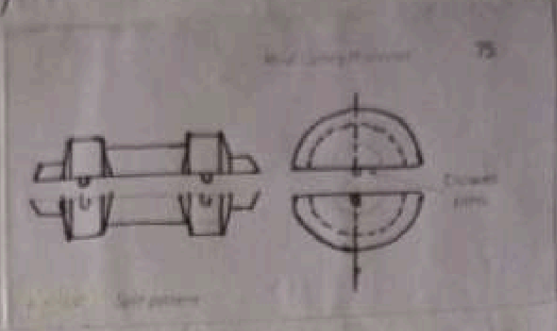
These are inexpensive and the simplest type of patterns. This type of pattern is used only in cases where the job is very simple and does not create any withdrawal problems. It is also used for applications in very small scale production



(a) Casting (b) Pattern

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.

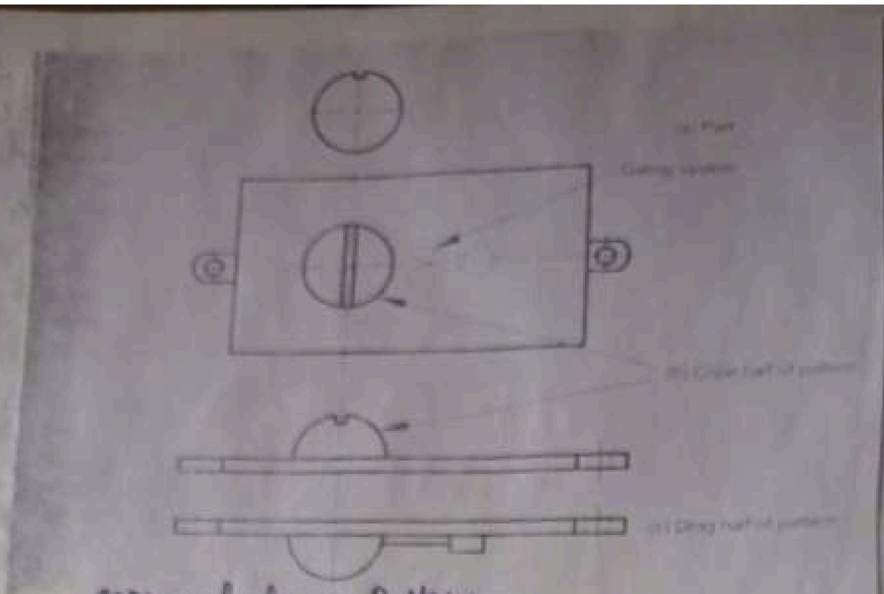


3. Gated Pattern

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

4. Cope and Drag Pattern

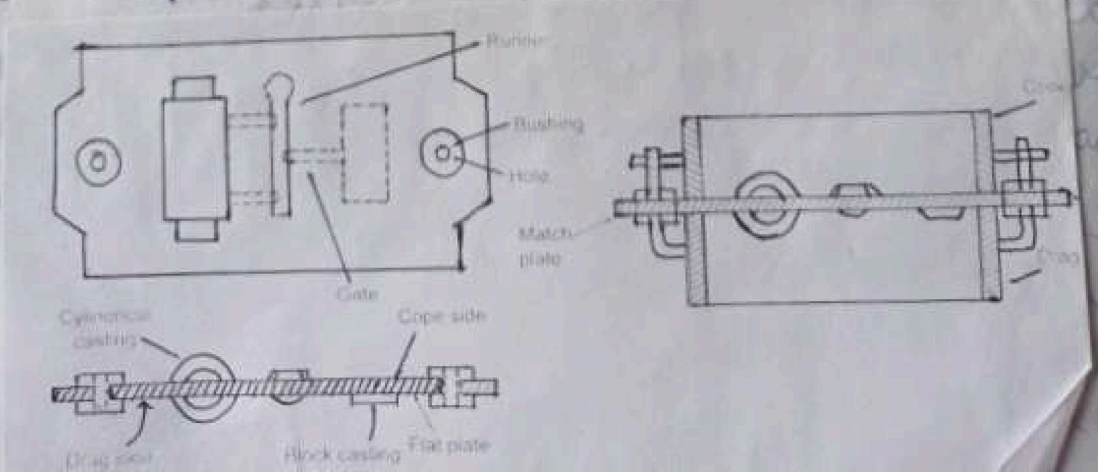
These are similar to split patterns. In addition to splitting the pattern, the cope and drag halves of the pattern along with the gating and runnering systems are attached separately to the metal or wooden plates along with the alignment pins. They are called the cope and drag pattern. The cope and drag moulds may be produced using these patterns separately by two moulders but they can be assembled to form a complete mould. These types of patterns are used for castings, which are heavy and inconvenient for handling as also for continous production.



cope and drag Pattern

5. Match-Plate Pattern.

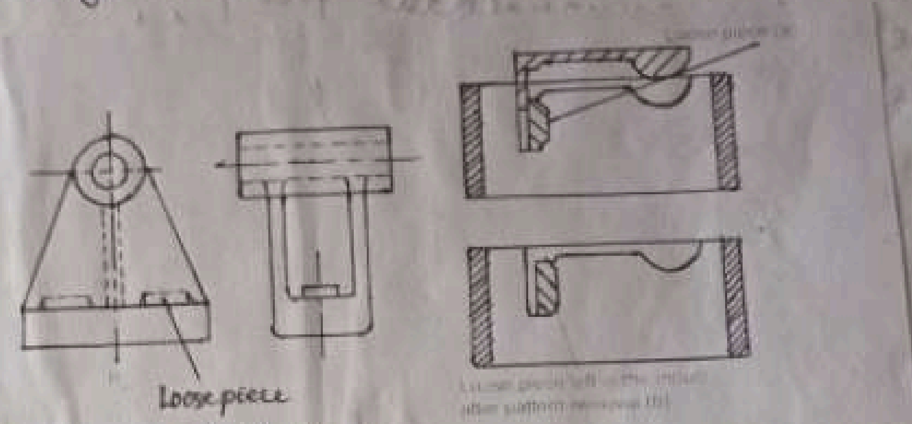
These are extensions of the previous type. Here the cope and drag patterns along with the gating and the risering are mounted on a single matching metal or wooden plate on either side. On one side of the match plate, cope flask is prepared and on the other the drag flask. After moulding when the match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



Match-plate pattern (Courtesy J S Campbell, "Principles of Manufacturing Materials and Processes" McGraw-Hill, New York)

5. Loose-piece Pattern

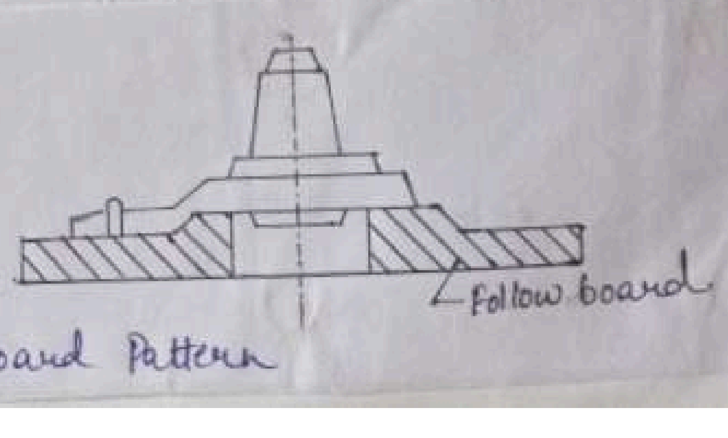
This type of pattern is used when the contour of the part is such that, withdrawing the pattern from the mould is not possible. Hence, during moulding, the ~~car~~ obstructing part of the contour is held as a loose piece by a wire. After moulding is over, first the main pattern is removed and then the loose pieces are recovered through the gap generated by the main pattern.



Loose piece Pattern

6. Follow-Board Pattern

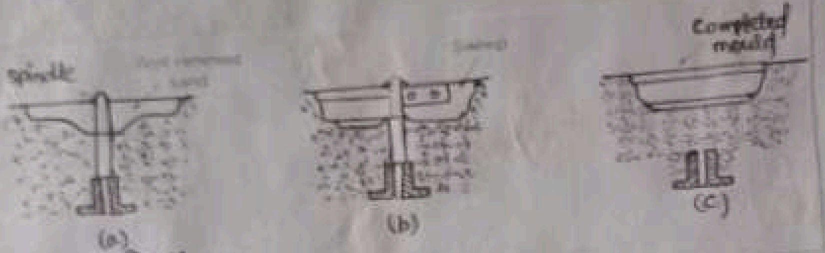
This type of pattern is adopted for those castings where there are some portions, which are structurally weak and if not supported properly are likely to break under the force of ramming. Hence, the bottom board is modified as a follow board to closely fit the contour of the weak pattern and thus support it during the ramming of the drag.



Follow board 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. This greatly reduces the cost of a three dimensional pattern. This type of pattern is particularly suitable for very large castings such as the bells for ornamental purposes used, which are generally cast in pit moulds.



Sweep Pattern

9. Skeleton Pattern

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

Moulding Materials

A large variety of moulding materials are used in foundries for manufacturing moulds and cores. They are:

→ moulding sand
→ system sand
→ rebonded sand
→ facing sand
→ parting sand
→ core sand

The choice of moulding materials is based on their processing ~~material~~ properties. The properties that are generally required in moulding materials are:

1. Refractoriness.

It is the ability of the moulding material to withstand the high temperatures of the molten metal so that it does not cause fusion

2. Green Strength

The moulding sand that contains moisture is termed green sand. The green sand should have enough strength, so that the constructed mould retains its shape

3. Dry strength

When the moisture in the ~~moouldin~~ moulding sand is completelly expelled it is called dry sand. When molten metal is poured into a mould, the sand around the mould cavity is quickly converted into dry sand, as the moisture in the sand immediately evaporates due to the heat in the molten metal. At this stage. it should retain the mould cavity and at the same time withstand the metallostic forces.

4. Hot Strength

After all the moisture is eliminated, the sand would reach a high temperature when the metal in the mould is still in the liquid state. The strength of the sand that is required to hold the shape of the mould cavity then is called hot strength.

5. Permeability

During the solidification of a casting large amounts of gases are to be expelled from the mould. The gases are those which have been absorbed by the metal in the furnace, air absorbed from the atmosphere, and steam and other gases generated by the moulding and core sands. If these gases are not allowed to escape from the mould, they would be trapped inside the casting and cause defects. The moulding sand should be sufficiently porous, so that the gases are allowed to escape from the mould.

Moulding Sand Composition.

The main ingredients of any moulding are

→ the silica grains (SiO_2)

→ the clay (as binder)

→ moisture

1. Silica Sand

The sand which forms the major portion of the moulding sand (upto 96%) is essentially silica grains, the rest being the other oxides such as alumina, sodium ($Na_2O + K_2O$) and magnesium oxide ($MgO + CaO$). These impurities should be minimised to about 2% since they affect the fusion point of the silica sands. The main source is the river sand, which is used with or without washing.

Zircon sand is basically zirconium silicate ($ZrSiO_4$). The typical composition is ZrO_2 - 66.25% SiO_2 - 30.96%, Al_2O_3 - 1.92%, Fe_2O_3 - 0.74% and traces of other oxides. It is very expensive. In India, it is available in Quilon beach of Kerala. It has a fusion point of about 2400°C and also a low coefficient of thermal expansion. The other advantages are high thermal conductivity, high chilling power and high density. It requires a very small amount of binder (about 3%). It is generally used to manufacture precision steel castings requiring better surface finish and for precision investment casting.

Chromite sand is crushed from the chrome ore whose typical composition is Cr_2O_3 - 44%, Fe_2O_3 - 28%, SiO_2 - 2.5%, CaO - 0.5% and Al_2O_3 + MgO - 25%. The fusion point is about 1800°C. It also requires a very small amount of binder (about 3%). It is also used to manufacture heavy steel castings requiring better surface finish. It is best suited to austenitic manganese steel castings.

Olivine sand contains the minerals forsterite (Mg_2SiO_4) and fayalite (Fe_2SiO_4). It is a very versatile and the same mixture can be used for a range of steels.

2. Clay

Clays are the most generally used binding agents, mixed with the moulding sands to provide the strength, because of their low cost and wider utility. The most popular clay types used are

Kaolinite or fire clay ($Al_2O_3 2SiO_2 2H_2O$)

Bentonite ($Al_2O_3 . 4SiO_2 H_2O nH_2O$)

Kaolinite has a melting point of 1750 to 1787°c and bentonite has melting temperature range of 1250 to 1300°c. Of the two, which bentonite can absorb more water, which increases its bonding power.

3. Water

Clay is activated by water so that it develops the necessary plasticity and strength. The amount of water used should be properly controlled. This is because, a part of the water absorbed by clay helps in bonding, while the remainder up to a limit helps in improving the plasticity, but more than that would decrease the strength and formability.

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 mean of cores so that really intricate shapes can be easily obtained.

Types of Cores.

The cores are essentially of two types:

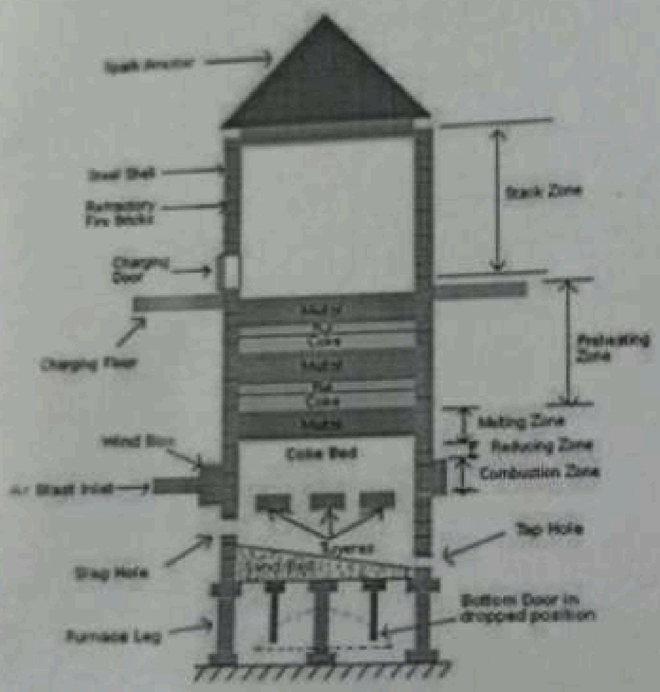
Green sand cores - are those obtained by the pattern itself during moulding. The green sand being low in strength cannot be used for fairly deep holes.

Dry sand cores - are those which are made by means of special core sands in a separate core box, baked and then placed in the mould before pouring.

Cupola

A cupola or cupola furnace is a melting device used in foundaries that can be used to melt cast iron, Ni-resist iron and some bronzes.

A cupola consists of a cylindrical steel shed with its exterior lined with heat resisting fire bricks. It consists of drop doors at the bottom after closing which, a proper sand bed could be prepared. This sand bed provides the necessary refractory bottom for the molten metal and the coke. Immediately above the sand bed is the metal tapping hole which



Cupola Furnace

is initially closed with clay called 'bot' till the molten metal is ready for tapping. Above the metal tap hole, normally in a position opposite to it is the slag hole, through which the slag generated during the melting process is tapped.

Above the slag hole is the wind box which is connected to the air blowers supplying the requisite air at a given pressure and quantity. The air enters the cupola through the tuyeres. A little above the charging platform is the charging hole in the shell from there where the charge consisting of a combination of pig iron, scrap iron, coke and fluxes is put into the cupola.

<u>Working</u>

To operate the cupola. first the drop doors at the bottom are closed and a sand bed with a gentle slope towards the tap hole is rammed. Then a coke bed of suitable height is prepared above the sand bottom and ignited through the tap hole or any other hole. When the coke bed is properly ignited, alternate layers of charge, flux and coke are alternately fed into the cupola through the charge door maintaining the necessary proportions and rate of charging. The charge is then allowed to soak in the heat for a while, and then the air blast is turned on. Within about 5 to 10 minutes, the molten metal is collected near the tap hole. When enough molten metal is collected in the well of the cupola, the slag is drained off through the slag hole before opening the tap hole. The molten metal is collected in the ladles and then transported to the moulds into which it is poured with a minimum time loss.

The charge needed to produce cast iron, essentially consists of pig iron, cast iron scrap and steel scrap when alloy cast iron is needed.

The fluxes are added in the charge to remove the oxides and other impurities present in the metal. The flux most commonly used is limestone ($CaCO_3$) in a proportion of about 2 to 4% of the metal charge. Some of the other fluxes that may is also be used are dolomite, sodium carbonate and calcium Carbide. The flux is expected to react with the oxides and form compounds which have low melting point and also are lighter.

Casting Defects

Any irregularity in the moulding process causes defects in castings which may sometimes be tolerated sometimes eliminated with proper moulding practice. The following are the major defects which are likely to occur in sandcastings

(i) Gas defects
(ii) Shrinkage cavities
(iii) Moulding-material defects
(iv) Pouring-metal defects.
(v) Metallurgical defects.

Gas Defects

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

1. Blow holes and Open Blows.
These are the spherical, flattened or elongated Cavities present inside the casting or on the

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. Because of the heat in the molten metal, the moisture is converted into steam, part of which when trapped into the casting ends up as a blow hole or ends up as an open blow when it reaches the surface.

The main reason for this is the low permeability of the sand mould. Low permeability is caused by the use of too fine grains, higher amount of binder or over ramming of the mould. This can also be caused by insufficient venting practice.

2. Air Inclusions.

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 main reasons for this defect are the higher pouring temperatures which increase the amount of gas absorbed, poor gating design such as straight sprues.

The Remedies — To choose the appropriate pouring temperature and improve gating practices by reducing the turbulence

3. Pinhole Porosity.

This is caused by hydrogen in the molten metal. This could have been picked up in the furnace or by the dissociation of water inside the mould cavity. As the molten metal gets solidified, it loses the temperature which decreases the solubility of gases and thereby expelling the dissolved gases. The hydrogen while leaving the solidifying metal would cause very small diameter and long pinholes showing the path of escape. These series of pinholes cause the leakage of fluids under high operating pressure.

The main reason for this is the high pouring temperature which increases the gas pick up. This is particularly severe in aluminium alloys or steels and irons having aluminium.

4. Shrinkage Cavities

These are caused by the liquid shrinkage occurring during the solidification of the casting. To compensate this, proper feeding of liquid metal is required as also proper casting design.

Moulding Material Defects

These defects are due to the characteristics of the moulding materials.

1. Cuts and Washes

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

Remedies- By choosing a proper moulding sand and using appropriate moulding method.

2. Metal Penetration.

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

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.

4. Run-out

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

5. Rat Tails and Buckles

Rat tails 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 heat, the sand expands, thereby moving the mould wall backwards and in the process when the wall gives away, the casting surface may have a number of cross-crossing small lines.

Buckles are the rat tails which are severe.

6. Swell.

Under the influence of the metallo static forces, the mould wall may move back causing a swell in the dimensions of the casting.

7. Drop

The dropping of loose moulding sand or lumps normally from the cope surface into the mould cavity is responsible for this defect. This is due to improper ramming of the cope flask.

Lecture –

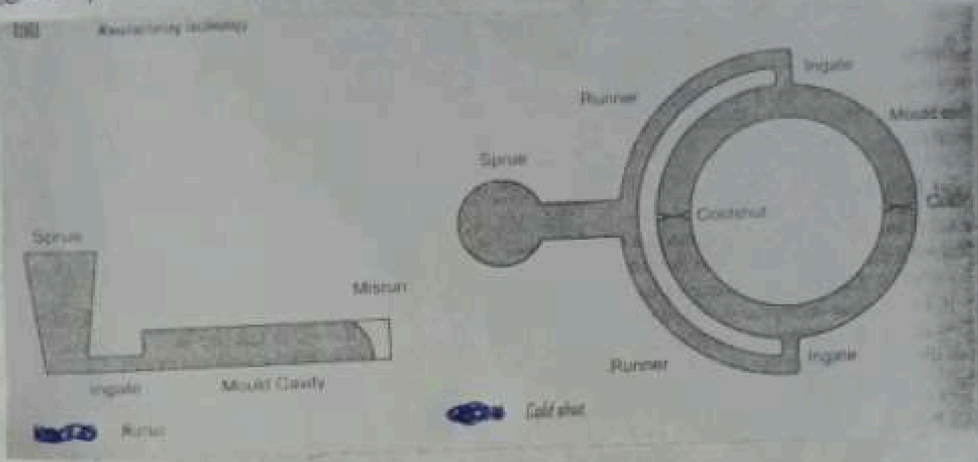
Pouring Metal Defects

The likely defects in this category are misruns and cold shuts and slag inclusions.

1. Misruns and Cold shuts

Misrun is caused when the metal is unable to fill the mould cavity completely, and thus leaving unfilled cavities.

A cold shut is caused when two metal streams while meeting in the mould cavity, do not fuse together supply, thus causing a discontinuity or weak spot in the casting. These defects are caused essentially by the lower fluidity of the molten metal or that the section thickness of the casting is too small. This can be rectified by proper casting design



2. 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. Otherwise, any slag entering the mould cavity will be weaking the casting and also spoil the surface of the casting.

Metallurgical Defects

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

1. Hot Tears

Since metal has low strength at higher temperatures, any unwanted cooling stress may cause the rupture of the casting. The main cause for this is the poor casting design.

2. Hot Spots

These are caused by the chilling of the casting. This hot spot will interfere with the subsequent machining of this region. Proper metallurgical control and chilling practices are essential for eliminating the hot spots.

Die Casting

Die casting involves the preparation of components by injection 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 die casting, any narrow sections, complex shapes and fine surface.

In die casting, the die consists 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 having cooling channels to extract the heat of the molten metal to maintain proper die temperature.

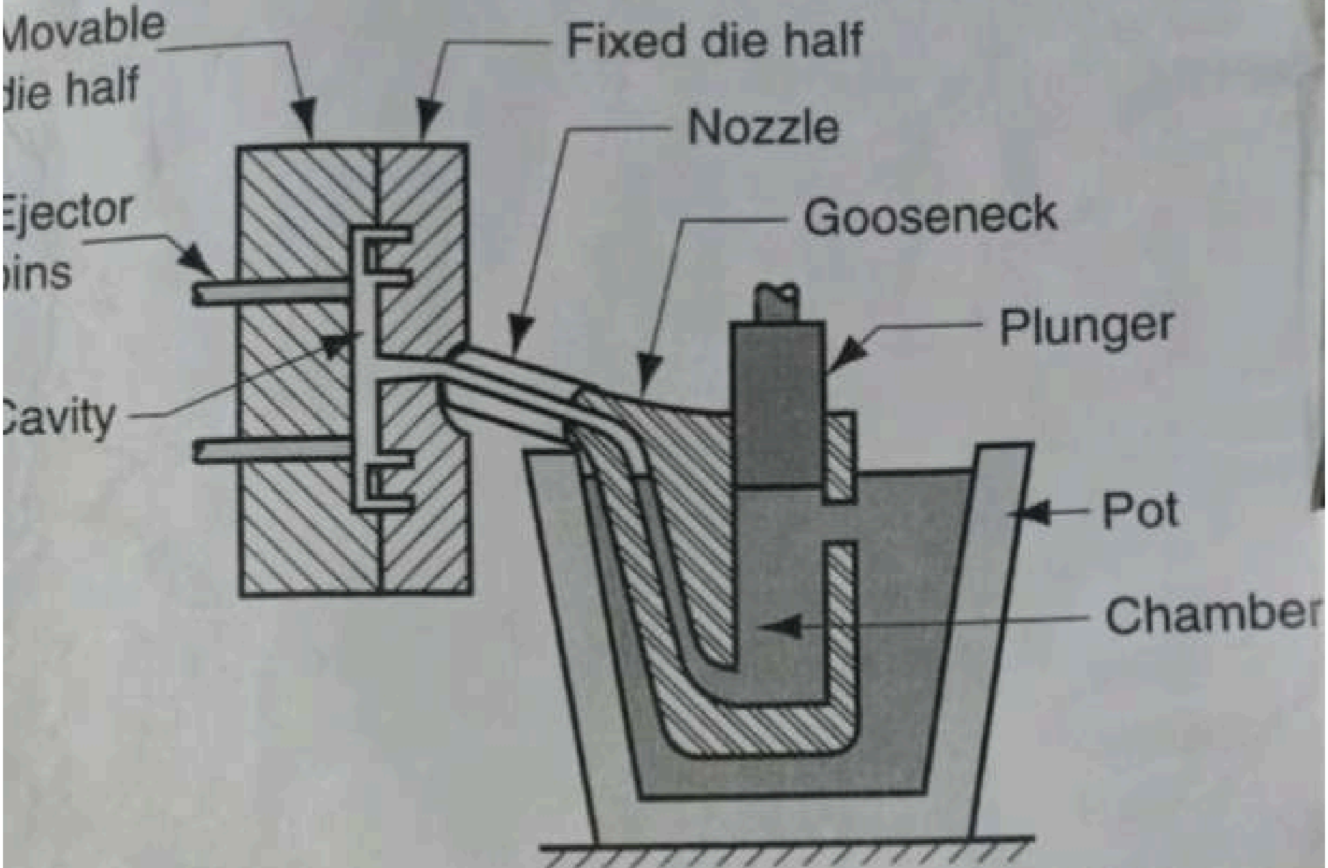
The die casting machines are of two types:

→ Hot chamber die casting

→ Cold chamber die casting.

The main difference between these two 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 casting cycle which is also called shot.

Hot Chamber Process



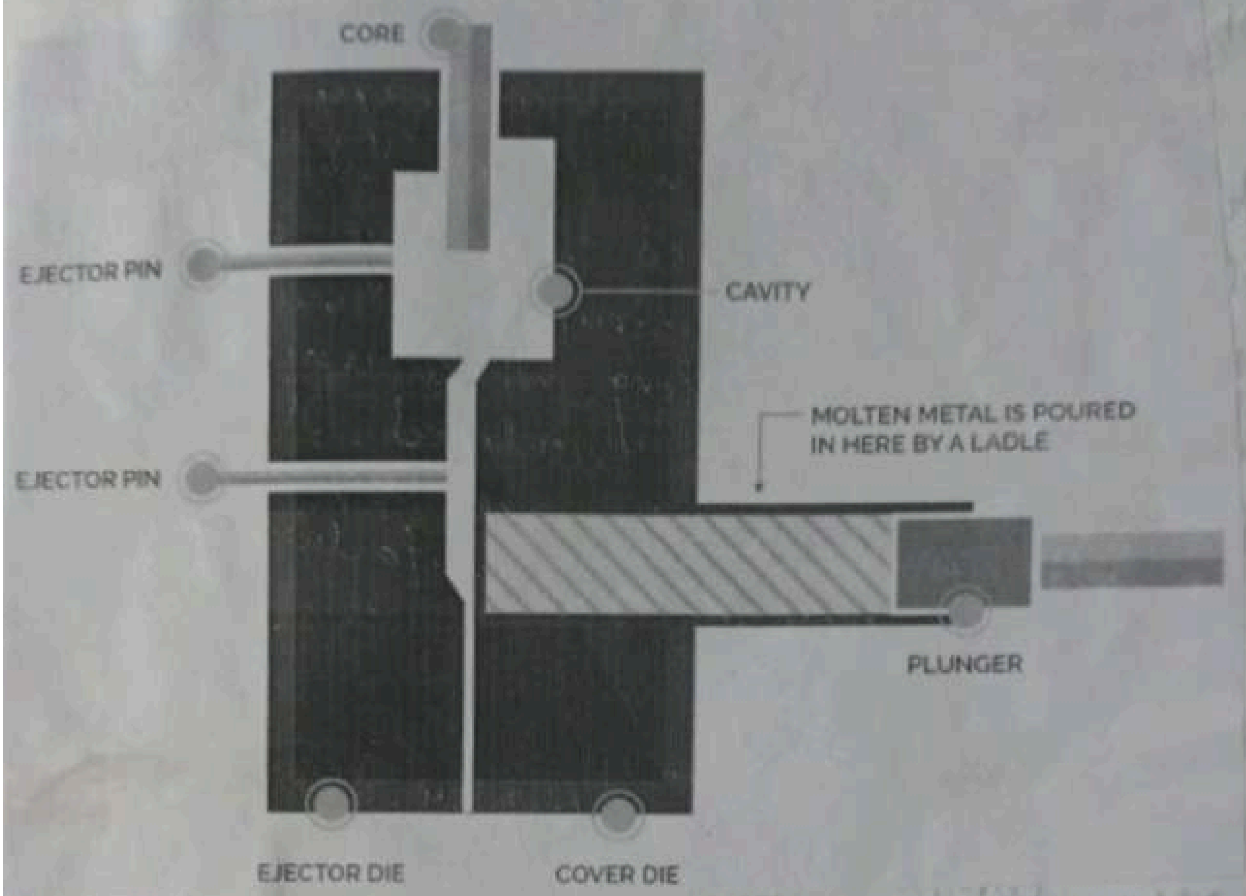
In this, a gooseneck is used for pumping the liquid metal into the die cavity. The gooseneck is submerged into the holding furnace containing the molten metal. The gooseneck is made of grey alloy or ductile iron or of cast steel. A plunger made of alloy cast iron, and which is hydraulically operated, 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 cycle starts with the closing of the die when the plunger is in the highest position in the 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. The casting which is in the ejector die is now ejected and at the same time the plunger uncovers the filling hole, letting the liquid metal from the furnace to enter the gooseneck. It is used for low melting temperatures alloys such as zinc, lead & tin.

Cold Chamber Process

For materials such as aluminium and brass, their high melting temperatures make it difficult to cast them by the hot chamber process, because of the gooseneck of the hot chamber machine is continously 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 laddle into the shot chamber for every shot. This process reduces the contact time between the liquid metal and the shot chamber.

The operation starts with the spraying of die lubricants throughout the die cavity and closing of the die when the molten metal is laddled into the shot chamber of the machine either manually by a hand ladle or by means of a auto ladle. An auto ladle 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. 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.



Cold chamber Process.

Powder Metallurgy.

Powder metallurgy is the name given to a process in which metallic powders are heated below their melting temperatures to achieve the bonding.

The metal or alloy powders need to be blended with suitable additives and lubricants. The thorough blending of powders and additives ensures that the additives are uniformly distributed which would facilitate the compaction process later. The blended powder is placed in the die and then pressed or compacted by a punch. There are number of compacting methods are used. The compacting methods can be broadly classified as cold, warm and hot compacting. After compacting the material is termed as 'green compact'. To achieve the bonding, the green compact is kept in a furnace with the requisite atmosphere

It is a process of manufacturing which produces parts or components from metal powders by placing these powders in moulds and applying pressure. These compressed parts are then heated to bind the particles together and improve their strength.

Components can be made from a single metal powder or alloyed metal powders.

→ It is one of the cheapest man[illegible]
for manufacturing high quality, high
strength, complex parts with a high degree
of accuracy.

→ Ex - tungsten carbide cutting tools, turbine
plow blades, self lubricating bearings.

Basic Steps in Process.

The production of a component by
powder metallurgy involves the following basic
steps.

→ Production of metal powders.
→ Mixing and blending.
→ Compacting.
→ Sintering.

Mixing and blending.

In this more than one powders are
mixed thoroughly and blended to ensure
their even distribution.

Compacting.

In this, the blended mixture is compacted
to bring the finely divided particles or

powder in close proximity while imparting the desired part of configuration and providing green strength to the part.

Sintering:

After the product compacted, it is heated at an elevated temp. to establish permanent strong bond b/w adjacent particles and thereby to impact strength to the compacts.

Press Work.

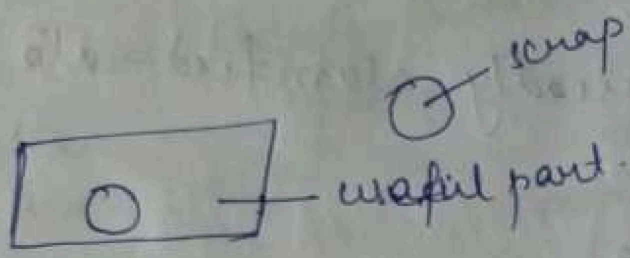
Metal forming is one of the manufacturing processes which are almost chipless manufactured process. These operations are mainly carried out by the help of presses and press tools. These operations include deformation of metal work pieces to the desired size and by applying pressure or force. Presses and press tools facilitate this mass production work. Press working is usually done at room temperature. Presses are used in mass production of identical components. The process of press working consists of shearing out and then plastically working the metal through a few quick strokes under heavy loads.

A press is a sheet metal working tool with a stationary bed and a powered ram can be driven towards the bed or away from the bed to apply force or required pressure for various metal forming operations. These typical press work is used to perform various sheet metal operations such as blanking, punching, forming, embossing etc

Punching or Blanking → Punching or blanking is a process in which a punch removes a portion of material from a larger piece or a strip of sheet metal.

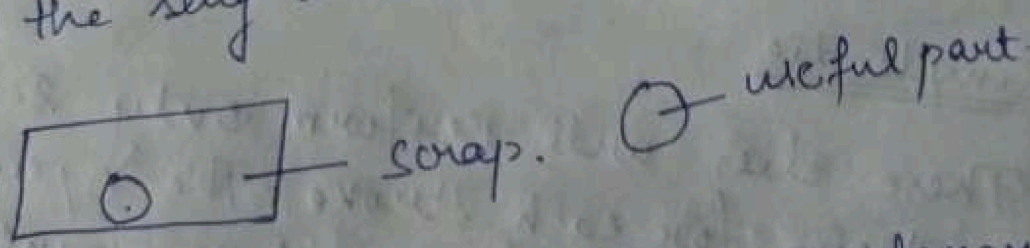
Punching is making a hole on the sheet by removing a slug or scrap.

Punching is identical to blanking except of the fact that the punched out portion coming out through the die is scrap.



Punching.

Blanking. → It is similar to punching except the slug is saved as the finished product.



* A punching operation that forms rectangular holes in the sheet is known as slotting.

Piercing → Process of making a hole in the metal without removing a slug. The metal is pushed back to form a ragged edge on the back side of the hole.

Trimming → Process of cutting unwanted material from the periphery of a previously formed part.

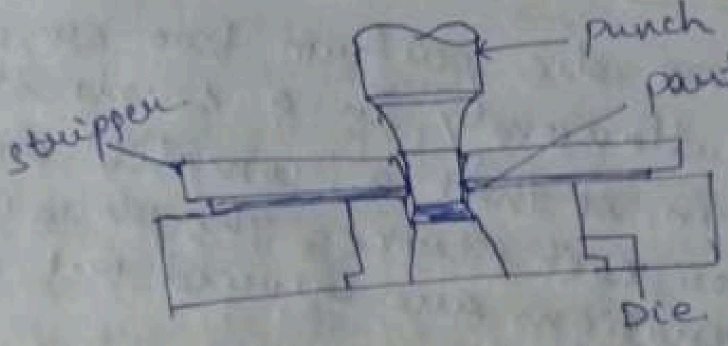
Types of Die

Dies are broadly classified into the following types:

→ Simple die
→ Inverted die
→ Progressive die.
→ compound die.

Simple die

These dies will perform only single operations for each stroke. The operation may be cutting operation like punching, blanking or forming operations like bending and drawing.

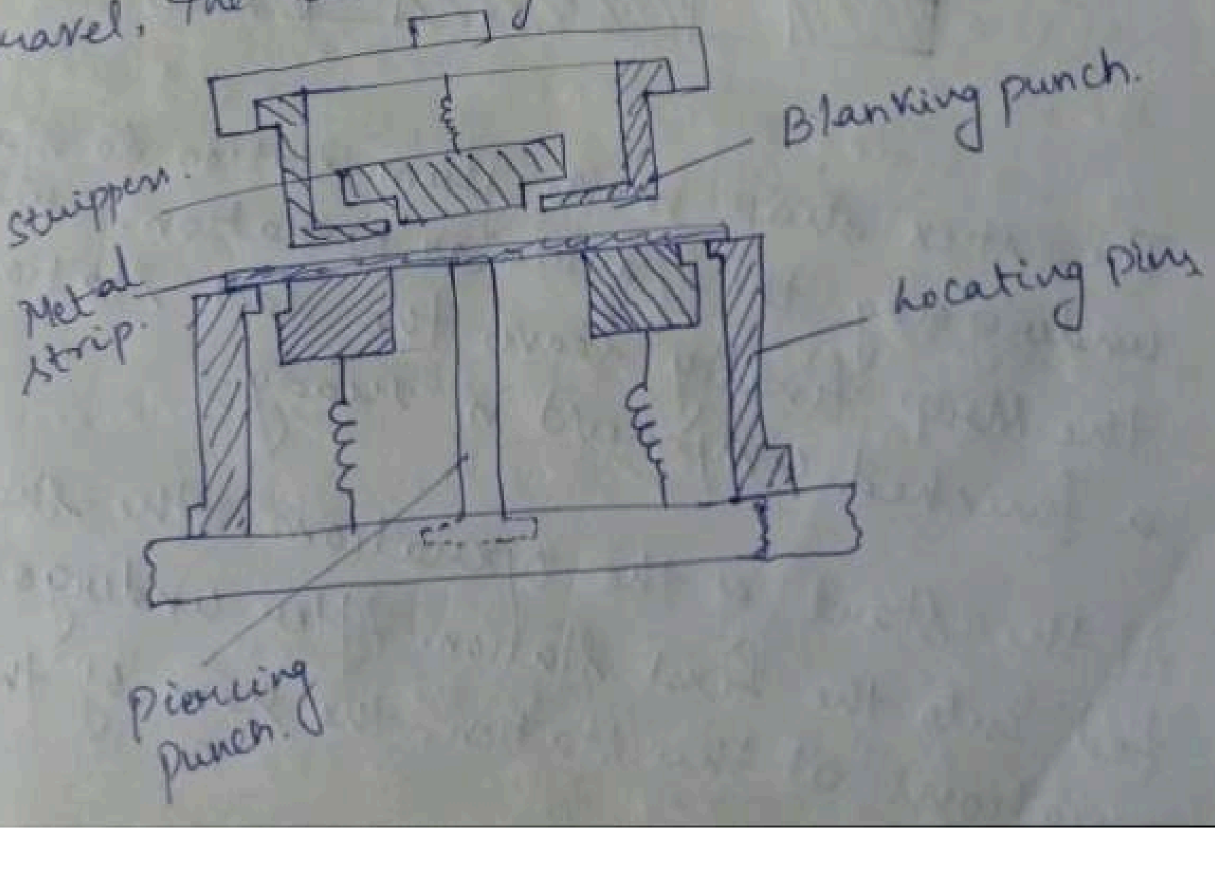


Simple Die

Compound die

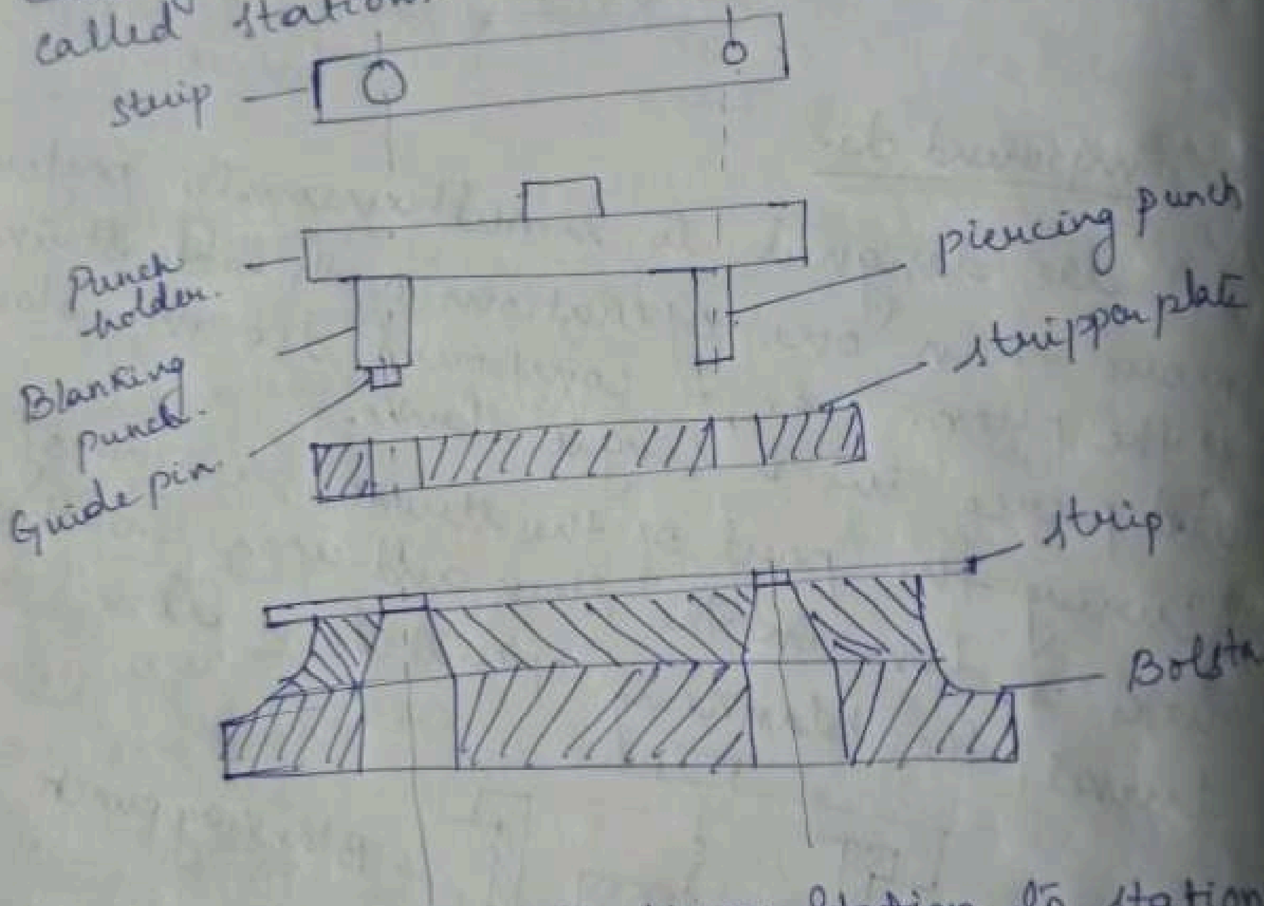
A die designed to simultaneously perform more than one operations with each stroke of the press. i.e. A compound die may blank and pierce in a single stroke.

During the part of the stroke, piercing of holes is done in the stock and upon further travel, the blanking operation is done



Progressive Die.

The progressive die perform two or more operations simultaneously in a single stroke of a punch press, so that a complete component is obtained for each stroke. The places where each of the operations are carried out are called stations.



The stock strip moves from station to station undergoing the particular operation. When the strip finally leaves the last station, a finished component is ready.

At the start of the operations, the sheet is fed into the first station. After undergoing the operations at this station, the ram of the press moves to the top and the stock is advanced from the first station to the second station, while a fresh portion of the stock comes under the first station.

The distance moved by the strip from station one to two, so that it is properly registered under the stations, is called advance statio distance.

Jigs and Fixtures.

Jigs and fixtures are used to produce repetive work in mass production. The use of jigs and fixtures reduces the overall cost of manufacturing as its leads to part or complete automation of the processes. These are special work holding and tool guiding devices.

A fixture holds and positions the work and fixes the work to the machine table by bolting. These are used in milling, grinding, planning or turning operations.

Jig. A jig holds, locates and guides the tool. They are used in drilling, taping operations etc. It is a frame or body which holds and positions the work and guides the cutting tool during the machining operation (drilling, reaming, tapping etc). Jigs are usually fitted with hardened steel bushings for guiding drills or other cutting tools.

Fixtures.

It is a production tool that locates, holds and supports the work ~~securtly~~ securely in a fixed orientation with respect to the tool so that the required machining operations can be performed.

→ A fixture differs from a jig in the sense that fixture does not guide the cutting tool. It is used only to hold work rigidly while machining operations such as milling, planning, shaping etc.

→ A fixture is securely fastened to the table of the machine upon which the work is done.

→ Jigs are lighter than fixtures for quick handling, fixtures are heavier in construction and are bolted rigidly on the m/c table.

Advantages of using Jigs & fixtures :-

(i) Manufacturing cost is reduced when large no. of identical and interchangable parts are produced using jigs & fixtures.

(ii) As work piece is automatically located in the right position and the tool is guided
a) machining accuracy is improved.
b) Semi- skilled workers can be employed.

(iii) Production work is rapid.

(iv) Productivity is improved.

(v) Due to high clamping rigidity of jigs & fixtures high power machines can be used at higher speeds, feeds & depth of cut.

(vi) Quality of the component parts are improved.

(vii) Jigs & fixtures eliminates marking out of the workpiece before machining, so reduces the production time overall economy of the machining process is increased.

Elements of Jigs and Fixture.

Main elements are:-

(a) Locating elements - Determine the position of the workpiece with respect to the cutting tool

(b) Clamping elements - For securing the workpiece.

(c) Tool guiding (jig) or cutter setting (fixture) elements - For imparting the req. direction of motion to the cutting tool or properly positioning the tool with respect to the workpiece.

(d) Indexing or rotary elements - For accurately changing the position of work piece with respect to the cutting tools.

(e) The body, base or frame carries all other elements.

(f) fastening parts - for holding the ~~several~~ elements together.

(g) Power devices - For operating the clamping elements.