GOVERNMENT POLYTECHNIC, DHENKANAL

Programme: Diploma in Mechanical Engineering

Course: Production Technology (Theory)

Course Instructor's Name: Suvendu Panda
E-mail-suvendu.panda@gmail.com
Contact no- 7008362373

Semester: 3RD

Metal Forming Processes

Metal forming process is a process where the work piece is reshaped into desired objects by the principle of plastic deformation . In this process the mass of thework piece remains unchanged. Example : Extrusion, Rolling

Extrusion:

Extrusion is a manufacturing process which involves forcing the work piece through a pre shaped die to create objects with a specific shape and profile.Inextrusionprocessthebilletisplacedinacontainer,pushedthrough a die opening using a ram or dummy block.

ApplicationofExtrusion:

Theprocessofextrusionsuitsbesttothenonferrousmetalsandalloys ,althoughsomesteelalloyslikestainlesssteelarealsoextruded.Extrusionof

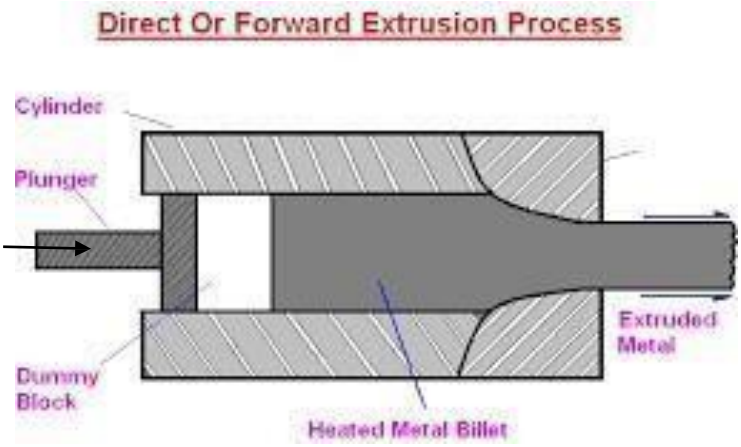
steel needs adequate lubrication around the billet . A coating of finely powdered glass over the surface of hot billet is utilized for this lubrication purpose.

ClassificationofExtrusion:

Extrusionisclassifiedingeneralintofourtypes.Theyare:

1. DirectExtrusionorforwardExtrusion
2. IndirectExtrusionorBackwardExtrusion
3. ImpactExtrusion
4. HydrostaticExtrusion

DirectExtrusion:



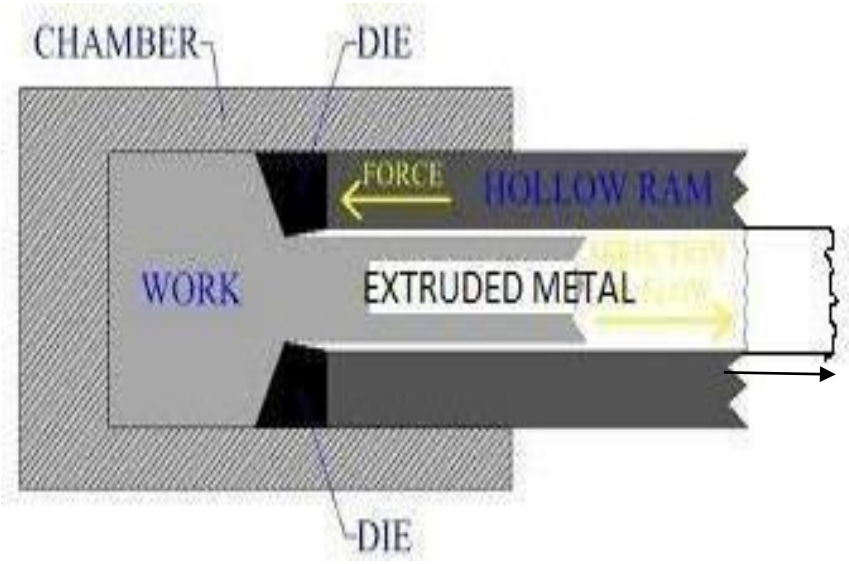
It is the most widely used method. The process is illustrated in the above figure . In this process the billet is heated to its forging temperature and fed into the machine chamber i.e the cylinder where pressure is applied tothebilletwiththehelpoftheramandthemetalflow inforwarddirection i.esamedirectionas thatoftheRAMandcomeoutthroughthedie opening. Theoverhangingextrudedlengthisfedintoalongsupportcalledtherunout table.Thelast10%lengthofbilletisleftunextrudedandthisportionisknown as discard and contains surface impurities of the billet.

Inforwardextrusion,frictionoccursbetweentheheatedmetalandthe cylinder walls due to relative motion between them. The problem of friction isseverincaseofsteelextrusionbecauseoftheirhighextrusiontemperature.

To reduce these friction lubricants are used. At lower temperature a mixture of oil and graphite is generally used. For steel extrusion, finely powdered glass is used as lubricant.

To reduce the damage to the equipment extrusion is finished quickly and cylinder is cooled before further extrusion.

IndirectExtrusionorBackwardExtrusion:



For this type of extrusion a hollow ram or plunger is used. In this case theplungerpressesthebilletagainstthebackwalloftheclosedchamberand the metal is extruded back into the plunger through the die.

Itistermedbackwardbecauseoftheoppositedirectionofflowofmetal to that of Ram movement.

As the billet does not move inside the chamber, there is no friction between them. Less force is needed in this method in comparison to the direct extrusion.

Better surface quality is achieved in this process as no heat cracking happens between the billet and extrusion cylinder interface.

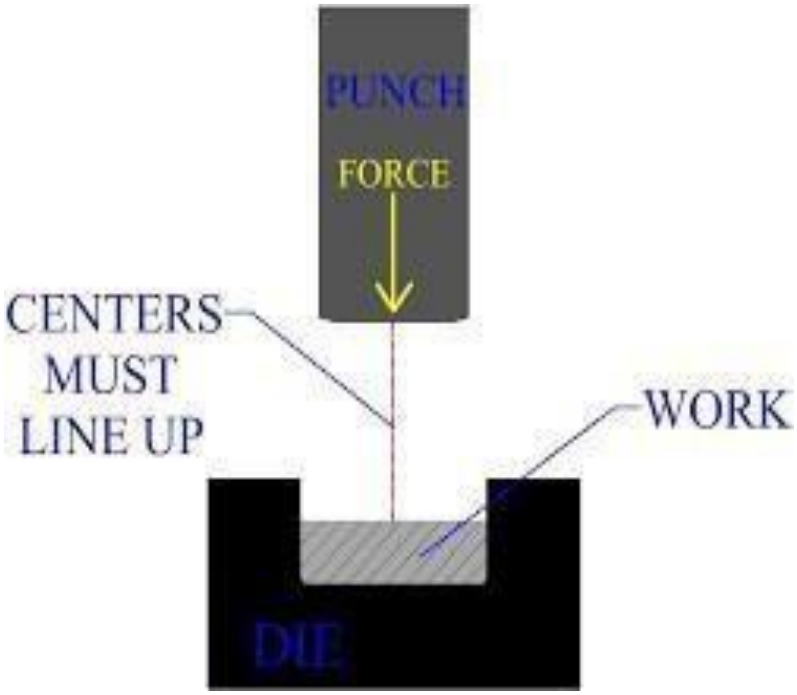
Thedisadvantagesofthisprocessare:

- Amorecomplicatedtypeofequipmentis requiredas theplunger becomes weak.
- Insupportingtheoverhangingextrudedpartcomingoutofmoving RAM.

ImpactExtrusionorbackwardcoldextrusion:

This method is chiefly used for making small work pieces from ductile material.Thematerialisplacedinthepositionintoablinddieandaramwith clearance is forced in to the die, making the metal to flow plastically around the ram. Because of the impact force the side walls go straight along the punch though they are not confined .

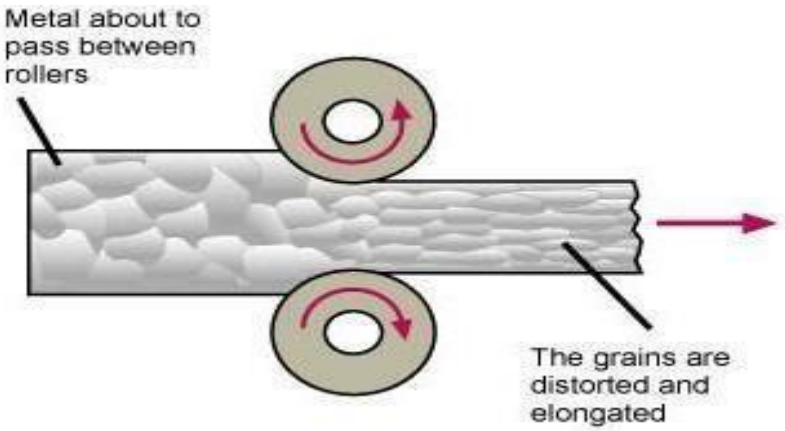
Withthehelpofthisprocess,collapsiblemedicinetubeandtoothpaste tubes are produced . Lead, aluminum, copper , tin and other soft metals are used in this process.



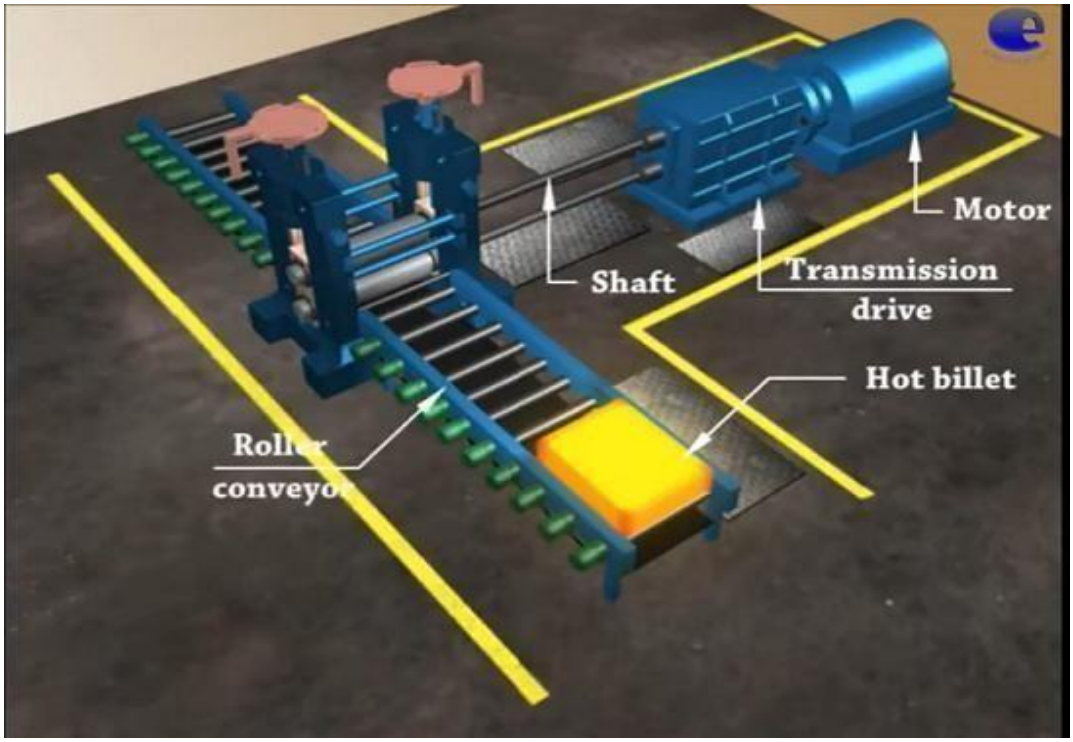
ROLLING

Rolling is a metal forming process in which the cross-sectional area is reduced by passing thework piece (ingot) through a pair of rolls.

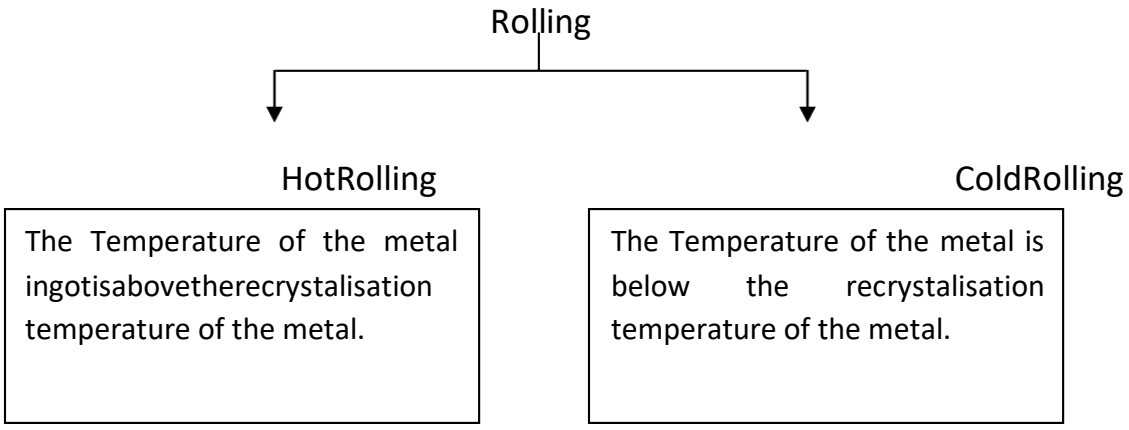
Inrollingprocessthicknessoftheingotreducesandlengthoftheingot increases by compressive force applied by rolls.



3DVIEWOFROLLING



CLASSIFICATIONOFROLLING:



Differencebetweenhotrollingandcoldrolling

HotRolling	ColdRolling
1. Hot rolling is conducted above recrystallisation temperature of metal i.e 0.3 to 0.5 of melting point of metal.	1.Coldrollingisconductedbelow recrystallisation temperature of metal.
2.Nostrainhardeningoccurs. Large reduction of crosssectionalareacan beobtained.	2. Strain hardening occurs. Strengthincreasesbutductility decreases.
3. Yield strength reducesand ductilityincreasesforwhich plastic deformation occurs by applying less amount of power.	3.Strainhardeningandhighyield strength limited deformation inonepass.
4.Coarse structure of cast ingot isconvertedintoafinegrained structure. Fine grained structure improves physical properties.	4.No scale formation or oxidation of metal surfaceoccurs. Results good surface finish.
5.Poorcontroloverdimension duetothermalexpansion.	5.Nothermalexpansion.

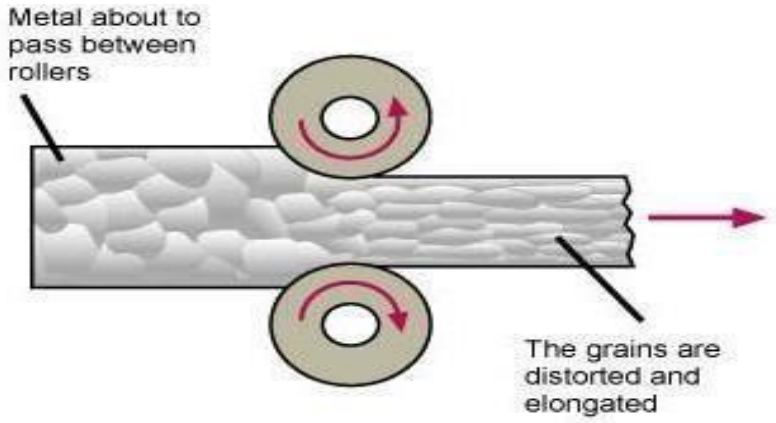
Limitation:	**Limitation:**
6.Oxidation,scale formation on surfacereducessurfacefinish. 7.Handingistough.	6.Noworkingoflowductility metal.

Rollingmillsmaybeclassifiedaccordingtothenumberandarrangementof the rolls.

TYPESOFROLLINGMILLS:-

1. Twohighrollingmills
    a. Nonreversing
    b. Reversing
2. Threehighrollingmills
3. Fourhighrollingmills
4. Tandemrollingmills
5. Clusterrollingmills
6. Planetaryrolls

Twohighrollingmills:-



TWOHIGHNONREVERSINGROLLINGMILL:

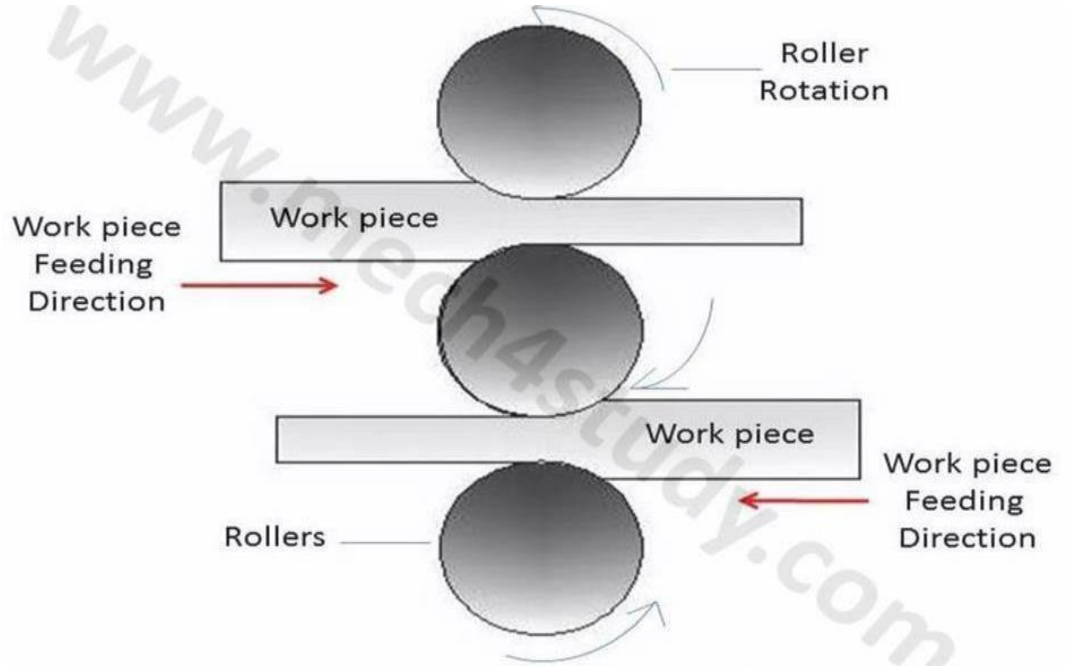
1. Boththerollsrotatesinoppositedirectionstooneanotherasshowninthe figure.Thedirectionofrotationisfixed,cannotbereversiblethusthework can be rolled by feed from one direction.
2. The space between the roll can be adjusted by raising or lowering the upper roll . The position of lower roll is fixed.
3. Thismillisusedwherethebarhastopassonceandinopentrainplatemill.

TWOHIGHREVERSINGROLLINGMILL:

1. In this type of rolling millthere is a drive mechanismwhichcanreverse the direction of rotation of the roll.
2. Becauseofthisdrivemechanismthemetalmaypassbackandforth through the rolls several times.
3. This type of mill is used in blooming and slabing mills and for roughing work in plate , rail structure and other mills.

THREEHIGHROLLINGMILLS:

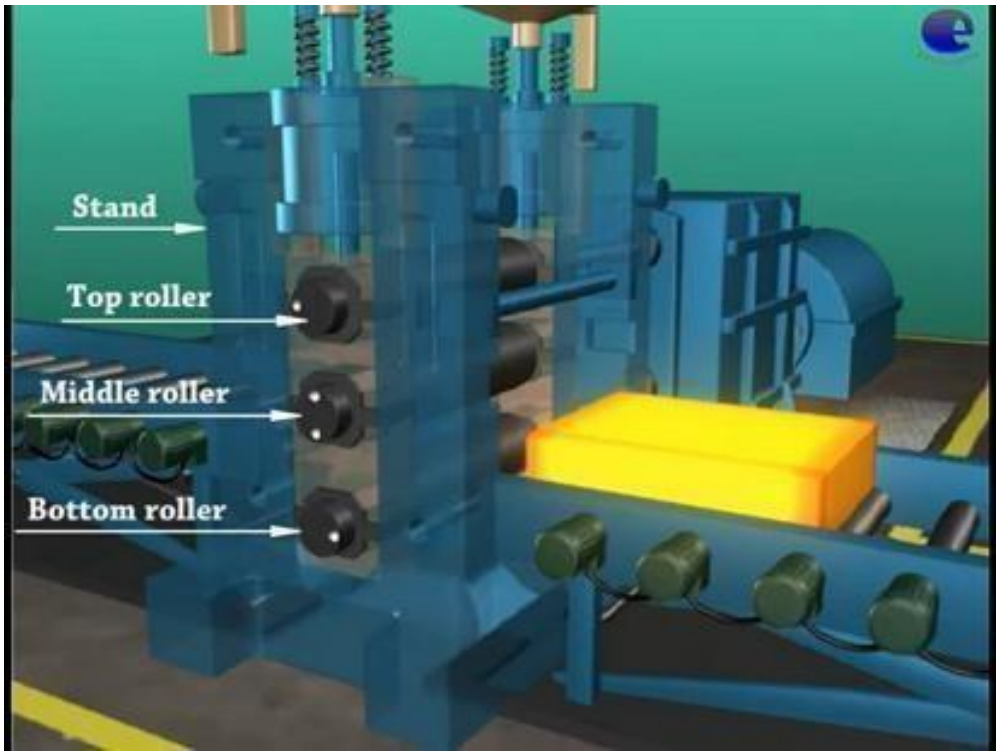
Itconsists of a rollstandwith threeparallel rolls oneabove theother . adjacent rolls rotate in opposite direction.



THREE HIGH ROLLING MILL

www.Mech4study.com

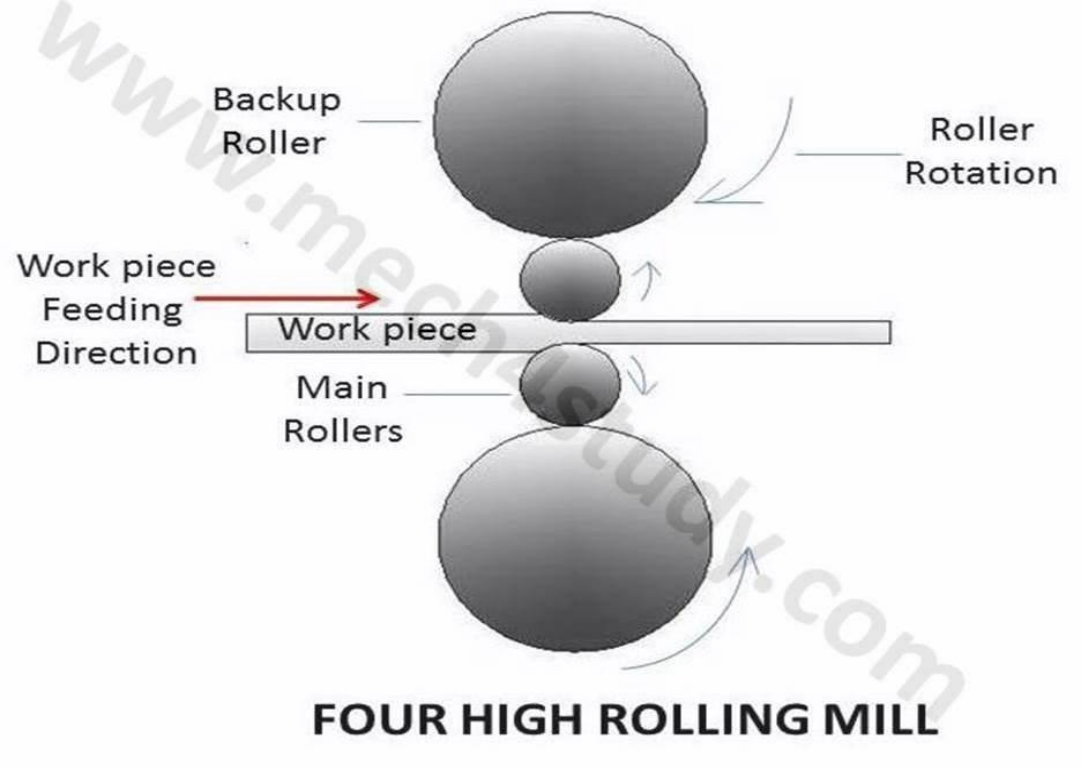
3DVIEW OF3HIGHROLLINGMILL



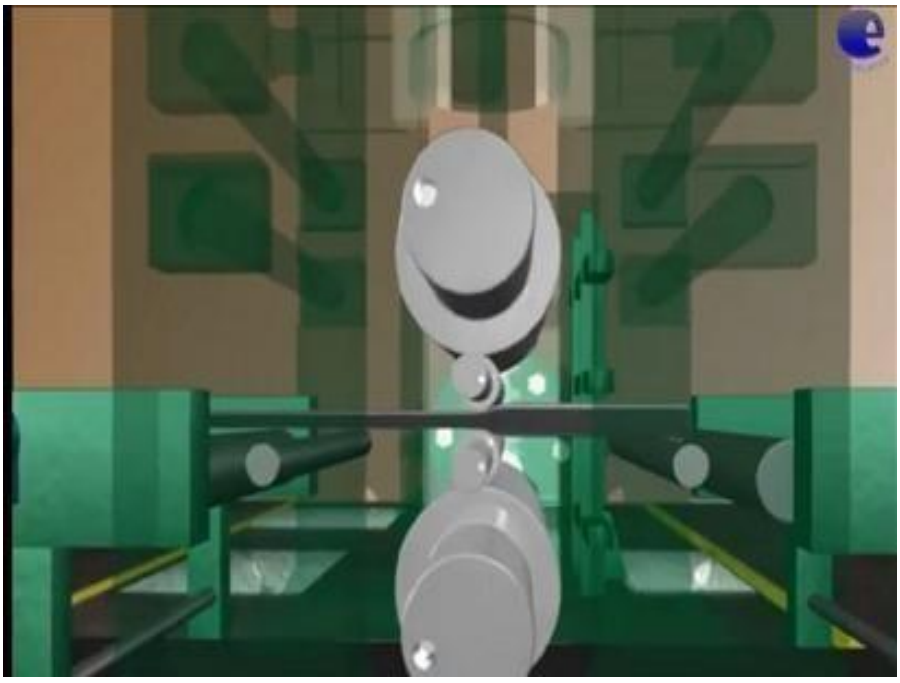
1. This arrangement is used for rolling of two continuous passes in a rolling sequence without reversing the drive.
2. First of all themetalhaspassedthrough thebottom &themiddleroll in onedirection,theendof themetalisenteredintotheother set of the rolls for the next pass..
3. For this purpose a mechanically operated lifted tables are used to bring the metals to the level of the rolls. Since the rolls run in one directiononlyamuchlesspowerfulmotor andtransmissionsystemis required .

FOURHIGHROLLINGMILLS:

The fourhighrolling mills hasa rollingstand with twosmall size rolls& two big size rolls. These four rolls placed parallely one above the other . The work piece passes through the two small rolls & the big size rolls works as backuprolls for providing thenecessaryrigidity. It works liketwohighrolling mills.

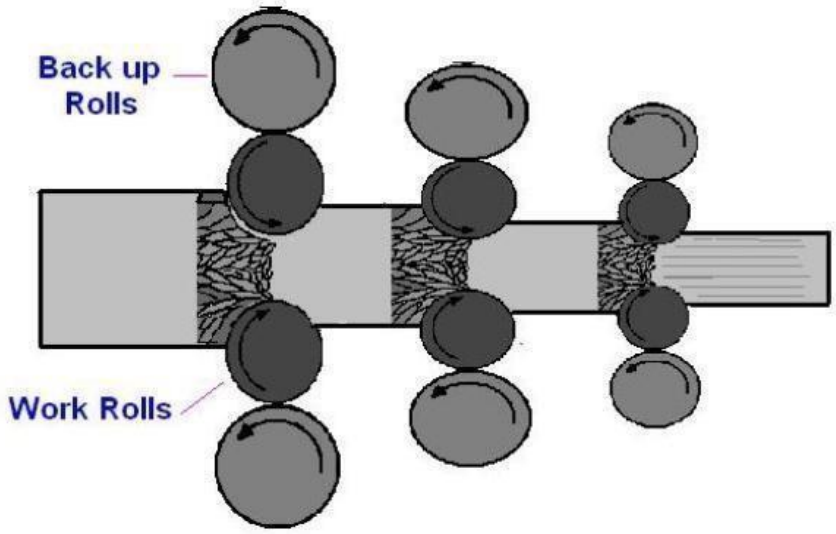


3DVIEWOF4HIGHROLLINGMILL

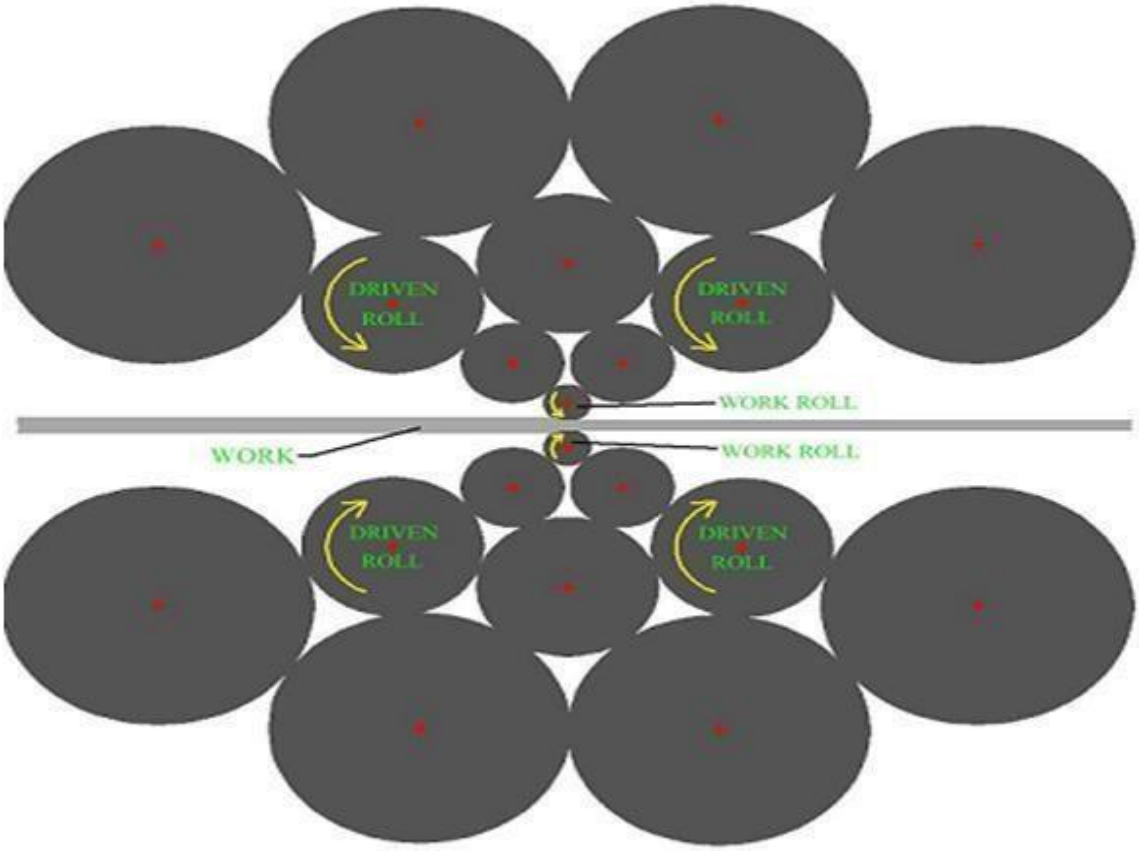


TANDEMROLLINGMILLS:

The tandem mill consist of 3 to 6 mills stands arrange in series to progressively reduced the thickness of the strip in a single pass. The advantages of the Tandem Rolling process include cost reduction and improve



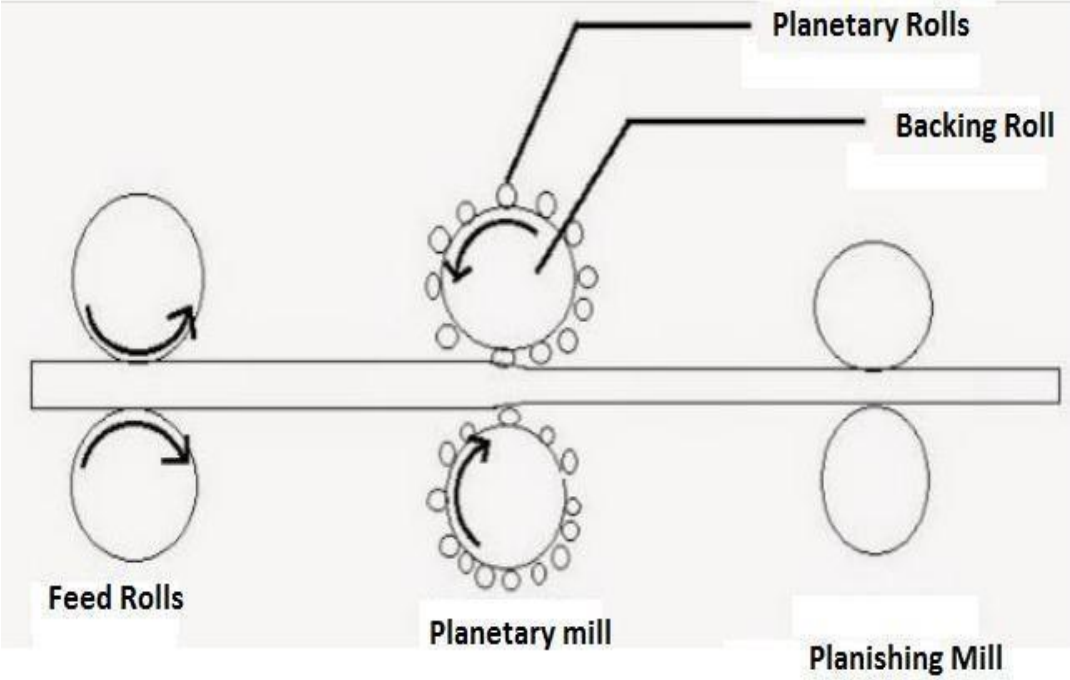
CLUSTERROLLINGMILLS:



1. It consist of two working rolls of smaller diameter and a number of backup rolls of larger diameter.
2. The no of backup rollers may go as high as 20 or more depending upon theamount ofsupportneeded for theworking rollsduring the operation.
3. Thistypeofmillisgenerallyusedforcold rolling.

4. Clustermills areused toreduced thethickness ofstainless steel, high carbon steel of any another high strength alloy steel .
5. The main advantages of cluster mill is the backup roll take out a large amount of heat from the working roll and the work piece.

PLANETARY:



[Planishing is a metal working technique that involves finishing the surface by finely shaping and smoothing]

1. In planetary rolling mill a no of rotating wheels are used as work roll instead of a single small roll , are fixed tothelarge backuproll.
2. Thismillcanbeusedtorollallmetalsbutitisspeciallyusefulfor those which has low ductility.
3. Inthis mill the metalat lowerthanitscriticaltemperaturecanbe entered for rolling which reduces scale formation.

WELDING

Weldingistheprocessofjoining similarordissimilarmetalsand plastics withoutusingfasteners and adhesives.

Thisprocessisbasicallyoftwotypes.

i) FusionWelding
ii) PressureWelding

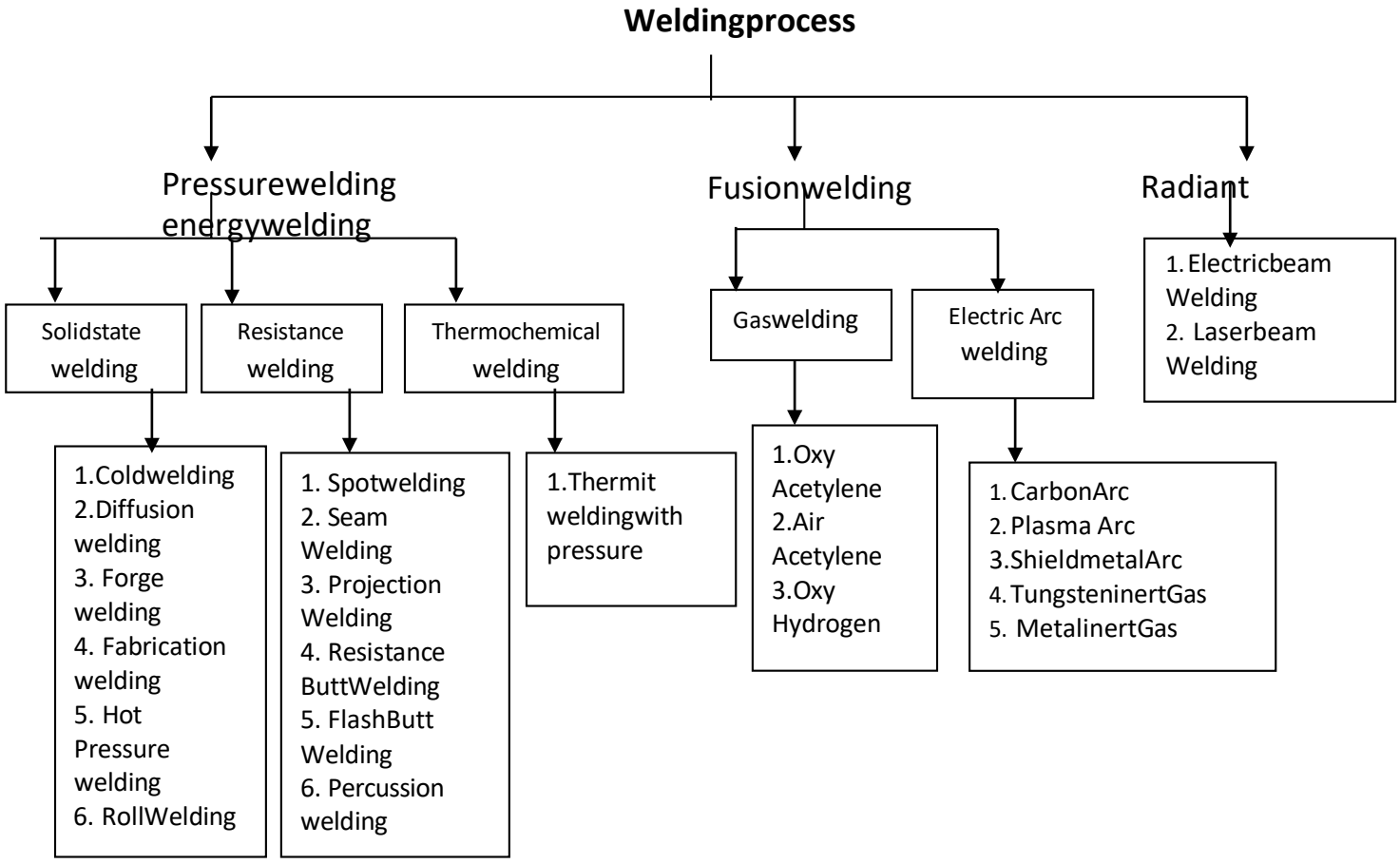
FusionWelding:

- In this process thetemperatureofendpartofbasemetals which are to be joined are raised to their fusion point by application of heat.
- As a result of which they form a sort of pool of homogeneous molten metal at the ends to be joined.
- Sometimesafiller metal(wireorrod)whichhasnearly thesame composition of the parent metals are used to supplement the pool.
- Aftersolidificationthetwoendsjoinedpermanently.

Pressurewelding:

- In this process the ends of the metal pieces are heated to their plastic state and then external pressure is applied to join them.

Classificationofweldingaccordingtosourceofenergyemployedtoheatthe metal



WELDINGFLUX:

- Weldingfluxisashieldingagentandsometimesactasaprimeanti-oxidizing agent which prevents the interaction of surrounding medium(like air) andreduce oxides respectively.
- Duringweldingprocessasthetemperatureofbasematerialaswell as filer material increase in very short time, leads to metal oxide formation by interacting with surrounding air. This oxide layer reduces the weld strength. The formation of sulfides and nitrides also hurt weld's strength.

Hence flux material is used either to shield thewelding area to prevent formation of oxides or to reduce the oxides formed.

- Inadditiontopreventionofformationofoxidesweldfluxalso,

- Createsaprotectiveslagoverthemoltenmetal.
- Removesimpuritiesfromthemoltenmetal.
- Reducessplatter.
- Preventshardeningbyslowingdowncoolingtime.

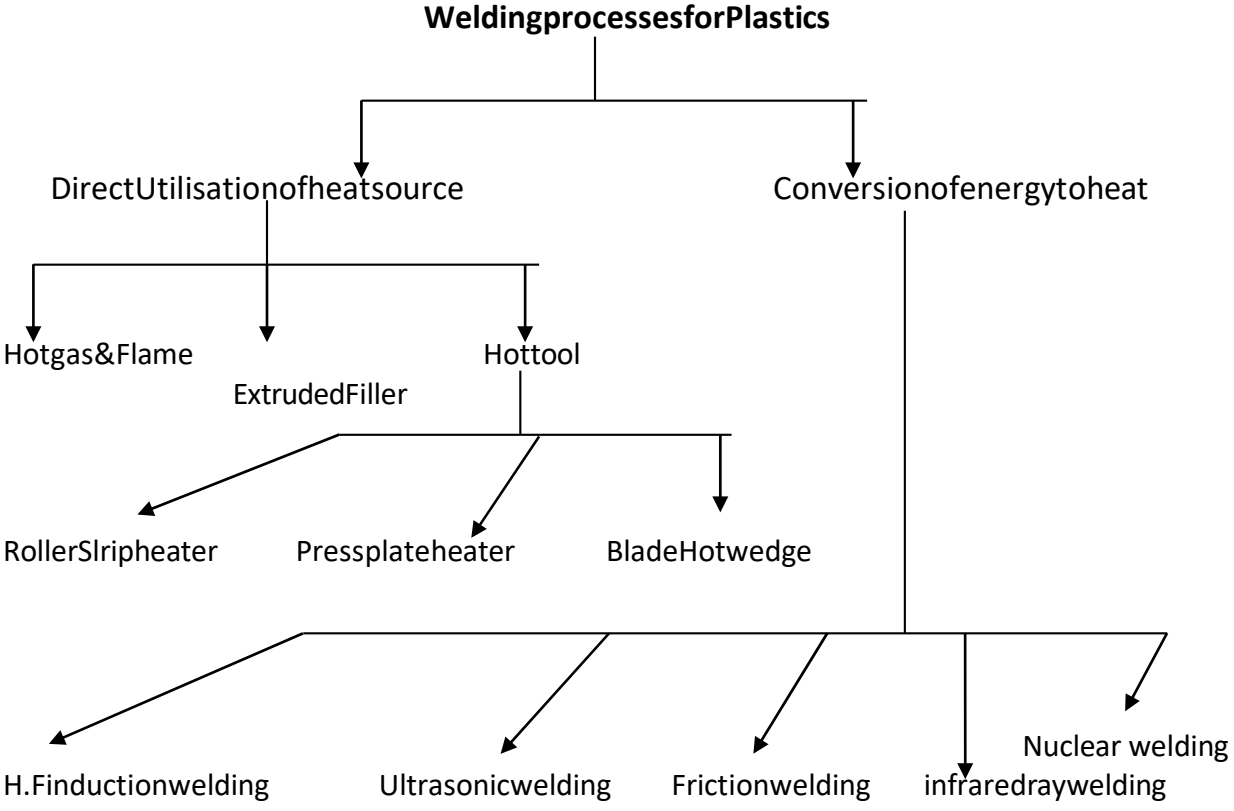
Becauseofitsgreatertoleranceforbaseplatecontamination,fluxcored welding requires less pre-cleaning than MIG.

- Depositionrateisuptofourtimesgreaterthanstickwelding.
- The use of self shielded electrodes eliminates the need for flux handling or gas apparatus for which it is convenient to use in outdoor construction.

Selfshielded---coreprovidesingredientsforshielding.

Gas shielded --- uses external shielding gases.

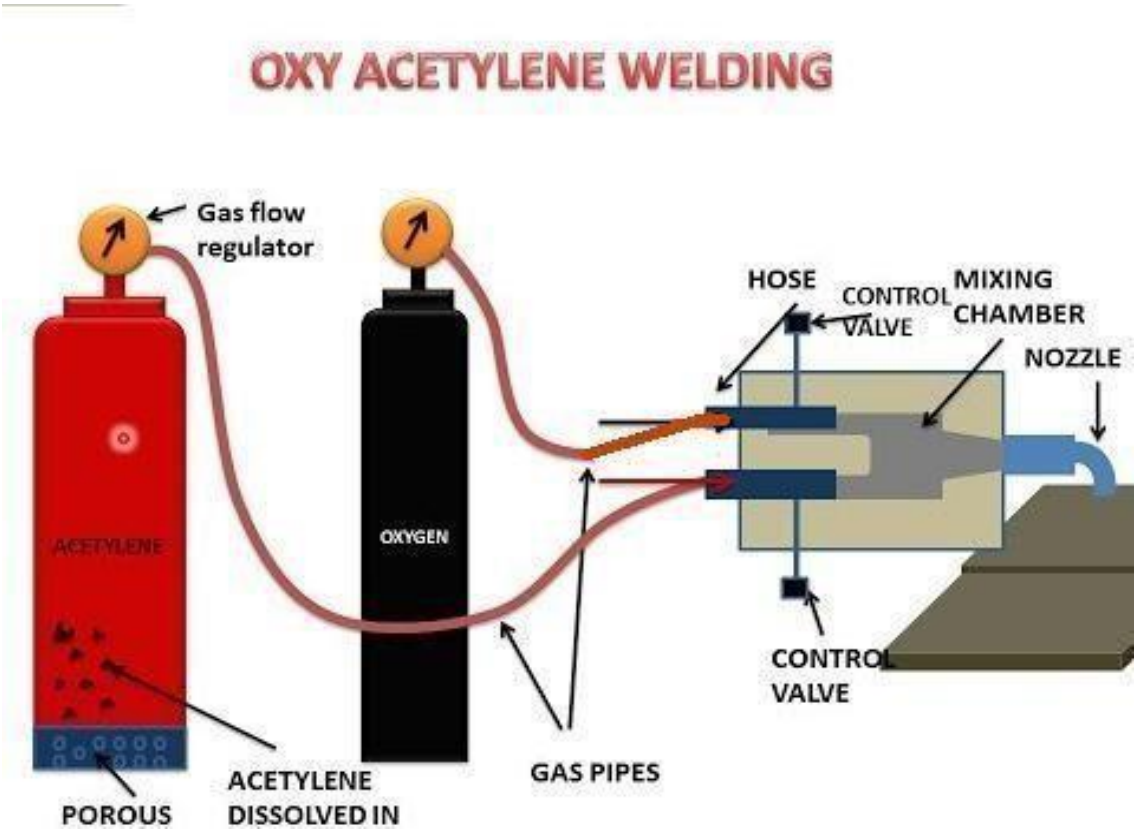
GasesforshieldingareCo$_2$,Ar,mixtureoftwo.



OXYACETYLENEWELDING

Oxy-Acetyleneweldingisonetypeofoxy-fuelwelding.Thisweldingcan beusedforweldingalmostallmetalsandalloysusedinengineeringfield.

Equipmentsandaccessoriesrequiredforoxy-Acetylenewelding



Equipment:

1. Oxygencylinder(paintedblack)
2. Acetylenecylinder(paintedmaroon)
3. Blowpipesandtorches
4. PressureRegulator

1. **Oxygencylinder(paintedblack)**

In this cylinder oxygen is filled at a pressure of 125 kgs to 140 kgs per square centimeter.

2. **Acetylenecylinder(paintedmaroon)**

In high pressuresystem,acetylenecylinder carry aporous mass inside, soaked in acetone, which has a capacity to dissolve 25 times its own volume of acetylene for every atmosphere of pressure applied.

In low pressure system , acetylene is drawn from a low pressure acetylene generator.

3. **Blowpipesandtorches**

The high pressure system blow pipe has two different passages which are connected to oxygen and acetylene hose pipe separately. The blow pipe or torch contains a chamber where both these gases are mixed and thendrivenoutthroughtheorificeoftheblow pipenozzle or tip. Thelow pressure blow pipe works on the principle of an injector .

4. **PressureRegulator**

Pressureregulators arefixedonthetopofthegascylinders andcarrya reducing valve to reduce theirpressurebefore feeding tothe blowpipe. This pressure is regulated according to requirement by adjusting the spring pressure on the diaphragm by means of pressure regulating screw.

Two pressure gauges are fitted to two chambers , one before the diaphragm, shows pressure inside the cylinder and the other after the diaphragm, shows working pressure at which the gas is being drawn for operation.

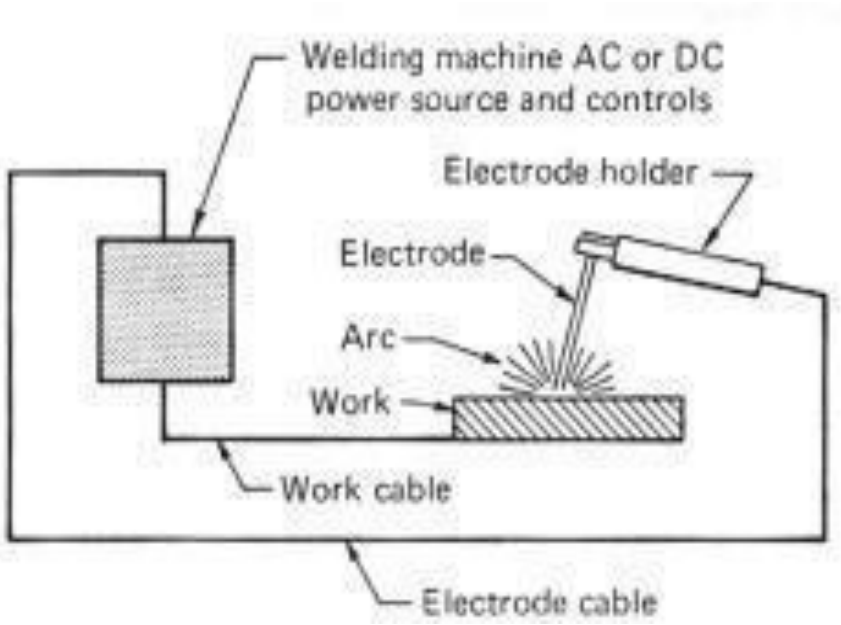
Twostage regulators are preferred to one stageregulator. In this type pressuredropinfirststageisfixedwherethedesireddropisregulated inthe second stage.

ARC WELDING

- It is a fusion welding process where the heat is generated by the application of arc.

Electricarcwelding

- InElectricArcwelding theendofthe metalpieces tobejoinedare heated locally to the melting temperature, by creating an electric arc and then allowed to solidify to form the welded joint.
- The arc is a flame of intense heat, generated by passing electric current through a highly resistant air gap between the electrode and the workpiece.



DifferentArcWeldingprocessesare:

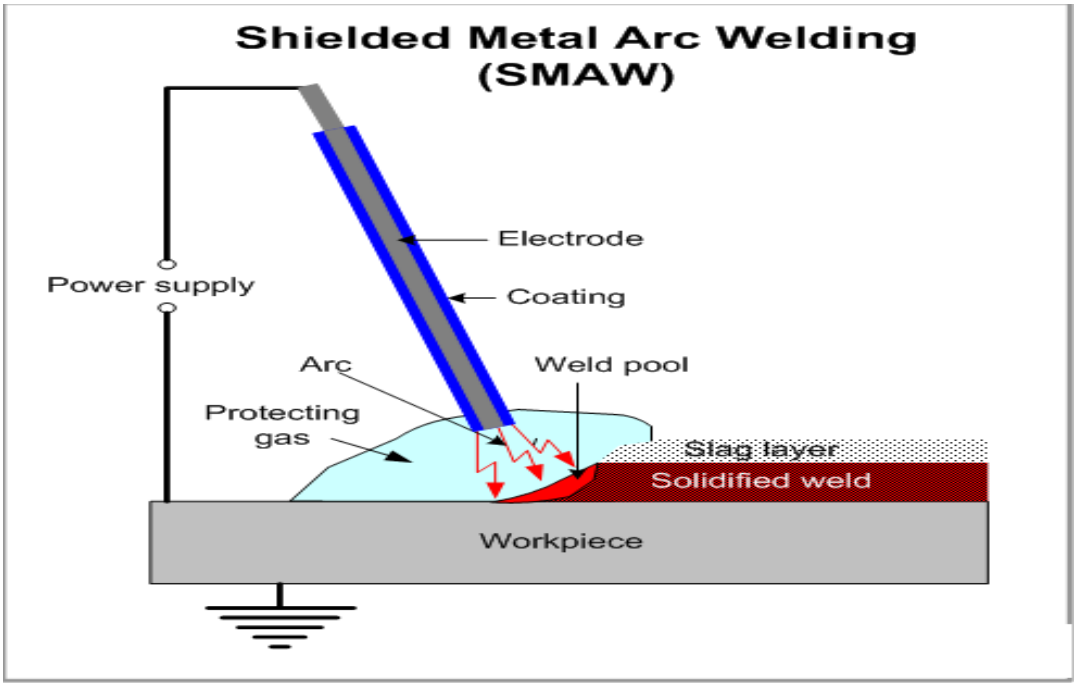
- ShieldedMetalarcwelding
- Carbonarcwelding
- Tungsteninertgaswelding
- Metalinertgaswelding

Shieldedmetalarcwelding

In this process a metal electrode is used and the arc is maintained betweenthiselectrodeandtheworkpiece,which respectivelyformthe two terminals.

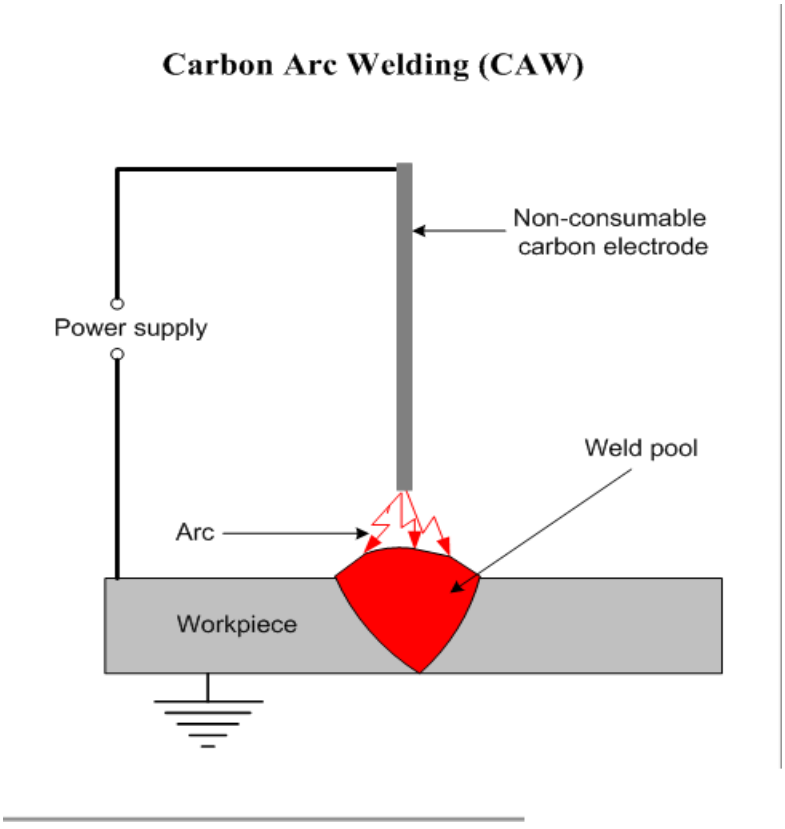
The metal electrode is coated with flux which produces a gas to shield andprotectthewelding areafrom atmosphericair. Insomecasesitalso carries certain alloying elements which promote conduction of electric current and stabilized the arc.

- Bothalternating current(A.C)anddirectcurrent(D.C)areusedfor arc welding.
- ForA.Carcweldingastepdowntransformerisusedwhichreceives current from the supply mains at 400-440 volts and transforms it to the required voltage for welding i.e 80-100 volts.
- Application:itisusedforweldingofsteelandcastiron.
- Thisweldingisnotusedtoweldcuppermetal.



Carbonarc welding

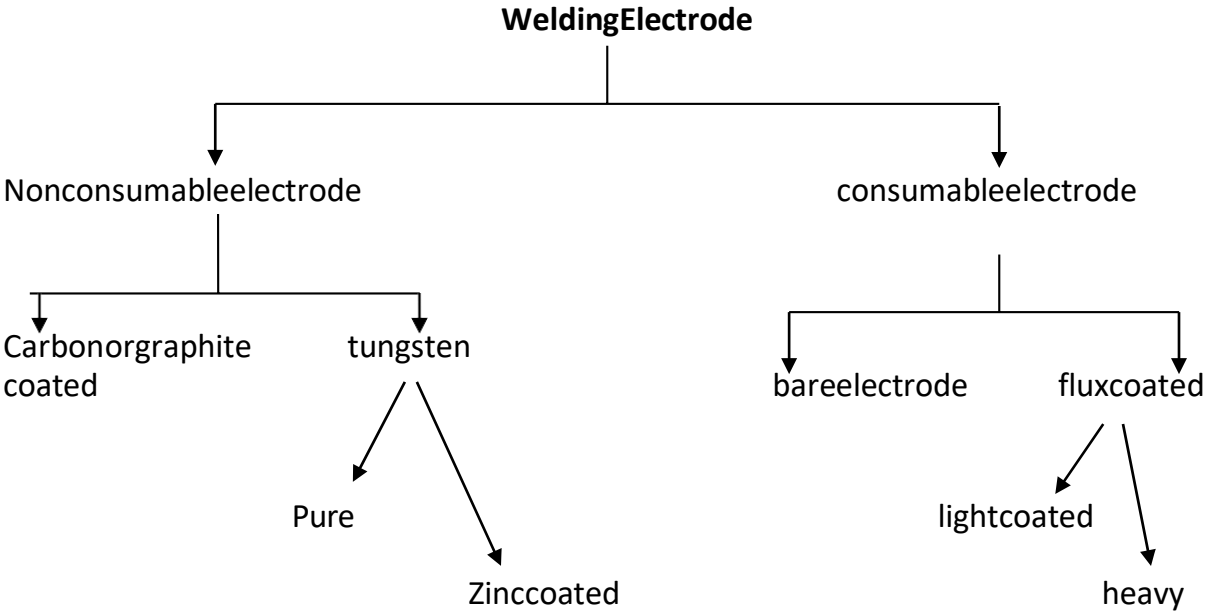
- Carbonarcweldingisafusionweldingprocesswhere non consumable carbon electrode is used.
- OnlyD.Cisusedincarbonarcweldingprocess.
- Thenegativeterminalofthesupplyisconnectedtothecarbon electrode and the positive terminal to the workpiece.
- A flux is used to prevent the weld metal from picking up carbonfrom the fused electrode.
- Application:thisweldingisusedforjoiningsteelsheets.



Arcweldingelectrodespecification:-

Electrode:-

It is a piece of wire rod (of metal or alloy) with or without flux coated material which carries current for welding.



Consumableelectrode:-

1. Havelowmeltingpoint.
2. When arc is generated between electrode and work piece the tip of theelectrodestartsmeltingandconvertedindropletswhichtransfers to the work piece.
3. Thesedropletstransferringtotheworkpiecegetsdepositedthereand produce large heat so the thermal efficiency of consumable electrode arrangement is higher (85%) as compared to non-consumable electrode welding arrangement.

Bareelectrodes:-

1. Itismadeupofmetalsoralloysbutwithoutfluxcoating.
2. It does not prevent to oxidation or atmospheric contamination for which the joint will be work and low ductile do it is used for minor repairs where strength is not dominant.

3. Ithaspoorweldquality.
4. Arcisunstable.
5. Impropermetaltransfer.
6. Itisnoiseless.

Fluxcoatedelectrode:-

1. It prevents to the oxidation and to the atmospheric contamination by creating a gaseous shield around the arc.
2. Betterarc
3. Stablearc
4. Betterweldingquality

Lightcoating:-

Theseelectrodeshavingcoatingparameterof1.25 Ex:
cyto blast

Heavycoating:-

Coatingparameterof1.6to2.2.

ELECTRODECLASSIFICATIONANDCODING:

AccordingtoISIcodingsystemanelectrodeisspecifiedbysixdigitswith a prefix letter M, which indicates its suitability for metal-arc welding. These six digits stand for the following:

1. **Firstdigit:**
   Numbering from 1 to 8. Each number stands for a particular type of covering provided on the electrode.

2. **Seconddigit:**
   It also carries numbers from 1 to 6 and each number represents a particularpositionorpositionsofweldinginwhichtheelectrodecanbe used.

3. **Thirddigit:**
   Maycarryanynumberfrom0to7.eachnumberrepresentsaparticular current condition suitable for that particular electrode.

4. Fourthdigit:

Iindicatestheminimumtensilestrengthoftheweldmetal.Itmaycarry any number from1 to and eachnumber represents a particular tensile strength in kg/cm2.

5. Fifthdigit:

It indicates the percentage elongation of deposited weld metal in tensiletesting.Differentpercentagesarerepresentedbynumbersfrom 1 to 5.

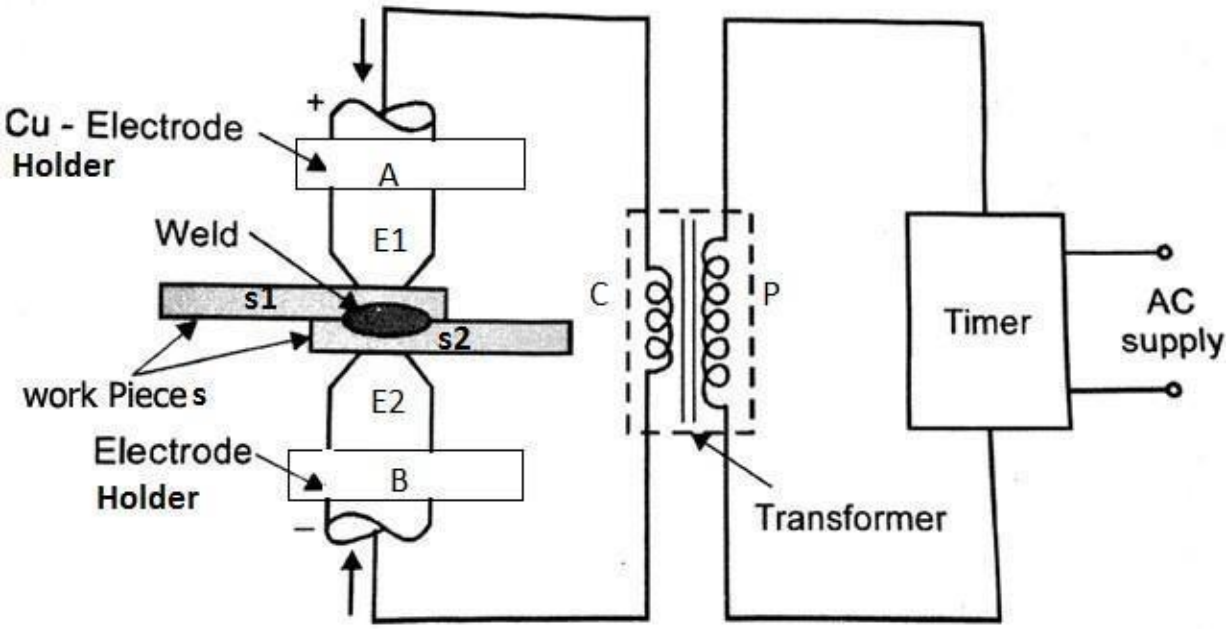
6. Sixthdigit:

It indicates the minimum impact value of the weld metal . Different values are represented b numbers from1 to 5.

VARIOUSRESISTANCEWELDINGPROCESSES

SPOTRESITANCEWELDING

- This welding process is used for making lap welds in thin sheets (up to a maximum thickness of 12.7 mm) using the principle o resistance welding.
- In this welding process one end of the secondary winding of the transformer is connected to the upper electrode E1 carried in the movable copper or bronze arm A and the other end to the lower electrode E2 mounted on the fixed arm B.
- The metal sheets S1 and S2 are held and pressed between the electrodes and astrong current at low voltage is applied.
- Developed resistance by the sheet metals to the flow of this current causes heat and raise the temperature at the contact surfaces to their fusion point and the weld is completed under the contact pressure of the electrodes.

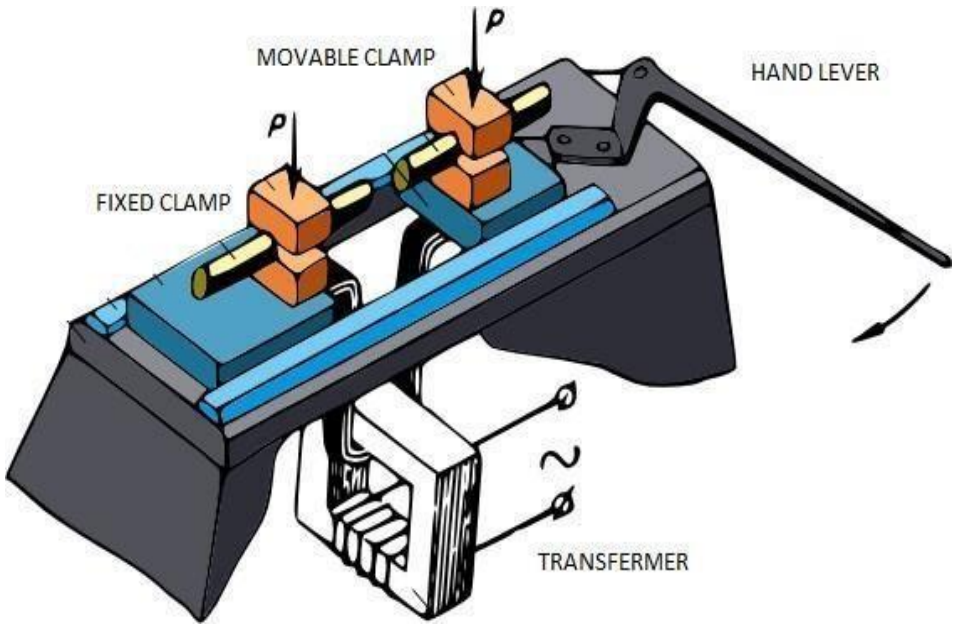


RESISTANCEBUTTWELDING

- Butt welding is also known as upset welding . It is used to join metal pieces end to end.
- In butt welding the metal pieces usual bars and rods of the same cross section are held in suitable clamps or vices with their prepared ends abuttingagainsteachotherthedevelopedresistanceofflowofcurrent depends on the projected lengths of the metal pieces and their cross sections. The projected length is to be adjusted to provide sufficient resistance to generate the desired amount of heat at the joining ends.
- The clamps either form the electrodes themselves or are fitted with separate electrodes in them.
- Oneoftheselamps is rigidly fixedtotheframeofthewelding machine andtheother is mounted ona movableslideoperated by a handlever

(forlargemachines)oraspring(forsmallmachinescapacityupto12.7 mm).

- Afterabuttingthe endstogetherthe currentis switchedon and the contacting surfaces heated to the fusion point.
- Atthis moment additionalmechanicalpressure is applied by means of thehand lever or the spring attachment and this completes the weld.
- Atripswitchautomaticallybreaksthecircuitassoonastheupsettingis over.
- Buttweldingisusedforweldingoftubes,wires,rods,chainsmadeup of metals having high range of electricalconductivity such as Cu.



RESISTANCEFLASHWELDING

- Flash welding is used for joining metal pieces end to end. It replaces buttweldingmethodforweldingarticleshavingthincross-section.Itis also used to weld thick sections.
- Inthismethod,firstthecurrentisswitchedonandthentheendsofthe piecestobeweldedareslowlybroughtcloseruntiltheyfinallycomein contact with each other.
- Once the ends come in contact with each other they forces the generatedheattolocaliseatthe endsasaresult ofwhichtemperature raises to fusion point.
- At this moment the ends are pressed against each other by applying Mechanical pressure.
- Thisforcesthemoltenmetalandslagtobesqueezedoutintheformof sparks enabling the pure metal to form the joint and disallowing the heat to spread back.

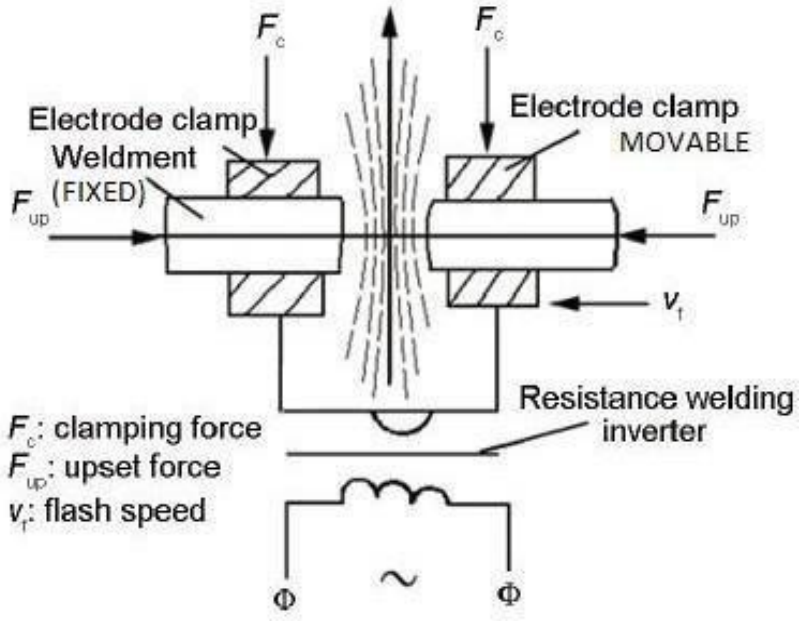
ADVANTAGES AND DISADVANTAGES OFFLASHWELDINGOVERSIMPLE BUTT-WELDING:

ADVANTAGES:

- Itiscomparativelymuchquickerthanbutt-welding.
- Onaccountofonlyasmallportionofthemetalbeingheatedthe current consumptionis less as compared to butt-welding.
- Aflashweldingjointisstrongerthanthebutt-weldingjoint.
- Theendfacesofthemetalpieces neednotbesquaredwhichis a primary requirement in butt-welding
- Lengthsandalignmentofworkpiecesismaintainedtoahighdegreeof accuracy.

DISADVANTAGES:

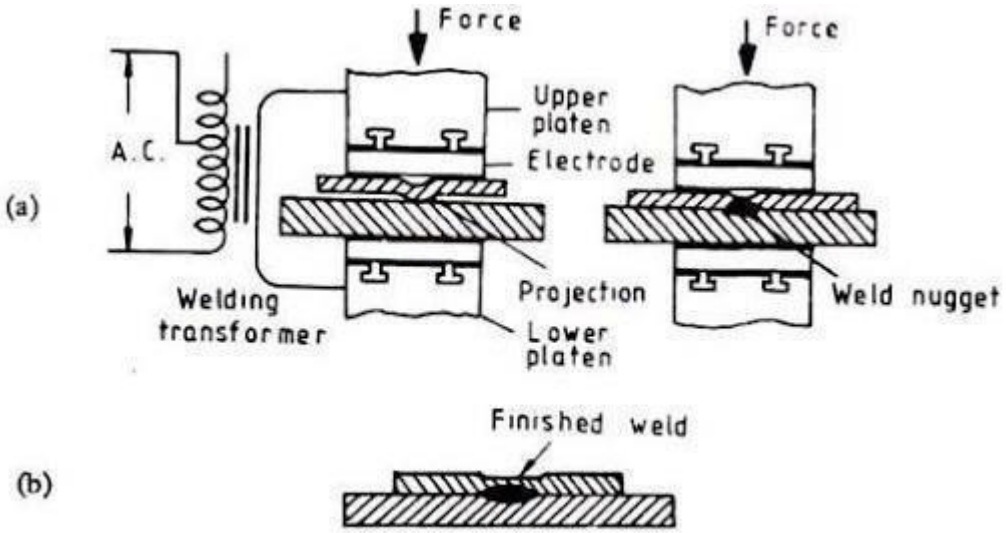
- During flashing particles of molten metal are thrown out, which may enter into the slideways and insulation, etc. this needs periodic maintenance of machine and replacement of insulation.
- Operator has to take enough care against possible fire hazard due to flashing.
- Additional stock has to be provided to compensate the loss of metal during flashing and upsetting. This adds to the cost of product.
- Costofremovalofflashandupsetmetalbytrimming,chipping,grinding etc. furtheradds to the product cost.



RESISTANCEPROJECTIONWELDING:

- Itisamulti-spotweldingtechnique.
- The pieces to be welded are arranged between two flat cupper electrode which exert pressure as current flow.

- In this welding process , projections at the desired location on the surface of one of the workpiceses are located. thus the surfaces of the workpiceses are in contact with each other at the projection. As per current is switched on the projections are melted and the workpiece pressed together to complete the weld , by pressing the upper electrode downwards.

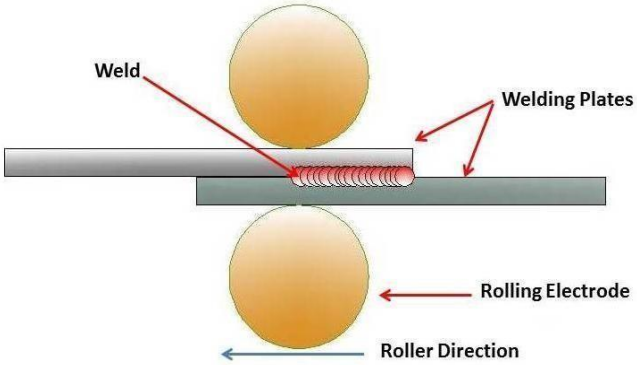


Projection welding (*a*) Setup (*b*) Finished weld.

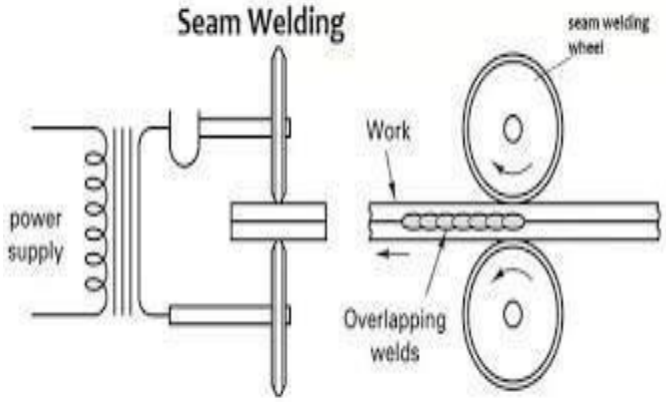
RESISTANCESEAMWELDING:

- It is similar to spot welding with difference that the electrodes are in the form of rotating rollers and w/p moves in direction perpendicular to roller axis.
- In this welding the current is switched on and the metal pieces pushed together to travel between the revolving electrodes. The metal between the electrodes gets heated to welding heat and welded continuously under the constant pressure of rotating electrodes as it passes between them.

- Theweldingisusually doneunderwatertokeeptheheatingofwelding rollers and the work to a minimum value to give lower roller maintenance.
- Weldingcurrentrangefrom2000Ato5000Awhiletheforceappliedto the roller may as high as 5 KN to 6 KN.
- Weldingspeedis1.5m/minforthinsheet.
- A series of spot welds at continuous interval can be made along the length of the seam called roll spot welding.



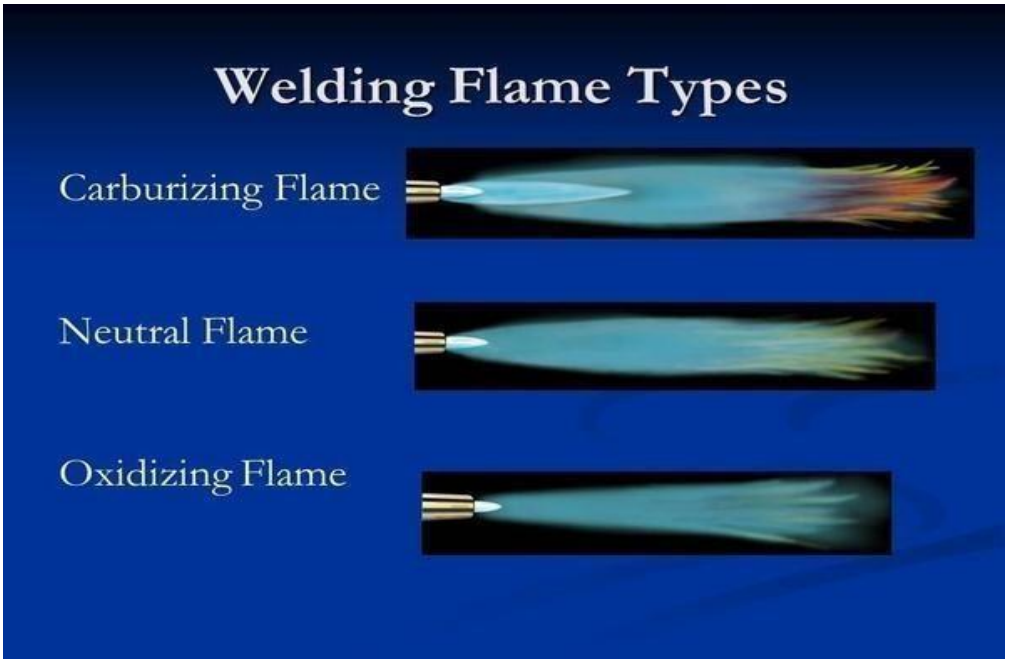
Seam Welding



TYPESOFFLAMES

It is an established fact that the properties and nature of the gas flame havethemaximumeffectonoxy-acetylenewelding.Properadjustmentofthe flameleadstosuccessfulandefficient welding.Thisadjustmentcanbemade bothinregardtothecharacteristics andthepoweroftheflamebyregulating thepressuresofoxygenandacetylene.Aflameinwhichonly acetyleneburns is yellow in colour and is of no commercial use, because of its incapability to develop high temperature . The three kinds of oxy-acetylene flames, which are used in engineering works, are as follows:

1. Oxidisingflame
2. Neutralflame
3. Carburisingflame



1. **Oxidisingflame:**

Whensupply ofoxygenismorethanthesupply ofAcetylene,thistype of flame is obtained. The ratio of O_2 andC_2H_2 is 1.15 to 1.5.

Thisflamehas asharpinnerconewhichiswhiteincolourandanouter envelope.

Maximumtemperatureisavailableatthepointedtiporendofthe inner cone.

Theouterenvelopeactsasacoveringforthemoltenpoolduring welding and prevents oxidization of surface.

Application:weldingofcopper,bronze,brass,zinc.

2. **Neutralflame:**

Whensupplyofoxygenisequaltothesupplyofacetylene,thistypeof flame is obtained.

Here

O_2: C_2H_2=1:1

Application: Welding of stainless steel, low carbon steel, cast ironand aluminum.

3. **Carburisingflame:**

Whensupply of oxygen is less than thesupply of acetylene , this type of flame is obtained.

Here

O_2: C_2H_2<1=0.5 to0.95

Itisknownasthereducing flame. Herealongwiththeconeor innertip and outer envelop another layer exists. This layer lies in between the cones outer envelop. This stage is known as brush or feather.
Thetemperatureattainedbytheseflamesvaryfrom3100°Cto3500°C.

Application:weldingofhighcarbonsteelandNialloys.

CHEMISTRY OFCOMBUSTIONINOXY-ACEYLENEWELDING:

The combustion of gases takes place in two or three stages in these flames . different types of flames, together with the different terms used in connectionwiththem.Theconeor inner tipis thesharpwhiteportionof the flame which extends just next to the tip of the nozzle. The maximum

temperature is available at the pointed tip or end of this cone. The second stage or the so called brush , or feather, is next to the cone and normally occurs in carburizing flame only. The outer envelop is relatively much larger than the other two described above and it acts as a covering for the molten pool during welding in order to prevent it from being oxidized.

Thechemicalactionthattakesplaceintheflameisthatthecombustion of gases in the first stage gives hydrogen and carbon monoxide. These products, on receiving oxygen from the atmosphere, burn further to give carbondi-oxideandwater vapour orsteamwhich forms theouter envelope.

Thesechemicalreactionscanbeshownthroughequationsasfollows: $C_2H_2 + O_2$ --- $2CO + H_2$

$2CO+H_2+3O$ --------$2CO_2+H_2O$

The flame can be adjusted to have desired atmosphere. The formation of inner cone I the result of increasing oxygen pressure . an oxidizing flame can be attained by increasing the supply of oxygen (i.e having excess of oxygen than acetylene). Such a flame is normally not required except incase of brass. If equal quantities of oxygen and acetylene are mixed they produce a neutral flame having a well defined white cone. This type of flame has the maximum use and a good many metals can be welded successfully by this flame. Acarburizingflameisoneinwhichthesupply ofacetyleneisinexcess as compared to oxygen. The temperature attained by these flame vary from 3100°Cto3500°Candthemostcommonlyusedtemperatureisabout3200°C which can be attained without any appreciable amount of difficulty.

Typesofflamesrequiredfordifferentmetals:

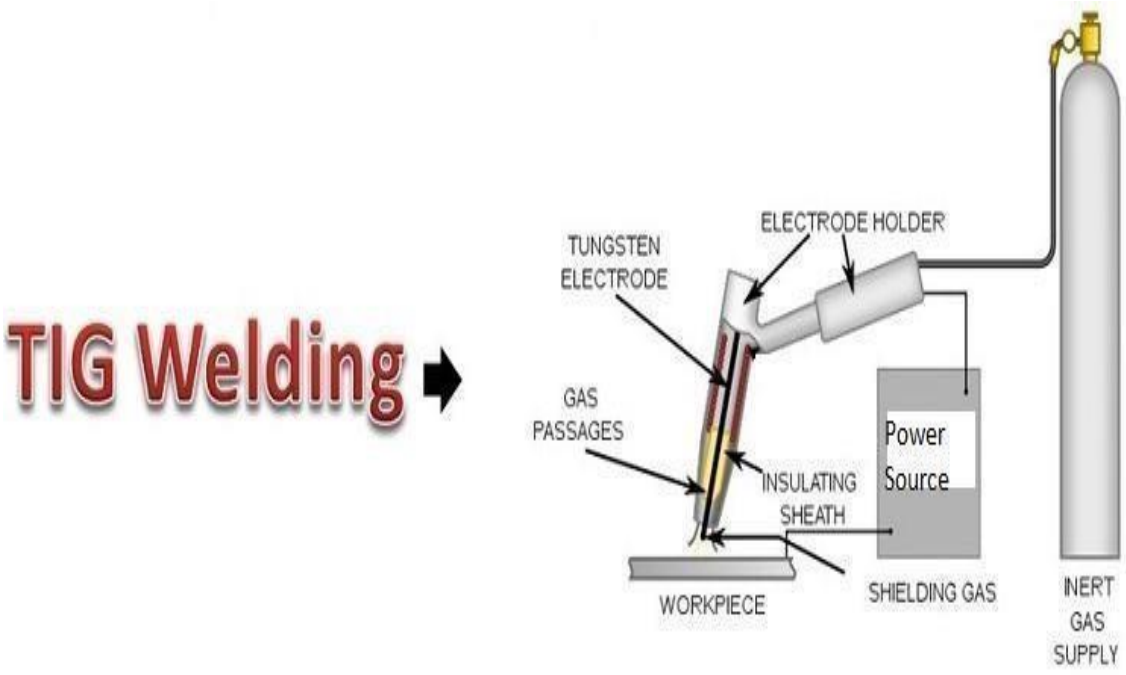
Sl.No	Metal	Flame
1.	Brass	Oxidizing
2.	Castiron	Neutral
3.	Mildsteel	Neutral
4.	Stainlesssteel	Neutral
5.	Copper	Neutral
6.	Aluminum	Neutral
7.	Nickel	Neutral
8.	Monelmetal	Neutral

9.	Lead	Carburizing

TIGANDMIGWELDINGPROCESS

Tungsteninertgaswelding

- Inthisweldingprocessthearcisstuckbetweenanon consumable tungsten electrode and the base metal.
- Theelectrodeisheldin aspecialtype ofelectrodeholder which is so designed that apart from holding the electrode it also carries a passage around the electrode for flow of inert gas to provide the protective shield around the arc.
- This gaseous shield protects the electrode, molten metal, the arc and adjacent heated areas of base metal from atmospheric contamination.
- The electrode holder also carries a provision for water cooling or air cooling.



ADVANTAGES:

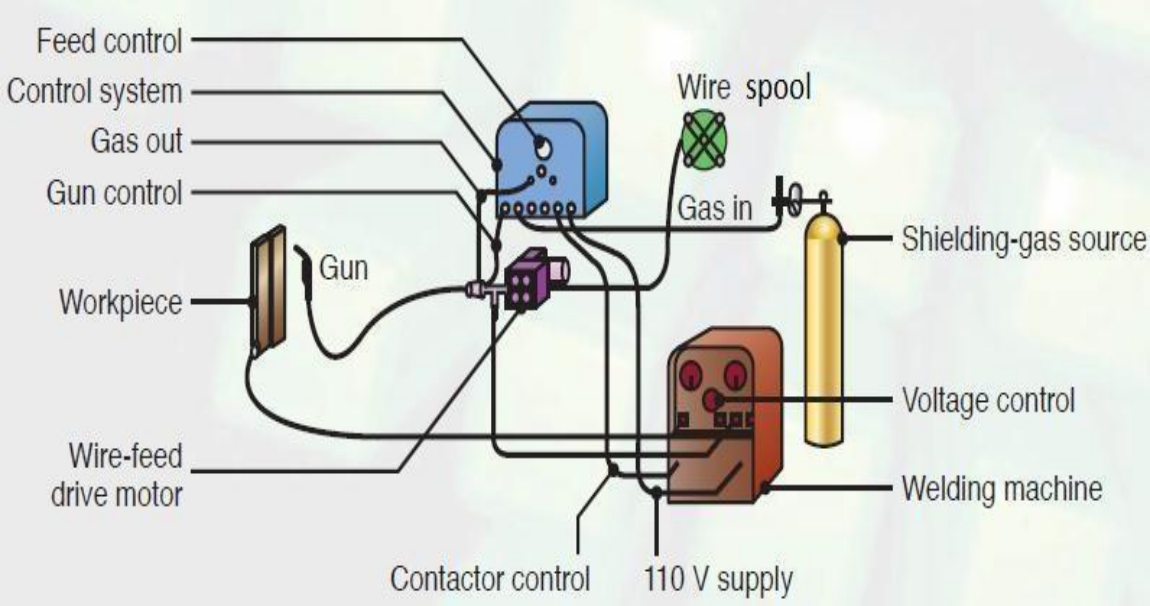
- TIGweldsarestronger,moreductileandmorecorrosionresistance than welds made with ordinary shield arc welding.
- Sincenofluxisuseditispossibletouseawidevariety ofdesignjoint thanconventional shield.
- Thereisalittleweldmetalsplatterthatdamagethesurfaceofthe base metal in traditional welding.

APPLICATION

- Widelyusedinaerospaceindustry.
- Usedforweldingaluminum,magnesiumalloys,stainlesssteel,nickel alloys, copper alloys.
- Itcanalsobeusedforcombiningdissimilarmetals.

Metalinertgaswelding

- In this process the power source (D.C. power) connected to bare metal wire electrode and the workpieces.
- Thewireelectrodeisconnectedtopositivepoleofpowersource.
- Thetorchisusedinthisprocesswherethewireelectrodefedfrom a spool through the torch (welding gun) at a constant speed and thetorchisalso connected to thehose pipecarryingshielding gas.
- Usually argon is used as shielding gas and some time mixture of ArgonandOxygen,HeliumArgonandCarbonDioxideorArgonand Carbon Dioxide are used as shielding gas.



ADVANTAGES:

- Itisfasterthanshieldedmetal–arcweldingduetocontinuousfeeding of filler metal.
- Thereisnoslagformation.
- Itprovideshigherdepositionrate.
- Theweldmetalcarrieslowhydrogencontent.
- Deeperpenetrationispossible.
- Moresuitableforweldingofthinsheets.
- Weldsproducedareofbetterquality.

DISADVANTAGES

- Equipmentusediscostlierandlessportable.
- Itislessadaptableforweldingindifficulttoreachportions.

- Itislesssuitableforoutdoorworkbecausestrongwindmayblow away thegas shield.

MOSTCOMMONWELDINGDEFECTS

- Anydiscontinuity(orirregularity) in the weld metal , which exceeds the specified code limit, is termed as welding defects.
- Duetouseofincorrectwelding process or wrong welding techniques , welding defects occur .
- 7typesofmostcommonweldingdefectsare:

1. Weldcrack
2. Porosity
3. Undercut
4. Incompletefusion
5. Incompletepenetration
6. Slaginclusion
7. Spatter

CRACKS

Cracks are the most common defects . They occur any where on the surface of the weld material especially on areas that are affected by direct heat.

Cracksmaybeformedduetovariouscauses.Theyare

- Wrongjointdesign
- Useofhydrogengasasashieldgaswhileweldingferrousmetals.
- Highcontentofcarbonandsulfurinthebasemetal.
- Highweldingcurrent.
- Rapidcoolingoftheweldjoint.
- Inadequatepreheating.
- Unequalphysicalpropertyoftheparentweldmetals.
- Faultywelding.

Theseareofthreetypes

a. Hotcracks

- The weld metalcracks are called hot cracks because these appear as a result of stress and lack of ductility of the deposited metal at hightemp.Thesecrackoccurduring thewelding processorduring the crystallization process of the weld joint.

b. Coldcracks

- These cracks are formed near the weld area and due to excessive cooling rateand theabsorbed hydrogen.Sincetheseappearafter a long time of completion of the welding operation, when the materialis cold, thesearetermedascoldcracks.They constitute a great danger in the low alloy and high carbon steelwelds.

C.Cratercracks

- These occur at the end of the welding process due to insufficient molten metal to overcome shrinkage of the weld metal when the weld pool cools and solidifies.

REMEDIESOFCRACKS

- Preheatthemetalasrequired.
- Providepropercoolingoftheweldarea.
- Useproperjointdesign.
- Removeimpurities.
- Useappropriatemetal.
- Makesuretoweldasufficientsectionalarea.
- Useproperweldingspeedandamperagecurrent.
- Topreventcratercracksmakesurethatthecraterisproperlyfilled.

POROSITY&BLOWHOLES

- Porosity is a cavity like discontinuity. Porosity is basically a small pore where as blow holes are comparatively larger holes.

- Porosity occurs as a result of weld metal contamination. The trappedgasescreateabubble-filledweldorporosityintheweldas a result of which the weld joint becomes weak.

CAUSESOFPOROSITY

- Inadequateelectrodedeoxidant.
- Usingalongerarc.
- Thepresenceofmoisture.
- Impropergasshield.
- Incorrectsurfacetreatment.
- Useoftoohighgasflow.
- Contaminatedsurface.
- Presenceofrust,paint,greaseoroil.

REMEDIESOFPOROSITY

- Cleanthematerialsbeforeyoubeginwelding.
- Usedryelectrodesandmaterials.
- Usecorrectarcdistance.
- Check the gas flow meter and make sure that it's optimized with pressure and flow settings.
- Reducearctravelspeed,whichwillallowthegasestoescape.
- Usetherightelectrodes.
- Useaproperweldtechnique.

UNDERCUT

- Thisweldingimperfectionisthegrooveformationattheweld toe, reducingthecross-sectionalthicknessofthebasemetal.Theresult is a weak weld joint and workpiece.

CAUSESOFUNDERCUT

- Toohighweldcurrent.
- Toofastweldspeed.
- The use of an incorrect angle, which will direct more heat to free edges.

- Theelectrodeistoolarge.
- Incorrectusageofgasshielding.
- Incorrectfiller metal.
- Poorweldtechnique.

REMEDIESOFUNDERCUT

- Useproperelectrode angle, withmoreheatdirected towards thicker components.
- Reducethearclength.
- Reduce the electrode's travel speed, but it also shouldn't be tooslow.
- Chooseshieldinggaswiththecorrectcompositionforthematerial type to be welded.
- Useofpropercurrent,reducingitwhenapproachingthinnerareas and free edges.
- Usethemultipasstechnique.

INCOMPLETEFUSION

- This type of welding defect occurs when there's a lack of proper fusion between the base metal and the weld metal. It can also appearbetweenadjoiningweldbeads.Thiscreatesagapinthe jointthatisnotfilledwithmoltenmetal.
- Lackoffusionisalsocalledascoldlappingorcoldshuts.

CAUSESOFINCOMPLETEFUSION

- Lowheatinput.
- Surfacecontamination.
- Electrodeangleisincorrect.
- Theelectrodediameterisincorrectforthematerial.
- Travelspeedistoofast.
- Theweldpoolistoolargeanditrunsaheadofthearc.

REMEDIESOFINCOMPLETEFUSION

- Use a sufficiently high welding current with the appropriate arc voltage.

- Beforebeginningofwelding,cleanthemetal.
- Avoidmoltenpoolfromfloodingthearc.
- Usecorrectelectrodediameterandangle.
- Reducedepositionrate.

INCOMPLETEPENETRATION

- Incompletepenetrationoccurswhenthegrooveofthemetalisnot filled completely, meaning the weld metal doesn't fully extend through the joint thickness.

CAUSESOFINCOMPLETEPENETRATION

- Therewastoomuchspacebetweenthemetalstobewelded.
- Beadformationrateistoohigh,whichdoesn'tallowenoughmetal to be deposited in the joint.
- Use oftoo low amperage setting, which results in the current not being strong enough to properly melt the metal.
- Largeelectrodediameter.
- Misalignment.
- Improperjoint.

REMEDIESOFINCOMPLETEPENETRATION

- Useproperjointgeometry.
- Useaproperlysizedelectrode.
- Reducearctravelspeed.
- Chooseproperweldingcurrent.
- Checkforproperalignment.

SLAGINCLUSION

- Slag inclusion is one of the welding defects that are usually easily visible in the weld.
- SuchinclusionsaremostlyformedbySulphurandphosphorus.

CAUSESOFSLAGINCLUSION

- Impropercleaning.
- Theweldspeedistoofast.
- Notcleaningtheweldpassbeforestartinganewone.
- Incorrectweldingangle.
- Theweldpoolcoolsdowntoofast.
- Weldingcurrentistoolow.

REMEDIESOFSLAGINCLUSION

- Increasecurrentdensity.
- Reducerapidcooling.
- Adjusttheelectrodeangle.
- Removeanyslagfromthepreviousbead.
- Adjusttheweldingspeed.

SPATTER

Spatteroccurswhensmallparticlesfrom theweldattachthemselves to the surrounding surface. It's an especially common occurrence in gas metal arc welding.

CAUSESOFSPATTER

- Therunningamperageistoohigh.
- Voltagesettingistoolow.
- Theworkangleoftheelectrodeistoosteep.
- Thesurfaceiscontaminated.
- Thearcistoolong.
- Incorrectpolarity.
- Erraticwirefeeding.

REMEDIESOFSPATTER

- Cleansurfacespriortowelding.
- Reducethearclength.
- Adjusttheweldcurrent.

- Increasetheelectrodeangle.
- Useproperpolarity.
- Makesureyoudon’thaveanyfeedingissues.

CASTING

- **Casting** is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is alsoknownasa *casting*,whichisejectedorbrokenoutofthemold to complete the process.
- Casting materials are usually metal or epoxy, concrete, plaster and clay.
- Casting is most often used for making complex shapes that would beotherwise difficultoruneconomicaltomakebyothermethods.
- Heavy equipment like machine tool beds, ships' propellers, etc. can be cast easily in the required size, rather than fabricating by joining several small pieces.

VARIOUSTYPESOFCASTINGPROCESSES

- SandCasting
- Investment Casting
- PlasterCasting
- DieCasting(MetalCastingProcess)
- CentrifugalCasting
- PermanentMoldCasting

STEPSINMAKINGSANDCASTING

1. Patternmaking
2. Coremaking

3. Molding

4. Meltingandpouring

5. Cleaning

6. Inspection

PATTERNMAKING:

Thepatternisareplicaofthecastingusedtomakethemold. Consideration to be taken during pattern making are :

1. Provision ofadditional allowance tocompensate for metalshrinkage and for machining or finishing operation of the casting.

2. Provisionofdraftforeasyremovalofthecastingfromthemold.

3. Provision of additional projections known as core prints to produce seats for cores.

COREMAKING:

- Cores are usually made upof sand which are placed into a mold cavity to form cavity of desired shape and size in a casting.
- Coresarepreparedusuallyfromgreensandusingcoreboxes.
- Sometimes forusing inpermanent mold ordies cores are formed as integral parts of the mold.

MOLDING:

- Itconsistsofalloperationnecessarytoprepareamoldforreceiving the molten metal . It includes ramming, withdrawing the pattern, settingthecoresinthemoldcavity,finishingandclosingthemold.

- The pattern is kept in a mold box which consist of two parts , the cope and the drag. If molding board is to be used, it is first placed on the floor followed by the pattern.
- Thepatternissurrounded bymolding sandonlyinthedrag partof the flask. Then the sand is compacted by ramming .Excess sand is parted off by the strike off bar and the box turned over. The other halfthepatternisplacedinposition,followedbythecope; runner and riser are placed in position and the box filled with sand and rammed properly. Runner and riser are taken out and the pouring basin is made. Vent-wire is then applied to provide the vents.
- After the sand is compacted enough to replicate the pattern, the cope is removed and the pattern is extracted. Repairs if any , are made and the gates cut. Then, any additional inserts called core boxes are installed. Now the mold is ready for pouring.

MELTINGANDPOURING:

- Therawmaterialismeltedusingafurnaceandthemoltenmetalis poured into the mold using laddle.

CLEANING:

- After proper solidification of casting the molds are broken to obtain the casting. This operation is called shake out operation. This casting carries risers , runners, gates, chills, and nails etc. attachedtoit.Alsoalotsofsandsremainadheringtoitssurfacein the form of core, etc. Removal of sands, excess metals in form of fins,risers,runners,gates,chills,andnailsisdoneforcleaningthe casting.

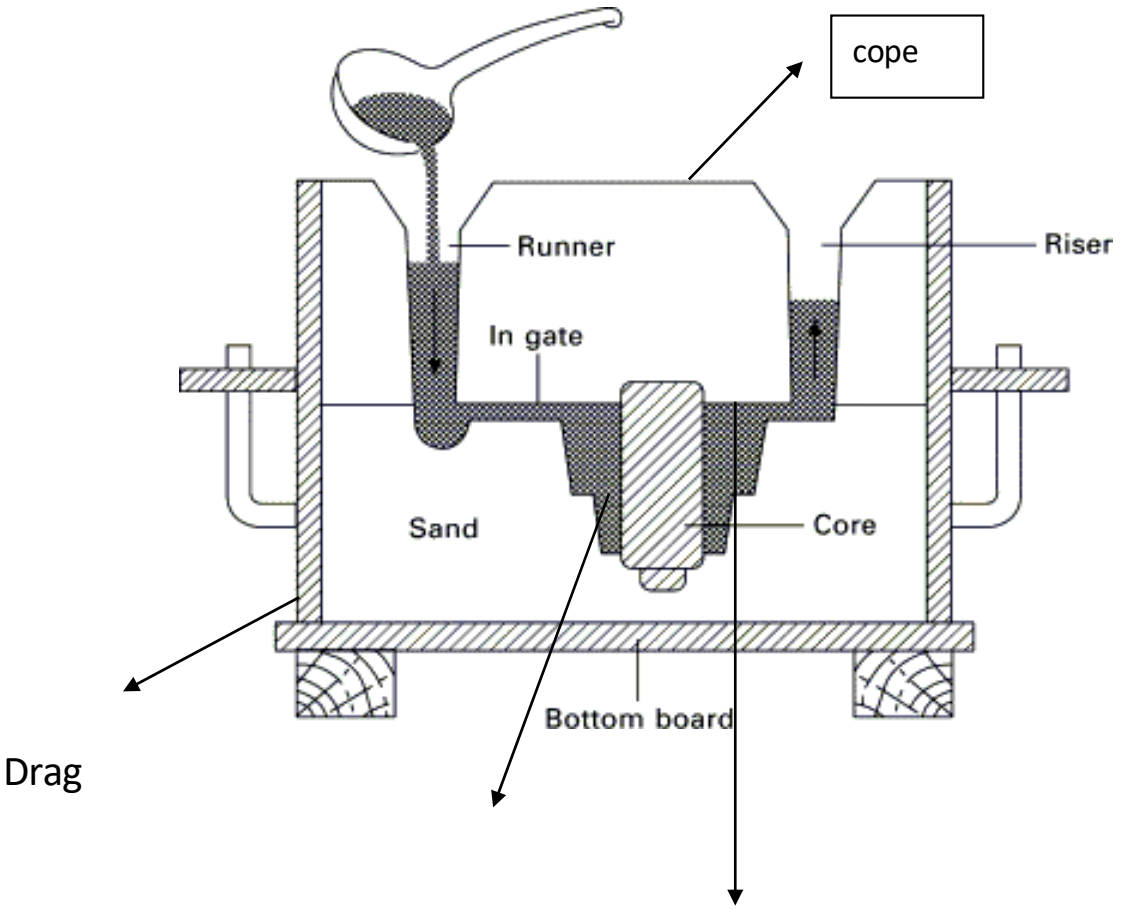
REPAIRANDHEATTREATMENTOFCASTING:

- Before use the required repairing is done and by heat treatment process , the required structure and mechanical properties of the casting is obtained.

INSPECTION:

- Inspection of the casting to detect internal and external defects and general quality is done.

SANDMOLDCASTING



ADVANTAGESOFSANDMOLDCASTING

- Relativelylowcostofproduction.
- Largecomponentscanbefabricated.
- Bothferrousandnonferrousmaterialscanbecasted.

DISADVANTAGESOFSANDMOLDCASTING

- Lowerdegreeofaccuracy
- Roughsurfacefinish.

DIFFERENTTYPESOFMOLDINGSAND

Moldingsandcanbeclassifiedmainlyintotwotypes. They

are :

1. Naturalmoldingsand
2. Syntheticmoldingsand

NATURALMOLDINGSAND

- Natural molding sands consistof refractory sandgrains associated with clay right from their origin.
- Itcontainssufficientamountofbindermaterial.

SYNTHETICMOLDINGSANDS

- Synthetic molding sands are prepared artificially using basic sand moldingconstituents(silicasandin85-91%,binder6-11%,wateror moisture content 2-8%) and other additives in proper proportion by weight .
- Molding sands can also be classified into **various types according to their use** .

- These are backing sand, core sand, dry sand, facing sand, green sand, loam sand, parting sand, system sand.

GREENSAND

- **Green sand** is known as **tempered or natural sand** . This is a prepared mixture of silica sand with 18 to 30% clay, having moisturecontentfrom6to8%.Theclayandwaterfurnishthebond for green sand. Green sand is commonly employed for production of small and medium casting of non-ferrous metals and alloys.

DRYSAND

- Green sand that has been dried or baked in suitable oven after making mold and cores is called **dry sand**. It possesses more strength, rigidity and thermal stability. Dry sand is mainly used for larger castings and for small casting which need higher accuracy. Molds prepared in this sand are known as dry sand molds.

LOAMSAND

- **Loam sand** ismixtureofsand,clayandwaterand madeintoa thin plastic paste. Loam sand possesses high clay as much as 30-50% and 18% of water. Patterns are not used for loam molding and shape is given to mold by sweeps.

- After preparing the mold, it is baked to give strength to resist the flow of the molten metal.

- Loamsandisparticularlyemployedforloammoldingusedforlarge grey iron castings.

BACKINGSANDORFLOORSAND

- Backing sand is used to fill the whole volume of the molding flask. Backing sand is also called black sand because of old, repeatedly used molding sand is black in color due to addition of coal dust.

CORESAND

- **Core sand** is used for making cores. It is known as oil sand. Core sandishighlyrichsilicasandmixedwithoilbinderssuchaslinseed oil, resin, light mineral oil and other bind materials.

FACINGSAND

- **Facingsand**formsthefaceofthemould.Itisnexttothesurfaceof thepatternand it comesintocontact withmolten metalwhen the metalispoured.Facingsandismadeofsilicasandandclay,without the use of already used sand.

PARTINGSAND

- **Parting sand** is clean clay-free silica sand. It is used in parting line or parting surface of the cope & drag.

SYSTEMSAND

- In mechanized foundries where machine molding is employed, System sand is used to fill the whole molding flask. The used sand is cleaned and re-activated by the addition of water and special additives.Sincethewholemoldismadeupofthissystemsand,the propertiessuch asstrength,permeability andrefractorinessofthe molding sand must be higher than those of backing sand.

BASICPROPERTIESOFMOLDINGSAND

1. FlowabilityorPlasticity:

- Itisabilityofthemoldingsandtoflowandgetcompactedall-round the patternwhen rammed and take up the required shape.

2. Refractoriness:

- Itistheabilityof themoldingsandto withstandthehightemp.of the liquid metal to be poured, without breaking down or fusing.
- Therefractorinessofsilicasandishighest.

3.Permiability :

- Itis the ability of the molding sandto allow air and anyhotgases to pass through it even in compacted condition.

4. Greenstrength:

- The molding sandthat contains moisture is termed as green sand. Green strength is the ability of green sand to retain the shape of the constructed mold.

5. Drystrength:

- Itistheabilityofmoldingsandtoretaintheexactshapeofthemold cavityinthedrycondition(whenthemoltenmetalispouredinthe mold) and to withstand the metal static pressure of the liquid metal.
- TheDrystrengthpreventstheenlargementofmold cavity.

6. Hotstrength:

- Itistheabilityofthemoldingsandtoretain theexactshapeofthe mold cavity at an elevated temp.

7. Adhesiveness:

- Itistheabilityofthemoldingsandtostickwiththewallofthe molding boxes.

8. Cohesiveness:

Cohesiveness is the property of molding sand by virtue of which the sand grain attract eachother within the molding box.

9. Collapsibility:

- Collapsibility is the property by virtue of which molding sand is easily stripped off the casting after the molten metal in the mold gets solidified.
- Thelackofcollapsibilityresultstearsandcracksinthecasting.

MISCELLANEOUSPROPERTIESOFMOLDINGSAND

- In addition to basic properties, the molding sand should not stick to the casting and should not chemically react with the metal. Molding sand need be economically cheap and easily available in nature. It need be reusable for economic reasons.

PATTERN

- Itisthereplicaofthefinalobjecttobemade.
- Themoldcavityismadewiththehelpofpattern.
- Inotherwordstocreatethecavityinthecompactedsandweneed a model , so this model is known as pattern.

FUNCTIONOFPATTERN

1. Itpreparesthemoldcavity.

2. Itenablescertaincoreprintsatbothendsofthepattern.

3. Itmakesprovisionforrunner,gateandriser.

4. Properlymadepatterns havingsmoothsurface,reducecasting defects.

5. Aproperlyconstructedpatternminimizestheoverallcostofthe casting.

PATTERNMATERIALS

1. Wood, metals and alloys, plastic, plaster of Paris, rubbers, wax, and resins are used for pattern making. Each material has its own advantages, limitations and field of application.

IDEALCHARACTERISTICOFPATTERNMATERIAL

- Lightinweight.
- Strong,hardanddurable.
- Resistanttowearabrasion.
- Resistanttocorrosionandchemicalreaction.

- Dimensionally stable and unaffected by variation of temperature and humidity .
- Availableinlowcost.

CLASSIFICATIONOFPATTERN

Theuseofapatternfor aparticularcasting dependsuponmanyfactors like

1. Typeofmoldingprocess
2. Noofcastingrequired.
3. Designofcasting

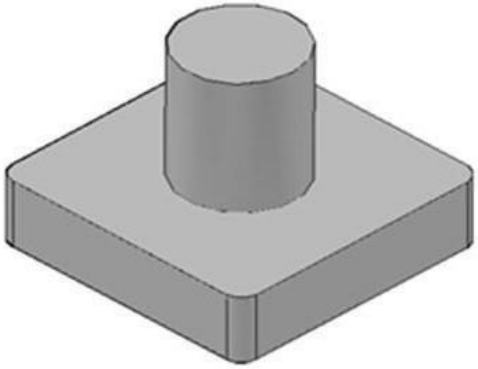
- Accordinglythepatternsareclassifiedintofollowingtypes:

1. SolidorSinglepiecepattern
2. Tow-pieceorsplitpattern
3. Multipiecepattern
4. Copeanddrag pattern
5. Matchplatepattern
6. Followboardpattern
7. Gatedpattern
8. Sweeppattern
9. Patternwithloosepieces
10. Skeletonpattern
11. Segmentalpattern

TYPESOFPATTERN

1. SINGLEPIECEPATTERN:

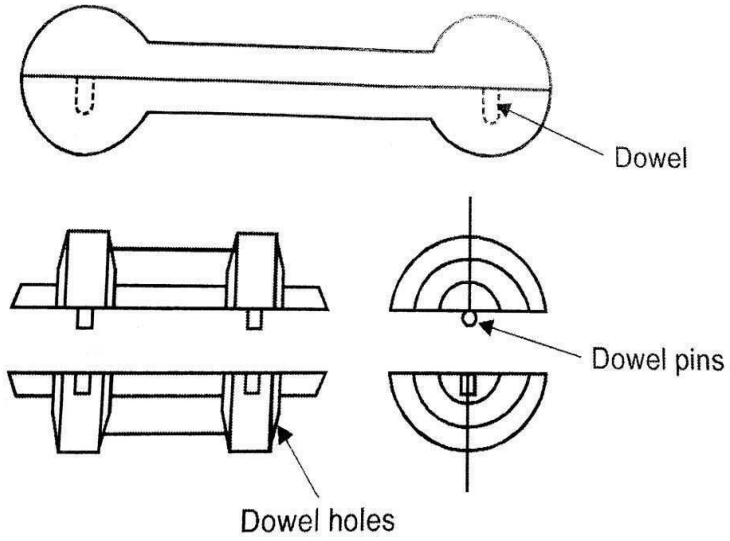
Theseareinexpensiveandthesimplest,asnameindicatestheyaremade upofsinglepiece.Thistypeofpatternisusedonlyincasewherethejob isverysimpleanddoesnotcreateanyproblems.Thispatternisexpected to be entirely in the drag part of the mold box .



One Piece or Solid Pattern

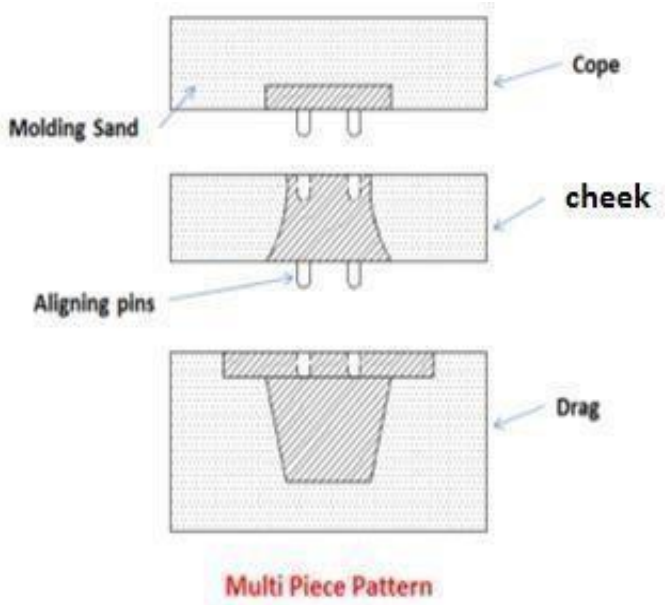
2. SPLITORTWO-PIECEPATTERN

This is the most widely used type of pattern for intricate casting, when withdrawalofthecastingfrom themoldisdifficultdue toitsshape.The pattern is split into two parts and they are joined at the parting line by means of dowels. While molding one part is contained by the drag and otheroneiscontainedbythecope.Thesplitsurfaceofthepatternisthe same as the parting plane of the mold.



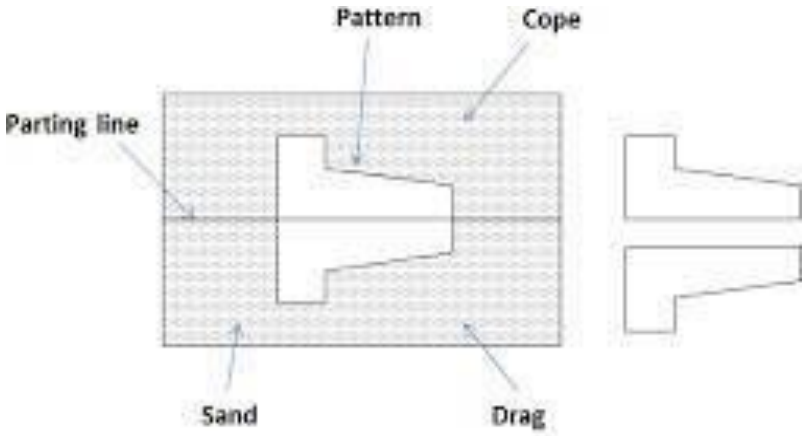
3. MULTIPIECEPATTERN

This pattern is used for casting of complicated parts . These pattern may consist of three ,four or more numbers of parts. Use of this patternfacilitedeasywithdrawalofpatternduringmoldpreparation.



4. COPEANDDRAGPATTERN

- This is similar to split pattern. The cope and drag halves of the pattern along with the gating and riser are attached separately to the metal or wooden plates. The cope and drag molds may be producedusingthispatternsseparatelybythemolderbuttheycan beassembledtoformacompletemold.Thistypeofpatternisused for casting which are heavy.
- Thisisusedforbigcasting.



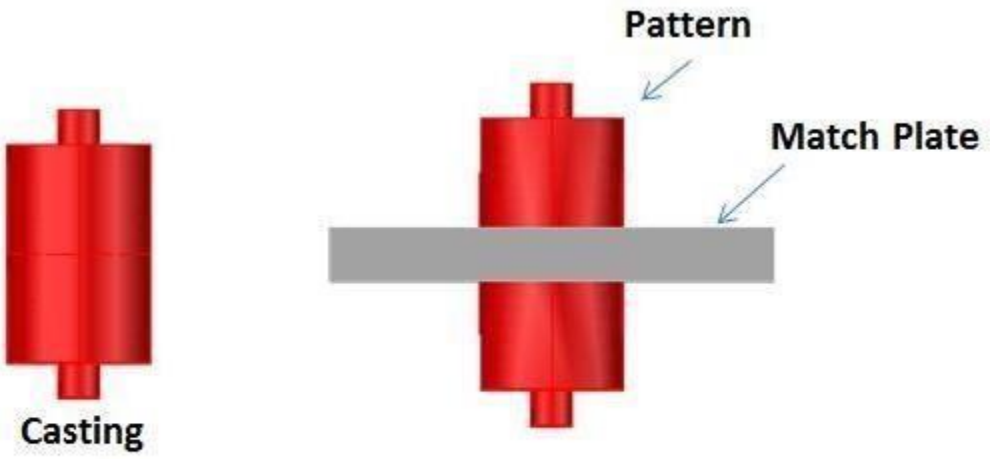
Cope and Drag Pattern

5. MATCHPLATEPATTERN

- These are extensions of cope and drag pattern. Here the cope and drag patterns along with the gating system and riser system are mounted on either side of the match plate, made up of metal or wood.Ononeside of the matchplatethe cope part of the pattern is mounted and on the other side of the match plate the drag part ismounted.Aftermoldingwhenmatchplateisremoveda

completemoldwith gating system isobtainedbyjoining thecope and the drag together.

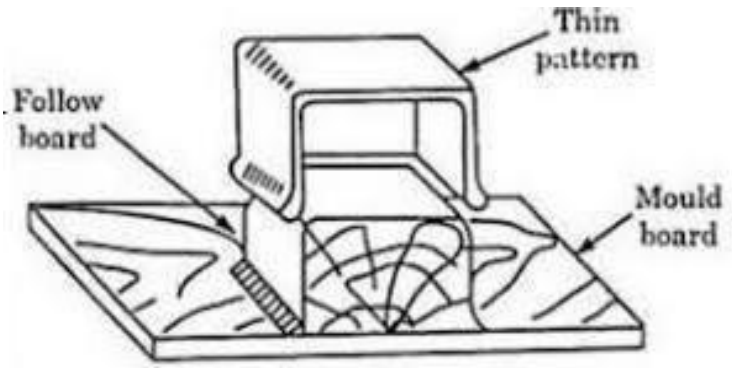
- The complete pattern is made up of metal, usually aluminum for its light weight and machinability.



Match Plate Pattern

6. FOLLOWBOARDPATTERN

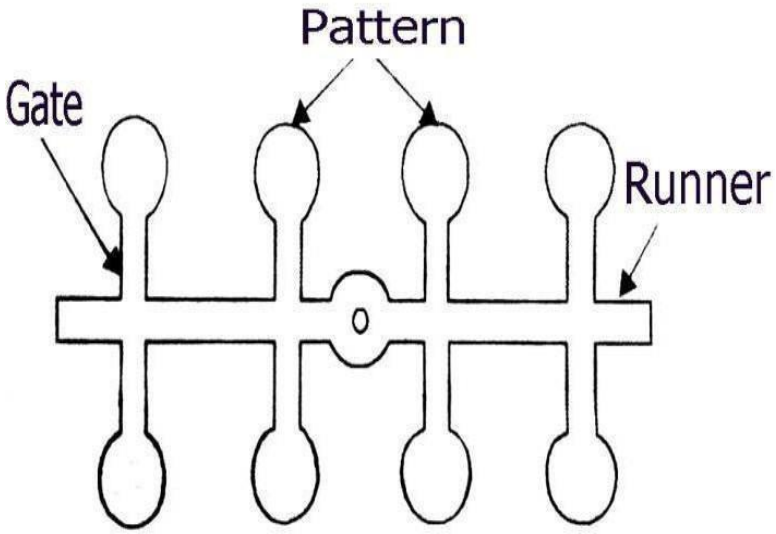
- A follow board is a wooden board used to act as a seat for the pattern. Patterns having an odd shape or very thin wall require a follow board. The follow board is provided with a cavity corresponding to the shape of the pattern in which the pattern is seated for molding.
- Thistype of patternis adopted for thosecastings,wherethereare some portions, which are structurally weak and if not supported properly are likely to break under the force of ramming .



Follow-board Pattern.

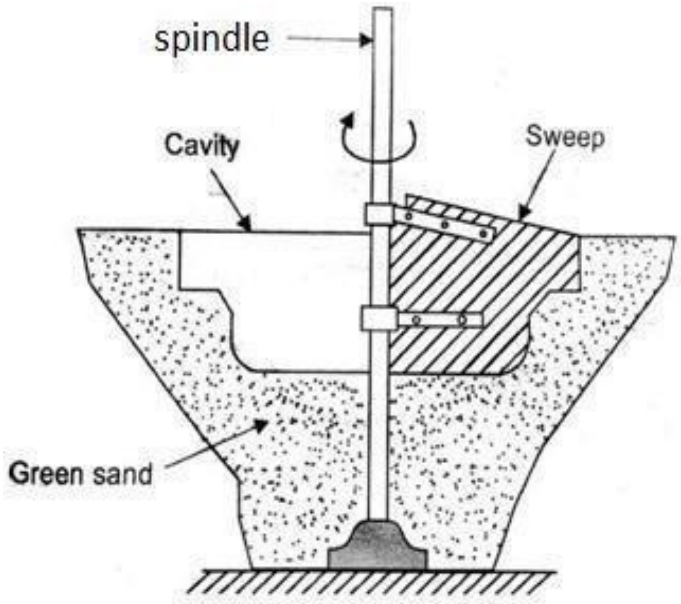
7. GATEDPATTERN

- Thisisusedformassproductionofsmallcastings.
- Thisisanimprovementoverthesimplepatternandareused, wheregatingandtherunnersystemareintegralpartofthemold.
- Byusingthispatternmulticavitymoldsalongwithgatesand runner can be prepared .



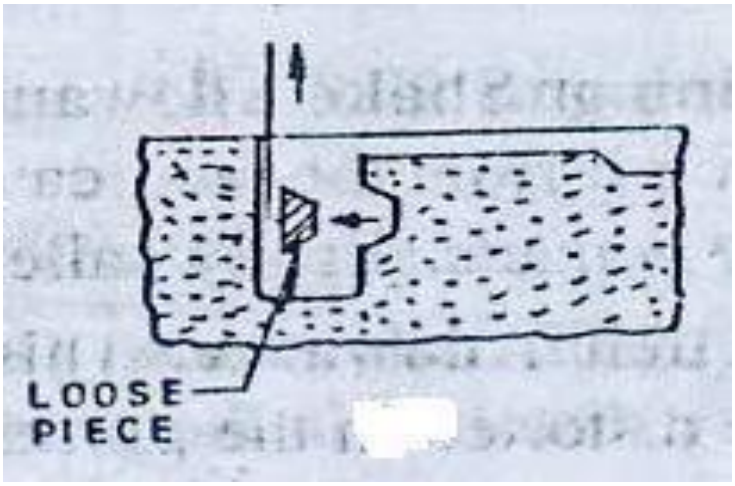
8. SWEEPPATTERN

- This pattern consists of a base , a verticalspindle and a wooden template, called sweep.
- The outer end of the sweep carries the contour corresponding to the shape of the desired casting.
- Thesweepisrotatedaboutthespindletoformthecavity.thenthe sweep and spindle are removed , leaving the base in the sand.
- Theholemadebytheremovalofspindleispatchedupbyfilingthe sand.
- These are used for generating circular or prismatic shape or cylindrical shape.
- Thisgreatlyreducesthecostofa3Dpattern.
- Thistypeofpatternisparticularlysuitableforverylargecylindrical castings.



9. LOOSEPIECEPATTERN

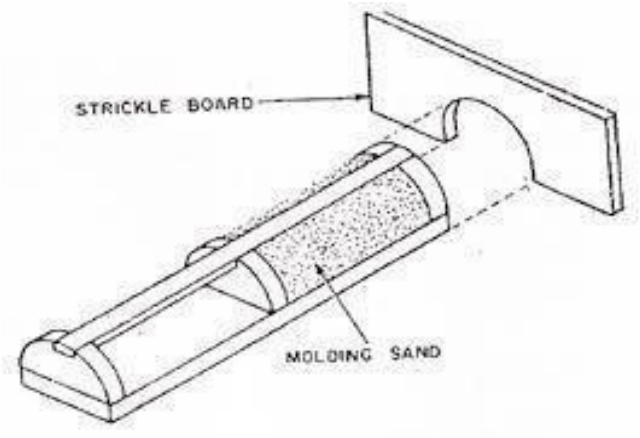
- Thistypeofpatternisusedwhen theshapeofthepartissuch that withdrawal of the pattern from the mold is not possible. Hence duringmoldingtheobstruction part oftheshapeis held as a loose piece by a wire.
- After molding is over first the main pattern is removed and then the loose pieces are removed through the gap generated by the main pattern.



10. SKELETONPATTERN

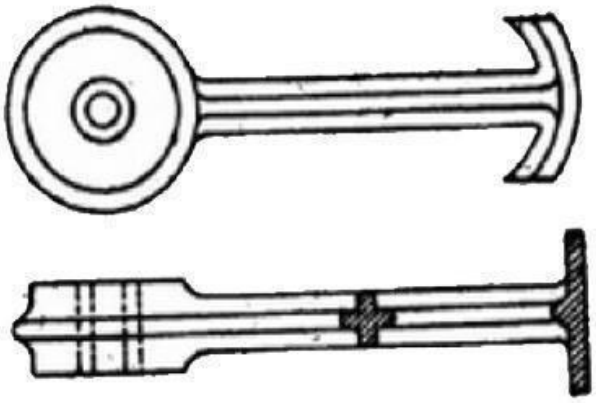
- Itisbuiltintwoparts-oneforcopeandotherfordrag.
- Skeletonpatternconsistsofawoodenframeandstrips.
- Itisfilledwithloamsandandthesurplussandisremovedbymeans of a stickle.
- The type of a skeleton to be madedepends on geometry of thework piece.

- Thistypeofpattern isusefulfor castingturbinebladeor anyother castings of very large size but easy to shape and when very few numbers are to be made.



11. SEGMENTALPATTERN

- These patterns are used for preparing molds of large circular castings .In this pattern a portion of thesolid pattern (required to develop the mold shape) is mounted on a central pivot . The part moldinonepositionispreparedandthenthesegmentismovedto thenextposition.Theoperationisrepeatedtillthecompletemold is ready.
- Thispatternworks likeasweeppatternbutthedifferenceisthata sweep is given a continuous revolving motion to generate the desired shape , where a segmental pattern prepared the mold in parts.



PATTERNALLOWANCE

Thepatternshouldmadelargerascompared totherequiredsizeof the casting.

The differencebetweenthe actual size and requiredsize isknown as pattern allowance.

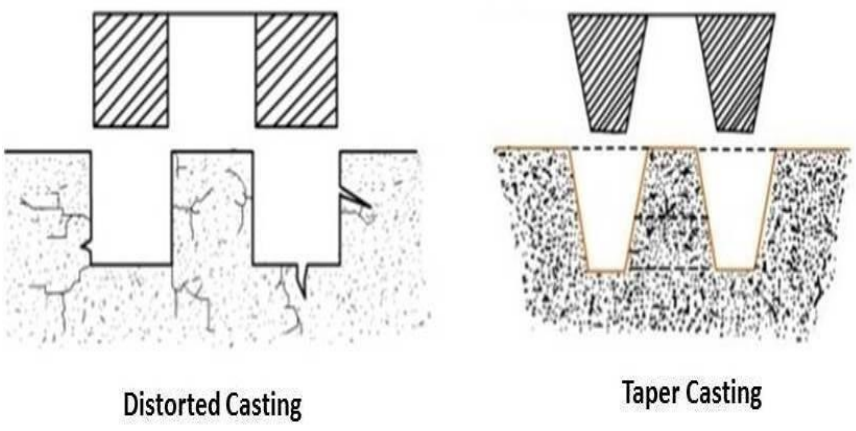
SHRINKAGE/CONTRACTIONALLOWANCE

- Most of the metal contract during Cooling from pouring temperaturetoroomtemperature.Thiscontractiontakesplacein three forms i.e liquid contraction , solidifying contractionandsolid contraction .
- Thefirsttwoare compensated bygatesandrisersand thelastone by providing adequate allowances in the pattern.
- The shrinkage allowance in the pattern varies with variation in casting metal.

DRAFTALLOWANCE

- Slight taper is provided on the vertical surfaces of the pattern, so thatit can beremoved from the sand without damaging the sides

ofthesandmold.Thistaper isknown asdraftallowance.Itcanbe expressed in degrees .



Draft Allowance

MACHININGALLOWANCEORFINISHINGALLOWANCE

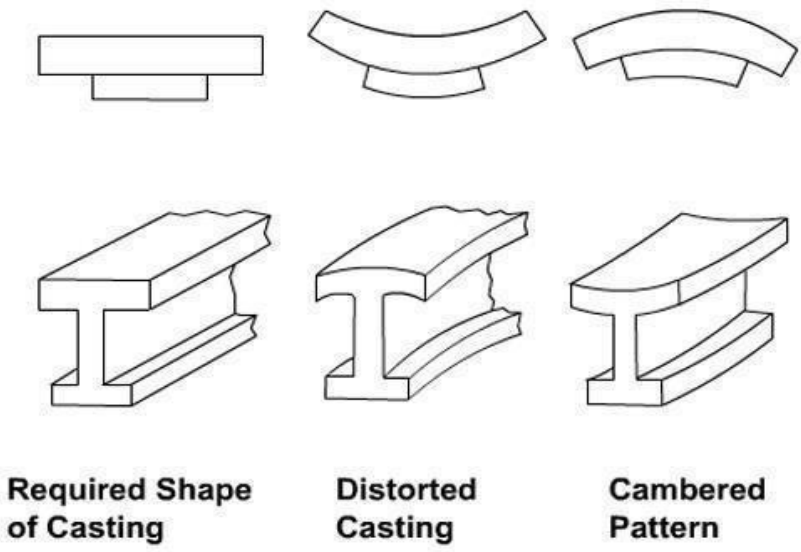
- Pattern size should be made little bigger than the required size of the casting because after machining we will get the exactly same size of the casting.
- Ferrousmetalneedmoreallowancethanthenon-ferrousmetal.

DISTORTION/CAMBERALLOWANCE

Sometimescastinggetsdistorteddduringsolidificationduetotheircritical shape.

- Non uniform contraction ofcasting during cooling causes thermal stresses, which results discursion.

- To eliminate this defect an opposite distortion is provided in the pattern, so that the effect is neutralised and the correct casting is obtained.



RAPPINGALLOWANCE

- Rapping means shaking the pattern from side to side , so that its surface may be free of the adjoining sand wall of the mold. By this action the volume of the mold cavity increases.
- Thepatternsizeshouldbelittlesmallerascomparedtothecasting size to compensate the increase of mold cavity due to rapping of the pattern.
- Thisnegativeallowanceisknownasrappingorshakeallowance.

MOLDWALLMOVEMENTALLOWANCE

- Movement of mold walls in sand molds takes place on account of the excessive heat and the static pressure exerted on the surface layer of sand which comes in contact with the mold metal.
- When this movement is not controlled by controlling the density and temperature of the molten metal and composition of the molding sand,allowanceisprovidedinthepatterntocompensate this difference in volume due to wall movement.

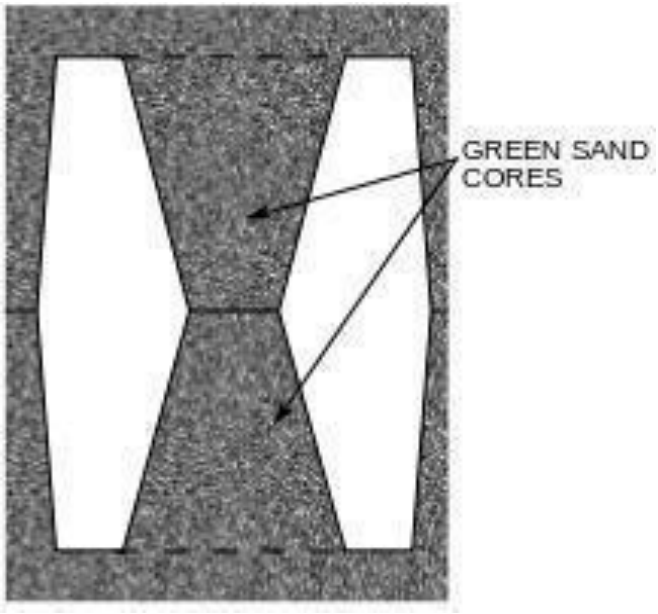
CORE

- Core comes into picture when we have to make components ofhollow cavity.
- Itismadeupofsand.
- A core can be defined as a body of sand, which is used to forma cavity of desired shape and size in a casting.
- The cores is divided into two types basing on the method of their preparation. They are:

  1. Greensandcore
  2. Drysandcore

GreenSandCore:

Theseareobtainedbythepatternitselfduringmolding.Thisisused only for those type of cavities which permit the withdrawal of the pattern, leaving the core as a part of the mold.



DrySandCore:

A**core**ispreparedseparatelyin**core**boxesanddried,is knownas dry sand **core**. The dry sand **cores** are also known as **process cores**. Thesecoresarelocatedinthemoldintheseatsformedbythecoreprints provided on the patterns.

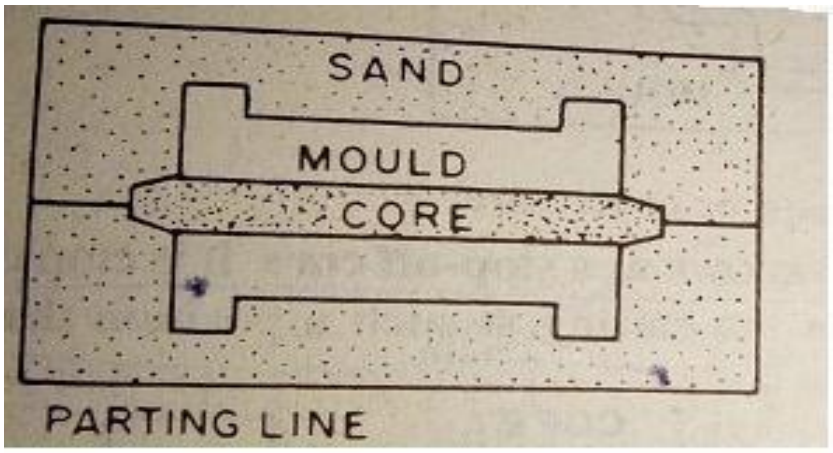
TYPESOFCORES

- Dependingontheshapesandpositionsinthepreparedmold,the cores are classified into following types :
- Horizontalcore
- Verticalcore
- Balancedcore
- Hangingorcovercore

- Stopoffcore
- Ramupcore
- Kiss core

Horizontalcore:

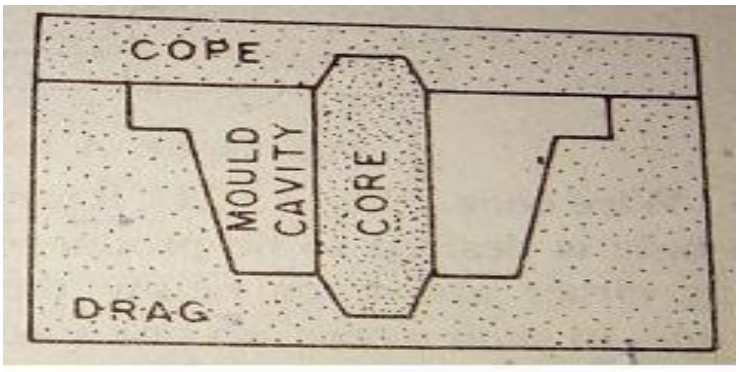
- It is the most common and simple type of core. It is assembled in the mold with its axis horizontal.



HORIZONTAL CORE

Verticalcore:

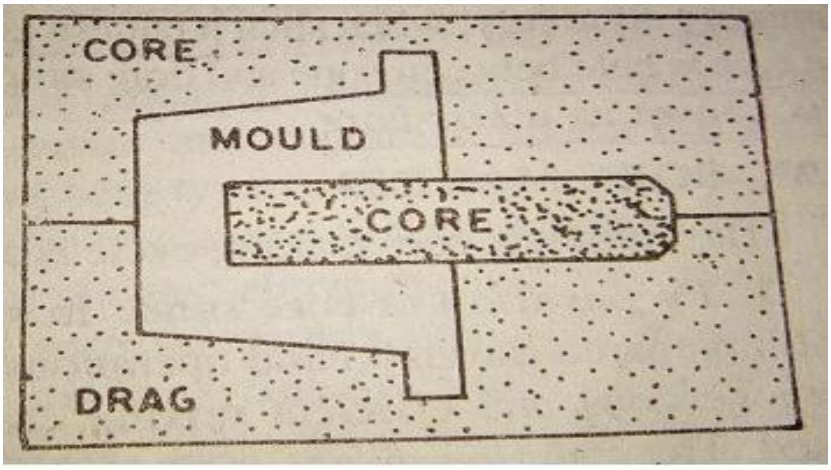
- It is quite similar to a horizontal core except that it is fitted in the mold with its axis vertical. A major portion of the core usually remains in the drag part of the mold.



VERTICAL CORE

Balancedcore:

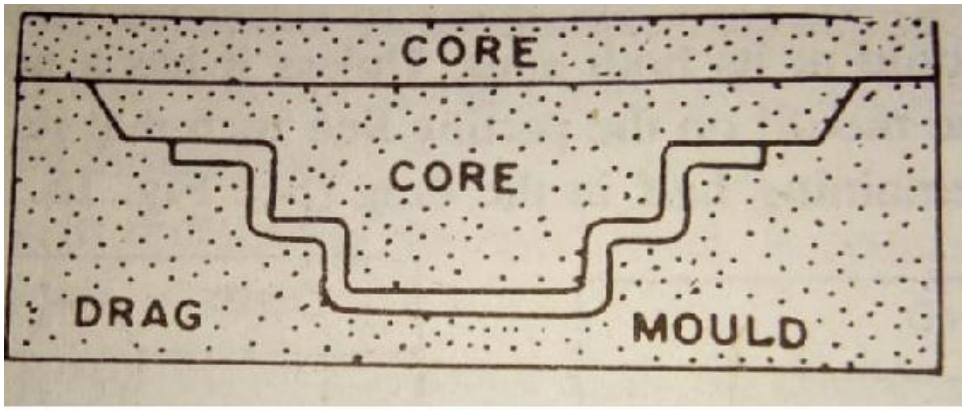
- Itisusedtoproduceablindholealongahorizontalaxisinacasting. Itissupportedonlyononeend,theotherendremainingfreeinthe mold cavity. Since it has to support the weight of the overhanging portion, the core print provided on the pattern should be long enough so that sufficient length of the core may be embedded in the sand to balance the weight of the overhung.



BALANCED CORE

Hangingorcovercore:

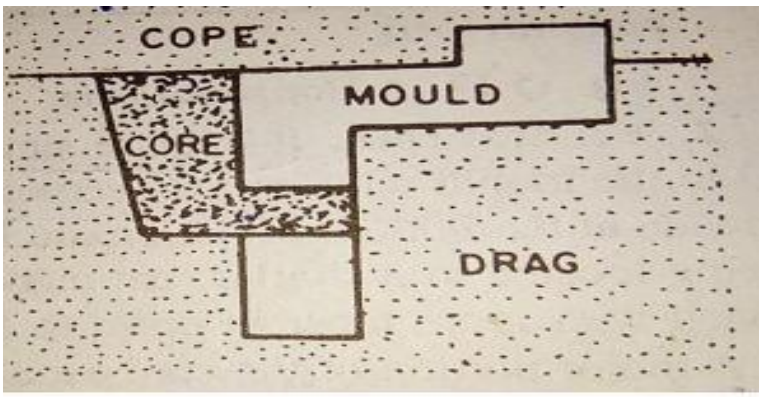
- Acorewhichhangsvertically inthe moldandhasnosupportatits bottom is known as a hanging core.



HANGING OR COVER CORE

Stop-off core:

- Itisemployed whenaholeisdesiredtobeproduced inthecasting at such a position that its axis falls either above or below the parting line.



STOP-OFF CORE

Ram upcore:

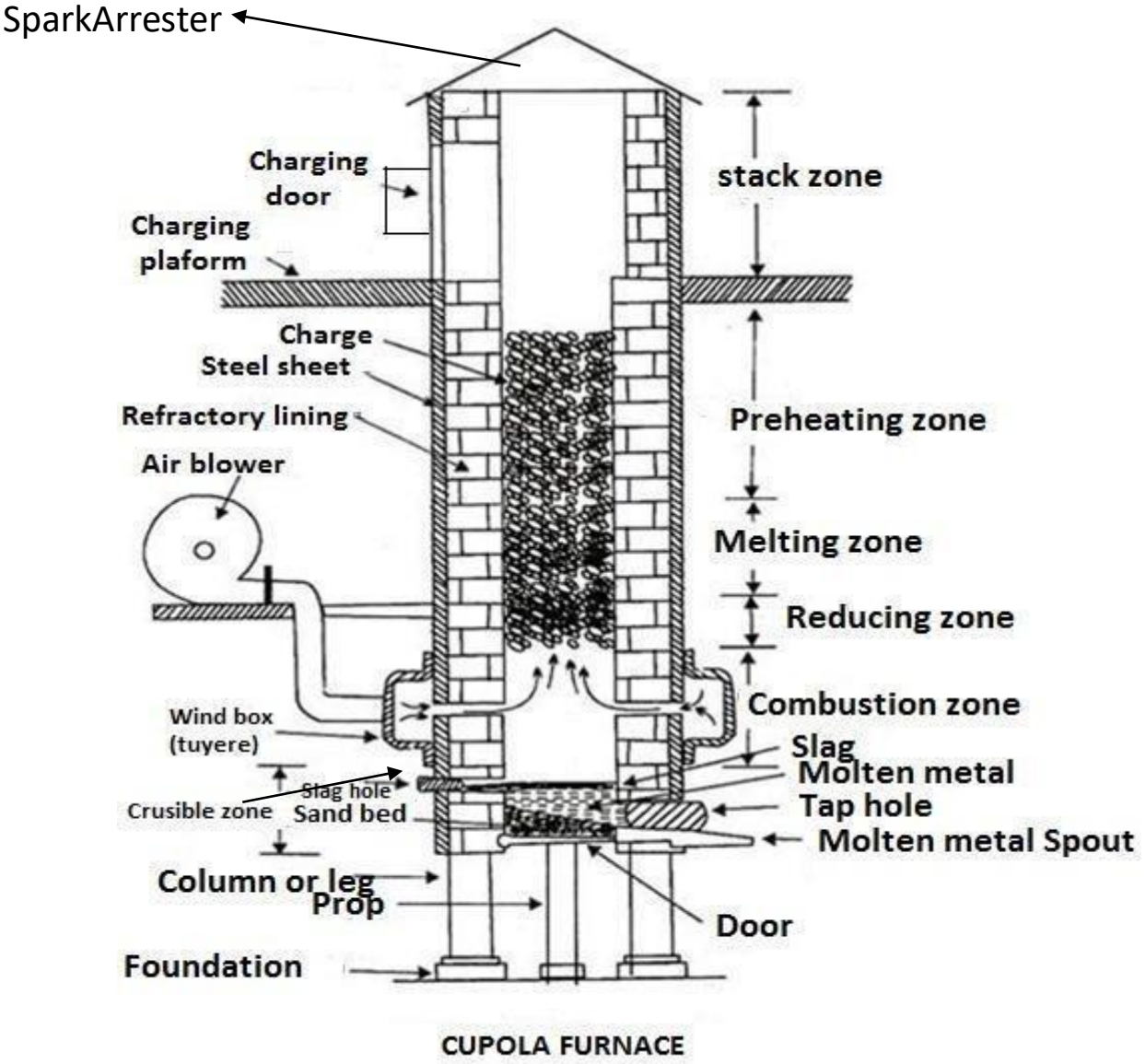
- Ram up core is embedded in the mold as placement of core is no possible after ramming.

Kisscore:

- Kiss core is used where a pattern is to be used without any core prints. The core is held between cope and drag simply due to the pressure put by the former .

CUPOLAFURNACE

- For melting of cast iron in foundry the cupola furnace is used. A diagrammatic sketch of this furnace is a cross sectional view of cupola.



CUPOLA FURNACE

CONSTRUCTIONOFCUPOLA

- Thepartsofcupolafurnaceare:
- Shell
- Foundation
- Tuyer
- Windbelt
- Blower
- Metaltappinghole
- Slaghole
- Chargingdoor
- Chimneyorstack

Shell:

- Itisin theformofahollowverticalcylindermadeupofstrongmild steel plates with a lining of refractory bricks and clay. The plates are reverted or welded at the seams.
- Tapered sand bed is provided at the bottom most part of shell to provide refractory bottom for the molten metal.
- The bottom door (drop door) is hinged to a supporting leg. When thecupolaisinoperation,thebottomdoorissupportedbyaprop.

Foundation:

- Brick wall or steel column foundation is provided to support theshell.

Tuyer:

- Tuyeres are the opening through which forced air enter into the furnacechamberfromthewindchamberwiththehelpofblowers.
- Tuyeres are provided all around the shell and have a definite numbers and size depending upon the amount of air required.

Windbelt:

- A wind chamber or a wind belt encircle the cupola shell at a place little above the bottom of the shell. This belt is connected to the furnace blower by means of a blast pipe.

Blower:

- Blower is used to ensure availability of adequate air through out the coke bed . The capacity of the blower varies directly with the size and capacity of the cupola.

Metaltappinghole:

- Metaltappingholeexistsjustabovethesandbed.

Slaghole:

- Slag hole may be kept at a height of about 25 to 30 cm from the bottom of the cupola and located above metal tap hole. Normally it exists in a position opposite to the metal tap hole.

Chargingdoor:

- This platform is of robust mild steel construction, supported on four strong steel legs and is provided with a ladder.
- A little above charging plat form is the charging door in the shell from where the charge consists of PIG iron, scrap iron, coke and flux is put into the cupola.

Chimneyorstack:

- Chimneyisprovidedtoescapethewastegasestotheatmosphere. Thetopofthechimney isprovidedwithameshscreenanda spark arrester.

WORKINGOFCUPOLAFURNACE

1. Tooperatethecupola1stthedrop doorsatthebottom areclosed and a sand bed with a gentle slope towards the Metal tap hole is rammed.Thenacokebedof suitable heightispreparedabove the bottom sand bed and ignited through the tap hole.
2. When the coke bed is properly ignited, alternate charge, flux and coke is fed into through the charge door until the level of the charging door .
3. Then the air blast is turn on and forced air comes through the tuyeres . Combustion occurs rapidly within the coke bed.
4. Within 5-10 min after the blast is turned on, molten metal is depositednear the tap hole.
5. Whenenoughmoltenmetalis deposited theslag isbendup tothe slag whole before opening the tap hole.
6. The molten metal is collected in the ladle and then transferred to the cavity into which it is to be poured.

CRUCIBLEFURNACES

1. Cruciblefurnaces:

- In these furnaces the entire meting of metal takes place inside a melting pot, called crucible, which is made of clay and graphite. Thereisnodirectcontactbetweentheflameandthemetalcharge .These furnaces are used for melting non ferrous metal and their alloytoproducesmallandmediumsizecastingsinfoundriesThese furnaces can be classified into two groups as follows:

  a) Coke-firedfurnaces

b) Oilandgasfiredfurnaces

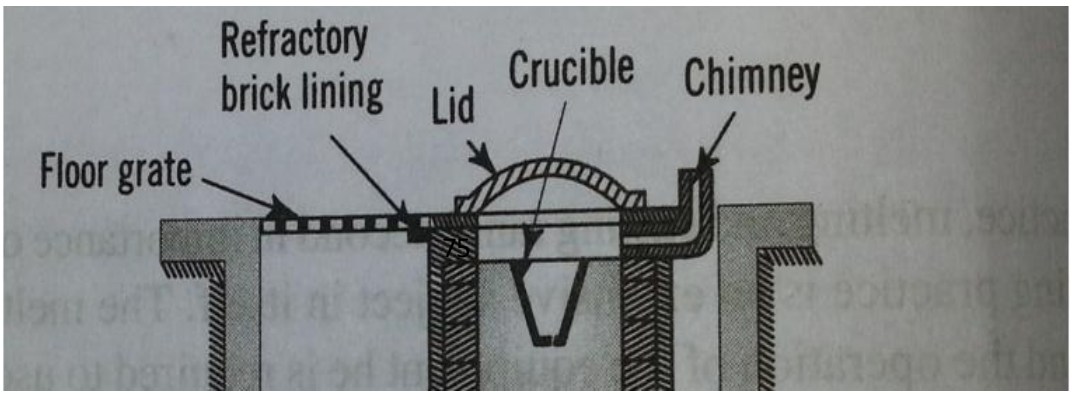
CONSTRUCTION

- These furnaces are generally installed in a formed pit. They are provided with refractory lining inside and a chimney at the top . Both natural as well as artificial draughts can be used .

WORKINGOFCOKEFIREDCRUCIBLEFURNACES

- Broken pieces ofmetalareplaced in thecrucible. Bed cokeis fired inthefurnaceandthecrucibleplacedintoit.Afterwardsmorecoke isplaced all around thecrucible.Theheatgenerated byburningof the coke melts the metal inside the crucible.
- These are used for melting small quantities of ferrous metals (pig iron)forproducingironcastingandalsofornon-ferrousmetalsand alloys. Coke is used as fuel.

COKE-FIREDFURNACES



OILORGASFIREDFURNACES

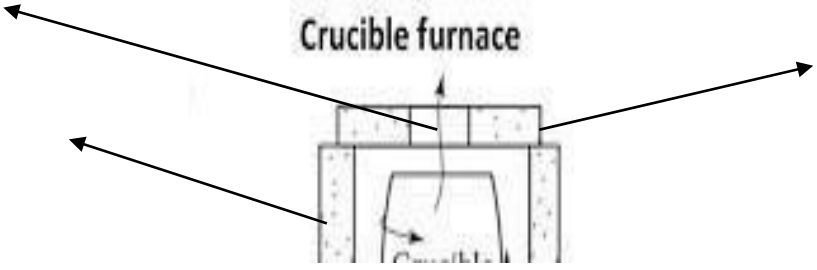
- These furnaces utilise oil or gas as a fuel. A mixture of gas and air or oil and air is fed into the furnace which burns inside to produce the desired temperature. The mixture usually enters tangentially and encirles the crucible while burning.
- Thesefurnaces maybe ofstationary typeor tilting type.Thelatter type are more preferred.

CONSTRUCTIONOFSTATIONARYTYPEGASFIREDFURNACES

- Thefurnaceessentiallyconsistsofacylindricalsteelshell,provided withrefractorylininginsideandproperpassageforentryofthefuel mixture. The crucible is seated on a pad formed at the bottom. A cover is provided at the top to prevent heat losses.

STATIONARYTYPEGASFIREDCRUCIBLEFURNACES

Toatmosphere



Cover

Refractorylining

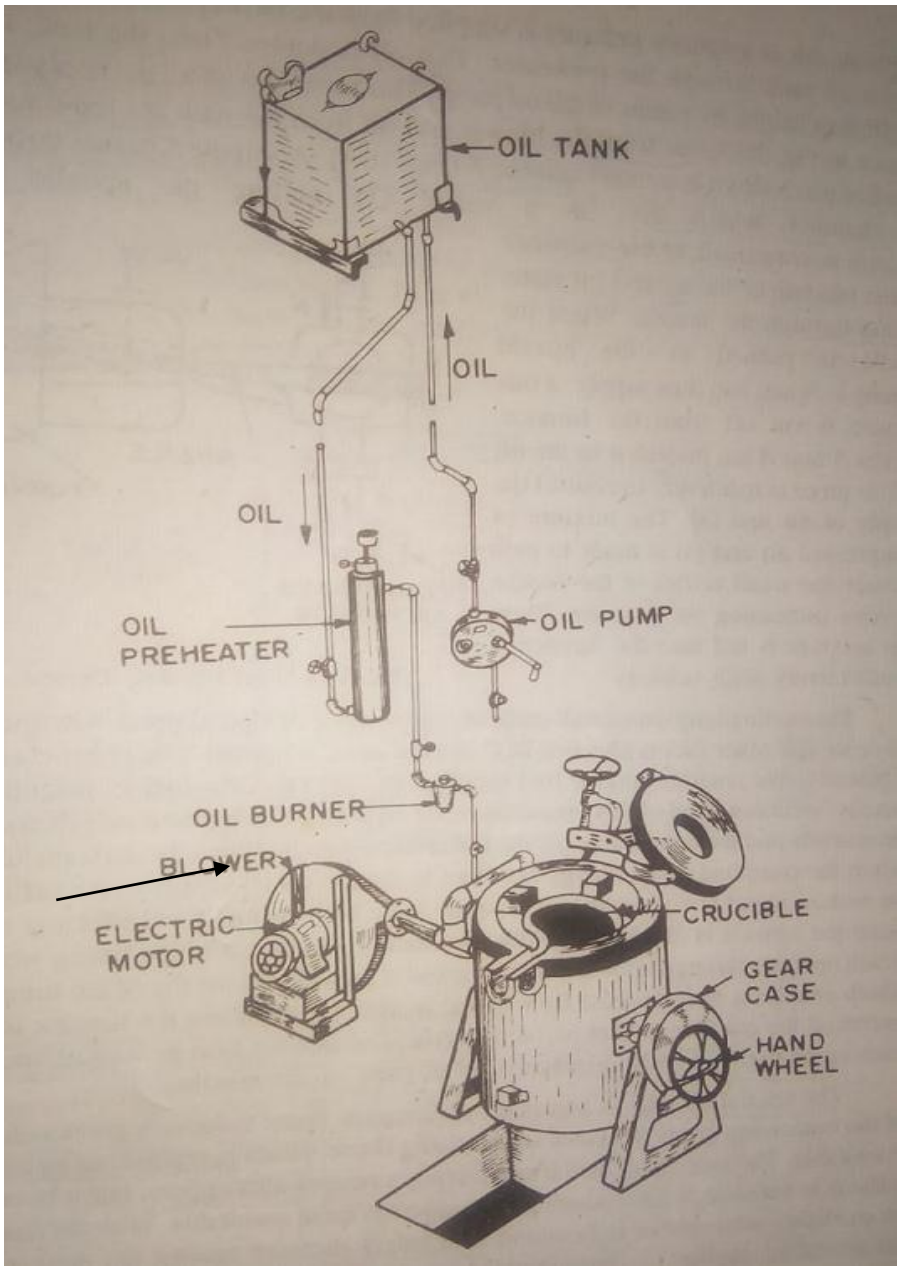
pad

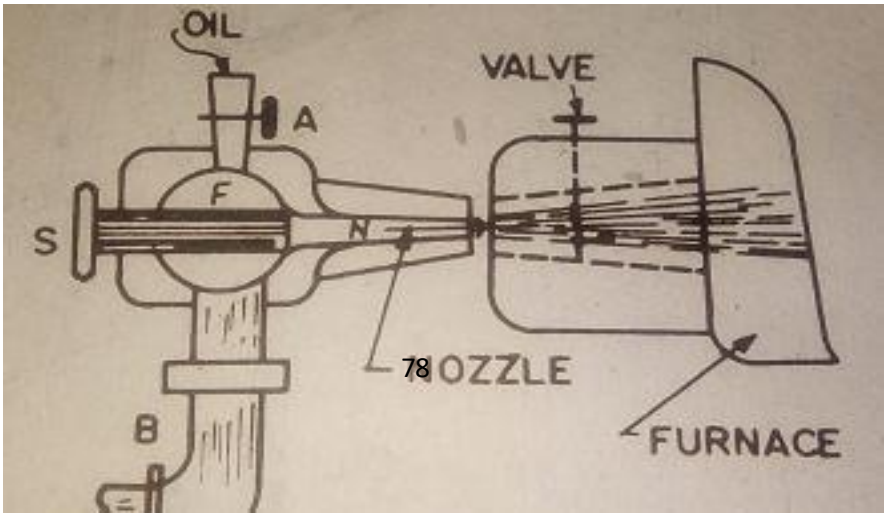
WORKINGOFSTATIONARYTYPEGASFIREDCRUCIBLEFURNACES

- These furnaces utilise gas as a fuel. A mixture of gas and air is fed into the furnace which burns inside to produce the desired temperature. The mixture usually enters tangentially and encirles the crucible while burning. The heat generated due to burning of fuelgasrisestemperatureofthemetalinsidethecrucibleandmelt the metal.

OILFIREDTILTINGCRUCIBLEFURNACES

- An oil-fired tilting furnace consists of an outer shell, having a refractory lining inside. The hollow portion around the crucible forms a chamber, through which circulates the burning fuel. The gases finally escape in to the open atmosphere. Air at a definite pressureissuppliedfromtheblowerandtheoilcomesfromtheoil tank through the oil preheater. The oil tank is kept at a sufficient height and the oilis pumped into the tank.


OIL TANK
OIL
OIL
OIL PUMP
OIL
PREHEATER
OIL BURNER
BLOWER
ELECTRIC
MOTOR
CRUCIBLE
GEAR
CASE
HAND
WHEEL


OIL
VALVE
A
F
S
N
NOZZLE
B
FURNACE

WORKINGOFOILFIREDTILTINGCRUCIBLEFURNACES

- As shown in thediagram airfrom theblowerand oilfrom the tank are fed through respective pipes into a common chamber F . A spindle S passes through this chamber which acts as a valve. On pulling the spindle the nozzle N is connected to the chamber and the mixture ofthe air and oil starts passing through the nozzle.
- For starting ignition a small piece of cotton waste or cloth dipped inkeroseneoilorsimilarotherfuelis attachedatCandthesameis lighted. The metal charge is placed in the crucible and the fuel supply is started. Once the fuel jet is ignited , there is no further need of this operation being repeated. The burning fuel encircles the crucible and the temperature of the metal rises, which ultimately starts melting.
- When the furnace is in operation the crucible is kept perfectly verticalso that theheatgenerateddueto burningof fuel is evenly distributed to all parts of the crucible.
- Whenthespindleispushedinthenozzleopeningisclosedandthus supply of this mixture is cut off from the furnace . Valves A and B are provided in the oil and air pipes respectively to control the supply of air and oil.

- When thecomplete metalcharge has been melted thefuel supply is cut off and the molten metal is collected in a separate ladle for pouring. For collecting this metal the furnace is tilted along with thecrucible, bymeansofthetilting wheelwhichoperatesthrough a set of gears. A spout is provided at the top of the furnace which enables a well directed flow of the molten metal.

DIE –CASTING

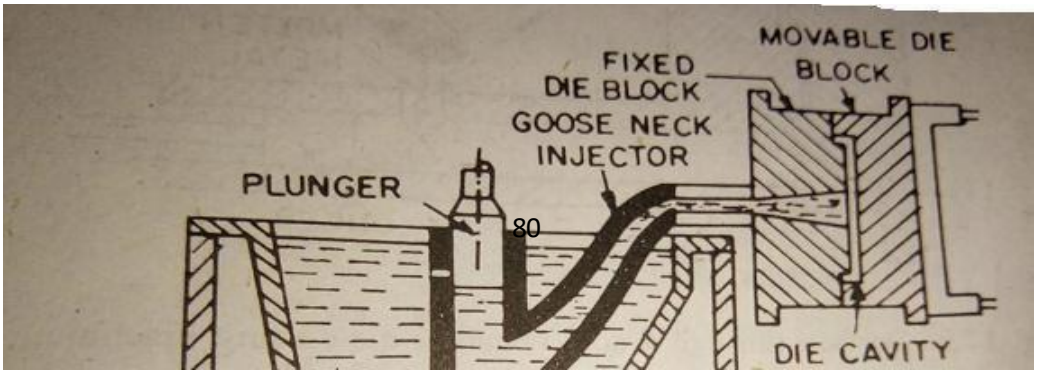
1. Diecasting isa typeofpermanentmoldcasting.Inthisprocessthe molten metal is forced into the permanent cavity of steel mold called a die under very high pressure. Thedie casting is also called pressure die casting.
2. Thediesareusuallymadeintwohalvesoneis fixedandanother is movable. The two halves must be locked perfectly during pouring and solidification of molten metal. After solidification the two halves are to be opened for ejecting the casting .
3. The die casting is suitable only for low melting point metals and alloys.

TYPESOFDIECASTING

1. Hotchamberdiecasting

2. Coldchamberdiecasting

HOTCHAMBERDIECASTING

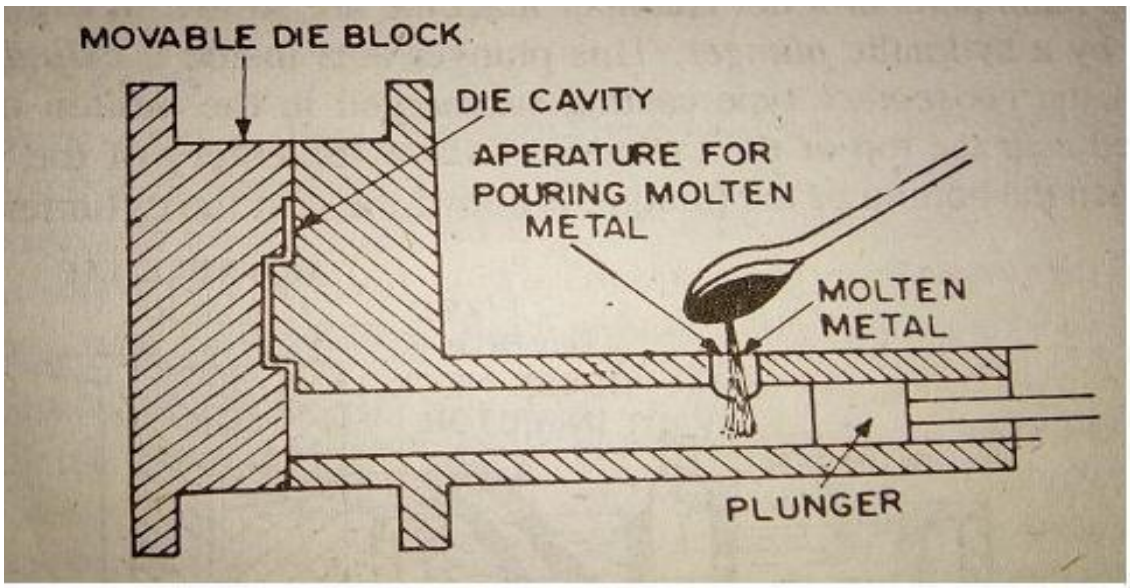


1. The melting unit or heating furnace for the liquid metal is an integral part of this die casting machine, that's why it is called hot chamber die casting machine.
2. Themoltenmetalfrom themetalcontainerisforcedinsidethedie with the help of a plunger which operates hydraulically.
3. This plunger acts inside a cylinder formed at the end of a gooseneck type casting which is submerged in the molten metal.
4. Aportisprovidednearthetopofthecylindertoallowtheentryof themolten metalinto it. when thebottom of theplunger is above theport, thecylinderisconnectedtothemeltingpotthroughthis port.
5. Whentheplungermovesdown,itclosesthisport,andcutsoffthe metal supply. The molten metal is forced into the die through the injecting nozzle by the pressure applied by the plunger on the molten metal present in the gooseneck.
6. After a certain period of time , in the next cycle when the plunger movesup,theremainingmolten metalin thenozzle fallsbackand when plunger uncovers the port, molten metal fills the cylinder. Duetosynchronisationofmovablediewiththemovementof

plunger , during the upward motion of plunger, the movable die moves away and the casting is ejected.

7. Low melting point alloys (Zn based alloy)are generally cast in this machine.

COLDCHAMBERDIECASTING



COLD CHAMBER DIE CASTING

1. In this machine the metal is melted separately in a furnace and transferred to this by means of small hand ladle.
2. Afterclosingthedie,themoltenmetalispouredintothehorizontal chamber through the metal inlet and is forced into the die cavity by a hydraulic operated plunger.
3. Aftersolidificationthedieisopenedandthecastingisejected.
4. Thesemachinesarewidelyusedforcastingagoodno.ofaluminum alloys and brass. So in this process comparatively higher melting point alloys can be processed.

APPLICATIONS

- Carburator,handlebar,differentpartsofscooter,motorcycle,and jeep.
- Otherdecorativeitems.

ADVANTAGES

1. Verysmallthicknesscaneasilycast.
2. Highproductionrate.
3. Bettersurfacefinish.
4. Possibletoobtainfairlycomplexcasting.

DISADVANTAGES

1. Notsuitableforallmaterials.
2. Thedieandthemachineareveryexpensive .
3. Themaximumsizeofthecastingislimited.
4. Sometimescoldshutdefectscanbeseen .

CENTRIFUGALCASTING

- As the name suggests , the centrifugal casting process utilizes the centrifugal force developed by the rotation of the mold to distribute the molten metal into the mold.
- Inotherwords, thisisaprocesswherethemoldisrotatedrapidly aboutthecentralaxiswhenthemetalispouredinto it; becauseof the centrifugal force the molten metal is directed outwards from

the centre towards the inside surface of the mold, with high pressure.

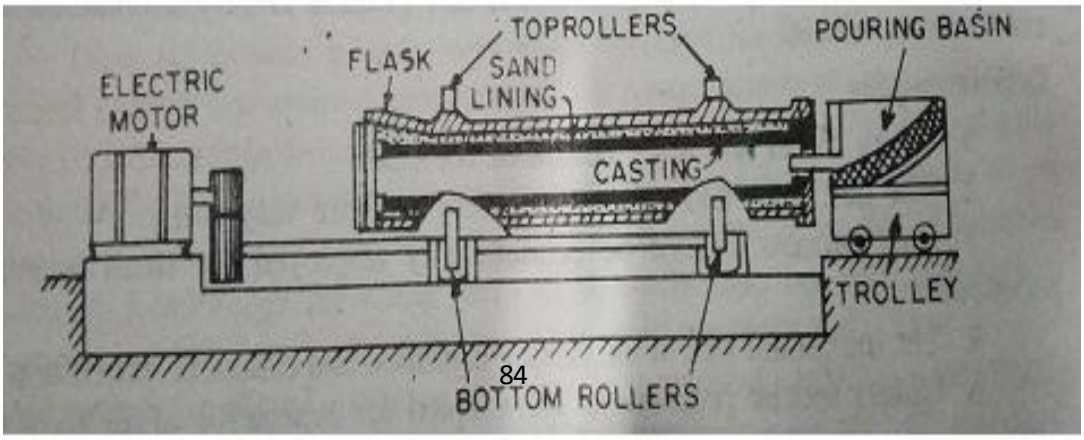
- Asaresultofthisauniformthicknessofmetalisdepositedallalong the inside surface of the mold.
- During solidification, the impurities being lighter remain nearer to the axis of rotation. Greater accuracy and better physical properties of the casting are obtained in this process.

Thecentrifugalcastingmethodcanbeclassifiedasfollows:

1. Truecentrifugalcasting.
2. Semi–centrifugalcasting
3. Centrifuging

Truecentrifugalcasting

- In true centrifugal casting the axis of rotation of the mold and the axis of the casting are the same. The axis of rotation of the mold maybehorizontal, verticalorinclinedatananglebetween70°and 90°.
- End cores are usually used at the two ends of themold to prevent thesplashingofmoltenmetal.Thecentralholethroughthecasting is produced by the centrifugal force without the use of a central core.
- If the axis of rotation of the mold remains horizontal then the casting method is known as horizontal true centrifugal casting.



- As shown in the figure an outer metallic flask with rammed sand linining inside is used as mold and is rotated bytwo sets of rollers. Avariablespeedmotorwhichismountedatanend,isusedtodrive therollers.Throughthepouring basin,moltenmetalispouredand during pouring the mold is rotated at a slow speed.
- After the pouring is over , the mold is rotated at a very fast speed for even distribution of the metal and for proper directional solidification, wall thickness is controlled by the volume of molten metal poured into the mold.
- Pouringtemperaturesrangebetween1482°cto1649°candspeed of rotation vary from 50 to 3000 revolutions per minute.
- In vertical and inclined axes true centrifugal casting methods, the axes remains vertical and at an angle between 70°to 90°respectively. Here the molten metal is poured towards the centre of the mold bottom.
- Convenience in metal pouring and ejection of casting is obtained but here the central hole produced is not truly cylindrical. This defect can be minimised by high spinning speed.

ADVANTAGES

- Soundandcleanmetalcastingareobtained.
- Inmostofthecases,coresare notusedtoproduceacentralhole.

- Noneedofseparategatesandrisers.
- Productionrateisveryhigh.
- Thinsectionsandintricateshapescanbeeasilycast.
- Inspectionissimplifiedasinthesecastingifanydefectoccurs,itis normally found on the surface of the casting.
- Thecastinghaveverygoodmechanicalproperties.
- Thepercentageofrejectsisverylow.

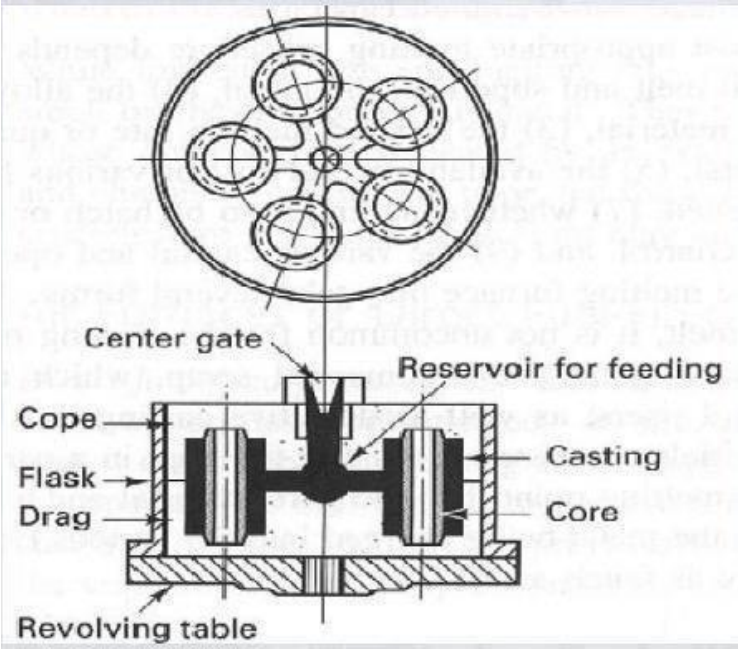
DISADVANTAGES

- Allshapescan'tbecastthroughthisprocess.
- Heavyinitialinvestmentisrequiredforthistypeofcasting.
- It'smaintenanceisexpensiveandskilledlabourisrequired.

CENTRIFUGING

- Thisisalsoknownaspressurecasting.Thiscastingprocessissimilar to true centrifugal casting process but in this case the axis of rotation andthe axis of the mold do not coincide with each other.
- Here the molds are situated at a certain distance from the central vertical axis of rotation. A common central sprue and radial gates are used for feeding molten metal to the molds.

- Like semi centrifugal casting, here also the mold assembly is rotated about a vertical axis and the generated centrifugal force forcesthemoltenmetalfromthecentralsprueintothemoldcavity through the radial gates.



ADVANTAGES

- Shapesofcastingsdon’tcarryanylimitations.
- Highrateofproductioncanbeachieved.

APPLICATION

- Horizontal true centrifugal casting is normally used for making hollow pipes, tubes, gun barrels, hollow bushes etc. which are symmetric with a concentric hole. Vertical or inclined axes true centrifugal casting is used for production of short length castings.

CASTINGDEFECTSWITHTHEIRCAUSESANDREMEDIES

- Variousdefectswhichcommonlyoccurincastingare:

1. Blowholes
2. Porosity
3. Shrinkage
4. Misrunandcoldshuts
5. Inclusions
6. Hottearsorhotcracksorpulls
7. Cutsandwashes
8. MetalPenetration
9. Drops
10. Fusion
11. Shotmetal
12. Shifts
13. Rattailsorbuckles
14. Swells
15. Hardspots
16. Runouts
17. Crushes
18. Warpage

Blowholes:Appearascavitiesinacasting

Possiblecauses	**Remedies**
a) Excessmoisturecontentin molding sand. b) Rust and moisture on chills, chaplets and inserts used. c) Coresnotsufficientlybaked. d) Excessive use of organic binders.	a) Controlmoisture content. b) Usecleanandrustfreechills, chaplets and metal inserts. c) Bakecoresproperly. d) Use organic binders with restraint.

e)Moldsrammedveryhard.	e) Provideadequateventing in moulds and cores. f) Ramthemouldsles hard.

Porosity:Appearintheformofmicroscopicpores

Possiblecauses	**Remedies**
a) Highpouringtemperature. b) Gas dissolved in metal charge. c) Lessfluxused. d) Moltenmetalnotproperly degassed. e) Slowsolidificationofcasting. f) High moisture and low permeability in mould.	a) Regulate pouring temperature. b) Controlmetalcomposition. c) Increasefluxproportion. d) Ensureeffectivedegassing. e) Modifygatingandrisering. f) Reduce moisture and increase permeability of mould.

Shrinkage:Appearintheformofvoidsduetovolumetricshrinkageof moltenmetal during solidification.

Possiblecauses	**Remedies**
a) Faultygatingandrisering. b) Imporperchilling.	a) Ensure proper directional solidification by modifying gating,riseringandchilling.

Misrun:Appear inthe form ofincomplete castingas certainsection of the mold remains unfilled. This defect is known as misrun

Possiblecauses	**Remedies**
a) Lackof fluidity inmolten metal. b) Faultydesign. c) Faultygating.	a) Adjust proper pouring temperature. b) Modifydesign. c) Modifygatingsystem

Coldshuts:Discontinuitybetweentwostreamsofmoltenmetal.

Possiblecauses	Remedies
a) Lackof fluidity inmolten metal. b) Faultydesign. c) Faultygating.	a) Adjust proper pouring temperature. b) Modifydesign. c) Modifygatingsystem

Inclusions: Theseinclusions maybe intheformofoxides, slag, dirt, sand and gas

Possiblecauses	Remedies
a) Faultygating b) Faultypouring. c) Inferior molding or core sand. d) Softrammingofmold. e) Roughhandling ofmold and core.	a) Modifygatingsystem b) Improvepouringtominimise turbulence. c) Useasuperiorsandhaving more strength. d) Provideharderramming. e) Takecareinhandling.

Hottearsorhotcrackorpulls

Possiblecauses	Remedies
a) Lackofcollapsibilityofcore. b) Lackofcollapsibilityofmold. c) Faultydesign d) Hardrammingofmold.	a) Improvecorecollapsibility. b) Improvemoldcollapsibility. c) Modifydesign. d) Providesofterramming.

Cutsandwashes

Possiblecauses	Remedies
a) Low strength of mold and core. b) Lackofbinders in facing and core stand. c) Faultygating	a) Improve mold and core strength. b) Addmorebinderstofacing and core sand. c) Improvegatingsystem.

Metalpenetration

Possiblecauses	Remedies
a) Largegrainsizeandused. b) Softrammingofmold. c) Moldingsandorcorehave low strength d) Moldingsandorcorehave high permeability. e) Pouring temperature of metal too high.	a) Usesandhavingfinergrain size. b) Provideharderramming c) Increase the strength to required extent. d) Reduce permeability with thehelpof(a)and(b)above. e) Suitably adjust pouring temperature.

Drops

Possiblecauses	Remedies
a) Low green strength in molding sand and core . b) Toosoftramming. c) Inadequatereinforcementof sand projections and core.	a) Modifysandcompositionfor increased green strength. b) Provideharderramming. c) Provide adequate reinforcement to sand

	projections and cope by using nails and gaggers etc.

Fusion

Possiblecauses	**Remedies**
a) Low refractoriness in molding sand. b) Faultygating. c) Too high pouring temperature of metal. d) Poorfacingsand.	a) Improverefractoriness. b) Modifygatingsystem. c) Use lower pouring temperature. d) Improve quality of facing sand.

Shotmetal

Possiblecauses	**Remedies**
a) Too low pouring temperature. b) Excess sulhpur content in metal. c) Faultygating. d) High moisture content in moldingsand.	a) Use higher pouring temperature. b) Reducesulphurcontent. c) Modifygatingsystem. d) Reducemoisture content.

Shifts

Possiblecauses	**Remedies**
a) Worn-outorbentclamping pins. b) Misalignment of two halves of pattern. c) Impropersupportofcore. d) Improperlocationofcore.	a) Repairorreplacethepins. b) Repair or replace dowels causing misalignment. c) Provideadequatesupportto core. d) Locatethecoreproperly.

e) Faultycoreboxes. f) Insufficient strength of moldingsand and core.	e) Repairor replacethecore boxes. f) Increasestrengthofmolding sand and core.

RattailsorBuckles

Possiblecauses	**Remedies**
a) Continuouslargeflatsurface on casting. b) Excessivemoldhardness. c) Lack of combustible additives in molding sand.	a) Breakcontinuity oflargeflat surfacebyprovidinggrooves and depressions. b) Reducemoldhardness. c) Suitably add cumbustible additives to sand.

Swells

Possiblecauses	**Remedies**
a) Toosoftrammingofmold. b) Low strength of mold and core. c) Mold not properly supported.	a)Provide harder ramming. Increase strength of mold andcore. Provide adequate support to mold.

Hard spots

Possiblecauses	**Remedies**
a) Faultymetalcomposition. b) Faultycastingdesign.	a) Suitablychangethemetal composition. b) Modifythecastingdesign.

Runouts

Possiblecauses	Remedies
a) Faultymolding b) Defectivemoldingboxes	a) Improvemoldingtechnique. b) Change the defective molding boxes.

Crushes

Possiblecauses	Remedies
a) Defective core boxes producing over-sized cores. b) Worn out core prints on patterns producing under sized seats for cores in the mold. c) Carelessassemblyofcoresin the mold.	a) Repairorreplacecoreboxes. b) Repairorreplacecoreprints. c) Take adequate care in settingofcoresinthemold.

Warpage

Possiblecauses	Remedies
a) Continuous large flat surfaces on castings, indicating a poor design. b) No directional solidification of casting.	a) Modify the casting design to break the continuity of the large flat surfaces and facilitate proper directional solidification.

POWDERMETALLURGY (FORMING)

Powdermetallurgyisametalformingprocessperformedbyheating compacted metal powders to just below their melting point.

Advantagesofpowdermetallurgy

1. Thepowdermetallurgypartsrequireverylittlefinishingprocess.
2. Powdermetallurgyprocessdoesnotcauseanywastageofmaterial during processing.
3. Reasonably complex shapes which cannot be economically machined or castedcan be produced bypowder metallurgy.
4. It is possible to produce parts with a combination of metals andceramic. Thus permits a wide varietyof alloy system.
5. Producesgoodsurfacefinish.
6. Automation of the powder metallurgy process can be easilyaccomplished reducing the labor required.
7. Thisprocessprovidescontrolled porosity.

Methodofproductionusingpowdermetallurgytechnique

Thebasicstagesofproductionare:

1. Productionofmetalpowders.
2. Mixingorblendingofthemetalpowdersinrequiredproportion.
3. Pouringofblendedpowderintodiedesiredshapeandsize.
4. Pressingandcompactingtheblendedpowderinthedie.
5. Sinteringthecompactedpartsinacontrolledfurnaceatmosphere.
6. Secondaryprocessingofthepart,ifrequired.

Productionofpowders

Methodsofproducingmetalpowders

Atomisation:

Inthisprocessthemoltenmetalisforcedthroughanorificeinto astreamofair,waterorinertgas.Asitcomesincontactwiththestream , the molten metal solidifies into small particles of metal due toextremely rapid cooling.

Inairandwateratomizationprocess metaloxidesareformedbutingas atomization process the particles are not oxidized.

Gaseousreduction:

Itconsistsofgrindingthemetallicoxidetoafinelydividedstateandthen reducing it by hydrogen or carbon monoxide, it is employed for metals such as iron tungsten nickel, cobalt and molybdenum.

Electrolysisprocess:

Inthisprocessofproducing powder, theconditionofelectrodeposition is controlled in such a way thata soft spongy deposit is formed which is then pulverized to form powder.

MillingandGrindingorMechanicalpulverisation

Thisprocessinvolvespulverizingthemetalbycrushingorimpactthrough ball mills or stampers. By this process the metal breaks down into small particles. The ball mill is employed for brittle materials while stamp mill for ductile materials. The cost is generally high and the powders produced by these methods are usually treated to remove the cold hardening received in this process.

Shotting : It consists of dropping the molten metal through a sieve into watertoproducesphericalparticles.Thisprocesscanbeappliedtomost

of the metals, but size of the particles is usually large. This may be followed by mechanical means to produce finer particles.

Machining: It is mainly used for producing magnesium and beryllium particles. The particles produced are, however , coarse , which can be converted into fine powder through ball milling and impact grinding.

Othermethodwhichareusedoccasionallyare:

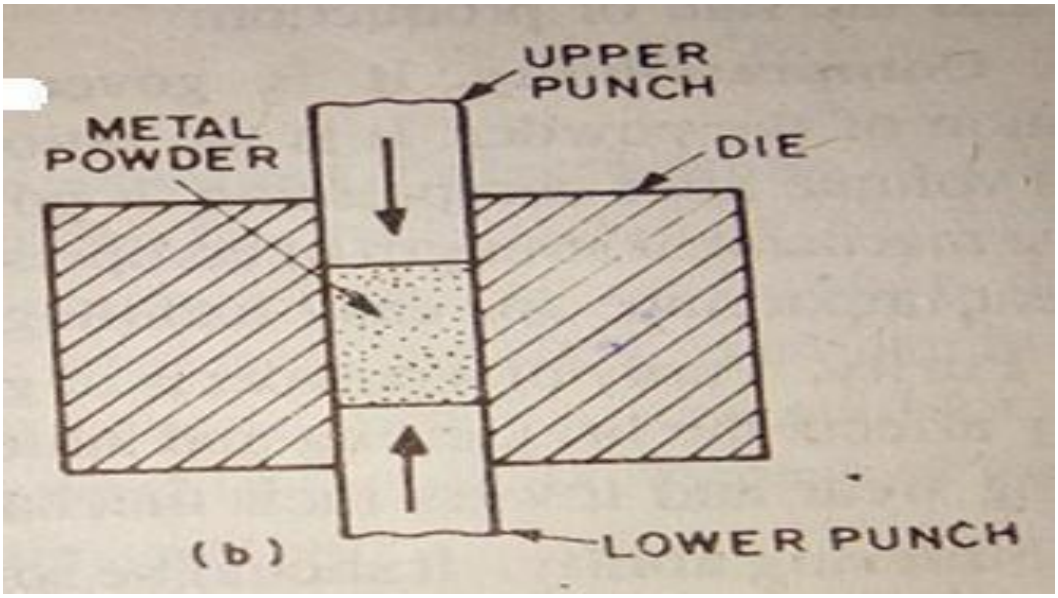
(i) Chemicalprecipitationfromsolution
(ii) Vapourcondensationwidelyusedforzinc.
(iii) Granulation process: It consists of rapid stirring of molten metal during cooling . This process produces a relatively course powder with a high percentage of oxide.

Blendingormixing:

Blending isnotrequired,whenonlyonemetalpowderis usedto produce the part. When different metal powders are used or when nonmetallicparticlesareaddedtoimpartcertainproperties,blending or mixing of constituents are required. The process consists of a thorough mixing of the constituents either wet or dry. Wet mixing reduces dust and minimizes the dangers of explosion. Lubricants are added during blending to reduce friction during pressing . common lubricants are graphite, stearic acid and lithium stearate.

Briquettingorcompacting

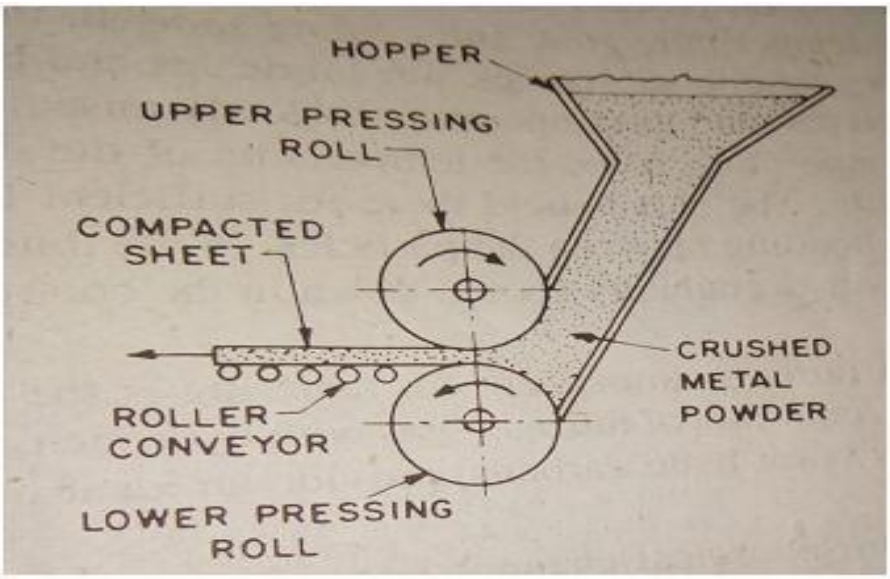
Itistheprocessofconvertingloosepowderintoagreencompact of accurate shape and size . It is done in steel dies and punches . Here two punches are employed , one from the top and the other from the bottom of the powder.



Thediesandpunchesarehighlypolishedonehavingminimumclearance between them to maintain proper alignment. The punches should be sufficientlytough.Highcarbonsteel,highchromium-vanadiumsteeland tungsten carbide are the principal die materials.

During the process, the powder is compressed to nearly one-third of its originalvolume.Eithermechanicalorhydraulicoracombinationofboth presses are used for this purpose.

The metal powder can also be compacted into the form of a sheet by passingacontinuousstream ofpowderthroughapairofrollsrotating in opposite directions. It is known as roll pressing.



Use of ro pressing process for producing sheets through powder metallurgy process

Presintering

Pre sintering is the process by which the green compact is heated to a temperature below the sintering temperature. It increases strength of green compact and removes the lubricants and binders added during blending . For materials which can't be machined after sintering , the machining is done after pre sintering. Example is tungsten carbide.

Sintering

Sinteringofbriquettedpartsisdoneinlargecontinuousfurnaceshaving controlled atmosphere for protection against oxidation and other chemical reactions. The important factors governing sintering are temperature time and atmosphere.

The sintering temperatures for most materials lie between 70 to 80 percent of their melting point. It is, however, quite high incase of

ceramics i.e 90 percent of melting point. In case of mixture of two or moremate rialsthesinteringtemperatureofthecompactedpartmaybe more than the melting point of some of the constituent.

Sintering operation has three distinct stages. To carry out these three stages, most of the furnaces have three distinct areas.

Theseare:

1. Purgeorburnoffchamber.
2. Hightemperaturezone.
3. Coolingzone.

In the first stage, i.e in the purge chamber, volatile substances , air , lubricants and binders are burnt off from the compacted part as its temperature is slowly raised.

Inthesecondstage, i.e.Inthe hightemperaturezone,thetemperature is raised to sintering temperature. The part is held here for sufficient time to complete solid state diffusion and bonding between the particles.

Inthethirdstage,i.eincoolingzonethesinteredpartisgraduallycooled downin the controlled atmosphere of the furnace.

The furnace atmosphere for sintering is either neutral or reducing . A mixture of nitrogen gas with hydrogen, methane provide an ideal reducing atmosphere for this operation.

By sintering , the strength , thermal and electrical conductivities and compact density of the material increases.

Inbrief,themainobjectivesofsinteringare:

a) Achievinghighstrength.
b) Achievinggoodbondingofpowderparticles.

c) Producingadenseandcompactstructure.
d) Producingpartsfreeofoxides.
e) Causing metallurgical diffusion and facilitate alloying of constituent materials.
f) Obtainingdesiredstructureandimprovedmechanicalproperties.

Secondary processes

To achieve close tolerances and better surface finish, secondary processes are performed . these processes include sizing , coining , machining, plating, heat treatment etc.

EconomicsofPowderMetallurgy

Powder metallurgy's cost competitiveness against other technologies is based on two factors.

1. Lowerenergyconsumption.
2. Maximumutilisationofrawmaterial.

Howevertheprocesswillbeeconomicalif:

1. Relatively small and high parts are to be manufactured due to limitation of powder metallurgy compaction presses.
2. Thethicknessorheightofthepartmustbesmall.
3. A large no of products is to be produced. More over down time betweeninvestmentofcapitaltoinstallequipmentandproduction ofjobsistobeminimizedandbatchsizemustbelargetominimize the tool change over time.

PRESSWORK

Press work is a method to form sheet metal into various shapes by using a press machine . A press machine has two parts. The upper part which is fastened to the ram, hits the workpiece, during pressing and the lower part of the machine presscontainsatoolwhichcorrespondstotheupperpart.Theupperpartisknown as the punchand the lowerpart is known as the die and the total unitis knownas Die assembly or Dieset.

Punch:

The male memberof the dieassembly iscalled punch. Itis usuallythatpart ofthe unit which is fastened orattached to the RAM and is forced into the die.

Die:

Thefemalememberofthedieassemblyiscalleddie.Itisusuallyrigidlyheld onthe bed ofthe press.Itcarriesanopeningintheperfectwiththepunch through which the punch enters into the die alignment.

Typesofdie:

1. Singleoperationdie:

Thesearedesignedtoperformonlysingleoperationineachstrokeofthe RAM.

2. Multioperationdie:

These are designed to perform more than one operation in each stroke of the RAM.

Singleoperationdiesarefurtherclassifiedas:

• Cuttingdies

These dies are used to cut the metal. They utilize the cutting or shearing action. The common cutting dies are blanking dies piercing perforating dies, piercing or perforating dies, notching, trimming dies.

• Formingdies

Theseare not metalcutting dies but theychangetheconfigurationof blank to form desired shape without metal removal, this include bending, drawing & sewing die.

Multioperationdiesareclassifiedinto

• Compound dies:

In which two more cutting operation can be performed in a single stroke of the RAM or at a single action.

• Combinationdies

In this dies a combination of cutting or some other operation can be performed at a single station.

• Progressivedies

Thisdiecarriesa noofstationinazeroaseparateoperationisperformedon eachstationandtheworkpieceshifts into stationtothenextone ineachstrokeof the RAM.

Differentcuttingoperations

Trimming;Shaving;Burnishing

Trimming:

Trimmingisanoperationusedforremovingexcessmetal,irregularoutlines andwaveedgesetc.fromthewalls.

Shaving:

Shavingisalsoasimilaroperationdone forfinishing andsizingtherough edges on the blanks.

Burnishing:

Burnishingusuallyfollowsshavingorsmoothingthesharpenededges.

TYPESOFPUNCH:

Punchesareclassifiedas;

1. Planepunch
2. Pedestalpunch
3. Punchesmountedonpunchplate

Planepunch:

These are the simplest type of punches. These are made of solid tool steel blockandaredirectlymountedtothepunchholder,thepunchesarejoined

together by means of dowels and screw. These must be large enough to provide necessary space for dowels and screws as well as the necessary strength to with stand the punching force. The length and width of this punches should be greater than the height of the punch.
Themainadvantageistheeconomyinpunchconstruction.

Pedestalpunches:

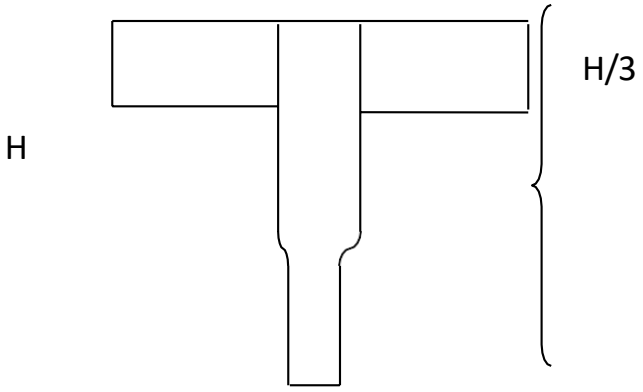
It is also called flanged punch or shoulder punch these are characterized by large base surface compared to the cutting face. The flanged portion which is an integral part of the punchoffers excellent stability of the punch.

The methodof mounting is similar to plane punch in fact the flange portion ofthelengthandthewidthofthebaseshouldbelargerthanorequaltothehighest of the punch. The flange thickness and the fillet radius are to be largely provided with stand the larger forces.

Punchesmountedinpunchplate

Apunchplateisusedgenerallytolocateandholethepunchinposition.

Asimplemethodofassemblingaplane punchinthepunchplateasshown.



Here the punch has uniformcross section throughoutandeachattached to the punch holder by meansof screw. The punch plate has the necessary holes for locating the punch properly.

Perforatortypepunch

Puncheswhosecuttingfacedieislessthan25mmarecalledperforator. The punches need not be round but the inscribe circle of the punch should have a die less than 25mm.

The simplest and the most common perforator is the step head type mounted in a punch plate by means of step head.

If cutting face is round than assembling the punch in any orientation is possible.

Quillpunch:

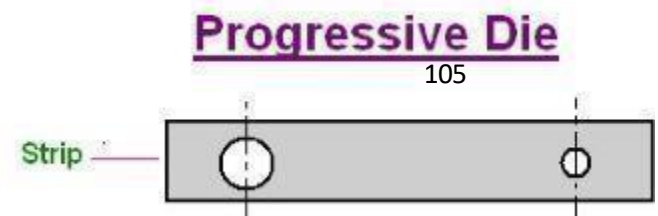
Forparsingverysmallholeslessthan6mmdieitisdesirabletoprovideextra support to the punch shank by means of a closely fitted quill, these are more expensive if made individually because of the close heating required between the punchandquill size, therefore theyare mass produced in various standard sizes.

Progressivedies:

Theprogressivediesperformtwoormoreoperationssimultaneouslyasingle stock of punch press so that a complete component is obtained for each stroke. The place where eachof the operation carried out are called station.

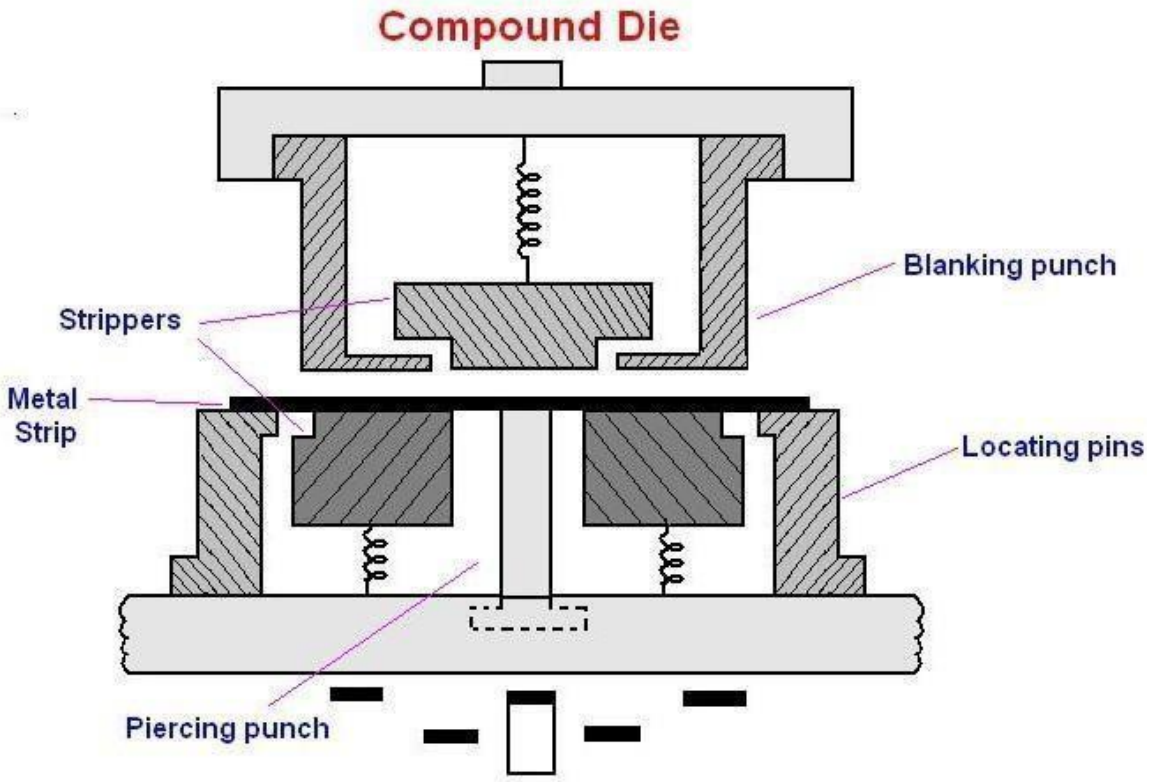
Atthestartoftheoperationthesheetisfedintothefirststationafter undergoingtheoperationsatthisstationtheramofthepressmoves to thetopand thestrokeisadvancedfromthe1ststationtothesecondstationthedistance movedbythestripfromstation1tostation2sothatitisproperlyregisteredunder thestation iscalledadvanceddistanceanothervariablecalled thefield distanceis theamountofstockfedunderthe punchwhenthe RAMcomestothe nextstroke

Progressivediescontentsalargenumberofstationsitisgenerallyperformed to have a piercing operation first in the sequence anda blanking operation in the end to get the final component .



Compound die

In a compound die all the necessary operation are carried out at a single station in a single stroke of the RAM to do more than one set of operation a compounddieconsistsofthenecessarysetofpunchesanddies.Duringthepartof the stroke piercing of holes is done in the stock and open further travel and blanking operation is done for the blanking operation the punch used for the blanking operation the punch used for piercing becomes a die. In other word blankingis done in a direction opposite to piercingcompound dies are same what slower than the corresponding dies in operation but higher tolerances can be achievedinthemcanprogressivediesthisismainlybecausethepartlocatedinone position under goes all the operations. Also in compound dies small strips can be used where as in progressive die very long strip are required to cover all the stations.


Compound Die
Blanking punch
Strippers
Metal
Strip
Locating pins
Piercing punch

JIGSANDFIXTURE

Jigs and fixture are the devices which helps in increasing rate of production of identical parts and simultaneously reducing the human effort required for producing this parts.

Differencebetweenjigsandfixture

Jigs:

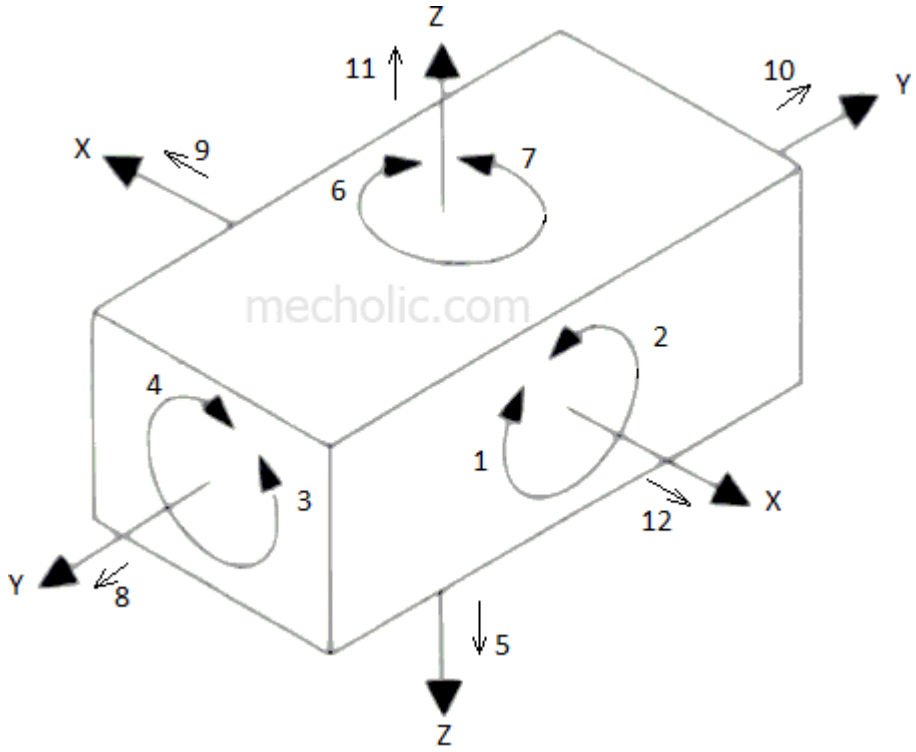
Ajigisaspecialdesignametalplateboxesanfrabcatedstructureintowhich thecompoundisheldoneaftertheotherinidenticalpositionstoperformidentical machining operation .

The jig provides a positive and trace identical locations to all the successive components and guides the tool as well as the work piece in the same way in all therespectiveoperationsothatthemachiningisdoneinexactlythesamemanner in all the operations.

Fixture:

Afixture doesmoreorlessthesame work asajiginthatitholdsandlocates the successive work piece in identical position but differs from a jig in that it does not guide and locate the tools. The tool has to be adjusted separately a fixture is usuallyofamassiveandheavierconstructionthanajigandisfixedorboltedtothe table of the machine. This show that jig holds and locates the work piece, guides thecuttingtools tothe workandnormallyisnotfixedinthemachine tableagainst this a fixture only holes and locate the work piece, does not guide the tool and is fixed to the machine table. Jigs are generally used in drilling tapping whereas the fixtures are employed in milling grinding turning and shaping.

Degreeoffreedomofmomentorprincipleoflocation:



Supposetheworkpieceisacube havingperfectlyflatandtruefacesandislocated in space to act as a free body, let us consider 3 mutually perpendicular axis x-x, y- y, z-z pass through the center of the body. Now this free body in space can have the following movement.

Translatormovement	rotationalmovement
Alongthex-xaxis	alongthex-xaxis
Alongthey-yaxis	alongthey-yaxis
Alongthez-zaxis	alongthez-zaxis

Thus a free body in space has 30 of freedom of straight line movement and 30 of freedom of rotation these are called 60 of freedom movement of a free body in space.
Butinsomecasesbothtranslatorandrotaryinoppositedirectionsalongthe3-axis as2differentdegreesoffreedomthusmakingtotalno.ofdegreeoffreedom

movementas12(fortranslational backandforthandforrotationeitherclockwise or anti clock wise).
So in finally locating a work piece in a fixture each to constrain with the help of suitable locating pins and by means of clamping in such a way that all or as many as degree of freedom are checked only than, it can be an ensured that the work piece will not dislocated from its position during the operation and therefore the operation will be complicated with the desired accuracy.

Mainelementsofjigsandfixture

Body:

Itisaplate,boxorframetypestructureinwhichthecomponenttobe machinedarelocated.

Locatingelement:

These elements locate the work piece in proper position in relation to the cutting tool.

Clampingelements:

Theseelementslocatethecorkpieceinthelocatedposition.

Guideandsettingelements:

Theseelements guide thecuttingtools incaseofjigandheld inpropertool setting in case of fixture.

Positioningelement:

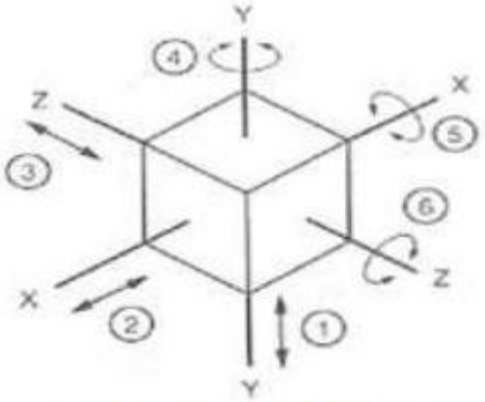
Theseelements include different types offastening devices whichareused in secure in jigof fixture to the machine at proper position.

Indexing element:

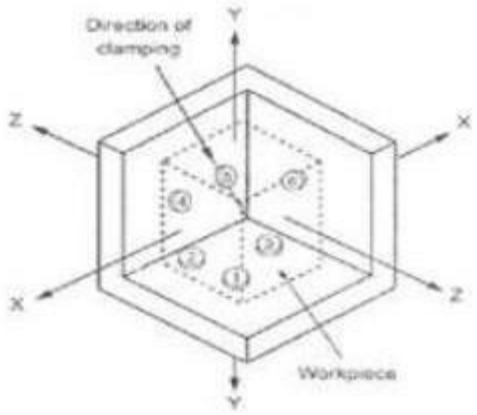
Manyworkpiecesmayhavetobeindexed to differentpositionsinorderto perform machining operations on different surfaces on different locations.

Theprincipleof6pointoflocation3-2-1-pointlocation

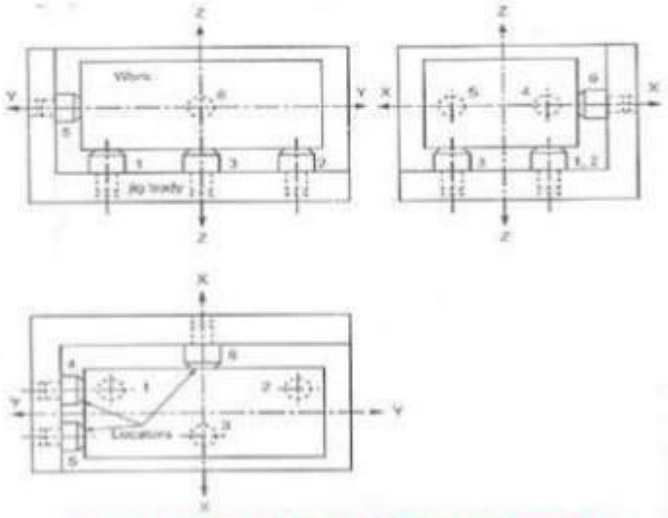
3-2-1 PRINCIPLE OF LOCATION



SIX DEGREES OF FREEDOM



Six point Location Principles



Pin 1,2 and 3
for z-z axis translation
y-y axis rotation
x-x axis rotation

Pin 4 and 5
for y-y axis translation
z-z axis rotation

Pin 6
for x-x translation

3-2-1 PRINCIPLE OF LOCATION

According to this principle a work piece can be completely restricted or hold by providing 3 location points in one plane, 2 location points in 2nd plane and 1 locationpointin3rdplaneinfig.shownacube issupportedat3roundfacesatthe bottombytworoundfacesononesidefaceandby1roundfaceontheotherside.

With this type of location of the object, it is evident that the component cannot rotate about any one of the 3 axis i.e. x-x, y-y, z-z. It is 3 D.O.F of movement 4-5-6 are constrained also due to the 3 supporting pins at the bottom. The work piece cannotmovedownwarddueto two pinsontheleftside. Itcannotmove leftward and due to the pin at the rear side. It cannot move backward. All these possible movements having been restrained the only free directions of movement remaining to be restrained for complete location, now at the forward movement along x-x axis right ward movementalong z-z axis and upward movement along y-y axis. If effort is made to provide pins in front top and right side to arrest these remaining directions of 3 movements, the jig and fixture will take the shape of a closed box and it will not possible to load or unload work piece therefore these 3 degree of freedom are restrained by means of clamping devices this is known as principle of 6 points of location 3-2-1-point location.

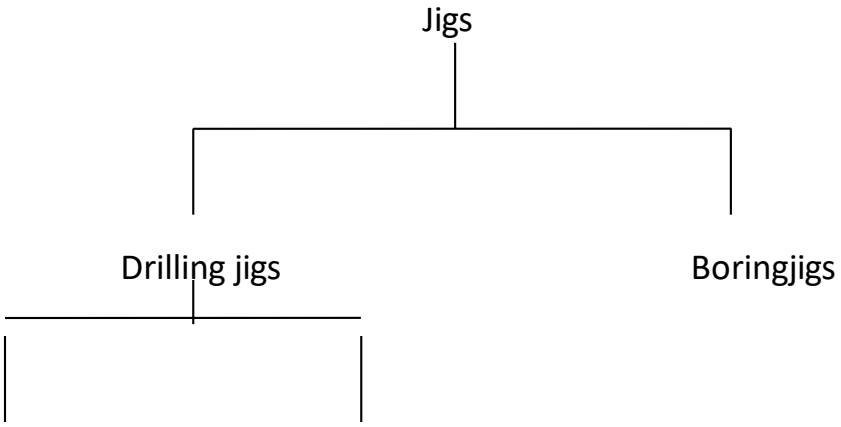
Advantagesofjigsandfixture:

- Theyenableeasymeansformanufactureofinterchangeablepartsandthus facilitated easy and quick assembly.
- Premachiningoperationlikemarking,measuringetc.required in caseof individual parts are totally eliminated with the use of jigs and fixture.
- Once a properly designed jigs on fixture is setup in position, any number of identical parts can be produced without any additional setup.
- Productioncapacity isincreasedwiththeir usebecauseanyno.ofpartscan be produces in a single setup.
- Theyenablequicksettinginproperlocationofwork.Hencetheworkhandling time is reduced.
- They occur aclamping rigidity. Therefore, higher speed,field and the depth of curve can be used for machining.
- Because of automatic location of the work and guidance of the tools, the machining accuracy is increased.
- The parts produced with their use are very accurate. As such, the expand each other due to inspection quality control of finished components is considerably reduced.

- Their use enables easy machining of complex and heavy components becausesuchpartscanberigidlyheldinproperlocationformachininginjigs and fixture.
- Also there use facilitated deployment of less stilled level because setting of toolsand work piece is not manual there byeffectingsaving andlaborcost.
- Thusnoconsiderablereductioninmanualhandlingoperationconsequently, there is a large reduction fatigue to the operator
- There use facilitated a partial or nearly full automation of the operations cycle, there by effecting a substantial reduction in the overall production cost.

Typesofjigs

1. Drillingjigs
2. Boringjigs



OpenType Closedtypeorboxtype

TypesofdrillingJigs:

Template jig
Platetypejig
Diameter jig
Box type jig

Platejigs:

This isanimprovementovertemplateJig. Aplatejigisa templatejigwithan added clamping arrangement. A plate having drill bushes and suitable means to hold and locate the work so that it can be clamped to the plate and holes drilled directly through the bushes in correct position.

Boxtypejigs:

Itisnamedsobecauseofits boxshapeconstructionclosedfrommostofthe sidessuchjigsarenormallydesignedandusedforthosecomponentwhichcarryan occurred shape and need machining more than one plane such components are usually difficult to be held or supported during the operation by hand or ordinary jigs of other types. They need a very rigid support from many sites which can be provided only by box type jigs.

Templatejigs:

Thisis thesimplesttypeofdrillingjigs.Itis simplyaplate madeto theshape and size of the work piece with the required a number of holes made in it accurately. It is placed on the work piece and the holes in the work piece will be made by drill, which will be guided through the holes in the template.

Diametertypejigs:

A diameter type jig is used for cylindrical work piece. It encloses the work piece in ‘v’shape groove. The diameter jig may have a cover person that contains guide holes for drill operation.