BASIC MANUFACTURING PROCESSES

Questions and answers

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BASIC MANUFACTURING PROCESSES (NME-101/201)

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Dedicated

to

INFINITE WORD

Preface

This collection is an effort in the direction to help and support the students of UPTU to have very good understanding of the basic manufacturing processes as per the new syllabus and to pass the examination with very good marks.

The important feature of this collection is that the questions asked in previous examinations have been included as they were asked in the question papers. This shall help students to know the pattern of questions before hand. The answers have been arranged and elaborated in such a way that **all the related aspects of the topic are covered together**, without leaving any voids.

All the criticism and suggestions are welcome and also requested to improve the collection for fulfilling the objective so that students are able to pass with very good marks. Your contributions shall be appreciated in future updates.

This is of utmost importance that I must acknowledge and accept that lot of illustrative material has been procured from works of various authors and web sites. I am obliged to all such sources from where the contents have been collected yet it is not possible for me to acknowledge them distinguishably.

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NEW SYLLABUS [Effective from Session 2013-14] (1st Year)

Further reading and reference books in addition to prescribed reference books

(1) Materials and manufacturing processes by E Paul DeGarmo, JT Black, Ronald A Kohser
(2)Workshop technology by SK Garg (3) Manufacturing Processes by V Narula
(4) Manufacturing Processes by B S Raghuvanshi

NME-101/201: BASIC MANUFACTURING PROCESSES

Unit-I Engineering Materials **L T P [2 0 0]**

Materials and Civilization, Materials and Engineering, Classification of Engineering Materials.Industrial applications of common engineering materials and their socio economic impact. **2**

Metals & Alloys: Properties and Applications

Mechanical Properties of Materials: Strength, elasticity, plasticity, stiffness, malleability, ductility, brittleness, malleability, toughness, hardness, resilience, hardness, machine ability, formability, weld ability. Elementary ideas of fracture fatigue & creep. **2**

Steels and Cast Irons: Carbon steels, their classification based on percentage of carbon as low, mild, medium & high carbon steel, their properties & applications. Wrought iron.Cast iron.

Alloy steels: stainless steel, tool steel.

Heat Treatment Processes: Introduction to Heat- treatment of carbon steels: annealing, normalizing, quenching, tempering and case-hardening. **2**

Alloys of Non Ferrous metals: Common uses of various non-ferrous metals (Copper, Zink, Tin, Magnesium, Lead, Aluminum etc.) & alloys and its composition such as Cu-alloys: Brass, Bronze, Al- alloys. **2**

Unit-II Basic Metal Forming & Casting Process.

Forming Processes: Basic metal forming operations & uses of such as: Forging, Rolling, Wire &Tubedrawing/making and Extrusion, and their uses.Press-work: Die & Punch assembly, cutting and forming, its applications.Hot-working versus cold-working. **4**

Casting: Pattern: Materials, types and allowances. Type and composition of Molding sands and theirdesirable properties. Mould making with the use of a core. Gating system.Casting defects &remedies.Cupola Furnace.Die-casting and its uses.
3

Unit-III Machining and Welding operations and their applications

Machining: Basic principles of Lathe-machine and operations performed on it. Basic description ofmachines and operations of Shaper-Planer, Drilling, Milling & Grinding. **4**

Welding: Introduction, classification of welding processes. Gas-welding, types of flames and theirapplications. Electric-Arc welding.Resistance welding. Soldering & Brazing processes and their uses. **3**

Unit-IV Misc. Topics

Quality: Introduction, basic concept about quality of a product. **1**

Manufacturing Establishment: Plant location.Plant layout–its types.Types of Production.Productionversus Productivity. **1**

Non-Metallic Materials: Common types & uses of Wood, Cement-concrete, Ceramics, Rubber, Plastics and Composite-materials. **2**

Misc. Processes: Powder-metallurgy process & its applications, Plastic-products manufacturing,Galvanizing and Electroplating. **2**

Reference Books:

1. “Processes and Materials of Manufacture”, Lindberg, PHI
2. “Manufacturing Engineering And Technology”, Kalpakjian and Schmid, Pearson
3. “Manufacturing Processes”, Kalpakjian and Schmid, Pearson
4. “Manufacturing Processes”, H. N .Gupta, R. C. Gupta, ArunMital, New Age

UNIT-I

Materials:

Material is any matter from which a thing is or can be made. It can be constituted of one or more substances. Wood, cement, hydrogen, air, water and any other matter are all examples of materials. Sometimes the term "material" is used more narrowly to refer to substances or components with certain physical properties that are used as inputs to production or manufacturing. In this sense, materials are the parts required to make something else, from buildings,parts, to airplanes and computers.

Materials and civilization:

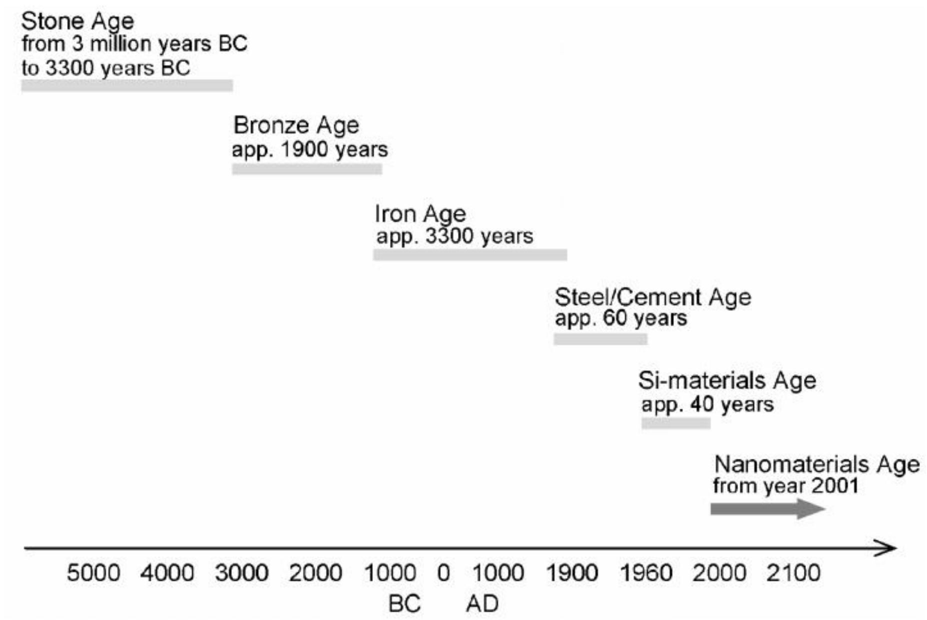
Discuss the importance of Materials on civilization.

Let us make a general survey of the development of history of human society. The development andapplication of materials is always the milestone for the civilization and economicprogress. The introduction and application of a new type of materials has always caused theimportant change for human society and civilization.

The reason is obvious since everything is either made ordepends on materials. Not to mention the food eaten, clothes worn, things utilized, all of thedevices, all of the tools, and various weapons which all cannot be manufactured withoutmaterials. Even the so-called spiritual food such as books, films, radio, television, internet,etc also cannot work without materials, but must rely on them.

Materials are the bases of allthings including people’s life, human progress and the basic civilization of human society.Use of the typical materials to designate the stages of the civilization of humansociety just reflects the basic role of materials in the process of development for humansociety, because any name of devices, articles and things, or some kind of abstract namecannot replace it. We know that a lot of great devices, buildings and other things were createdby our human, such as The Great Wall, The Pyramids, various skyscrapers, various greatbridges, automobiles, trains, planes, spacecrafts, satellites, internet etc. They are all importantsymbols for the civilization of human society, and we are proud of them. However,who can imagine that such great things can be created without materials? Or from the otherpoint of view, can we have The Great Wall Age, The Pyramid Age, or automobile, train andplane age? Of course, we cannot do so though sometime some people have referred to theworld as to the automobile age or plane age.

The civilization of human society may be classified as shown below:



Materials and engineering:

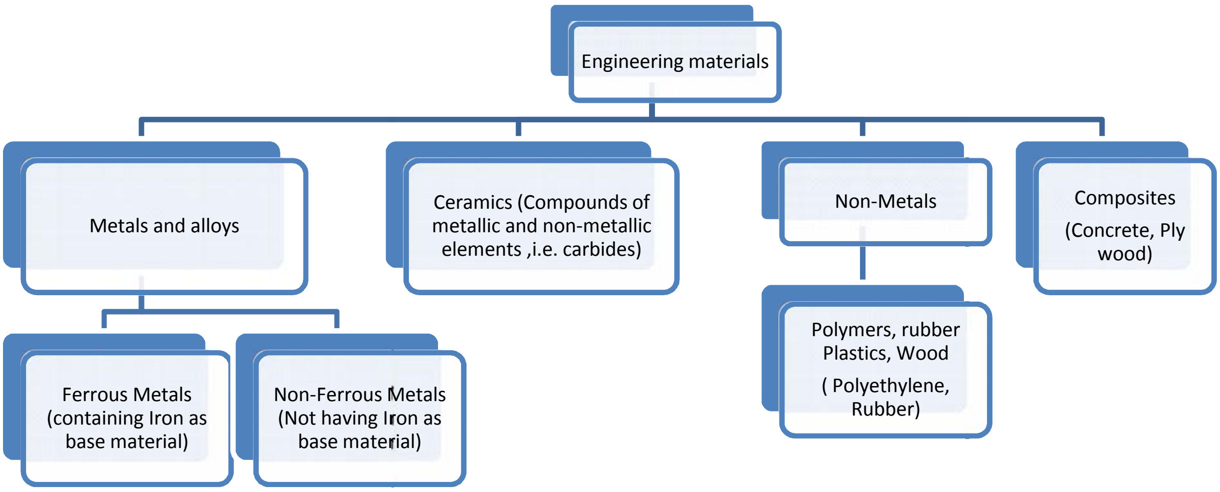
The creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance (awareness) of their design; or to forecast their behavior under specific operating conditions; in all respects of an intended function, economics of operation or safety to life and property.

Now relating the materials with the engineering we can say that materials engineering is the designing or engineering the structure of a material to produce the predetermined set of properties in the material.

Classification of engineering materials:

1. **Classify the engineering materials.** Explain the different types of plain carbon steels with their properties and applications. 2010-2011, SEM-I, Spl-Carry

The engineering materials are those materials which are used for engineering and structural purpose, such as to make bridge, road, machine, building, etc. these can be classified as:



Industrial application of engineering materials:

Sl. No.	Classification	Engineering Material	Application
1	Metals	Steel	Used for making of buildings, automobiles, trains, machine and their components.
		Gold	Used for making of ornaments, computers, coins.
2	Non-metals	Plastics	Used in the making of pipelines, cable insulations, chairs.
		Wood	Doors, windows, bridges, furniture.
3	Ceramic	Aluminum oxide	Used in the grinding wheels, abrasives
		Silicon carbide	Used in the cutting tools.
4	Composites	Fiberglass	Used in the making of bulletproof jackets.
		CFRP	Used for aerospace and sports applications.
5	Advanced Materials	Semiconductors, Bio-Materials, Smart Materials, Shape memory alloy	Used in the making of electronic equipments, Used in the replacement of damaged body parts, Used in the sensors and actuators.

Engineering materials and their socioeconomic impact:

2. **Discuss the role and importance of materials and manufacturing for the growth of any nation. Explain with suitable example.

*Discuss the role and importance of materials and manufacturing for the growth of any nation. Explain with suitable examples, the types of production. 2009-10, Sem-II

*Write a detailed note on the impact of materials and manufacturing on the development of a country. 2011-12, Sem-I

*Discuss the role and importance of materials and manufacturing for the growth of any nation. Explain the production and productivity. 2008-09, Sem-II

*Discuss the role and importance of materials and manufacturing for the growth of any nation. Explain with suitable examples, the types of production. 2008-09, Sem-I

ANSWER

Importance of Materials and Manufacturing

One can easily understand the significance of Materials and Manufacturing if he carefully observes the different types of products around him, and used in daily life, viz., a Pen, a Steel rule, a Stapler, a Paper Punch, a Telephone, an Auto Vehicle, an Aircraft, various types of Electronic Gadgets, Medical Equipment and Surgical Instruments, House hold goods, etc. to cite a few examples. All such articles are not directly obtained from nature. They are converted from Raw Materials, obtained from nature in various forms, through a number of operations to bring them to the forms in which they are used. These usable forms are actually the net results of different Manufacturing Processes.

In essence the importance of materials and manufacturing can be realised from the fact thaat "***In absence of the materials and manufacturing processes, our civilisationwould have been totally deprived of all the facilities and comforts we are enjoying today***".

The term **Manufacturing** has been defined by different persons in several different ways. Some have put forward a very simple definition as a **Process of Converting Raw Materials into usable Products**, while others have defined it as The application of Physical and Chemical Processes to alter the Geometry, Properties and Appearance of a Raw Material to make a part and or Products, including their Assembly, to obtain the intended Product.

Materials and Manufacturing as a Economic and a Technological activity

Manufacturing is both, an Economic Activity as well as a Technological Activity. One activity effects the other and vice-versa. It is a universally accepted fact that there is no standard measure to assess the well being of the people of a country or its society. It is, however, acclaimed that the Gross National Product (GNP) is indicative of its material well being. The GNP is determined by adding the values of all the goods and services produced by a country.

These goods and services may be in several different forms, like Agriculture, Animals, Forests, Seas, Industries, etc. and they all contribute towards the GNP. The extent to which a particular type of resource or its produce will contribute will depend upon its requirement, availability, extent to which it can be exploited and similar other factors. However*, with the development in the manufacturing* ***Rate and Quality of Production*** *is increased, Manufacturing Costs are decreased , Human Fatigue has reduced, provision of better and safe working conditions and overall safety is made, thereby making the Products more acceptable and competitive, both locally as well as globally*. This has resulted in better earnings and, in turn, better

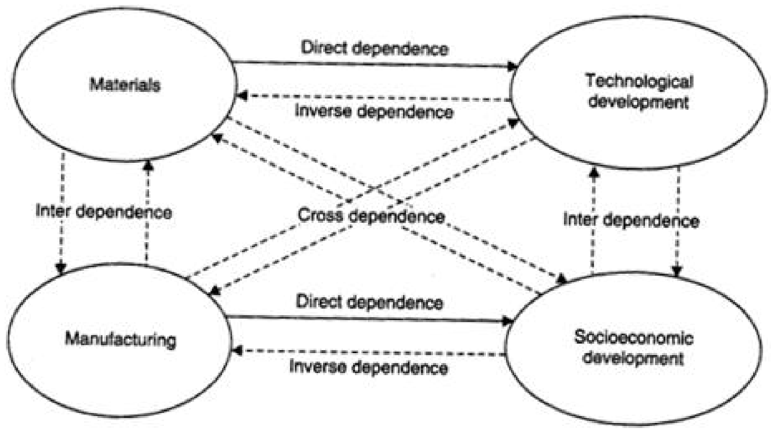


Diagram showing the Direct dependence and the various Indirect dependences (Inverse, Inter and Cross) among Materials, Manufacturing, Technological and Socio-economic Development purchasing capacities of people, more Job opportunities, etc. Thus, overall Living Standards of the societies is improved and with more comforts and emenities. This has made a very significant contribution to the **Economical Development of the country.**

As a **Technological Activity**, Manufacturing involves the proper use of talents and skills of the Technical Manpower, including Engineers, Supervisors, Managers, Technicians and similar other categories to give shape to the conceived ideas through proper Design, Planning, Processing, Inspection and Quality Control, Testing, Finishing, Shipment, etc. Natural resources, of course, are very vital for producing anything, because the basic raw materials are commonly available only from them only, but proper exploitation of these resources and their shaping into useful products and services is the function of Manufacturing Activity only. So, ***the availability of enough natural resources, combined with appropriate manufacturing activities can only make a society, its people, and the country at large, prosperous and strong*****.**

Example: Let us consider an example to illustrate the importance of materials, manufacturing and its relation with the economic and technological development of any society or nation. Let us consider an example of production of consumer good cotton vest, in an area where cotton is easily available and the labor is cheap because they are jobless and their economic status is also low.

a. As the factory is set up, the local people get employment and now they are no more jobless and their economic status is improving.
b. As a consequence of setting up of factory the consumption of cotton is increased and the demand is increased, thus the farmers get better price for their produce.
c. They start sending their wards for better education as now they can pay for the fee.
d. As the people have more money now they start buying better equipments and clothing.
e. As a result another local market is developed to meet the requirements of the local people.
f. In this market also some people get job.
g. Here we see that now the economic level and social level of the society is improved as result of setting up of the factory.
h. Now since we started with the production and we are able to sell cheaper and competitively, the more profits are earned by the company and more wages are paid to the workers. Also the government is getting increased taxes.
i. With increase in the profits the owner of company will be able to get some better and new technology equipments which will be able to give even more and good quality production with reduced worker fatigue.
j. Thus because of setting up of a new factory the quality of life (socio-economic status), quality of product, (technological development) and revenue generation has improved.
k. This example elaborates the different aspects of the materials and manufacturing and its importance in the development of the nation.

The materials, manufacturing, socio-economic development and technological development are related in following manner as shown in the figure.

a) Direct dependence:
b) In verse dependence
c) Inter dependence:
d) Cross dependence

Conclusion: From the above discussions it can be easily concluded that the general well being of people and the ***strength of a society and the country as a whole depends on it Economy, which will be a function of its natural resources (available Materials) and their exploitation***

through Manufacturing processes. Also, a Global recognition of the Economic and Technological strength of a nation will largely depend on these factors only.

Metals & alloys: Properties and applications

Mechanical Properties of metals:

3. ***Explain toughness. Indicate the toughness of brittle and ductile materials on stress-strain curve indicating the proportional limit, elastic limit, yield point, UTS and fracture point.***

**Draw stress-strain diagram for ductile and brittle material. Explain, what do you understand by toughness? 2008-09, SEM-I & sc*

** Draw stress-strain diagram for ductile and brittle material. Explain the behavior of these materials with help of the diagram. 2008-09, SEM- sc*

** What is the difference between brittle and ductile material, explain with stress-strain curve?*

** Explain the difference between: 2010,Spl-Carry(SEM-I/II)*

(i) Elastic limit and proportional limit,
(ii) Hardness and brittleness
(iii) Strength and stiffness

** Draw a neat sketch for stress and strain in case of ductile and brittle material. Explain the difference between ductility and brittleness.*

** What is toughness? Where such property is desirable? 2011-12,Spl-Carry*

** Compare the following: 2011-12, Sem-II*

a) Hardness and toughness
b) Strength and stiffness

***Write Short notes on the following:**

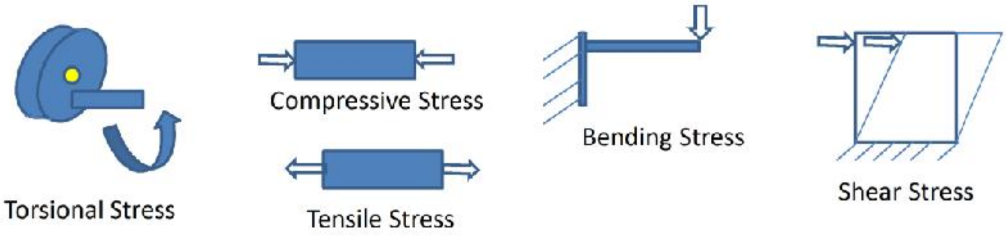
a) **Brasses** 2011-2012, SEM-I
b) **Fatigue in metals** 2011-12, SEM-I, 2010-11,SEM_I,Spl-Carry, 2010-11, SEM-II
c) **Ductility** 2011-12, SEM-I, 2008-09, Spl-Carry, 2008-09, SEM-II
d) **Annealing** 2011-2012, SEM-I
e) **Creep** 2011-12, SEM-I, 20-2011,SEM_I,Spl-Carry, 2008-09, Spl-Carry
f) **Toughness** 2011-12, SEM-I, 2010-11,SEM-I, Spl-Carry, 2010-11, SEM-II, 2008-09, Spl-Carry, 2008-09, SEM-II
g) **Plasticity** 2010-2011, SEM-II

ANSWER:

Strength: Strength is the measure of the ability of the material to with stand or to resist external forces. Higher the strength of the material, higher will be the resistance offered by the material to the applied external force.

For example a wooden bar will break easily and iron bar will not break easily because the resistance offered by the iron bar is very high.

Depending upon the type of loading the strength may be **tensile, compressive, shear, torsional and bending Strength.**



Strength of the material is represented or measured by the stress. The stress is defined as the internal resistance set up by the molecules of the material to resist the deformation on application of the external force.

$$Stress = \frac{Force\ or\ Load\ \text{Applied}}{Cross - Sectional\ \text{Area}}$$

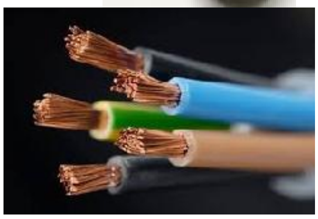
Elasticity: Elasticity is the property of material because of which the material is able to regain its original shape and size after removal of deforming forces. As in case of a rubber ball, if the ball is pressed between two hands it gets deformed and as soon as we release the force of the hands the ball regains its original shape and size. Steel is more elastic than rubber.

Plasticity: Plasticity is the property of the material because of which the material is able to retain (maintain) the deformed shape even after removal of deforming forces. Clay, polyethylene, etc.

Stiffness: Stiffness is also called as the **rigidity** and is the ability of the material to resist the deflection or Elastic deformation. Stiffness is generally related to the springs, thicker springs are stiffer.

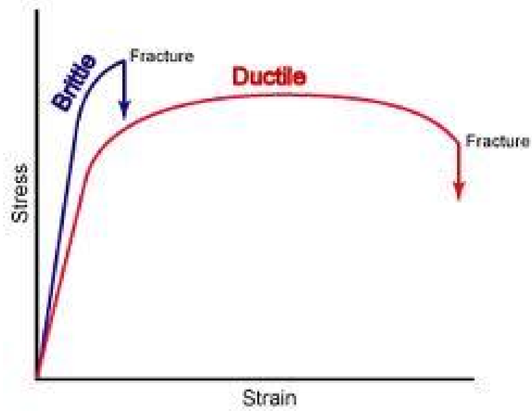
$$Stiffness = \frac{Load}{Deflection}$$

Malleability: Malleability is the ability of a metal to be hammered into thin sheets. It is the ability of a solid to bend or be hammered into other shapes without breaking. Examples of malleable metals are gold, iron, aluminum, copper (to a degree) and lead.When a piece of hot iron is hammered it takes the shape of a sheet.

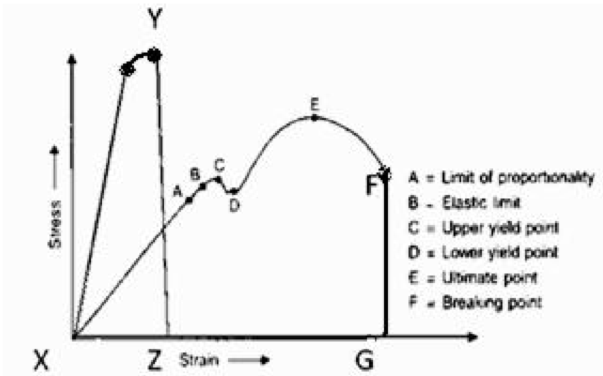


Ductility: *Ductility is the property of the material by virtue of which the material can be drawn into thin wires without rupture or fracture*.It is the ability of a metal to withstand elongation (deformation in longitudinal direction) under tension without rupture.
Example of ductile material*: Gold, silver, aluminum.*

Brittleness: Brittleness is the property of the material because of which the material fails or breaks or fractures or ruptures without any appreciable amount of deformation, before failure.In other words, lack of ductility is brittleness. An elongation of less than 5% is often taken to indicate a brittle material.
Example of brittle material*: Chalk, glass, cast iron etc.*, it will not stretch and bend before breaking.



Toughness: Toughness is a measure of the amount of energy a material can absorb before failure or fracture takes place. The toughness of a material is expressed as energy absorbed (Nm) per unit volume of material (m^3) or Nm/m^3.Toughness is related to impact strength *i.e.* resistance to shock loading and it is desirable in the components subjected to shock and impacts such as gears, hammer, anvil. The area under the stress and strain curve of brittle and ductile material represents the toughness of the brittle (X-Y-Z) and ductile (X-A-B-C-D-E-F-G) materials.
Example: If a load is suddenly applied to a piece of mild steel and then to a piece of glass or chalk, the mild steel will absorb much more energy before failure occurs. This indicates that mild steel is tougher than glass.



Stress-Strain Curve for Ductile Materials (e.g. Mild Steel).
And Brittle Material (e.g. cast iron)

Hardness: Hardness is usually defined as resistance of material to penetration, indentation or scratching action. Hard materials resist wear and scratches.

Example: Diamond is the hardest known material.Stone, tungsten carbide, etc. Hard materials are chosen for the manufacturing of cutting tools.

Resilience: Resilience is the ability of a material to absorb energy when it is deformed elastically, and release that energy upon unloading. The deformation is carried out within the elastic limits (Point B in the stress strain diagram).

Machine ability: The Machine ability represents the ease or suitability with which the material can be cut or removed to make a desired and size. Machine ability is expressed as a comparative index by comparing the metal under consideration with free cutting steels.

Formability: Formability represents the ease or suitability with which the metal can undergo plastic deformation without fracture. Formability improves at higher temperatures for most of the metals.

Weld Ability: Weld ability represents the ease or suitability with which the metal can be weld by welding processes. The welding processes are the joining or fabrication processes.

Stress strain diagram: The stress strain diagram is the curve plotted on the paper when the metal specimen is subjected to tensile stressesupto the fracture point.The stress strain diagram for the ductile (Curve from X-A-B-C-D-E to F)and brittle (X to Y) material is shown in figure. The various points of interest are:

Proportional Limit or limit of proportionality: It is the maximum stress up to which Hook's law is valid i.e. upto this point stress is directly proportional to strain.

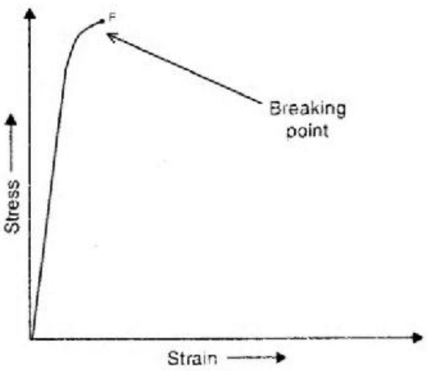
Elastic Limit: The elastic limit is the maximum stress which the material can withstand without causing permanent deformation *i.e.* after the removal of load; material regains its original dimensions.

Yield Point: If the material is stressed beyond elastic limit, plastic stage will reach *i.e.* with the removal of load; the material will not be able to recover its original size and shape.

Beyond elastic limit, strain increases at a faster rate with very little increase in stress. At point C material yields and there is an appreciable strain without any increase in stress. For mild steel, there are two yield points C and D. The point C and D are called upper and lower yield point respectively. The stress corresponding to yield point is known as yield point stress.

Ultimate Tensile Stress (UTS): If further load is applied beyond point D, the stress goes on increasing till the point E is reached. At E, the stress attains the maximum value known as ultimate tensile stress.

Breaking Stress: After the specimen has reached the ultimate stress, a neck is formed, which decreases the cross-sectional area of the specimen. The stress corresponding to point F (**fracture point**) is known as breaking stress.



Stress and strain curve for Brittle material

Difference between (properties of) Ductile and Brittle materials

Ductile material	Brittle materials
Ductile materials can be converted into thin wires.	These cannot be converted into thin wires.

These materials have high toughness.	These materials have low toughness.
These materials show appreciable amount of deformation before failure.	The materials fail without any appreciable amount of deformation
Failure takes place with cup and cone feature	The failure surface is shard and reflects light
Example: Gold, silver, copper	Example: Chalk, glass, Concrete,

Elementary ideas of fracture, fatigue and creep

4. ***Explain fatigue, creep and fracture with neat sketches.*** ***2008-09,SEM-II,2008-09,Spl-carry***

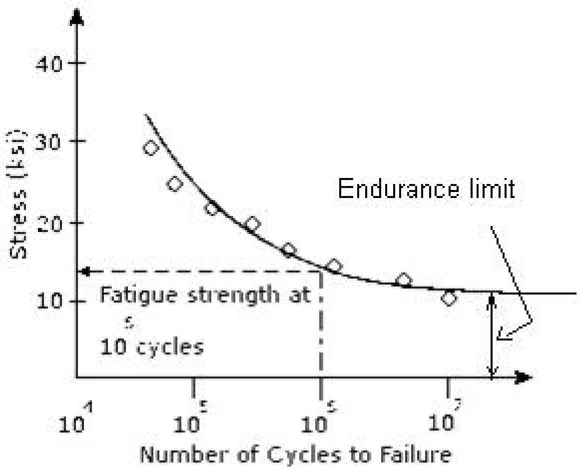
* Due to which type of loading the fatigue failures occurs? 2011-12, Sem-**II**
* What do you understand by creep? Discuss the creep curve. 2011-12, Sem-**II**
* Differentiate between ductile fracture and brittle fracture. 2011-12, Sem-**II**
* *Write a short note on brittle fracture. 2012-13, Sem-II*
* *Briefly discuss the characteristics of a ductile fracture. 2012-13, Sem-II*
* *Differentiate between creep and fatigue failure. 2012-13, Sem-II*

ANSWER:

Fatigue:*Fatigue is the behavior of the material when subjected to fluctuating, cyclic or repeated loads, which is different from the one when under steady loads. In this case the material fails much below the yield strength of the material.* **The fatigue failures occur due to repeated, cyclic, alternating or reversing loading/ stresses.**

The fatigue properties of a material determine its behavior when subjected to thousands or even millions of cyclic load applications in which the maximum stress developed in each cycle is well within the elastic rangeof the material. Under these conditions, failure may occur when the material continues to give service indefinitely. Bridges and, many components of high speed aero and turbine engines have failed because of fatigue.

The stress at which the material fails due to fatigue is known as fatigue strength, corresponding to the number of loading cycles.



Fatigue curve OR stress and number of cycles before failure (S/N Curve)

Endurance limit or fatigue limit is the limiting value of stress, much below the normal yield stress, at which the material will not fail, regardless of number of load cyclesand this may taken to be infinite life.

Creep:*Creep is a time dependent phenomenon and observed after a long period of time. Creep is the slow plastic deformation of metal with time, under constant stresses usually at high temperature.* It can take place and lead to failure at static stresses much smaller than those which will fail the specimen by loading it quickly. Metals generally exhibit creep at high temperatures, whereas plastics, rubbers are very temperature sensitive to creep.

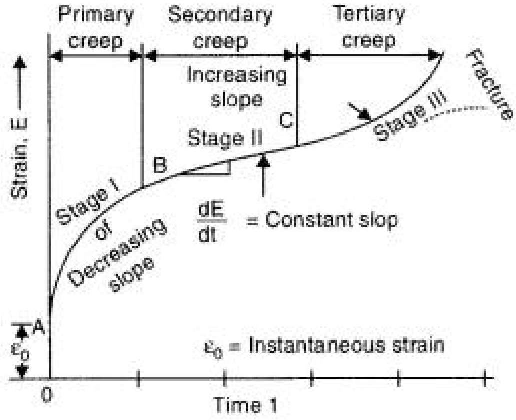
Creep can be classified as primary, secondary and tertiary creep depending upon the rate of deformation. The plot between the *strain developed in the specimen* with respect to *time* is known as creep curve. The creep curve has four distinct regions such as:

Instantaneous Strain:This is produced instantly as soon as the load is applied.

Primary creep: The initial portion of creep curve extending from A to B with a decreasing rate of deformation and this covers a short part of total period.

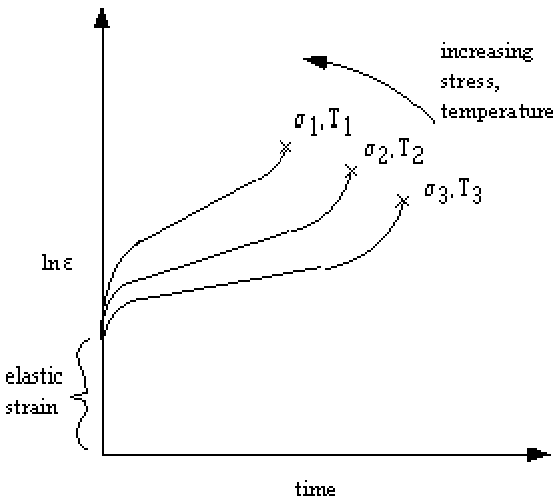
Secondary creep OR steady state creep: The middle part of the creep curve (B to C) with a long span and nearly constant rate of deformation. The constant rate is obtained because of the balance between the strain hardening and softening due to temperature.

Tertiary creep: The last part of the creep curve (C to fracture point) with an increasing rate of deformation and final failure or fracture.

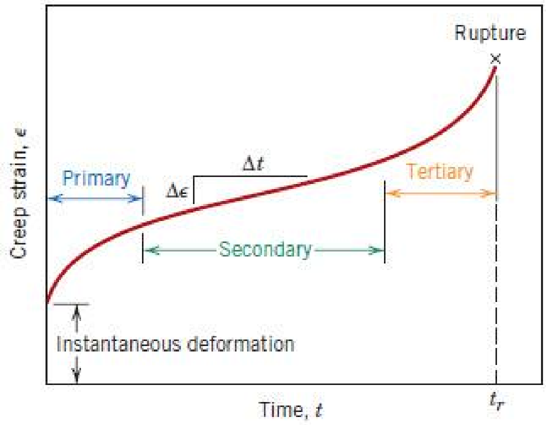


The creep curve showing the four stages in creep curve i.e. instantaneous deformation, primary, secondary and tertiary stages of creep

Effect of temperature (or stress) on creep: The temperature and stresses decrease the time period and the failure takes place earlier with increasing rate of deformation.



Effect of temperature (or stress) on creep



The creep curve showing the four stages in creep curve i.e. instantaneous deformation, primary, secondary and tertiary stages of creep

Fracture: *Fracture means the failure, of material under the application of external load/stress/force by, breaking into two or more pieces*.

Types of Fracture
- Ductile
- Brittle
- Fatigue
- Creep

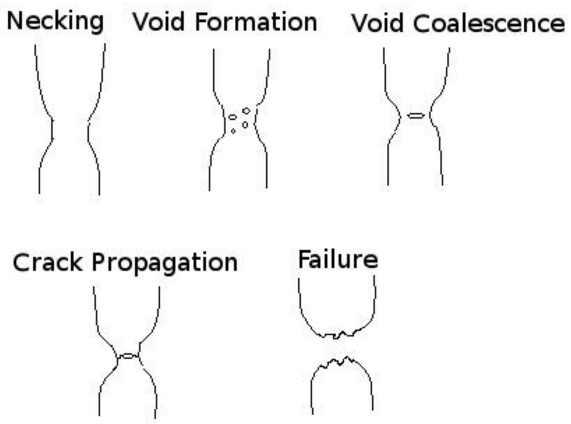
Ductile fracture is the failure of material after considerable amount of plastic deformation and associated with neck formation & cup and cone formation.

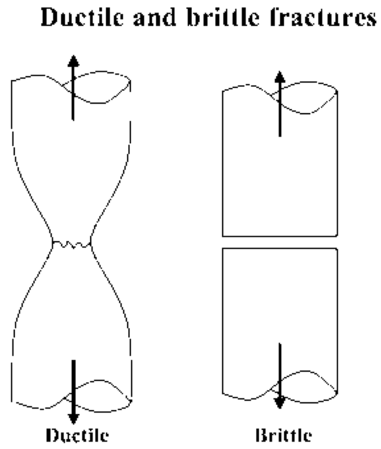
Brittle fracture is the failure of material without appreciable plastic deformation. If the two broken pieces are placed together, then the original shape can be obtained.

Fatigue and creep fractureare fractures which takes place when the part is subjected to fatigue and creep respectively. Fatigue fractures take place in brittle manner whereas the creep fracture take place in ductile manner.

Differentiation/ comparison/ characteristics of ductile and brittle fracture

Ductile fracture	***Brittle fracture***
Associated with large plastic deformation	*No or Minimum plastic deformation*
A rough & dirty surface	*Sharp and shiny surface*
Cup and cone formation	*Fracture surface is generally Plane*
Two broken pieces will not regain original shape if placed together	*Two broken pieces will regain original shape if placed together*





The ductile and brittle fractures

Steel and Cast Irons:

5. ***Classify steels based on percentage of carbon with their applications. How does steel become stainless steel?***

* Classify the carbon steel based on the percentage of carbon as low, mild, medium and high carbon steel. Write their properties and applications. 2008-09, SEM-II

* Based on % of carbon, classify carbon steels. How does stainless steel become stainless? 2008-09, SEM-I

* Classify the engineering materials. Explain the different types of plain carbon steels with their properties and applications. 2010-2011, SEM-I, Spl-Carry

* What do understand by Carbon steels? List their properties and applications. 2011-12, Spl-Carry

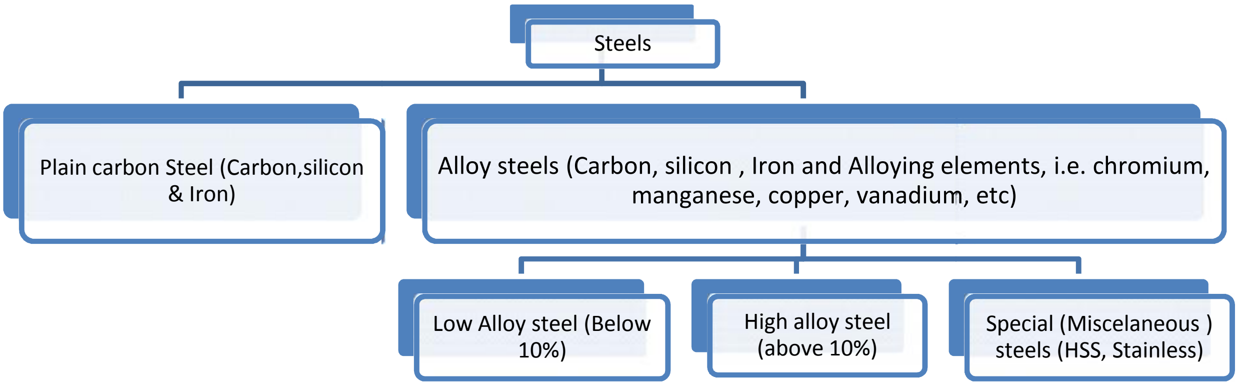
* What are various classifications steels? 2012-13 Sem-II

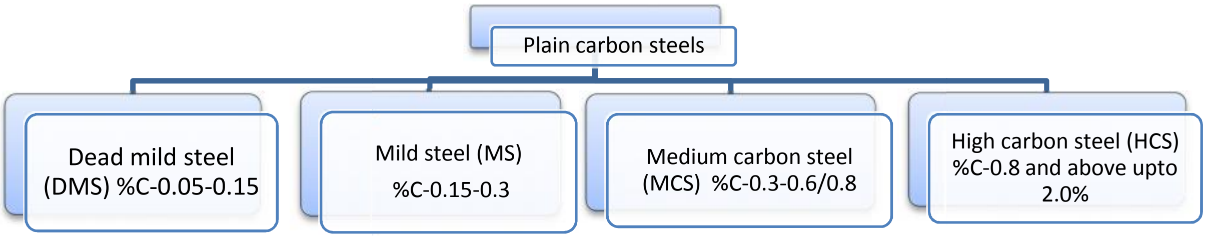
Steel is a mixture or alloy of iron, carbon and silicon; it may contain carbon upto 2%. (Practicallyupto 1.7%). Steel may be categorized into plain carbon and alloy steels.

Plain carbon steels (Carbon steels) are those steels which contain primarily Iron and Carbon. Silicon, Manganese, Sulphur and Phosphorus are present in small quantity but these are considered as impurities. The properties of plain carbon steels are greatly influenced by an increase in carbon content.

Stainless steel (OR Corrosion resistant steels): The addition of chromium in the low carbon steels makes them corrosion resistant, chromium reacts with the oxygen and forms a oxide layer on the metal surface and protects the metal from corrosion. The amount of chromium added may be from 10% to 18%.

Classification: Depending upon the percentage of carbon the steels may be classified as and their applications and properties are represented by the figure.

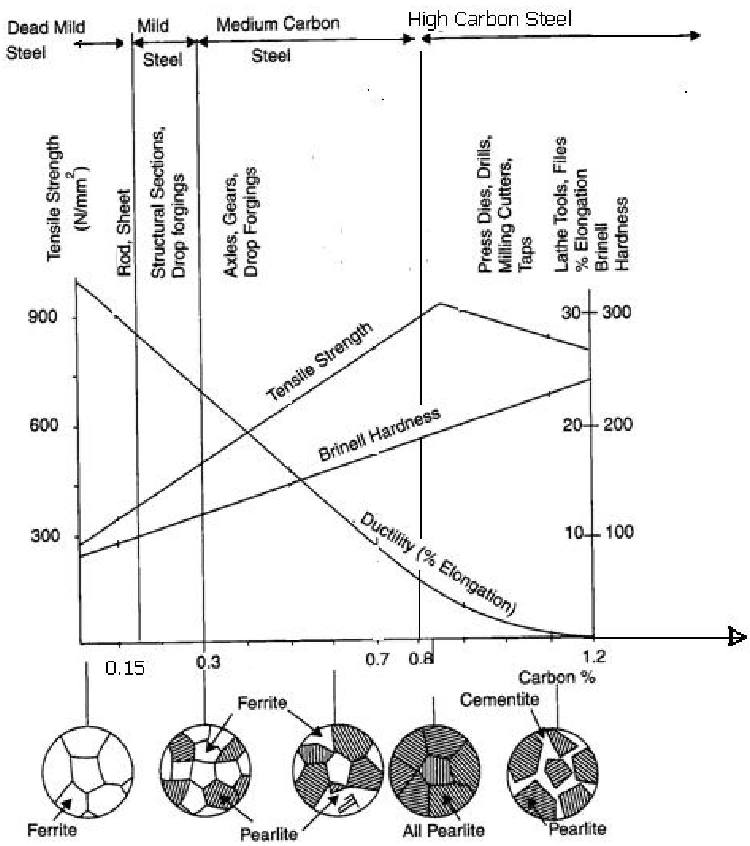




Classification of Plain carbon steels

Type	% of Carbon	Property	Uses/ Application
Dead mild steel (DMS)	Below -0.15	Good ductility and formability	Rods and sheets
Mild steel (MS)	0.15-0.3	Good weld ability	Structural sections, making of doors and angles
Medium carbon steel (MCS)	0.3-0.6/0.8	Good strength and toughness	Axles, springs and gears, Hand tools
High carbon steel (HCS)	0.8 and above upto 2.0%	High wear resistance & hardness	Dies, drills and cutting tools

Wrought Iron: It is the purest form of iron 99.9 % pure. It is corrosion resistant, malleable and soft. It was used for agricultural implements, ship anchors and railway couplings. It use has been replaced by steels.



Classification, properties and uses of plain carbon steel as the % of carbon

Cast iron

6. ***Write short notes on: Cast Iron***

Cast Iron: It is primarily an alloy of iron and carbon. The carbon percentage varies from 2 to 4.5 per cent. It also contains small amount of silicon, manganese, phosphorus and sulphur. The cast iron is obtained by re-melting pig iron with coke, limestone and steel scrap in a furnace known as **cupola**.

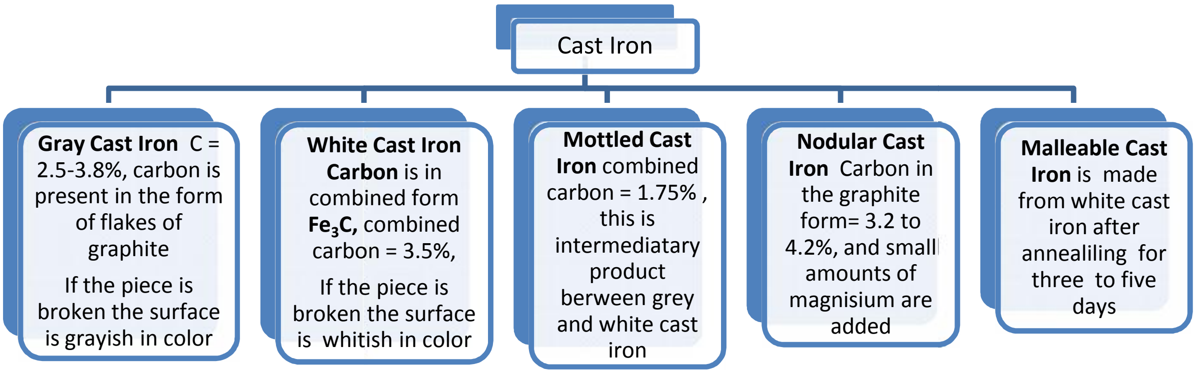
Properties of cast iron:

a) Cast iron is brittle.
b) Cast iron is weak in tension so it cannot be used for making bolts and machine parts which are liable to tension.
c) It is having low cost.
d) It is having good casting characteristics.
e) High compressive strength.
f) High wear resistance.
g) Good corrosion resistance

Uses of Cast Iron:

a) In the making of castings, hand pump
b) Water pipes
c) Sewerage pipelines
d) Beds of machines such as lathe machine, drill machine, etc.
e) Bodies of motors and engines

Classification: Cast Iron may be classified as grey cast iron, white cast iron, mottled cast iron, nodular cast iron, and malleable cast iron.



Alloy steels: Stainless steel, tool steel

7. ***What is alloy steel and why alloying is required?***

* What are alloy steels? Discuss the importance of any five alloying elements used in steels. 2012-13 Sem-II

Alloy steels:When certain special properties are required, some alloying elements are added to carbon steels. The alloying element may be nickel, chromium, manganese, vanadium, tungsten etc. The steels thus obtained are called alloy steels.

Purpose of Alloying is to improve the following:

a) Corrosion resistance.
b) Wear resistance.
c) Ability to retain shape at high temperature.
d) Machine ability
e) Ability to resist distortion at elevated temperature
f) Cutting ability.
g) Hardness, toughness and tensile strength

Alloying elements and their importance:

a) **Chromium:** Improves corrosion resistance
b) Vanadium: Improves toughness and wear resistance
c) Molybdenum: Improves hardness and strength
d) **Tungsten:** Improves high temperature resistance, toughness, wear resistance
e) Magnesium: Improves machine ability

Stainless steel (OR Corrosion resistant steels): The addition of chromium in the low carbon steels makes them corrosion resistant, chromium reacts with the oxygen and forms a oxide layer on the metal surface and protects the metal from corrosion. The amount of chromium added may be from 10% to 18%. These are used in the making of utensils and medical instruments.

Tool steel: Tool steel refers to a variety of carbon and alloy steels that are particularly well-suited for making cutting tools. Their suitability comes from their distinctive hardness, resistance to abrasion, their ability to hold a cutting edge, and/or their resistance to deformation at elevated temperatures (red-hardness). Tool steel is generally used in a heat-treated state. The carbon content in the tool steels is between 0.7% and 1.5%.these are used for making of cutting tools.

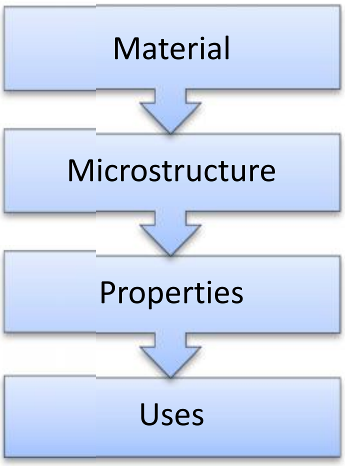
Heat Treatment Processes:Introduction to Heat- treatment of carbon steels: annealing, normalizing, quenching, tempering and case-hardening

8. ***What isheat treatment and the objective of heat treatment.***

* Give the elementary idea of heat treatment of carbon steels. 2008-09, SEM-sc

* Why the heat treatment of carbon steel is required? Give the elementary idea of various annealing operations. 2008-09, SEM-II
* What is the purpose of annealing treatment? Explain the process of annealing and hardening heat treatment.
* Write short notes on annealing and normalizing of carbon steels. 2009-2010, SEM-I
* What do you understand by heat treatment of carbon steels? Explain any process in detail. 2010-2011, SEM-II
* What are the objectives of heat treatment process? Explain various heat treatment processes in brief. 2010-2011,SEM-I,Spl-Carry
* What are the objectives of tempering? 2012-13 Sem-II
* With neat diagrams explain full annealing and process annealing. 2012-13 Sem-II
* Describe the process of steel hardening. Why steels are required to be tempered after it has been hardened? 2012-13 Sem-II

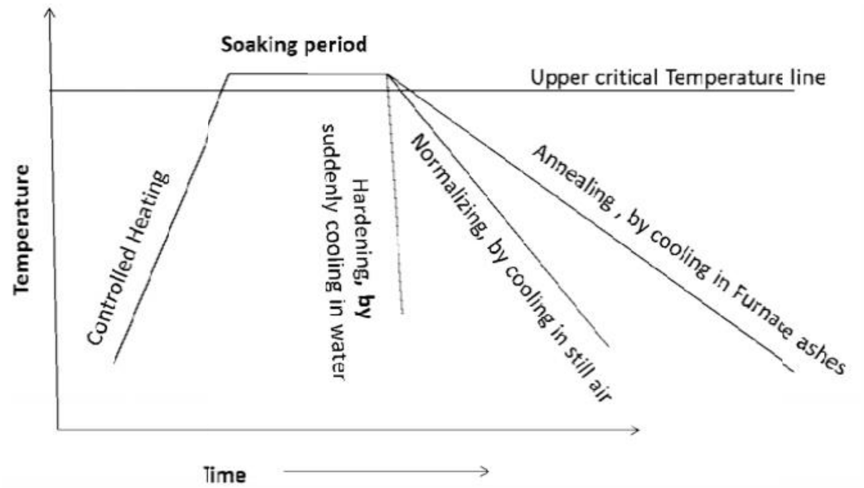
ANSWER:***Heat treatment*** *is defined as an operation or combination of operations, involving controlled heating and controlled cooling of a metal or alloy in the solid state with the purpose of changing the properties of the material.*



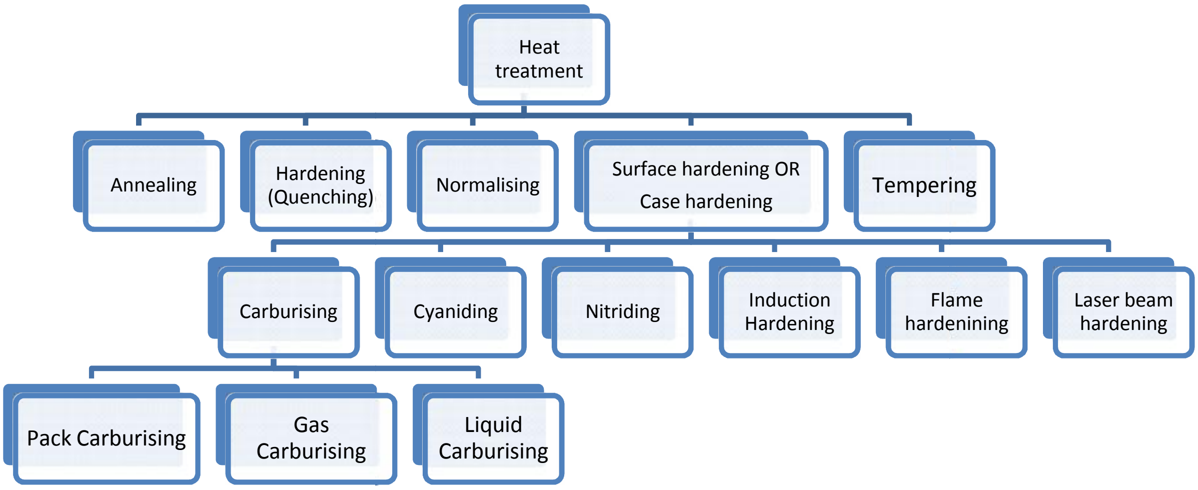
Heat treatment consists of three steps (1) Heating of the metal (2) Soaking or holding (3) Cooling of the metal.

Purpose or objectives of heat treatment

a) To improve machine-ability.
b) To improve mechanical properties, *e.g.,* tensile strength, ductility, hardness, shock resistance, resistance to corrosion etc.
c) To relieve the stresses induced during hot or cold working.
d) To change or refine grain size.
e) To improve magnetic and electrical properties.
f) To improve heat resistance, wear resistance.
g) To improve weld-ability



Different types of heat treatment processes on time and temperature plot



Classification of heat treatment processes

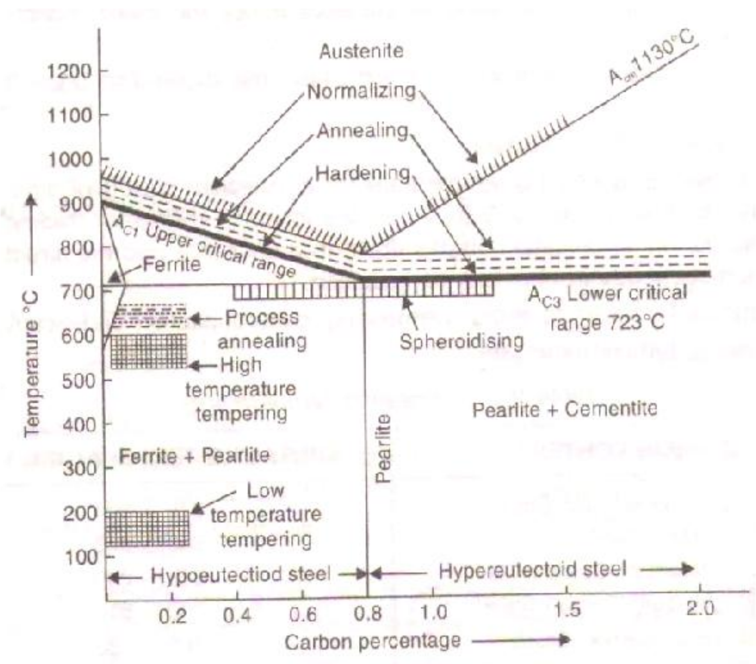
The process of heat treatment consists of the following or steps:

1. Controlled Heating of Metal/Alloy (Steel)

Heating temperature of metal depends upon its grade, grain size, type and shape of a metal or alloy. Generally, the metal is heated upto its upper critical temperature.

2.Holding or Soaking period

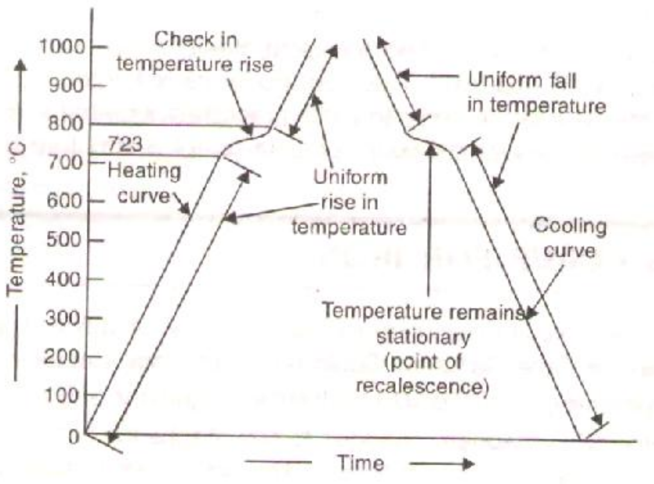
Metal or alloy to be given heat treatment, is held at the specified temperature for a specified period so that there is a uniformity of temperature throughout the mass. The period of heating depends upon the size and shape of the component.



HEAT TREATMENT PROCESSES AND TEMPERATURE RANGES WITH CARBON PERCENTAGE AND MICROSTUCTURE

3.Controlled Cooling of the Metal (Steel)

Main changes in the properties of metal or alloy take place in the cooling process. Change in properties or transformation depends mostly on the rate at which the cooling takes place. Cooling of metal is also known as quenching. Generally five quenching media adopted for quenching are: caustic soda solution, brine, water, oil and air.



Heating and Cooling curve for steel showing upper and lower critical temperature

What happens during heat treatment?

During heat treatment process the

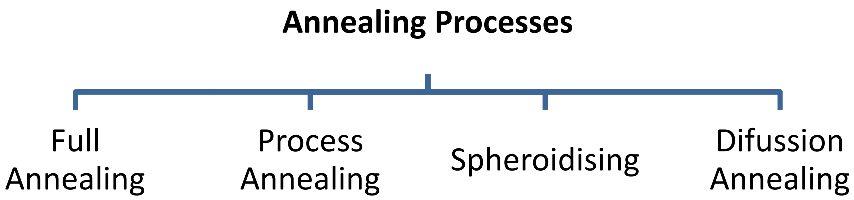
internal microstructure of the metal is changed. The heat supplied during heating brings the structural and chemical changes in the metal. In between the upper and lower critical temperatures the carbon is in solid solution of iron. At normal temperature the steel consists of pure iron(ferrite) combined with iron carbide (cementite).

What are different microstructures of steel?

a. *Ferrite:* It is very soft and magnetic
b. *Cementite:* It is combined carbon with iron also known as cementite and it is very hard.
c. *Pearlite:* It is the mixture of ferrite and cementite.
d. *Austenite*: It is solid solution of carbon and iron and it is stable only above upper critical point. If cooled below 723^{O}C it transforms into pearlite and ferrite.
e. *Martensite:* It is very hard and brittle.
f. *Troostite*:
g. *Sorbite:*

Annealing: The various **purposes** of annealing are:

a) To soften the metal to improve machine ability.
b) To refine grain size and structure to improve mechanical properties.
c) To relieve internal stresses.
d) To remove trapped gases.
e) To modify electrical, magnetic and physical properties.
f) To increase ductility of metal.
g) To prepare the steel for further treatment.



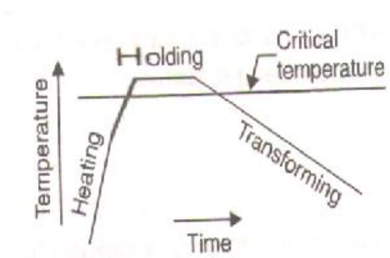
<u>Full Annealing Process</u>

Annealing removes all structural imperfections by complete re-crystallization. The purpose of full annealing is to soften the metal, to refine the grain structure, and to relieve the stresses. Full annealing process consists of:

(a) Heating the steel above the upper critical temperature (about 50°-60°C).

(b) Holding it at this temperature for a sufficient time depending upon the thickness of work

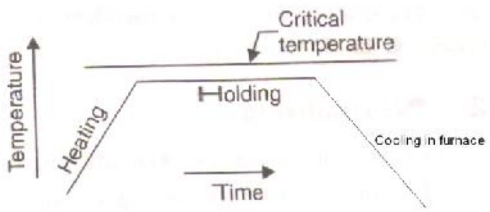
(c) Slowly cooling it in the furnace ashes to room temperature.



The metal is held at annealing temperature for a sufficient period of time so that proper structurechanges can take place.

Process Annealing

<u>In this case the metal is heated below the lower critical temperature and the rest of the procedure is as for the full annealing process.This is applicable to low carbon steels only.</u>



Quenching

Quenching is the process of suddenly cooling of the material by dropping in the cooling medium. Sometime this refers to hardening process also.

Hardening

In this process, steel is heated to temperature above the critical point (30°C to 50°C), held at this temperature for a considerable time, depending upon its thickness and then quenched (rapidly cooled) in water, oil or molten salt baths.

The purposes of hardening are:

a. To increase the hardness of the metal so that it can resist wear.

b. To increase the wear resistance so that it can resist wear.

c. To make it suitable for cutting tools

Normalizing

In normalizing process, steel is heated to a temperature above the critical point (40°C to 50°C), held at this temperature for a relatively shorter period (About 15 minutes) and then cooled down to room temperature in the still air.

The purposes or the objectives of normalizing are:

a. Internal stresses caused during previous operations are removed

b. Internal structure is refined

c. Mechanical properties of steels are improved

Tempering

The hardened steel (Martensitic structures) formed by direct quenching of high carbon steel are hard and strong, but **unfortunately are also brittle**. Since they are brittle and possess very little toughness so they are unable to resist impact loads. The hardness and strength is sacrificed to obtain suitable ductility and toughness to make the steels usable for different applications.This is done bythe tempering process.

The objectives of tempering process are:

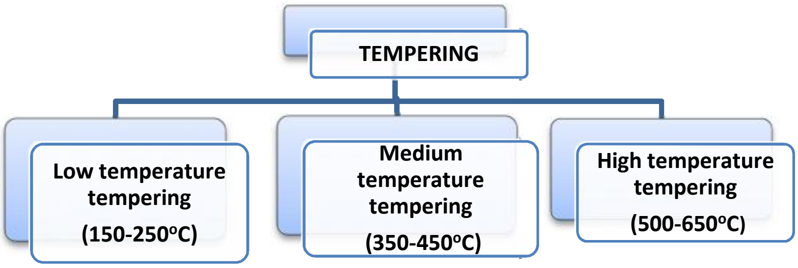
(1) To make steel tough to resist shock and fatigue

(2) To remove internal stresses

(3) Tostabilize the structure

(4) To decrease the hardness.

(5) To remove the ill effects of hardening process and make the steel usable.



Tempering Process: In tempering process the steels are heated to certain temperature in the range of 150°C to 650°C and held at that temperature for some time may be 1 to 3 hours and then cooled to room temperature. The cooling may be done in open air. Depending upon the temperature the tempering may be classified as:

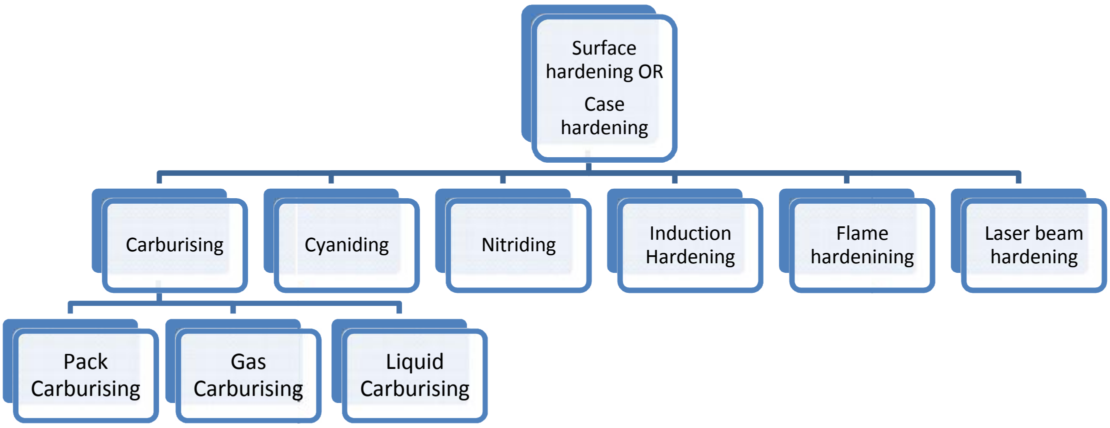
9. ***What do you mean by case-hardening? Explain different methods of case hardening in detail.***

* What is case Hardening? 2011-12, Spl-Carry

ANSWEER:

Surface Hardening or Case Hardening: The process by which the surface of an object or part can be made hard and leaving the interior as it is, is called as surface or case hardening process. In many engineering applications, it is required that a steel being used should have a hard surface so that it can resist wear and tear. At the same time it should have soft and tough interior so that steel is able to absorb any shocks, impact, etc. This is possible only when the surface is hard

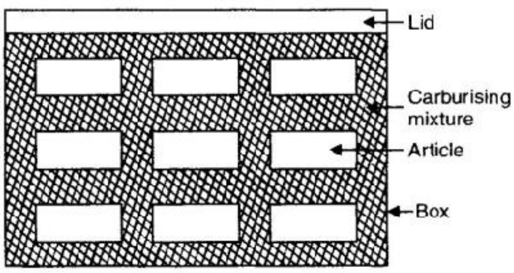
while rest or interior of the metal is left as soft and ductile. This type of treatment is called surface hardening or case hardening and is applied to gears, ball bearings, railway wheels etc.
Various types of surface hardening or case hardening processes are shown in figure:

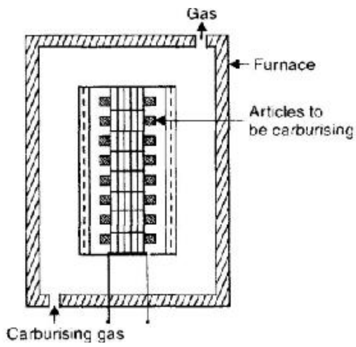


Surface or Case hardening processes

A. Carburizing: The process of inducing of additional carbon to low carbon steels in order to give it a hard surface is known as carburizing. The surface is made hard only upto a certaindepth using the any one of below:

i)Pack or Solid Carburizing: The article to be carburized is placed in a carburizing box and surrounded by solid carbonaceous materials—usually a mixture of charcoal, leather, horn and barium carbonate as catalyst. The boxes are sealed with clay to exclude air and are placed in an oven or furnace where they are heated to a temperature between 900-950°C for several days depending upon the extent of carburizing action desired. In this way, carbon from the carburizing compound soaks or diffuses into the surface of the hot- steel. After carburizing, steel is reheated to a temperature just above its critical point followed by quenching in water, brine or oil. This hardens the skin and at the same time refines the core. This steel is also given a second heat treatment at a lower temperature range *i.e.* 750-770°C, in order to improve the ductility and impact resistance of the core and case.





Pack carburizing AND Gas Carburizing

ii) Liquid Carburizing: The articles to be carburized are heated in a container filled with a molten salt, such as sodium carbonate. If only selected portions of the components are to be carburized, then the remaining portions are covered by copper plating.

Advantages: (a) Very little deformation of article.
(b) Time saving process.
(c) Greater depth of penetration possible.
*(d)*Selective carburizing is possible if needed.
(e) Ease of carburizing a wider range of products.
(f) Uniform heating.

(g) Parts leave the bath with a clean and bright finish. There is no scale as there in pack hardening.

iii) Gas Carburizing: In gas carburizing, the article is heated and surrounded by a hydrocarbon gas (such as methane, ethane, carbon monoxide, etc) in the furnace.

B. Cyaniding: It is used to give a very thin but hard outer case. The articles are heated in the salt bath of Sodium cyanide or potassium cyanide in the temperature ranging between 700°C to 820°C and both carbon and nitrogen are added to the outer surface resulting in a surface harder than that produced by the carburizing process.

C. Nitriding: Nitriding is a case hardening process in which nitrogen is added instead of carbon, in the skin or outer surface of the steel. The article is placed in a container and heated in the range of 450°C to 550°C and ammonia gas is circulated over the articles.
Advantage of nitriding: The articles may be used directly without ant secondary machining operations because the steel is not exposed to elevated temperatures.

D. Induction hardening and Flame hardening: In Induction hardening and gas flame hardening the articles are heated using induction heating and flames and followed by cooling with spray of water.

Alloys of Non Ferrous metals: *Common uses of various non-ferrous metals (Copper, Zink, Tin, Magnesium, Lead, Aluminum etc.) & alloys and its composition such as Cu-alloys: Brass, Bronze, Al- alloys.*

10. ***What is the ore of copper? Write the properties and uses of copper. What are the alloying elements of brass and bronze?*** 2008-09, SEM-I

ANSWER:

ORE: Copper is extracted from copper ores such as copper glance (Cu_2S), copper pyrites ($CuFeS_2$),
Properties:
a) Copper is a reddish brown metal.
b) Pure copper is one of the good conductors of heat and electricity.
c) It can withstand severe bending and forging without failure.
d) Copper can be welded at red heat.
e) It is highly resistant to corrosion.
f) Melting point = 1084°C, boiling point = 2595°C.
g) Pure copper does not cast well.
h) If copper is heated to red heat and cooled slowly it becomes brittle, but if cooled readily it is soft, malleable and ductile.

Uses:
a) It is largely used in electric cables and wires, electrical machinery, motor winding etc.
b) Used in electroplating
c) Copper tubes are used in mechanical engineering.
d) It is used for household utensils.
e) It is used to form alloys like brass, bronze and gun metal.
f) Used in boilers, condensers, roofing etc.

Alloying elements of brass and bronze:
Brass is an alloy of **copper and zinc**.

Common types of brass are

Cartridges brass (70%Cu +30% Zn)

Naval brass ((60%Cu +39% Zn+ 1%Tin)

Bronze:

Bronze is basically an alloy of **copper and tin**. Various properties of bronzes are:

a) Bronze has higher strength than brasses.

b) Bronze has better corrosion resistance than brasses.

c) Bronze has antifriction or bearing properties.

d) Bronze is costlier than brass.

e) Bronze is most ductile when it contains about 5% of tin. As the amount of tin increases about 5%, the ductility gradually decreases and practically it disappears with about 20% of tin.

f) Addition of phosphorus increases the tensile strength, elasticity and resistance to fatigue

Phosphor Bronze

When bronze contains phosphorus, it is called phosphor bronze. A common type of phosphor bronze has the following composition: Cu = 89 to 94%+Tin = 5 to 10%+ Phosphorous = 0.1 to 0.3%.

11. Write short notes on Duralumin

Duralumin:

It is an alloy of aluminum and it contains Al = 94%, Cu = 4%; Mg, Mn, Si, Fe - 0.5% each.

Properties:

a) It can be cast, forged and stamped.
b) It has high tensile strength.
c) It has high electrical conductivity.
d) It hardens spontaneously when exposed to room temperature.
e) The alloy is soft enough for a workable period after it has been quenched.
f) It is light in weight as compared to its strength.

Uses:

a) It is used for sheets, tubes, rivets, nuts, bolts etc.

b) Because of lighter weight, it is used in automobile and aircraft components.

c) It is also employed in surgical and orthopedic work and for non-magnetic and other instrument parts.

d) Utensils, window frames, engine bodies, etc.

12. What are non-ferrous metals? Discuss the properties and uses copper, aluminum and its alloys.

Write a short note on brasses and their application. 2011-12,Spl-Carry

Name two alloys of aluminum. 2011-12, Sem-II

ANSWER

All the metals and alloys **not containing iron**as base metal are known as non-ferrous metals such as aluminum, copper, zinc, nickel, etc.

The different non-ferrous metals and alloys and their properties are given in the table:

Metal/ Alloy	Properties/ Type &Alloying elements	Uses/ properties
Copper	Found in metallic state after extraction	Used in In electrical equipments
Ore: Copper glance	Reddish brown in color	Used in Electroplating

&Copper pyrites	Good conductor of heat & electricity	Used in Soldering iron bits
	Resistant to corrosion	Used in boiler & condenser tubes
	Soft, Malleable, ductile & tough	Used in house hold utensils Used in coins and jewelry
Brass it is an alloy of Copper and Zinc	Muntz metal Cu 60% + Zn 40%	Resistance to corrosion, used in valves, taps and pumps
	Cartridge brass Cu 70% + Zn 30%	Used in making of cartridge & tubes
	Naval brass Cu 60% + Zn 39% +Tin 1%	Used for forged fittings in ships
Bronze it is an alloy of Copper and Tin	Gun metal Cu 90% + Tin 8% +Zn 2%	Used in making of guns, bearings bushes
	Phosphor bronze Cu 90% + Zn 5-9%+ small amounts of phosphorous	Used in making of bearings, bushes, bolts
Aluminum	Pure aluminum is corrosion resistant	Used in Wire drawing
Ore: Bauxite $Al_2O_3.2H_2O$	Ductile and malleable	Used in forgings
	Good heat & electrical conductor	Used in furniture's
	Light in weight	Used in automobiles
	Non magnetic	Used in Aircraft body panels
		Used in aluminum foils for food packing
Duralumin	High tensile strength	Used in sheet making
It is an alloy of Al 94%+ Cu 4% and Mg, Mn, Si, in small amounts	Can be forged, cast, stamped	Used in tubes, nut, rivets
	High electrical conductivity	Used in surgical equipments
	Age hardens	Used in automobiles
	Remains soft for workable period after quenching	Used in Aircraft body panels
		Used in making of ***alclad***
Y-Alloy		
93% Al, 4% Cu, 2% Ni and 1% Mg	Maintains good strength at elevated temperatures	Mainly used as casting alloy
		also used as sheet and strip forms
		Used for pistons of IC engines
Tin		
Ore: Cassiterite	Good resistance to acid corrosion	Used in making of solder
	Soft and plastic in nature	Used in making of thin sheets and foils
Magnesium		
Ore: Magnesite	Light in weight	Used in motor gear box
	Easily die casted	Used in castings
	Good machine ability	
Lead		

	Good corrosion resistance	Used in making of solder
	Good resistance to chemical action	Used in making of battery terminals
	Soft heavy and malleable	
Zinc		
	High corrosion resistance	Used as protective coating on iron
	Low melting	Used in the making of castings

******UNIT-1 ENDS*******

UNIT-II

1. ***Write short notes on hot working of metals*** 2011-12, Sem-I

*Compare hot working and cold working processes giving suitable examples.2010,Sem-I/II, Spl-carry

*Differentiate between hot and cold working of metals. Mention two advantages and disadvantages of each of these techniques. 2009-10,Sem-II

*Differentiate between hot and cold working of metals. Bring out the advantages and disadvantages of each of these techniques. 2009-10, Sem-I

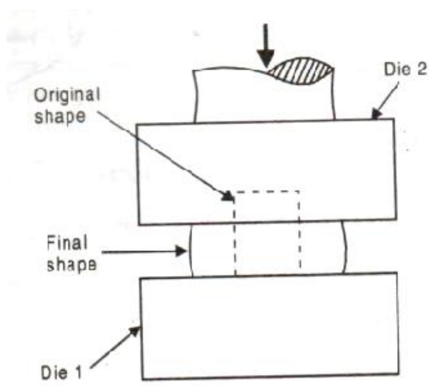
*Differentiate between hot and cold working of metals. Classify the forming operations and mention their specific applications. 2008-09, Sem-II

*Differentiate between hot and cold working of metals. Bring out the advantages and disadvantages of each of these techniques. Explain with neat sketch the rolling of steel bar. 2008-09, Sem-I

*Compare hot working and cold working processes with suitable examples. Also discuss the advantages and disadvantages of each. 2011-12, Sem-II

*Define the term re-crystallization. 2011-12, Sem-II

ANSWER:



Metal forming or mechanical working is a process of intentional deformation of metals for shaping the metals into required shape or form by plastic deformation with application of external forces. In these processes the metals are given a required shape, size, dimensions and properties without any significant amount of wastage of material. The plastic deformation takes place once the forces are applied beyond the yield point stress. The figure shows the process of metal working, a metal block shown by dashed lines is given required shape by application of external force using Die-1 &Die-2 and the final shape obtained is shown by solid lines

Objectives of metal forming:

a) To refine grain structure
b) To induce the directional properties into the material
c) To achieve high dimensional accuracy
d) To improve mechanical properties of the metal

Re-crystallization is the process of formation of new grains or crystal structure and the temperature at which the old crystal structure is destroyed and formation of new crystal structure is complete, is known as**Re-crystallization Temperature**.

Classification: The metal forming processes/ operations can be classified, depending upon the temperature, into Hot and Cold working processes. A comparison of hot working and cold working is presented below.

Metal Forming
OR
Mechanical working

Hot working

1. It is carried out above the recrystal-lisation temperature but below the melting or burning point. Hence, deformation of metal and recovery take place simultaneously.
2. No internal or residual stresses are set up in the metal in hot working.
3. Due to recrystallisation and recovery, no or very negligible hardening of metal takes place.
4. Due to higher deformation temperatures used, the stress (load) required for effecting deformation is less.
5. Hot working refines metal grains, resulting in improved mechanical properties.
6. If cracks and blow holes are present in the metal, they are finished through hot working.
7. Rate of production in Hot Working is higher.
8. Example: Forging, Extriusion, Hor Rolling

Cold working

1. It is carried out below the recrystal-lisation temperature. As such, there is no appreciable recovery.
2. In this process, internal or residual stresses are set-up in the metal.
3. Since this is done below recrystal-lisation temperature, the metal gets work hardened.
4. The stress required to cause deformation is much higher.
5. Most of the cold working processes lead to distortion of grains.
6. In cold working the existing cracks propagate and new cracks may develop.
7. Rate of production is lower as compared to Hot Working
8. Example: Wire making, Tube making, Blanking, Punching, etc

Warm Working

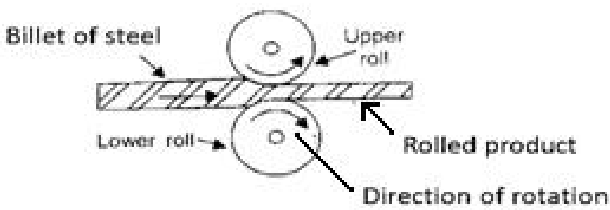
Advantages and of hot and cold working:

Advantages of hot working	Advantages cold working
1.Large deformation can be accomplished	1. Better dimensional accuracy can be obtained
2. Porosity of metal gets reduced	2. Good surface finish
3. Grain structure gets refined	3. Strength and Hardness increase
4. No residual stresses are induced	4. Easier to handle cold material

The advantage of one process is the disadvantage of the other, and in this manner we can understand that each process has its own advantage and disadvantages.

Rolling of steel Bar:

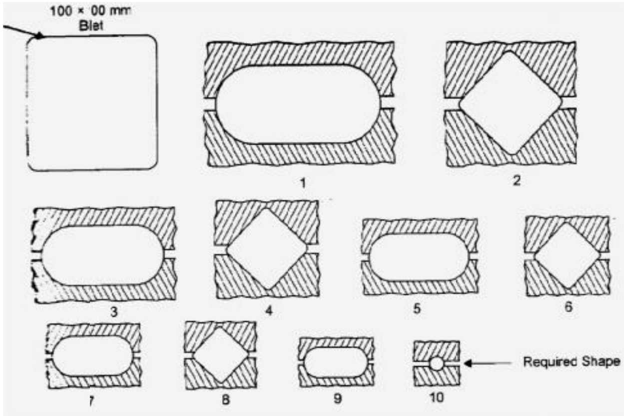
Rolling is the process of compressing the metal by passing it between the two or more revolving rolls or cylinders. As a result the area of cross section gets reduced and length is increased. The process of rolling a steel bar is shown in the figure.



Schematic diagram for rolling process

Two High Rolling Mill

Steps Involved: Initially a billet with the square cross-sectional area is taken and passed through set of rollers which reduces the area of cross section and also its shape, after a number of passes through the set of rollers with different cross sections and orientations the bar is finally reduced to a round bar as shown in the figure.



Steps involved in the rolling process for making a round bar of steel

2. ***Explain with neat sketch, basic working principle of rolling. Describe its applications in industry.*** 2009-10, Sem-I,

*Compare the different rolling mill arrangements in brief.

* Explain with neat sketch, basic working principle of rolling. Describe its applications in industry. Name the four rolled products. 2008-09, Sem-I/II, Spl-Carry

* Draw a neat sketch and explain metal rolling process. Give the example of four rolled products. Is rolling a cold working process? Explain.

* With the neat sketch define the following operations: 2008-09, sem-I

a) Forging
b) Rolling
c) Drawing
d) Extrusion

*With the neat sketch define the following operations: 2008-09, sem-II

a) Forging b) Rolling c) Taper turningd) Galvanizing

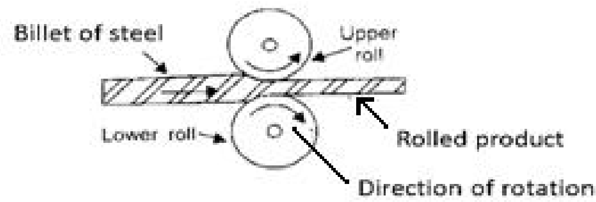
*Explain rolling process, giving a neat sketch. What are the products made by rolling?

2011-12, Spl Carry

* Define rolling process. Using schematic diagram and state the difference between cluster mills and continuous rolling. 2012-13 Sem-II

ANSWER:

Definition: Rolling is the process of shaping the metal by compressing the metal, by squeezing or passing it between the two or more revolving rolls or cylinders. As a result the area of cross section gets reduced and length is increased. Rolling is normally a hot working process unless specifically mentioned as cold working and associated with re-crystallization of the grains after rolling.

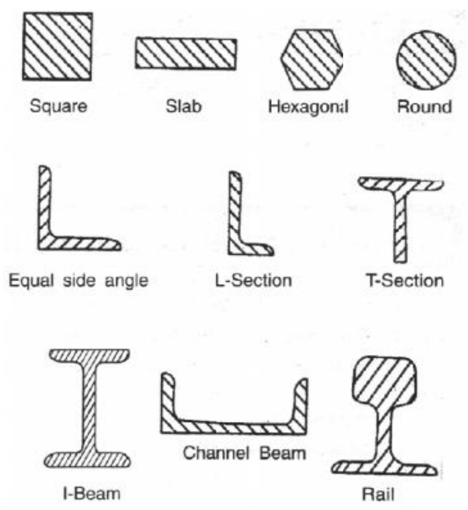


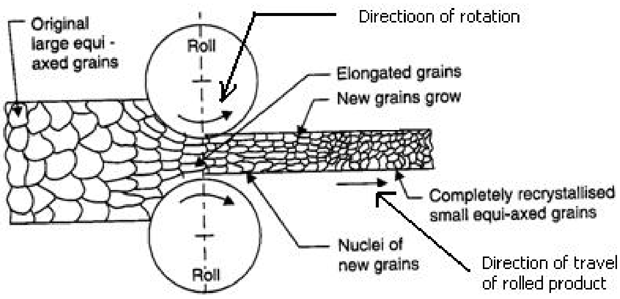
Two High Rolling Mill

Rolling process: Heated metal is passed between two rolls, rotating in the opposite direction; the gap between the rolls is somewhat less than the thickness of metal at entrance. Thus the rolls will squeeze the ingot material and reduce the area of cross section & also increase the length. Original coarse grain structure is initially elongated and then the re-crystallization takes place and the finer grains are produced.

Principleor Characteristics of rolling process:

1. The frictional forces are pulling and drawing the metal inside the rolls after initial engagement of metal. The amount of area reduction depends upon frictional forces.
2. The metal stock enters the rolls with a lesser speed than the peripheral speed of the rolls.
3. The metal after being squeezed exits the rolls at higher speed.
4. The area of cross section at entry is more than the area at exit; however the quantity entering is equal to the exit quantity. This can be presented by the following equations and figure:





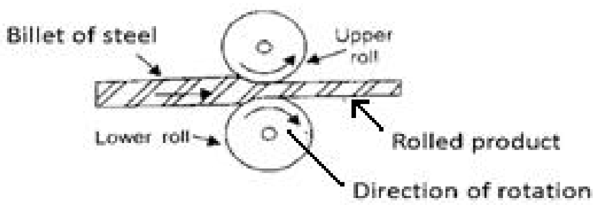
Schematic presentation of rolling process

Different cross- sections produced by rolling (**Products of rolling process**)

ApplicationsOr Products: The different shapes which can be rolled are plates, sheets, bars, structural shapes, I, L, T, or channel section such as shown above left side.

Types of Rolling MillsOR Rolling Mill arrangements: There are different rolling mill arrangements as shown in the next figure.

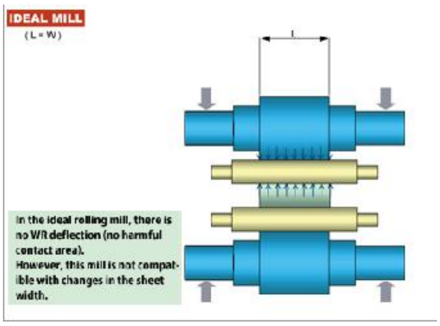
a) **Two high rolling mill:** Consists of two heavy horizontal rolls, supported on the bearings. The bearings are placed in the side frames called as stands. The space between the rolls is adjustable.
b) Two high reversible rolling mill: In this case the rolls have the capacity to rotate in both direction depending upon the requirement.
c) Three high rolling mill: This set up is used to give two continuous passes to the metal

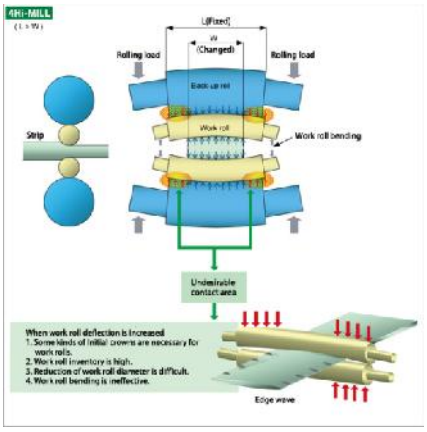


Two High Rolling Mill

d) **Four high rolling mills:** In this set up four rollers are used and two are smaller called as working rollers and other two are large and called as Back uprolls.

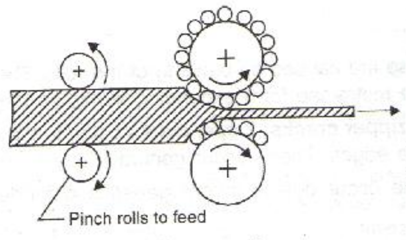
e) **Cluster rolling mill:** This is improvement over the four high rolling mill and provides better supports.



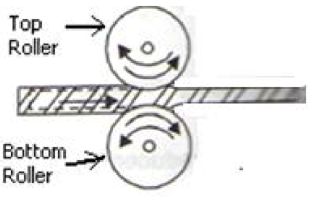


f) **Planetary rolling mill:**This provides anumber of free rolls over the periphery of large back up roll and suitable for large reduction in area in one pass.

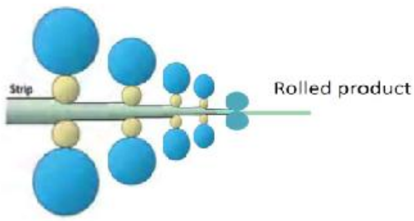
g) **Continuous rolling mill:** It consists of many non-reversing two- high rolling mills arranged on after the other, so that the material can be passed through all of them in a sequence. It is suitable for mass production.



Planetary mill



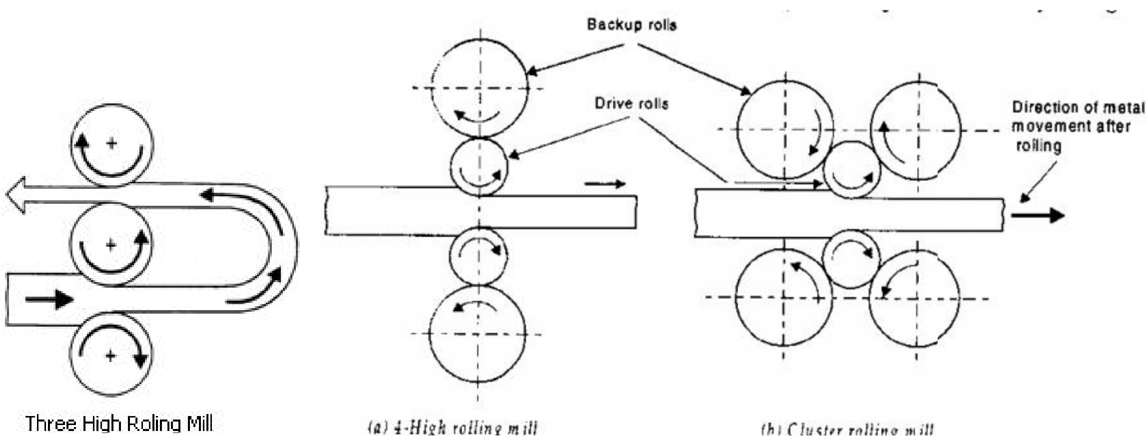
Two High Reversing rolling



Continuous Rolling

<u>Comparison of different rolling mill arrangements</u>

Two High Rolling mill	Two High Reversible Rolling mill	Three high rolling mill	Four high rolling mill	Cluster rolling mill	Planetary Rolling mill
Two rolls rotate in opposite direction.	Two rolls can rotate in the reverse direction to increase the production.	These increase the rate of production.	Working rollers are supported by two Back up rolls.	This is improvement over the four high rolling mill and provides better supports by additional rollers	A number of free rolls over the periphery of large back up roll
		Direction of rotation of middle roll is opposite to top and bottom roll.	The rollers deflection is reduced by back up rollers.		Suitable for large reduction in area in one pass.
Used for bars and general sections	Used for bars and general sections	For rods and billets	Used for Sheets and plates	Used for cold rolling of Sheets and plates	



3. ***Draw a neat sketch and explain metal Extrusion process. Give the example of four extruded products. What are different types of extrusion? Explain.***

* Explain with neat sketch, the basic working principle of extrusion. Describe its application in industry. Name the four extruded products. 2008-09, SEM-II
* What do you understand by Extrusion process? What are items made by extrusion process? Explain in detail giving suitable examples. 2010-2011, SEM-II
* Explain briefly different processes of extrusion. Discuss their relative merits and demerits. 2010,Spl-Carry
*Compare the different Extrusion processes.
* Explain extrusion process. What do you mean by direct and indirect extrusion? Give its applications. 2011-12, Spl-Carry
* What is extrusion? Differentiate between forward and backward extrusion process with suitable sketches. 2012-13 Sem-II

ANSWER:

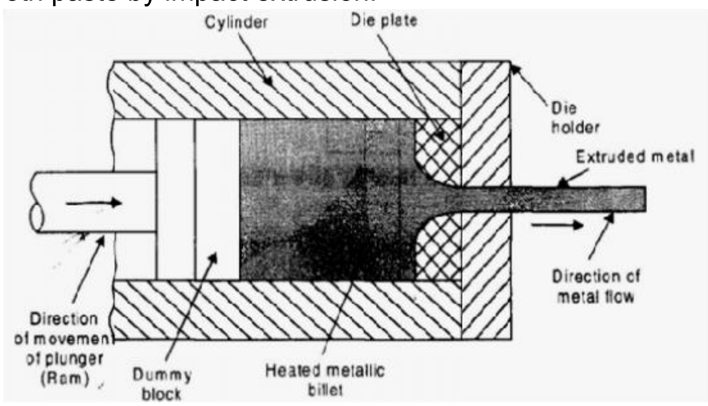
Basic working principle of extrusion: Extrusion is the process in which the metal is forced to flow through a shaped opening or die, so that metal will take the shape of the opening. The operation of extrusion is similar to squeezing of the tooth paste tube as a result the tooth paste comes out in the shape of the opening. The heated metal is placed in the cylinder and pressure is applied by ram, while keeping a dummy block in between. The metal is forced to pass through the die/ orifice opening.

Extruded Shapes/Applications: (Examples of extruded products)

a. Rods, tubes, splined shafts, structural sections and bars of different cross sections.
b. Almost any length can be producedbut with constant cross section only.
c. tubes such as shaving cream, tooth paste by impact extrusion.

(1) **Direct extrusion OR forward extrusion**: If the direction of extruded product is same as the direction of force application then the extrusion is called as **direct extrusion.**

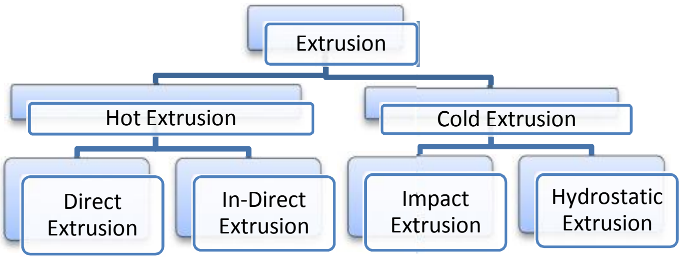
Direct Extrusion

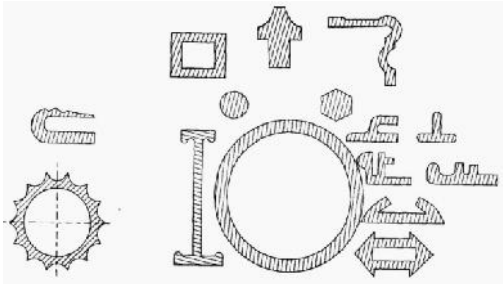


The different cross sections which can be produced with extrusion process are shown as:

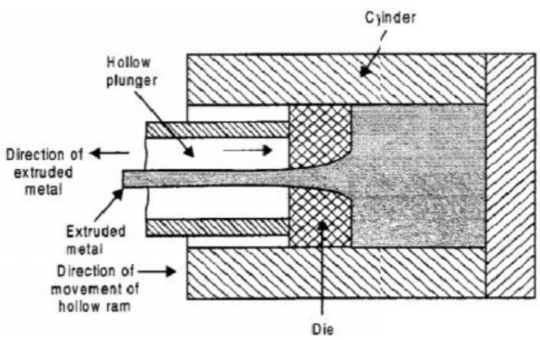
Classification Extrusion can be classified as:

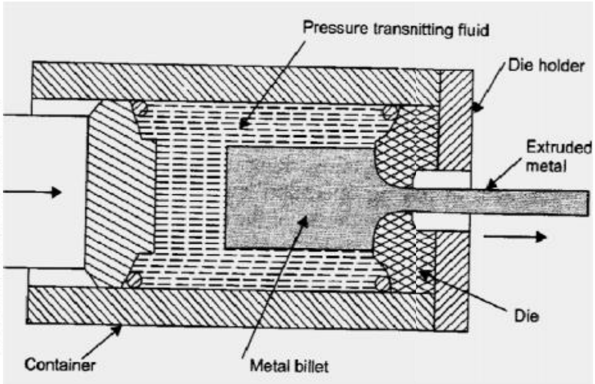
Examples of extruded products





(2) **In-Direct extrusion OR backward extrusion:** If the direction of extruded product is opposite to the direction of force application then the extrusion is called as **In-Direct extrusion** as shown in figure:

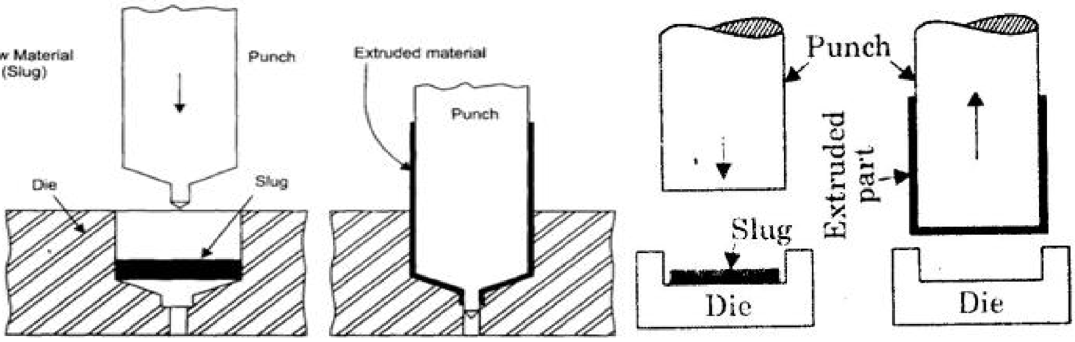




In-Direct extrusion Hydrostatic Extrusion

(3) **Hydrostatic extrusion**: In this type of extrusion the force is applied indirectly using a liquid medium and force is uniformly applied because of presence of fluid/liquid. The difficult to extrude materials can be extruded by this method and the process is schematically shown in the figure.

(4) **Impact extrusion:** Impact extrusion is most suitable for producing collapsible tubes of soft materials, aluminum and copper etc. This may be tooth paste tubes and cans etc. The impact extrusion is performed using a punch and die as shown in the figure.The material is placedon the die and punch is struck from top with high pressure and speed, the metal flows up and forms cup shape over the punch which is removed from the punch using the compressed air.



Figures showing the process of impact extrusion for tooth paste tube and cup shape

Comparative merits and demerits of different types of extrusion

Direct extrusion	In-Direct extrusion	Impact extrusion	Hydrostatic extrusion
Problem of friction is dominant	Problem of friction is eliminated	High speeds are involved	No Problem of friction
High force is required	Less force is required	Applicable to soft materials only	Difficult to extrude materials may be worked
Lubricants are required	Ram gets weakened		Additional Lubricant is not required
Brittle material cannot be extruded	Brittle materials cannot be extruded	Brittle materials cannot be extruded	Brittle materials may be extruded

4. *What is forging? Classify the different methods of forging.

*What are methods of forging and compare forging with machining and casting process?

* Explain the smith forging and different forging operations.

* With the neat sketch define the following operations: 2008-09, sem-I

a) Forging
b) Rolling
c) Drawing
d) Extrusion

*With the neat sketch define the following operations: 2008-09, sem-II

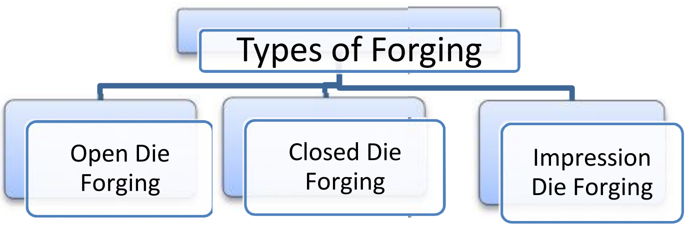
a) Forging
b) Rolling
c) Taper turning
d) Galvanizing

* Write short notes on the following with neat sketches (if required):

(a) Extrusion (b) Forging (c) Riser (d) Die Casting (e) Casting defects

ASNSWER:

Forging is the process of compressing or squeezing the material between two or more dies to get the required shape and size. In this the shaping or intentional deformation is induced by localized compressive forces. In hot forging process the metal is heated above re-crystallization temperature and pressure is applied with help of hammers or presses to get the required shape.



Steps involved in open die forging

a) The metal is heated in the furnace.
b) The process may be carried out manually or mechanical hammers may be used.
c) The heated metal is squeezed or compressed between two flat or open dies, with the help of hammers.
d) The metal may have to be heated and rotated during the process for many times
e) Many hammer blows may be required to get the final shape

Steps involved in closed die/ impression die forging

a) The hot material stock is placed in the Die block cavity.
b) Pressure is applied using machine/ press to compress the die set.
c) Material flows to fill the die cavity.
d) Flash may be produced in case of impression die forging.
e) Final shape is obtained

Applications of forging: The following are the applications of forging processes:

a) Bars and Step shafts.
b) Hooks, agricultural equipments.
c) Blocks, discs, spanners, bolts, etc.
d) Brackets, fittings, elbows, etc.

Advantages of forging process:

a) Refinement of metal grain structure takes place
b) The metal improves in directional properties
c) The time consumed is reduced in comparison to other shaping processes
d) Reasonable degree of dimensional accuracy is obtained

A bolt and spanner made by forging process the figure shows the grain flow

Different types of forging Operations: The different types of forging operations are as:

a) Upsetting or jumping: Cross-sectional area is increased with reduction in length
b) Drawing out or drawing down: Cross-sectional area is decreased with increased in length; usingfullers or swages or hammer
c) Cutting: Metal is cut in two pieces using the chisels
d) Bending: The bars or flats can be bend to required shape
e) Punching: this is a process of making a hole in the bar or work piece
f) Forge welding: the two pieces of metal are joined together by this process

Comparison of forging processes with machining and casting

Smith forging OR Hammer forging	**Drop forging**	**Press forging**	**Machining & Casting**
Forging is carried out manually in case of smith forging and by mechanical hammers in case of hammer forging	Forging is carried out with help of drop hammer and two halves of dies, one kept on the anvil and other attached to the hammer	Forging is carried out with help of press which may be mechanical or hydraulic, pressure is applied continuously	In case of machining and casting the directional properties are not induced
Skilled labor is required	Highly skilled labor is not required	Highly skilled labor is not required	The parts will be weaker in tension compared to produced by forging
Open Dies are used	Closed or impression dies are used	Closed or impression dies are used	The parts will have low fatigue life
Any shape can be produced	Only die shape can be produced	Only die shape can be produced	The crack initiation and propagation is easy in case of machined and cast parts
Less dimensional accuracy	High dimensional accuracy	Very high dimensional accuracy	Production rates are low in case of machining and casting
Blows are repeated	Blows are repeated	Continuous pressure is applied	
Small size work can be carried out	Medium size work can be carried out	Large work can be carried out	

Operation is not safe	Operation is not safe	Operation is safer	
Operation is slow	Operation is faster, noisy and with vibrations	Operation is faster and quieter without vibrations	

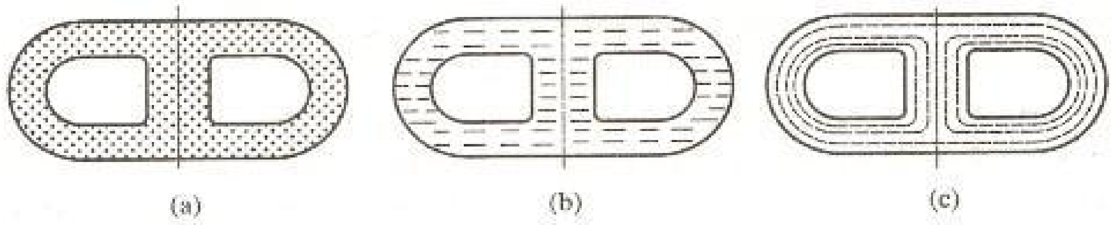


Fig. 4-1 A part made by three different processes, showing grain flow

(a) casting (b) machining (c) forging

<u>Comparison of types of FORGING OPERATIONSOpen die, closed die &impression die forging</u>

<table>
<tr><th>Open die forging</th><th colspan="2">Closed die forging</th><th>Impression die forging</th></tr>
<tr><td>The metal being shaped during open die forging is not completely confined during the process, which derives the name open die forging.</td><td colspan="2">Close die forging is a special form of impression-die forging, in this case flash dose not form, and the work piece completely fills the die cavities.</td><td>Impression die forging is a special form of die forging, in this case the flash is formed and metal is squeezed out from the die cavities.

This can be performed by Drop forging or Press forging methods</td></tr>
<tr><td>Many hammer blows are required to get the final shape

Machining may be required</td><td>Drop forging
Drop forging has several blows or compressions.

The force comes from the ram [hammer free fall by gravity]. The ram is lifted by a</td><td>Press forging
1. Uses steady pressure instead of impacting pressure.

2. The energy is transmitted into the surface layers of the workpiece.

3. Part gets produced in only a single stroke.</td><td>In impression-die forging, the work piece acquires the shape of the die cavities, while being forged between two shaped dies. During forging, some of the material flows outward and forms a flash.

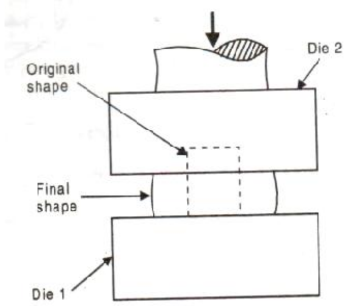
Once the part is</td></tr>
</table>

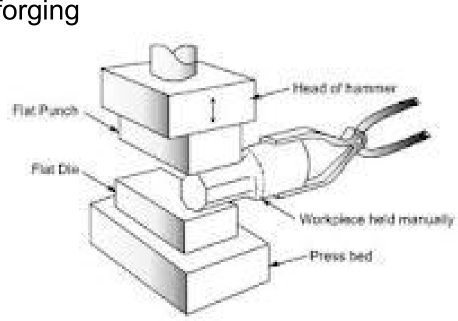
The dimensional accuracy is poor	single-acting steam (or air) cylinder.	**Advantages** 1. High strength-to-weight ratio. 2. Surface is smooth. 3. Good dimensional accuracy. 4. Product is tougher than casting. 5. Have little or no waste. 6. No machining required after part is produced by closed die forging	produced then flash is removed by machining. Dimensional accuracy is very good

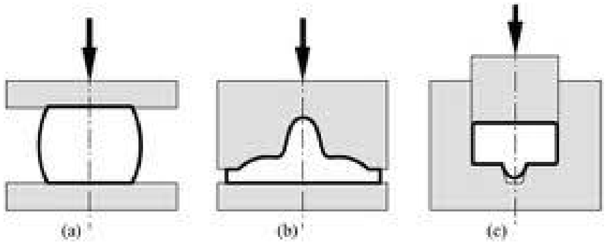
Forging Methods

- Open-die drop hammer or Smith Forging
  The process may be performed ***manually*** by the iron smith using open or flat faced dies OR by Drop hammers.
- Imprssion die **Drop** hammer **Forging**
  The process is performed by the macine and ***series of blows*** is applied over the dies after placing the heated material inside the closed die or impression die.
- Press Forging
  The process is performed by the macine and ***continuous pressure*** is applied over the dies after placing the heated material inside the closed impression die.
  The pressure may be applied using hydraulic or mechanical presses
- Machine forging Or Upset forging
  The process is performed by the macine continuous pressure is applied for upstting the bar into a shape similar to bolt.
- Roll Forging
  The rollers with shaped grooves are used to reduce the thichness of bar stock and give required shape.

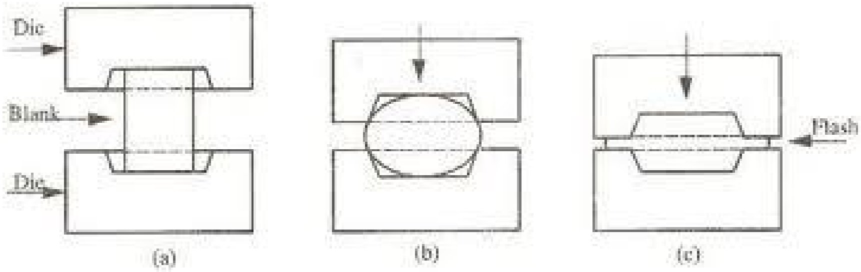
Examples of open die forging



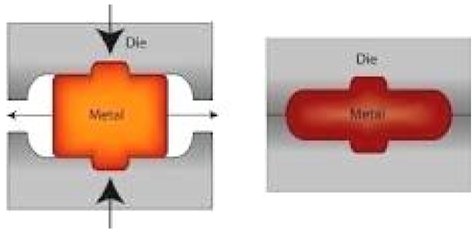




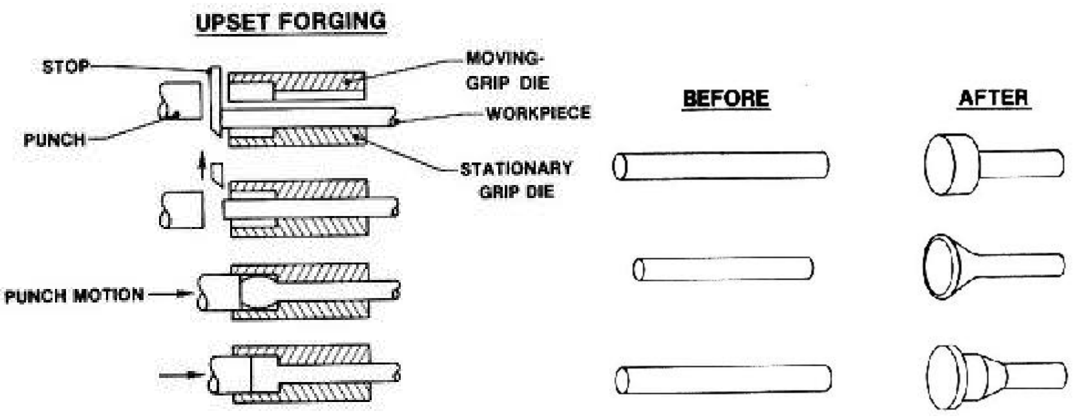
The figure showing the open die, impression die and closed die forging operations



The figure showing the steps in impression die forging operation



The processes of Closed die forging



Process of upset forging and its product shapes

5. ***Describe with neat the wire and tube drawing/ making process**.

OR

With the help of neat sketch, define the following operations: 2008-09, Sem-I/II, Spl-carry

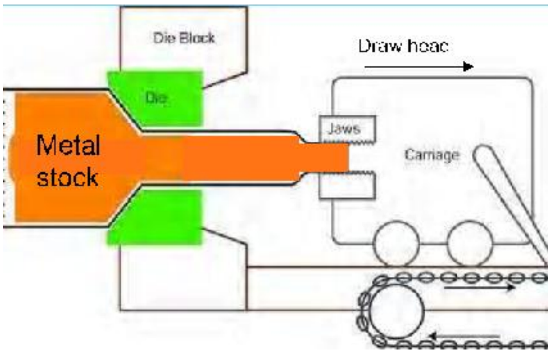
a) Extrusion
b) Brazing
c) Taper turning
d) Wire drawing.

ANSWER

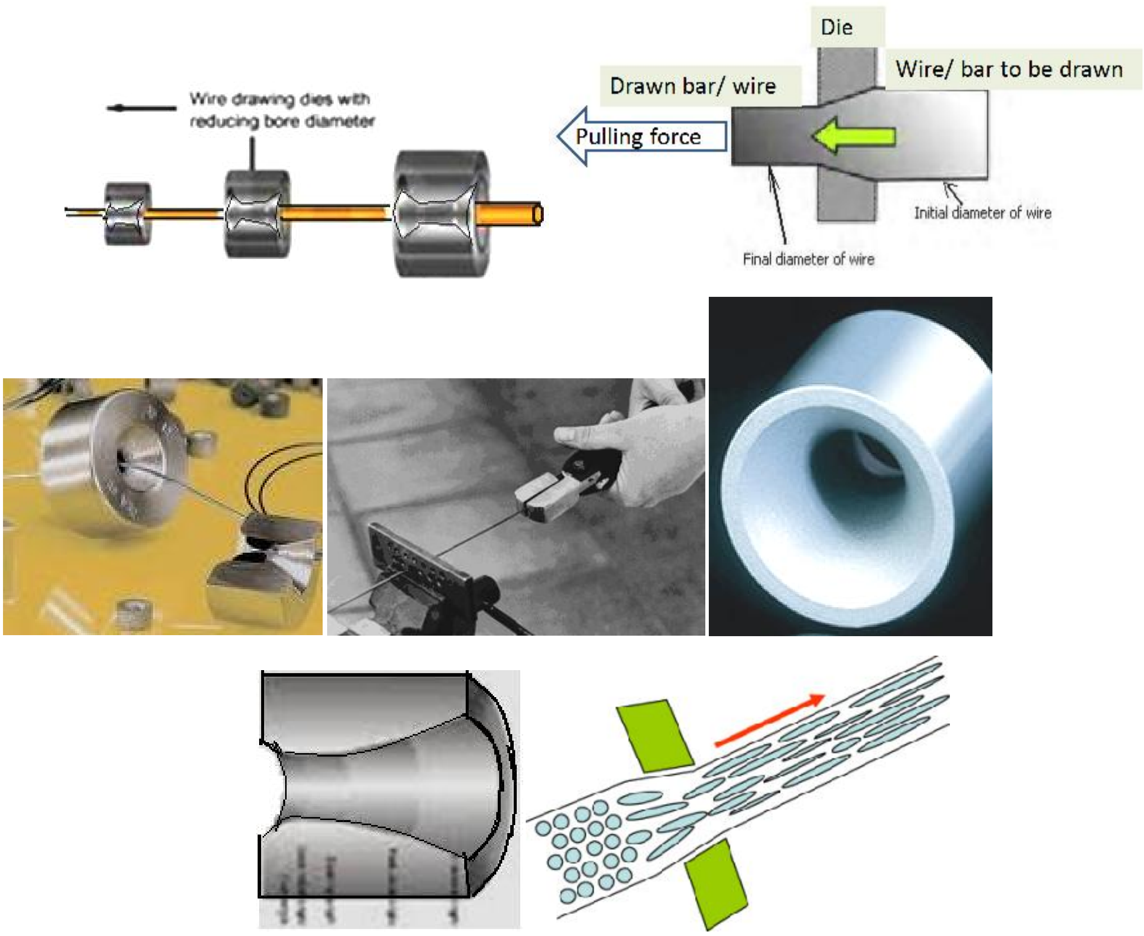
Wire/ bar drawing is a metalworking process used to reduce the cross-section of a wire/ bar by pulling (applying tensile force on) the wire through a single, or series of, drawing die(s).Drawing is usually performed at room temperature, thus classified as a cold working process, but it may be performed at elevated temperatures for large/ thick wires to reduce forces. The figure below shows the process of wire drawing and dies used for the purpose.

Process of wire or bar drawing:

- **a)** The wire/ barare prepared by shrinking the beginning of wire, by hammering, filing, rolling or swaging.
- **b)** Then wire is passed through the die and **lubricant** is used to reduce friction.
- **c)** The wire is then pulled through the die by applying the pulling force.
- **d)** As the wire is pulled through the die, its volume remains the same, so as the diameter decreases, the length increases.
- **e)** Usually the wire will require more than one draw, through successively smaller dies, to reach the desired size.
- **f)** Annealing may be required in between the number of passes.



Applications: There are many applications for wire drawing, including electrical wiring, cables, tension-loaded structural components, springs, paper clips, spokes for wheels, and stringed musical instruments.

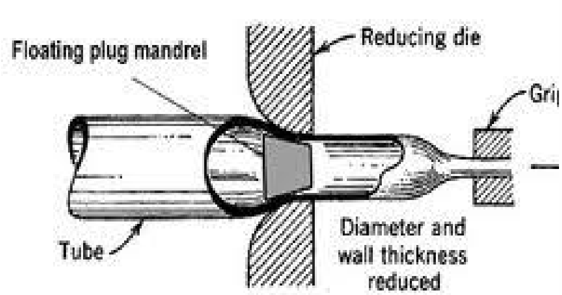


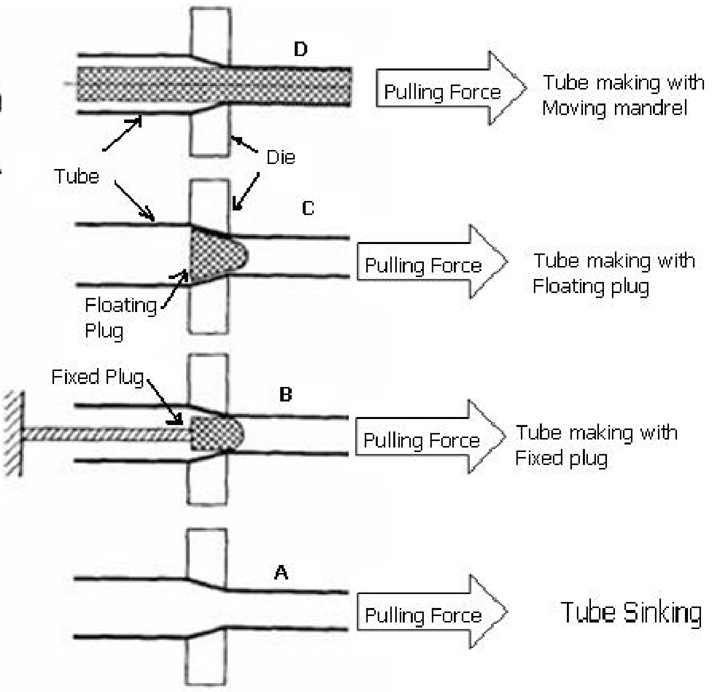
Wire/ bar making process with the views of dies drawing arrangement and grain flow direction

TUBE Making/ Drawing is a metal working process to reduce the diameter of tubes or tube shells by shrinking the large diameter tube into a smaller one, by drawing the tube through a die.

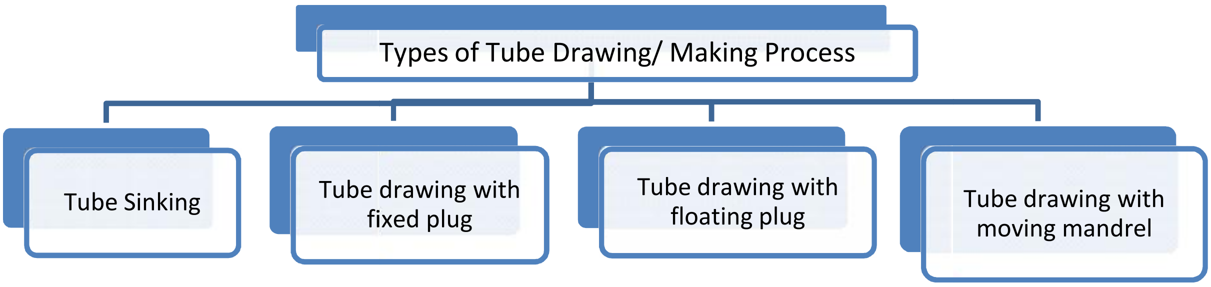
Basic Process of tube making/ drawing:

- **a)** The tube with larger diameter is prepared by shrinking the beginning of tube by hammering, filing, rolling or swaging.
- **b)** Then tube is passed through the die and **lubricant** is used to reduce friction.
- **c)** The floating plug or mandrel or fixed plug is inserted
- **d)** The tube is then pulled through the die by applying the pulling force.
- **e)** Usually the tube will require more than one draw, through successively smaller dies and plugs to reach the desired size.
- **f)** Annealing may be required in between the number of passes.





Tube drawing process by (a) Sinking (b) Fixed plug (c) Floating plug (d) Moving mandrel



The comparison table of tube making processes

Tube Sinking	Tube drawing with fixed plug	Tube drawing with floating plug	Tube drawing with moving mandrel
Tube sinking, also known as free tube drawing, reduces the diameter of the tube without a mandrel or float inside the tube.	Fixed plug drawing, also known as stationary/ fixed mandrel drawing, uses a mandrel at the end of the die to shape the ID of the tube.	Floating plug drawing, also known as floating mandrel drawing, uses a mandrel that is not anchored fixed.	The tube is drawn with a mandrel. The mandrel consists of along hard rod or wire that extends over the entire length of the tube and is drawn through the die with the tube.
The inner diameter (ID) is determined by the inner and outer diameter of the stock tube, the outer diameter of the final product, the length of the die landing, the amount of back tension, and the friction between the tube and the die.	This process is slow and the area reductions are limited, but it gives the best inner surface finish of any of the processes. This is the oldest tube drawing method.	The mandrel is held in by the friction forces between the mandrel and the tube. This axial force is given by friction and pressure.	In this design, the area reduction can be 50 per cent. However, after drawing, the mandrel must be removed from the tube by rolling (reeling), which increases the tube diameter slightly and disturbs the dimensional accuracy.
Simple to perform		The greatest advantage of this is that it can be used on extremely long lengths	

6. *Describe the various processes in sheet metal working and draw a neat sketch of die and punch assembly.

*What do you understand by press work? What is the working principle of press? Differentiate between blanking and punching or piercing.

* Explain working of press.

* Explain in detail drawing process giving suitable diagram. Also list various items produced by this process. 2011-2012, Sem-I

* Write a short on deep drawing. 2011-2012, Sem-II

* What is the difference between Punching and Blanking? 2011-12, Spl-Carry

ANSWER:

Drawing process: <u>Drawing can refer to two different operations, if the starting metal is in the sheet form, then it refers to forming of cup shaped objects, produced by punch and die with plastic deformation of metal sheet on application of pressure.</u>

If the starting metal is in the bulk form, such as wire, rod, or tube then drawing refers to the process of reducing the cross sectional area by pulling it through a die.

Various items produced by drawing are Tubes, rods, wires, cup, metallic glass, and cylindrical objects.

Sheet metal forming processes are those processes in which force is applied to a piece of sheet metal to modify its geometry rather than remove any material. The applied force produces the stresses in the metal beyond its yield strength, causing the material to plastically deform, but not to fail. By doing so, the sheet can be bent or stretched into a variety of complex shapes.

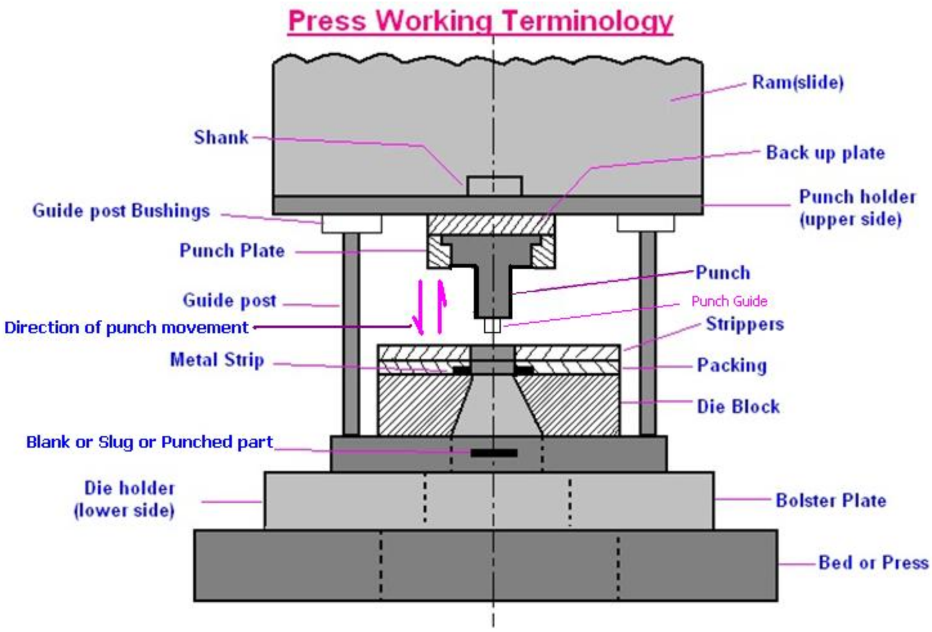
Sheet metal working or forming processes are the processes used to give required shape and size to the metal sheets, using different operations.

Principle: The materials are sheared or formed between a die and punch without formation of chips.

Press: The press is a sheet metal forming machine tools designed to shape or cut the metal by applying mechanical force or pressure.

Details or construction of Press: It is a hand operated press. It has a fly wheel, with operating handle. The screw of the press operates in a nut, fixed in the vertical columns of press body. A ram is attached to the lower end of the screw. When the screw is operated by a handle; the ram moves in a vertical direction in the slides on the press column face. A punch is fixed in the ram. A die is fixed on a bolster plate which is mounted on the table.

A simple cutting die used for punching and blanking operation in the press is shown in the figure with different terms associated with press work and press machine:

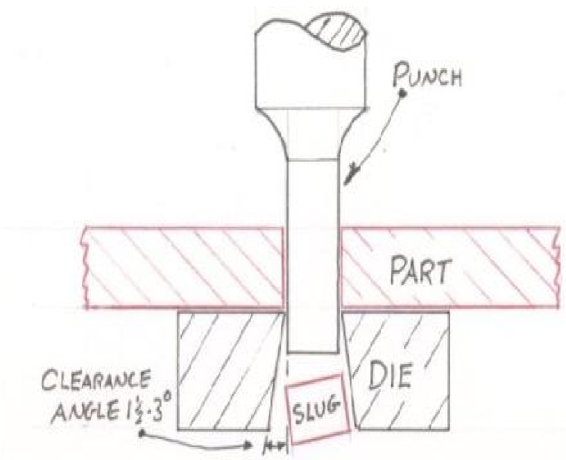


Schematic view of die and punch assembly and its related terms

a) **Bed**:The bed is the lower part of the press frame that serves as a table to which aBolster plate is mounted.
b) **Bolster Plate**:This is a thick plate secured to the press bed, which is used for locating andsupporting the die assembly.
c) **Guide post and bushings**:To hold the punch and keep alignment.
d) **Die Block**:It is a block or a plate which contains a die cavity
e) **Die holder**:This is generally mounted on the bolster plate of the press. The die block is mounted on it, also the guide post are mounted on it.
f) **Punch:**This is male component of a die assembly, which is directly or indirectly moved by and fastened to the press ram or slide.

g) **Punch holder & Plate**:The punch plate or punch retainer fits closely over the body of the punch and holds it in proper relative position.

h) **Stripper**:It is a plate which is used to strip the metal strip from Punch during returning.



Process of punching

Working of press: The sheet metal to be worked is placed over the die. Arm is pulled to give a quick rotation by means of handle. This enables the rotation of fly wheel to store kinetic energy, for giving further movement to the screw. These moves ram and punch downwards, which in turn, gives enough thrust on the sheet to do the required operation.

Sheet Metal Operations: The different sheet metal operations based upon operation can be classified as (another classification is based on type of dies a. Simple b. Progressivec. Combination and d. Compound):

Sheet Metal Working Classification (Based on operations)

Shearing
1. Blanking
2. Piercing(Punching)
3. Slittng
4. Notching
5. Perforating
6. Nibbling
7. Shaving
8. Slotting
9. Trimming
10. Lancing

Drawing
1. Ironing
2. Redrawing
3. Reverse drawing
4. Deep drawing

Bending
1. U-Bending
2. Edge Bending
3. V-Bending
4. Forming
5.Strectch Forming

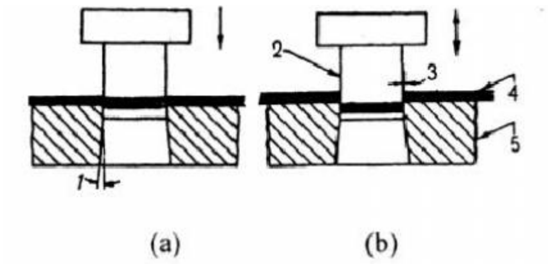
Squeezing
1 . Coining
2. Embossing
3. Flattening
4. Rolling

1. Shearing:Shearing is a sheet metal cutting operation without formation of chips or the use of burning or melting.

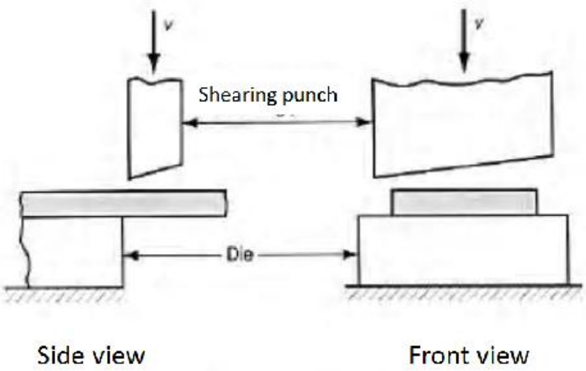
1.2.Piercing: The piercing is the operation of production of hole in a sheetmetal by the punch and the die. The materials punched out to form the holeconstitute the waste.

1.3.Blanking and punching (Difference)

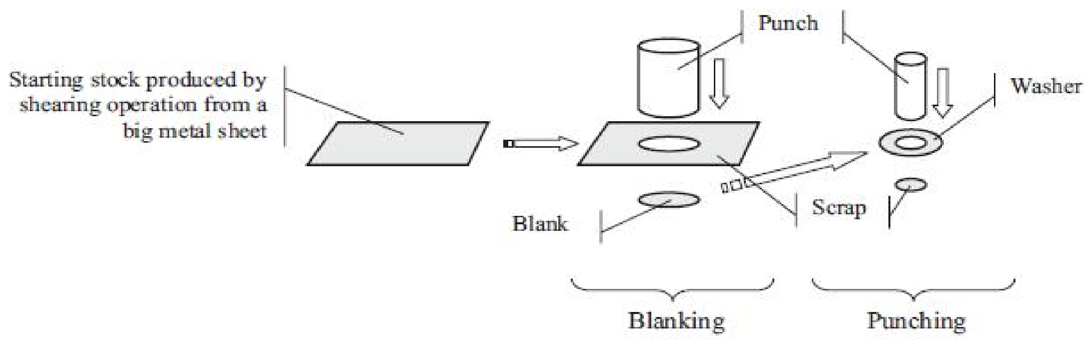
Blanking and punching are similar, sheet metal operations that involve cutting the sheet metal, by a die and punch, along a closed outline. If the part that is cut out is the desired product, the operation is called blanking and the product is called blank. If the remaining stock is the desired part, the operation is called punching. Both operations are illustrated by the example of producing a washer.



(a). Plastic deformation. (b). Shear
1. Die clearance. 2. Punch. 3. Punch clearance.
4. Plate. 5. Die.



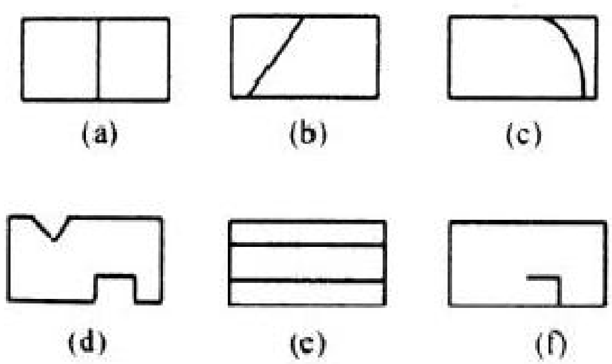
Shearing Operation



Steps in production of washer

1.4.Cutting off: The cutting off is the operation of severing a piece from asheet of metal or a bar with a cut along a single line. The cutting offoperation illustrated in Fig. a) (b) (c) can be performed along a straight lineor a curve.

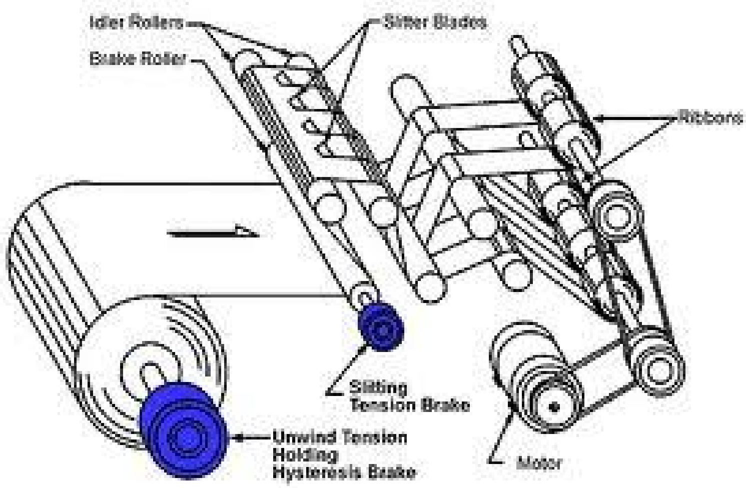
1.5. Notching: The notching is the operation of removal of the un-desired shapefrom the edge of a plate. The operation is illustrated in Fig. d. The punch andthe die set up are similar to the piercing or punching operation.



1.6. Slitting: The slitting is the operation of cutting a sheet metal in a straightline along the length. Generally used for making many coils of small width from one wide coil of the metal. The slitting operation is shown in Fig. e above and below.

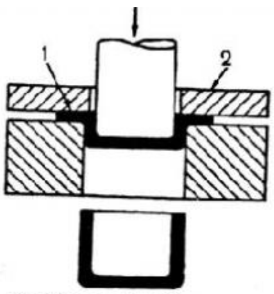
1.7. Lancing: The lancing is the operation of cutting a sheet metal through partof its length and then bending the cut portion. The operation is illustrated inFig. f and below.

Three steps to show the lancing process

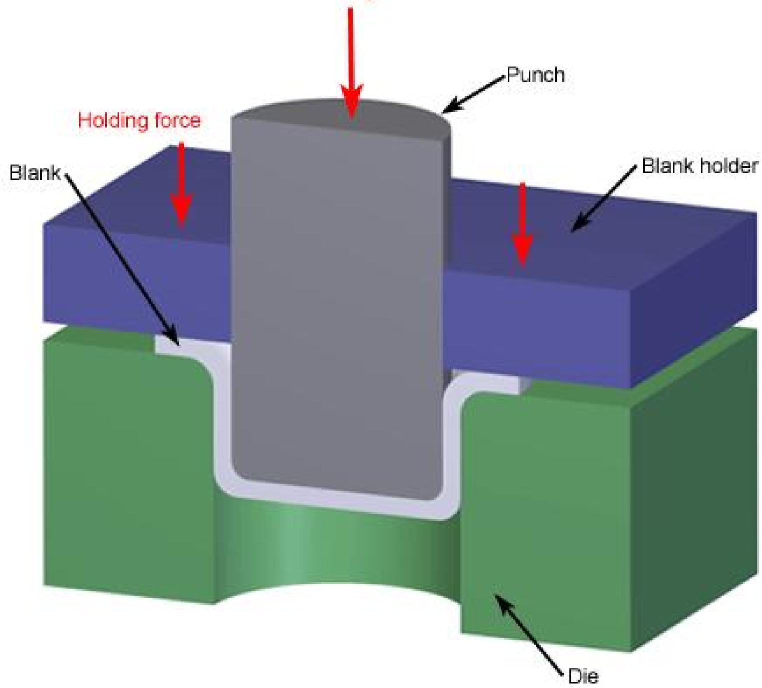


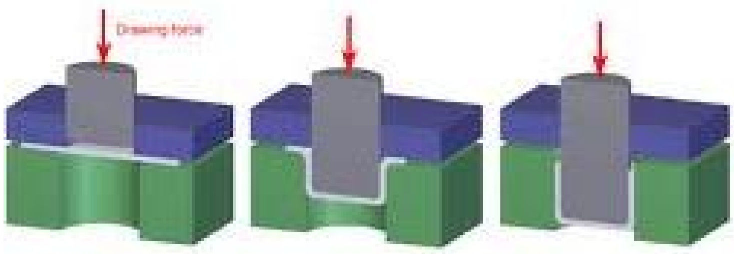
2. Drawing

Drawing is a sheet-metal operation to make hollow-shaped parts from a sheet metal such as cup. The drawing is the operation of production of cupshaped parts from flat sheet metal blanks by bending and plastic flow of themetal. The operation is also known as **cupping**.Different drawing operations are:**Deep drawing**operation is performed to draw very deep parts (When the depth is more than the diameter) from the metal strips through plastic deformation (example of deep drawing is the aluminum cap of the electric bulbs,**Ironing**is the operation of reducing the wall thickness), **redrawing** (drawing is performed many times to reduce the diameter of earlier drawn cup shape), **Reverse drawing** (the drawn cup is subjected to force in opposite direction). The drawing operation isillustratedin belowFig.



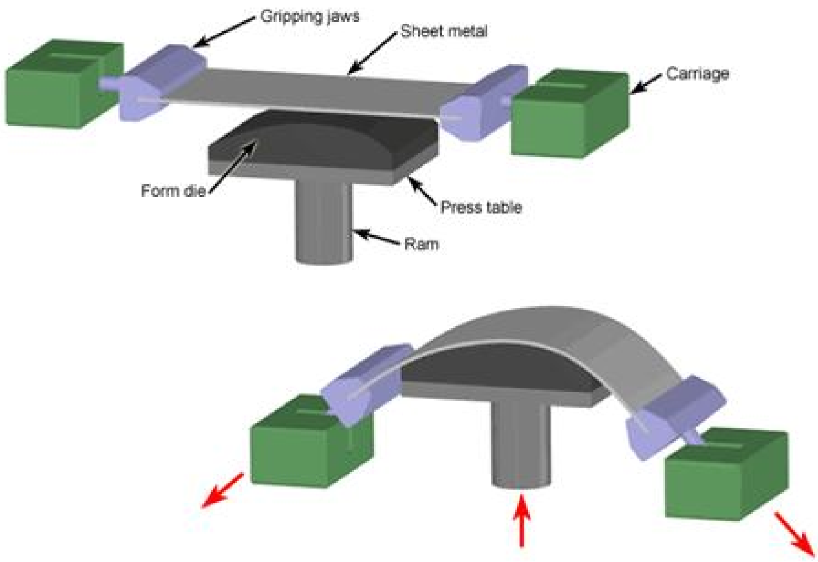
Drawing operation
1. Blank, 2. Pressure pad.

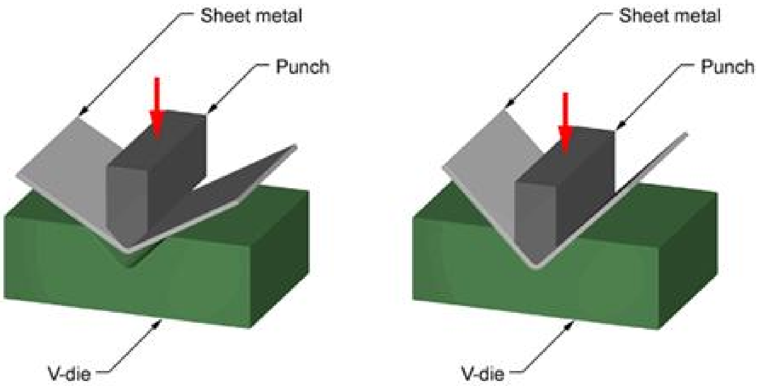




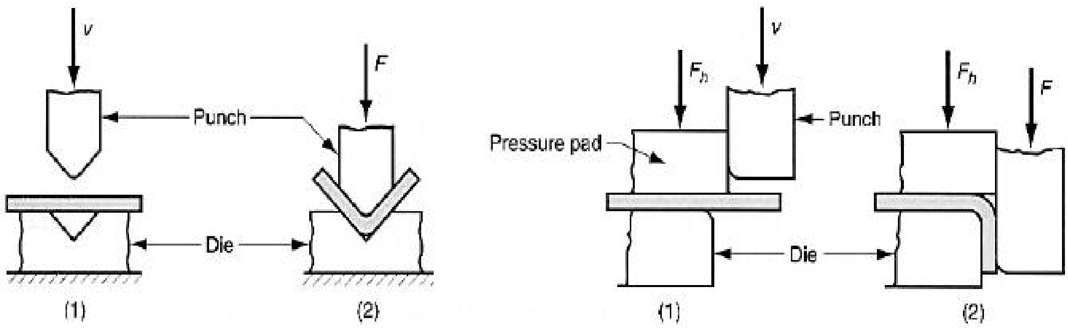
3. Bending

Bending is defined as the plastic deformation about a linear axis with little or no change in the surface area. Figure illustrates the bending operation on a metal sheet. The different bending operations may be angle or simple bending, edge bending, U & V bending, forming and stretch forming. Stretch forming is a metal forming process in which a piece of sheet metal is stretched and bent simultaneously over a die in order to form large contoured parts.





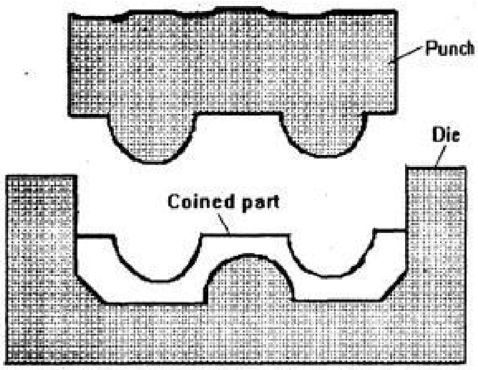
Bending operations involve the processes of *V-bending* and *edge bending*.



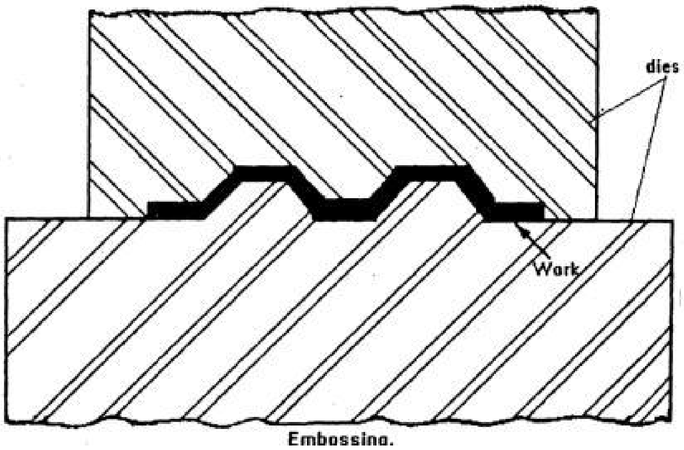
4. Squeezing: In the squeezing operation large amount of pressure is required to squeezea metal which is made to flow in a cold state within the cavity of the die andthe punch to attain the desired shape. For this reason the squeezingoperation is performed in a hydraulic press. The metal may be in the bulk or sheet form. Rolling is alsoa squeezing operation. The different squeezingoperations are described below:

4.1 Coining: The coining is the operation of production of coins, medals orother ornamental parts by squeezing operation.

4.2 Embossing: The embossing is the operation of giving impressions offigures, letters or designs on sheet metal parts. The punch, or the die, or bothof them may have the engravings which are marked on the sheet metal bysqueezing and plastic flow of the metal. Figure below illustrates the coining and embossing operations.



Coinning process



Embossing.

Applications of sheet metal working

Coin and medal making, Sheets for Roofs, Air conditioning Ducts, and Vehicles body buildings like 3 wheelers, 4 wheelers, ships, aircrafts, Furniture, Household utensils, pans, and Railway equipment

7. *Differentiate between the casting and pattern. Why pattern is different from casting? Explain different pattern types.

*Describe with neat sketch, the various operations in casting process. What is the function of core in casting? 2008-09, Sem-I/II, Spl-carry

*Describe with neat sketch, the various operations in casting process. What is the function of core in casting? 2008-09, SEM-sc

*Why the pattern is different from casting? Describe with neat sketch, the design steps in casting process. What is the function of core in casting? 2008-09, SEM-II

*What is casting and casting process explain?

*What is master pattern? 2011-12,Spl Carry

*Why the pattern is different from casting? Describe with neat sketch, the various steps in casting process. What is the function of core in casting? 2009-10, SEM-II

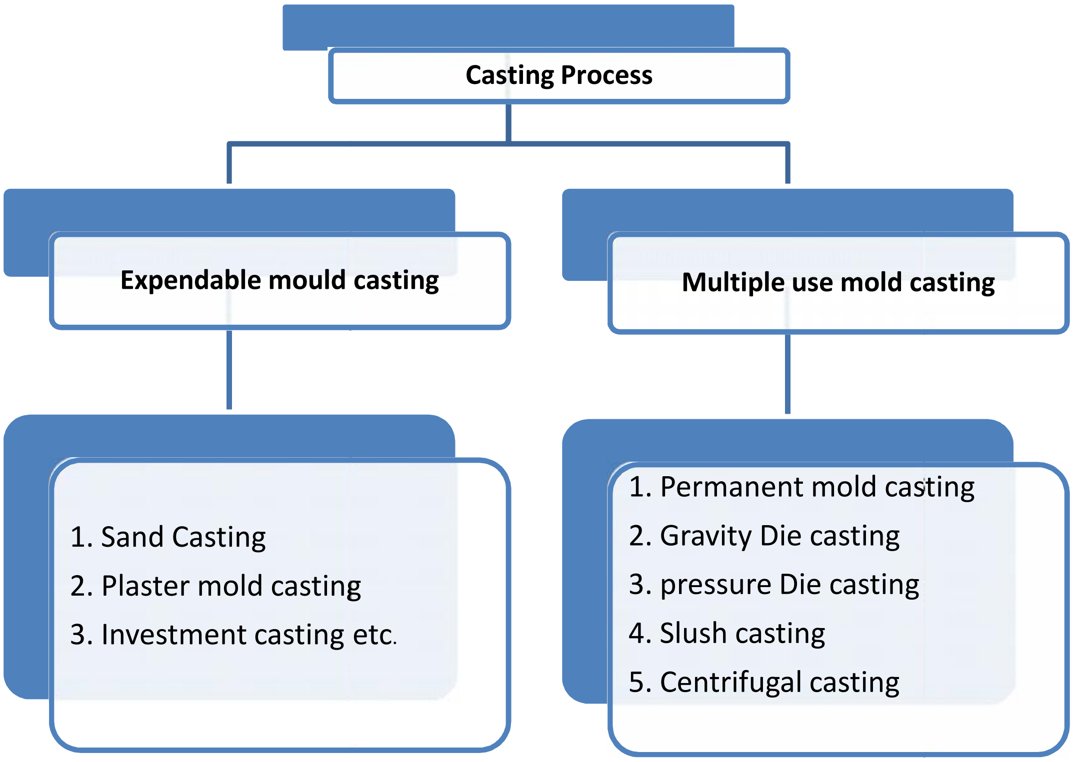
*Describe the various kinds of patterns in use. What are the allowances provided, when making a pattern? How does the pattern differ from casting required?

Casting: Castingis a process and also it is a product of the process. The *casting process* is carried out in the *foundry* and the product of the casting process is called as *casting*.

Principle: The molten metal is poured into a cavity (called as mould) of required shape & size and allowed to cool and solidify. The solidified product is called as Casting and it is a bit smaller in size from that of the cavity because of contraction of the metal on cooling.

Why the pattern is different from casting: The pattern is different from the casting because the pattern is used to make the cavity for the casting, and the metal may shrink or expand on solidification. Also other factors (known as allowances) influence the dimensions of the casting and are listed under the differences in the casting and pattern.

Classification of casting process



Sand Casting: In this casting process the sand is used as mould making material.

Plaster mold casting:the mould is made from Plaster of paris.

Investment casting: The process involves making of wax patterns and used for high precision and complex products i.e. turbine blades, jewelry, dentistry.

Permanent mold casting: Reusable mould is used and molten metal flows in the cavity by gravity.

Slush casting: In this process the material is allowed to stay in the mould cavity only till a thin layer of the metal is solidified to form a shell and then the mould is inverted to drain the metal.

Die casting: Reusable mould is used and molten metal is forced in the cavity by applying large pressure in case of pressure die casting and by gravity in the gravity die casting.

Centrifugal casting: The centrifugal force is used to distribute the metal in the cavity and the mould is rotated at large speed approximately at 500 rpm.

Advantages of casting Process

a) Intricate shapes internal or external can be produced in one step.
b) Objects can be cast in single piece without needing machining or forging.
c) Thin sections of the complex shape are possible.
d) High production rate.
e) Greater surface finish.
f) The labour cost involved is less.
g) A number of non-ferrous alloys can be die cast.

Pattern:*The pattern is the replica OR duplicate of the casting* to be produced. A pattern is a model of the desired product (called casting), constructed in such a way that it can be used for forming an impression called mould (cavity) in damp sand. When this mould (cavity) is filled with molten metal, it solidifies and produces a casting (desired product). *Patterns are used to mold the sand mixture into the shape of the casting. They may be made of wood, plastic, or metal.* The selection of a pattern material depends on the size and shape of the casting, the dimensional accuracy, the quantity of castings required, and the molding process.

Master Pattern: This is a type of pattern and used in the process of investment casting for making of wax patterns.

Pattern materials: The patterns are generally made from following materials:

(i) Wood (ii) Metals (iii) Cast iron (iv) Brass (v) Plaster of Paris (vi) Plastic (vii) Wax

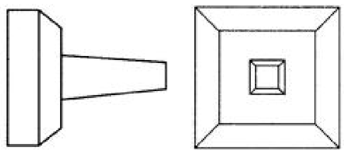
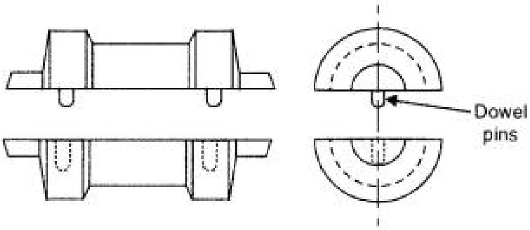


Fig. 14.1. *Solid Pattern.*

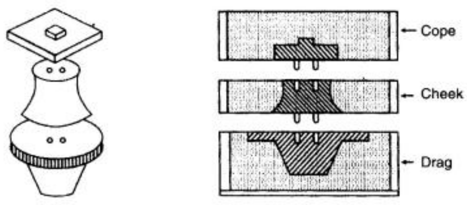
Types of Patterns

a) **Solid or single piece pattern**: This pattern is made without joints, partings or any loose pieces in its construction and is called a single piece or solid pattern.



b) **Split (Two piece)** *pattern:* Sometimes patterns cannot be made in single piece because of the difficulties encountered in molding or difficulty in withdrawal from the mould. Because of these, patterns are usually made in two pieces called split patterns. One part will produce the lower half of the mould and the other part will produce the upper half of the mould. These two pieces are held in their proper relative position by means of dowel-pins fastened in one piece and fitting holes bored in the other. The surface which is formed at the line of separation of the two parts, usually at the centre-line of the pattern is called as parting surface or parting line.

c) **Multi piece pattern**: Sometimes the patterns are made in more than two parts if the shape is complex. Then these patterns are called multi-piece pattern which may consist of 3, 4 or more number of parts depending upon their-design.



d) **Match plate pattern***:* if the split patterns are mounted with one half on one side of a plate (Match plate) and the other half directly opposite to the other side of the plate, the pattern is called a match plate pattern.These patterns are advantageous in Machine molding, Mass production, Greater dimensional accuracy and Minimum machining requirement.

Patterns

Pattern material

1. Wood
2. Metal
3. Plaster of paris
4. Wax
5. Plastics

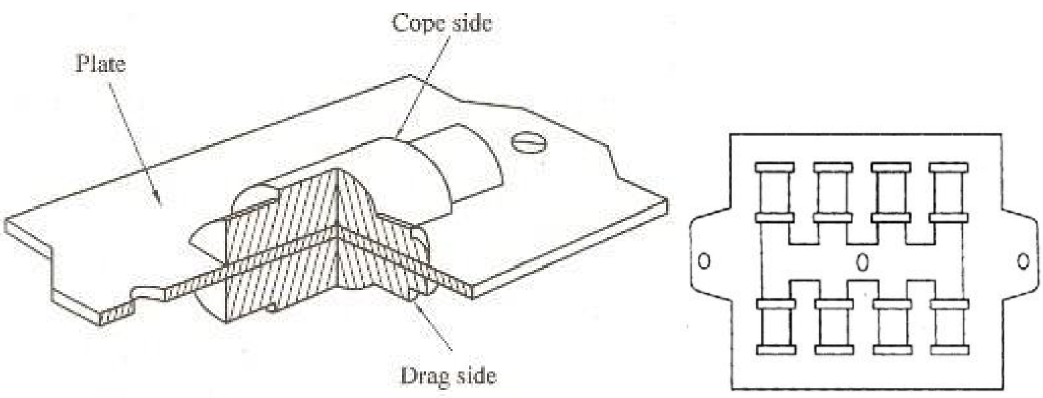
Pattern types

1. *Solid or single piece pattern*
2. Solid or single piece pattern
3. Split (Two piece) pattern
4. Multipiece pattern
5. Match plate pattern
6. Gated pattern
7. Skeleton pattern
8. Sweep pattern
9. Follow board pattern
10. Segmental pattern

Allowances

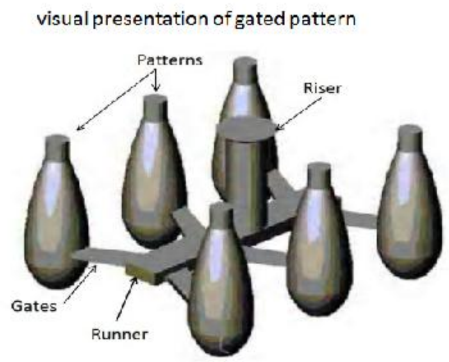
1. Shrinkage or contraction
2. Machining or finish allowance.
3. Draft or taper allowance.
4. Distortion or camber allowance.
5. Shake or rapping allowance.
6. Mould wall movement allowance

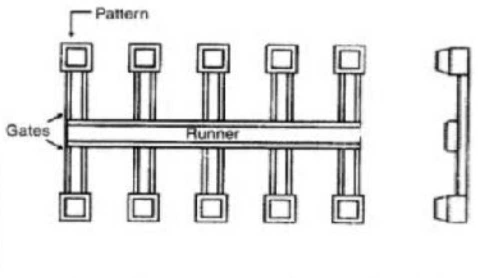
A single pattern or a number of patterns may be mounted on a match plate. The match plate may be of wood, steel, magnesium or aluminum. Gates and runners are also attached to the plate along with the pattern. So when the match plate is lifted off the mould, patterns are also withdrawn. The gates and runners are also completed in one operation because patterns for runner and gates are also attached with the match plate along with the patterns of the desired castings. So lot of manual work is reduced.



Match plate patterns

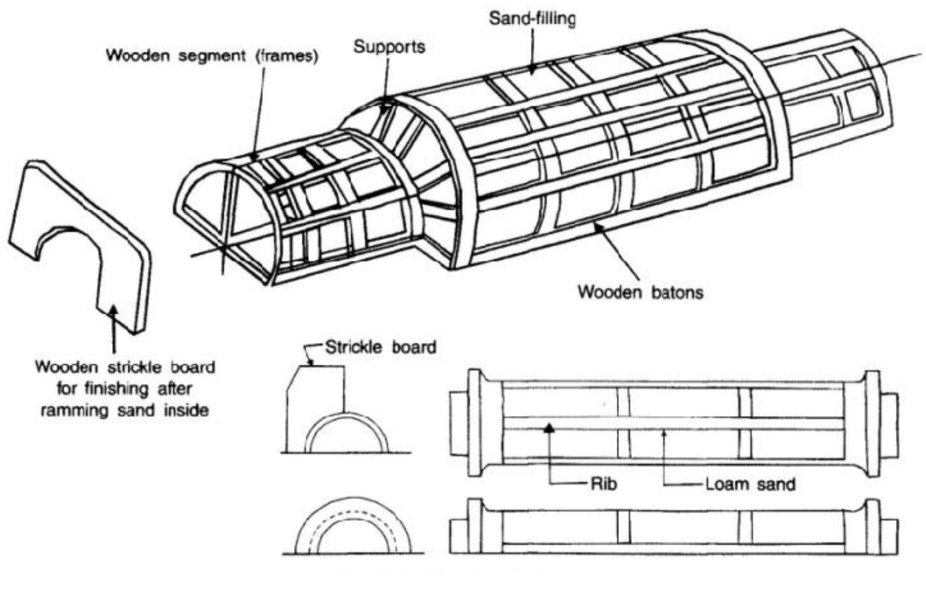
e) **Gated pattern***:* The provision of gating is provided in the gated patterns.In gated patterns, a single sand mould carries a number of cavities. Patterns for these cavities are connected to each other by means of gate formers which provide suitable channels (path) or gates in sand for feeding the molten metal to these cavities. A single runner can be used for feeding all the cavities. This enables a considerable saving in molding time and a uniform feeding of molten metal. For small quantities, these patterns may be made of wood, but for large production metallic patterns are preferred. To produce good casting, it is necessary to ensure that full supply of molten metal flows into every part of the mould. Provision for easy passage of the flowing metal in the mould is called gating and is provided in the gated patterns.





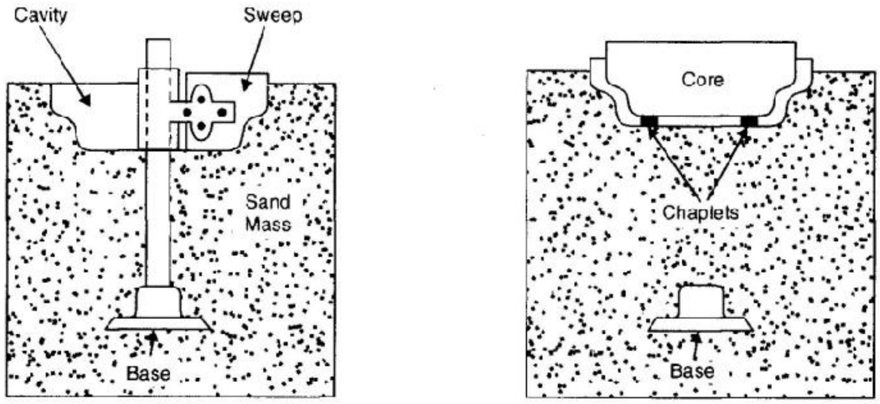
Gated pattern top and Side view

f) **Skeleton pattern:** Patterns for very large castings would require a large amount of pattern material. In such cases skeleton patterns are used. Skeleton patterns are hollow patterns and made up of a wooden frame and strips. The frame work is filled and rammed with loam sand and stickle board is used to remove the excess sand. Stickleboard is having the same contour as desired so it can remove the extra sand by passing over the skeleton pattern.



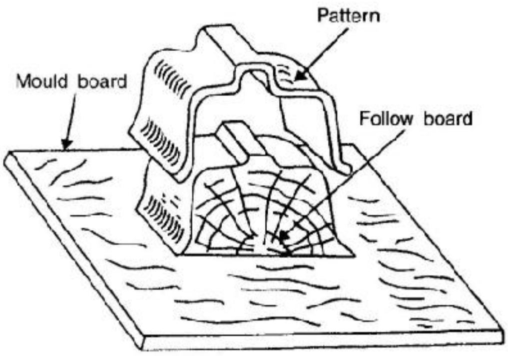
Skeleton pattern

g) **Sweep pattern**: Sweep pattern is just a form or shape made on a wooden board which sweeps the shape of the casting into the sand all round the circumference. The sweep pattern rotates about the post. The moulds of large size and symmetrical in shape particularly of circular section can be easily prepared by using a sweep instead of a full pattern. Once the mould is ready, sweep pattern and the post (spindle) can be removed. Sweep pattern avoids the necessity of making a full, large circular and costly three-dimensional pattern. Sweep patterns are used for large patterns of cast iron, ridges etc. The figure is shown below:

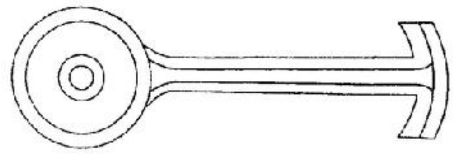


(a) A sweep pattern in action (b) Mould ready with core in position

h) **Follow board pattern:** A follow board pattern is a wooden board and is used for supporting a pattern which is very thin and fragile and which may give away and collapse under the pressure when the sand above the pattern is being rammed. In addition to supporting a thin sectioned pattern, a follow board forms the natural parting line of the mould or the casting.



i) **Segmental pattern:** Segmental patterns are sections of a pattern so arranged as to form a complete mould. A segmental pattern completes one portion (stage) of the mould and then moved to the next position to make the next part of the mould and so on till the mould is completed. A segmental pattern differs from a sweep pattern in the sense that it does not revolve, continuously about the post to make the mould rather it prepares the mould by parts. For example making of a flywheel using only one segment of the flywheel.



Difference between casting and Pattern: The various differences between casting and pattern are as tabulated below:

Factor	Pattern	Casting
Material	The material of the pattern is not necessarily same as that of the casting. Pattern may be made from wood.	Casting is made of required material, i.e. cast iron, aluminum
Color	The colour of the pattern may not be same as that of the casting.	Depends upon casting metal.

Allowances	Pattern carries an additional allowance to compensate for metal shrinkage.	No allowances provided.
Allowances	It carries additional allowance for machining.	No allowances provided.
Allowances	It carries the necessary draft to enable its easy removal from the sand mass.	No allowances provided.
Allowances	It carries distortions allowance. Due to distortion allowance, the shape of casting is opposite to pattern	No allowances provided.
Core Prints	Pattern may carry additional projections, called core prints to produce seats for cores.	Core prints Not present in casting.
Pieces	Pattern may be in pieces (more than one piece) whereas casting is in one piece.	Casting is always in single piece.
Surface finish	Surface finish may not be same as that of casting.	Surface finish will change on machining.
Sharp corners	Sharp changes are not provided on the patterns. These are provided on the casting with the help of machining.	These sharp corners if required are produced by machining.

Operations OR steps involved in the making of casting OR Casting process

Casting process comprises of the following steps:

1) **Making a pattern**: Pattern is the model/ replica/ duplicate of the desired product (called casting), constructed in such a way that it can be used for forming an impression/ cavity called mould (cavity) in damp sand. Various allowances such as shrinkage, machining, draft, shaking, distortion etc., are provided. Sometimes core prints are also provided to the patterns to make a core seat in the damp sand.
2) **Preparing Molding Sand**: Sand is the principal molding material in a foundry shop. The quality of the casting depends upon be the selection and mixing of sand, which may be natural or synthetic and is used for mould and core making.
3) **Preparing a mould and core making**: Moulds are prepared with the help of pattern to produce a cavity of desired shape. Usually the mould is made of sand is used only once. But sometimes permanent metal moulds are also used. For obtaining hollow portions, cores are prepared separately in core boxes. Moulds and cores are baked to impart strength.
4) **Melting the Metal**: The required quantity of the metal with proper composition is melted in a suitable furnace.
5) **Pouring the metal into the mould**: When the molten metal attains pouring temperature, it is taken into ladles and poured into the moulds.
6) **Cooling i.e., Solidification**: After pouring the molten metal into the mould cavity it is allowed to cool down so that the metal solidifies.
7) **Removing the Solidified casting from the mould**: The solidified casting are extracted by breaking the mould and cleaned by removing adhering sand.

8) **Fettling**: The unwanted projection in the form of gates, risers etc. are cut off and the entire surface is cleaned and made uniform.
9) **Heat Treatment**: The castings may need heat treatment depending on the specific properties required.
10) **Testing and Inspection**: Finally the casting is inspected to ensure that it is free from casting defects and is as per desired specifications.

Making a pattern

⇩

Preparing Molding Sand

⇩

Preparing a mould and core

⇩

Melting the Metal

⇩

Pouring the metal into the mould

⇩

Cooling i.e., Solidification

⇩

Removing the Solidified casting from the mould

⇩

Fettling OR Cleaning

⇩

Heat Treatment

⇩

Testing and Inspection

The flow chart indicating the main steps in the making of a casting

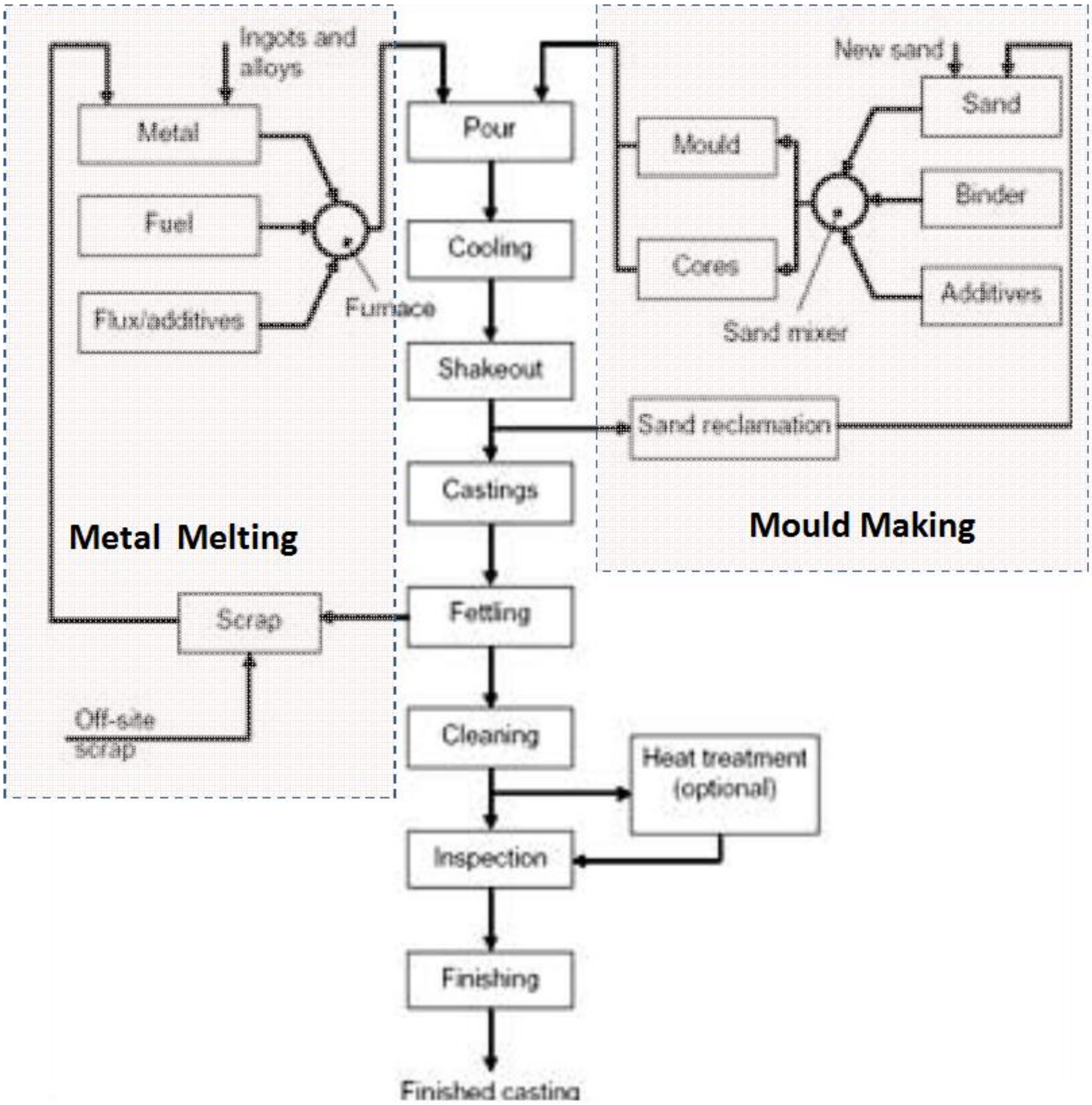


Figure presents ***all*** the steps involved in the making of a casting

8. Describe various kinds of patterns in use. What are the allowances provided when making a pattern? How do pattern differs from the casting? 2010-11, Sem-I, Spl-Carry

*Why allowances are given on pattern? What are different types? Explain. 2011-12, Sem-I

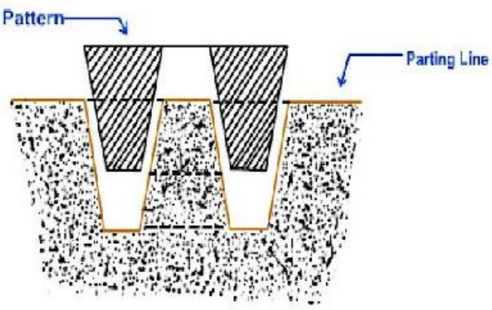
* What are the common allowances provided on pattern and Why? 2010, Sem-I/II, Spl-Carry
* Write a note on : Allowances on pattern 2011-12, Spl-Carry
* What is a pattern? Explain various allowances provided in pattern making and the reasons for it. 2012-13 Sem-II

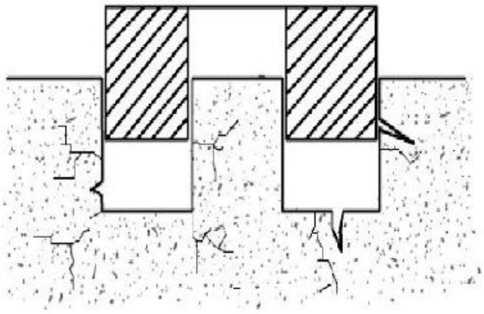
ANSWER
Pattern allowances: Pattern is having different size/ dimension as compared to casting because it carries certain allowances or deviation from the actual dimension of the casting due to metallurgical, mechanical and process variables.The difference between the dimensions of pattern and casting is known as pattern allowance. The allowances are provided so that the produced final castings are to the correct dimensions. The various allowances used when making a pattern are:

a) Shrinkage or contraction allowance: As metal solidifies and cools, it shrinks and contracts in size. To compensate for this, a pattern is made larger than a finished casting by means of a shrinkage or contraction allowance.Contraction is different for different metals.Wood patterns used to make metallic patterns are given double allowance, one for the shrinkage of the metal of the pattern and the other for that of metal to be cast.The total contraction is volumetric but the shrinkage allowance is added to the linear dimensions.

b) Machining or finish allowance: For good surface finish, machining of casting is required. For machining, extra metals are needed. This extra metal is called machining or finishing allowance.The amount of this allowance depends upon the type of casting metal, size and shape of casting, method of casting used, method of machining to be employed and the degree of finish required.This allowance is added in addition to shrinkage allowance

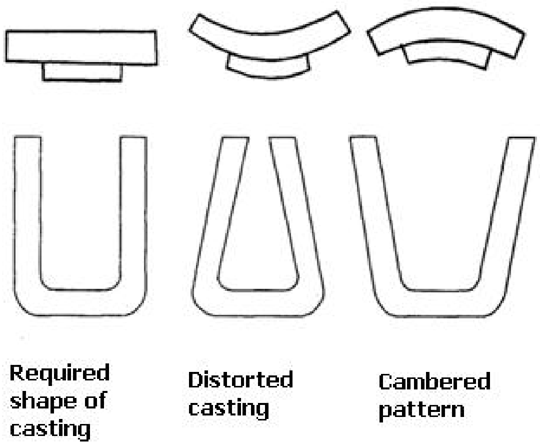
c) Draft or taper allowance: It is provided for easy removal of pattern from the sand mold.At the time of withdrawing the pattern from the mould, the vertical faces of the pattern are in continual contact with the sand, which may damage the mould cavity. This danger is greatly decreased if the vertical surfaces of a pattern are tapered inward slightly. The slight taper inward on the vertical surface of a pattern is known as the draft or taper allowance. This is explained in the figures given below.





d) Distortion or camber allowance: If the shape of the casting changes after the production that is called distortion of the casting. A casting will distort or warp, if.It is of irregular shape.

i. All its parts do not shrink uniformly.
ii. It has long flat casting.
iii. The arms possess unequal thickness.



Distortion can be practically eliminated by providing an allowance and constructing the pattern initially distorted. e.g., For U shape casting, legs will diverge so we make the pattern having legs converging so that after casting, the product is having legs parallel.

e) Shake or rapping allowance: When a pattern is rapped (shaked) in the mould before it is withdrawn, the cavity in the mould is slightly increased. So in order to compensate this, pattern is made slightly smaller than the actual. This allowance is called shaking or rapping allowance. Rapping allowance is negative.

f) Mould wall movement allowance: Movement of mould wall in sand moulds takes place because of heat and the static pressure exerted on the walls of the mould which comes in contact with the molten metal.Because of this, the size of the mould (cavity) increases. In order to compensate this, the size of the pattern is made smaller so that the casting produced has an accurate size (i.e., desired size).

WHY? The pattern allowances are provided to compensate for the various expansion and contraction in dimensions of the metal on solidification and of also of pattern. Also the other parameters of casting process are considered; so that the final casting produced is of correct dimensions.

Functions of a pattern

a. A pattern prepares a mould cavity for the purpose of making a casting.
b. To produce seats for cores in the moulds so need core prints on the pattern.
c. Runner, gates and riser may form a part of the pattern.
d. Pattern establishes the parting line and parting surfaces in the mould.
e. Patterns properly made and having finished and smooth surface reduce casting defects

9. *Describe with neat sketch, the various operations in mould making with use of a core. What is the function of core in casting?

*Explain (i) Mould (ii) Pattern 2008-09, Sem-I

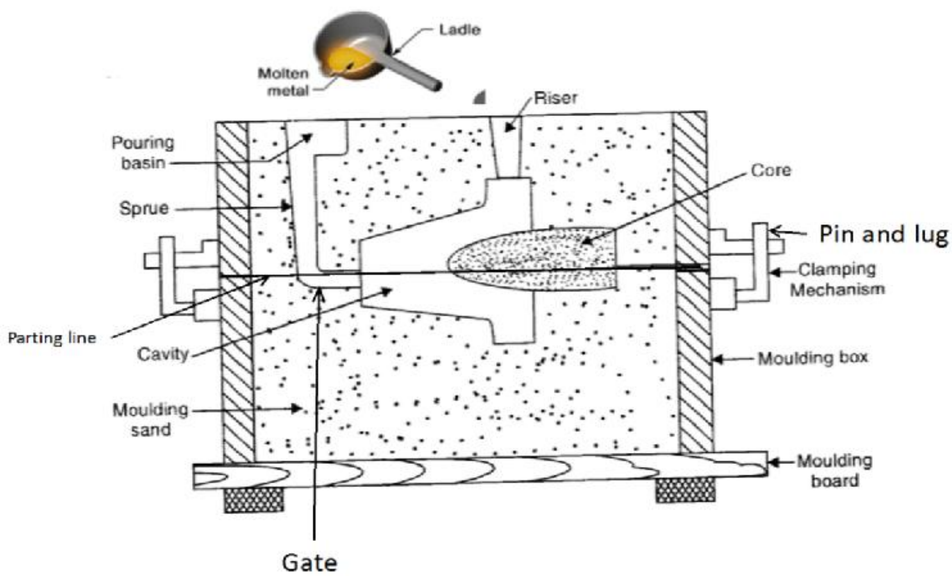
*Define the following terms with neat sketch as used in sand casting: (i) Core (ii) Core-prints (iii) Sprue (iv) Runner (v) Riser 2008-09, Sem-I

ANSWER

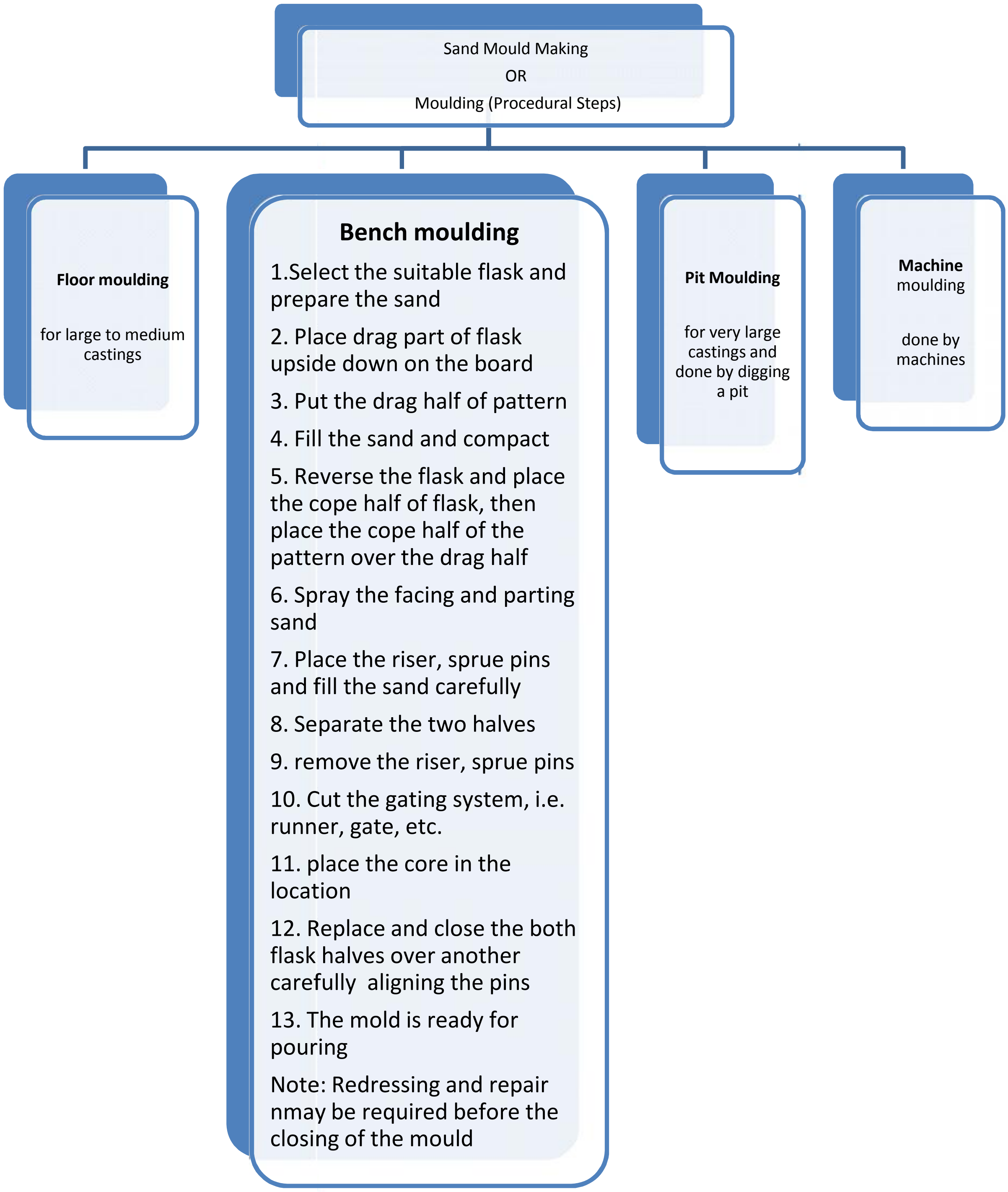
Function of cores: Core is used for making cavities (holes) and hollow projections in the casting. For all those castings, where coring is required, provision should be made on the pattern to support the core inside the mould.

Mould: A mould can be described as a void or hollow or cavity created in a compact sand mass with the help of pattern which (Mould), when filled with molten metal will produce a casting.

Molding: The process of making this cavity or mould in the compact sand is called molding.



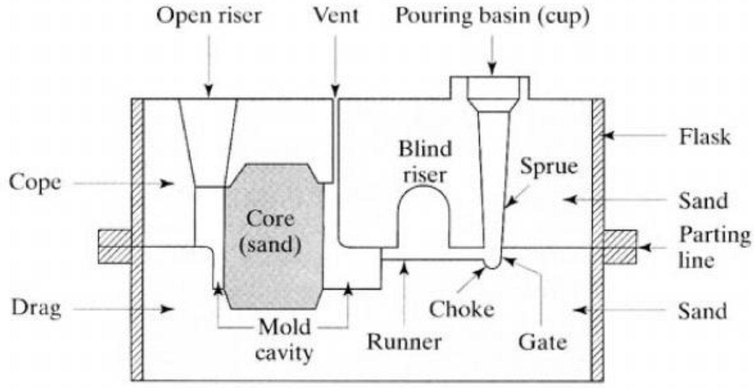
Steps involved in making of a mould: The mould ready for the pouring of molten metal is shown on previous pgein the figure and the steps involved are mentioned in this flow chart.



The different terms related to the sand mould and casting are and shown in the figure:

a. **Core**: A sand shaped insert placed in the mold cavity to produce internal features on the part.
b. **Cope**: The upper half of the sand mold, flask or pattern as referred.
c. **Drag**: The lower half of the sand mold, flask or pattern as referred.
d. **Flask**: A box made of wood or metal to contain the sand.

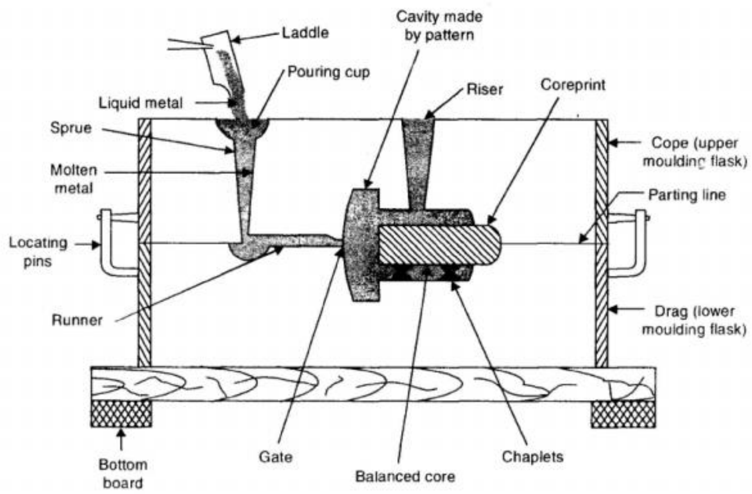
e. **Gates**: Multiple openings in the mold to allow the molten metal to flow into the mold cavity.



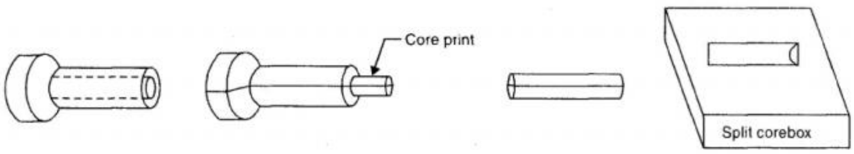
f. **Gating System**: A passage from where the molten metal flows into the mold. The gating system is made up of the pouringcup, sprue, runner and gates.

g. **Mould**: A cavity by which molten metal is shaped into a desired product.

h. **Parting Line**: The line where the top and bottom halves of the sand mold meet.



(a) Two part moulding



(b) Component to be cast (c) Pattern (d) Core (e) Corebox

i. **Pattern**: A representation or replica or duplicate of the final product used to make cavity / imprint of the shape into the sand.

j. **Risers**: Reservoir is called risers inside the mold, which is filled with the molten metal to compensate for shrinkage or "feed" the mold cavity during the solidification process.

k. **Runner**: The horizontal part of the gating system, which supplies molten meatl to the gates.

l. **Sprue**: The vertical part of the gating system, which is connected to the pouring cup at the top and feeds the runner with molten metal at the bottom.

m. **Vent**: An opening in the mold to allow the escape of hot gases.

10. *Why gating system is required in the casting? Explain the purpose of different elements of gating system.

*Draw labeled diagram of a mould box showing pattern, gates, runner and riser. What do you understand by directional solidification of casting? 2011-12, Sem-I

* Define the following terms with neat sketch as used in sand casting: 2008-09, Sem-I,

a) Core b) Core-Prints c) Sprue d) Runner e) Riser

*What is the function of riser in the casting process? 2011-12, Sem-II

ANSWER

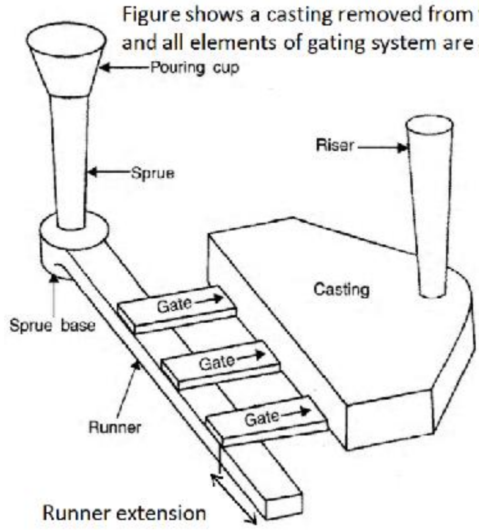
Gating system means the system of all the passages/ ways through which the molten metal enters the mould cavity *i.e.* it includes the pouring basin, runner, gate and riser etc. The manner in which the molten metal enters the mould has a great impact on the quality of the casting produced. So the gating system should be carefully designed and produced.

A good Gating System should meet the following requirements:

a) The velocity of molten metal entering into the mould cavity should be as low as possible, so that there is no erosion of mould.
b) Gating system should ensure the complete filling of the mould cavity.
c) Gating system should prevent the molten metal from entrapping/ absorbing air/steam while flowing through it.
d) Gating system should prevent the formation of oxides.
e) Gating system should prevent the entry of oxides, slag, dross etc.
f) Gating system should assist in directional solidification of the casting.
g) Gating system design should be practicable and economical

Elements of a Gating System(the elements of gating system are shown in figure below)

Figure shows a casting removed from the mould and all elements of gating system are attached



a) **Pouring Basin**: Molten metal is poured into a pouring basin which acts as a reservoir from which it moves smoothly into the sprue. The pouring basin is also able to stop the slag from entering the mould cavity by means of a skimmer.
b) **Sprue**: It is the channel through which the molten metal is brought into the parting plane where it enters the runners and then gates. Sprueshould be conical in shape because:
   i. The molten metal when moving from top of the cope to the parting plane gains in velocity so requires a smaller area of cross section for the same amount of metal to flow at the bottom.
   ii. Liquid tries to attain the minimum area at the bottom so there may be air gap between the liquid jet and sprue wall so air inspiration will be there which will causes problem.
c) **Sprue Base/ Well**: This is a reservoir for metal at the bottom of the sprue to reduce the momentum of the molten metal.
d) **Runner**: It is generally located in the horizontal plane (parting plane) which connects the sprue to gates.
e) **Runner Extension**: This extension is provided to trap the slag in the molten metal.
f) **Gates**: These are the openings through which the molten metal enters the mould cavity.
g) **Riser**: Most of the foundry Metals/ alloys shrink during solidification. As a result of this volumetric shrinkage during solidification, voids are likely to form in the castings so these (voids) needs the additional molten metal. Hence a reservoir of molten metal is to be maintained from which the metal can flow readily into the casting when the need arises. The riser work as reservoirs. These may be blind or open type.

Functions of Riser: Metals and their alloys shrink as they cool and solidify. It creates a partial vacuumwithin the casting.Partial vacuum will lead to a shrinkage void.This shrinkage void will grow and form shrinkage cavity, if extra liquid metal from outside the mould (cavity) is not supplied.

a. The primary function of the riser (attached with the mould) is to feed the metal to the solidifying casting so that shrinkage cavities are not formed. Shrinkage is a very common casting defect.

b. A riser permits the escape of air and mould gases as the mould cavity is being filled with the molten metal.
c. A riser full of molten metal indicates that the mould cavity has already been completely filled up with the same.
d. Riser promotes directional solidification.

Advantage of riser: A casting solidifying under the liquid metal pressure of the riser is comparatively sound.

Directional solidificationrefers to the process of solidification when the casting is being cooled. It is desired that the cooling starts from the bottom and continues in gradual manner to the top. The use of CHILLS is made to achieve this. Chills are the made of metals and accelerate the cooling rate, so that cooling progresses gradually.

11. Write two types of casting defects. 2010, Sem-I/II, Spl-carry

ANSWER

Defect can be defined imperfection or a fault. Casting defects are the defects developed in the casting during the process of making the casting; they occur because some steps in the manufacturing cycle are not properly controlled.

The factors, which are normally responsible for the occurrence of these defects are:

a. Design of casting
b. Design of pattern equipment
c. Molding and core making equipments
d. Mould and core material
e. Gating and risering
f. Melting and pouring.
g. Melting and core making techniques
h. Metal composition

Various casting defects may be categorized as:

a) Metallic projections: jointsflash or fins: These are formed where two parts of the gating system meet and intersect.
b) Cavities: Blow holes, pinholes: These are formed as holes or cavities because of gas entrapment of excess of moisture.
c) Discontinuities: Shrinkage, cracks: these are formed because of improper temperature of molten metal, discontinuity during the pouring and improper directional cooling.
d) Defective surface: Flow marks: These are formed near the side wall of casting because of metal erosion during the filling process.
e) Incomplete casting: Poured shortThe molten metal poured is less in quantity.
f) Incorrect dimension or shape: Distortion
g) Inclusion: Metallic inclusions

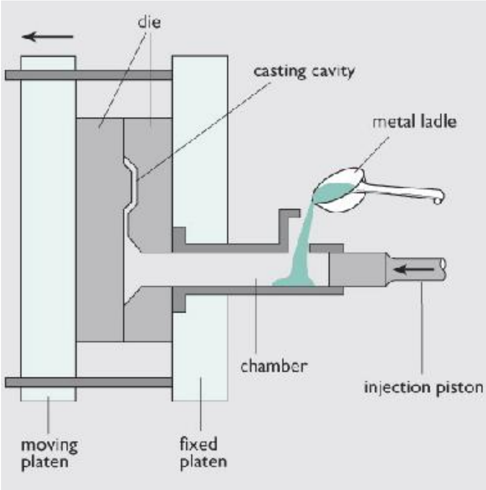
12. What do you understand by die casting? And explain the hot chamber die casting and write the advantages of die casting process.

*Write short notes on any three of following: a) Soldering b) Brazing c) Centrifugal casting d) Die casting process. 2010-11, Sem-I

ANSWER

In die casting, the molten metal is forced into permanent mould (die) cavity under pressure or due to gravity (then known as gravity die casting). The pressure varies from 20 to 2000 kgf/cm2 and is maintained till solidification stage is reached. The pressure is generally obtained by compressed air or hydraulically.

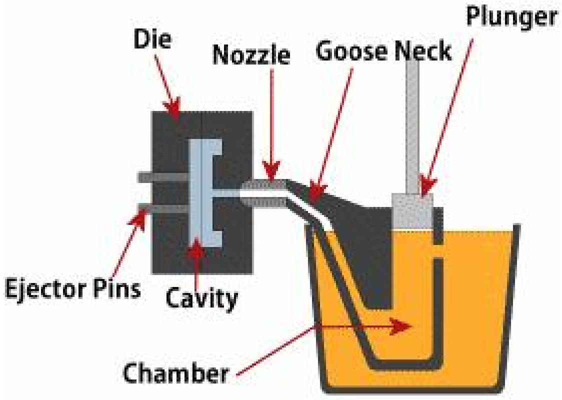
Cold Chamber Die Casting



In cold chamber die casting, the metal is melted separately in a furnace and transferred by means of small hand ladle. After closing the die, the molten metal is forced into the die cavity by a hydraulically operated plunger and pressure is maintained till solidification. These machines can either have vertical plunger or horizontal plunger for forcing molten metal into die. These machines are widely used for casting of aluminum alloys and brasses.

Hot Chamber Die Casting

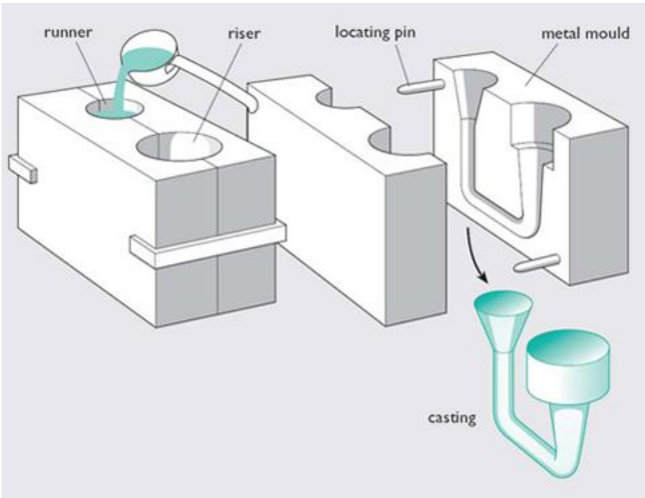
In hot chamber die casting machines, the melting unit is integral part of the machine itself that is why it is called hot chamber die casting machine.The molten metalneeds less pressure to force the liquid metal into die.It has further two types of arrangements:



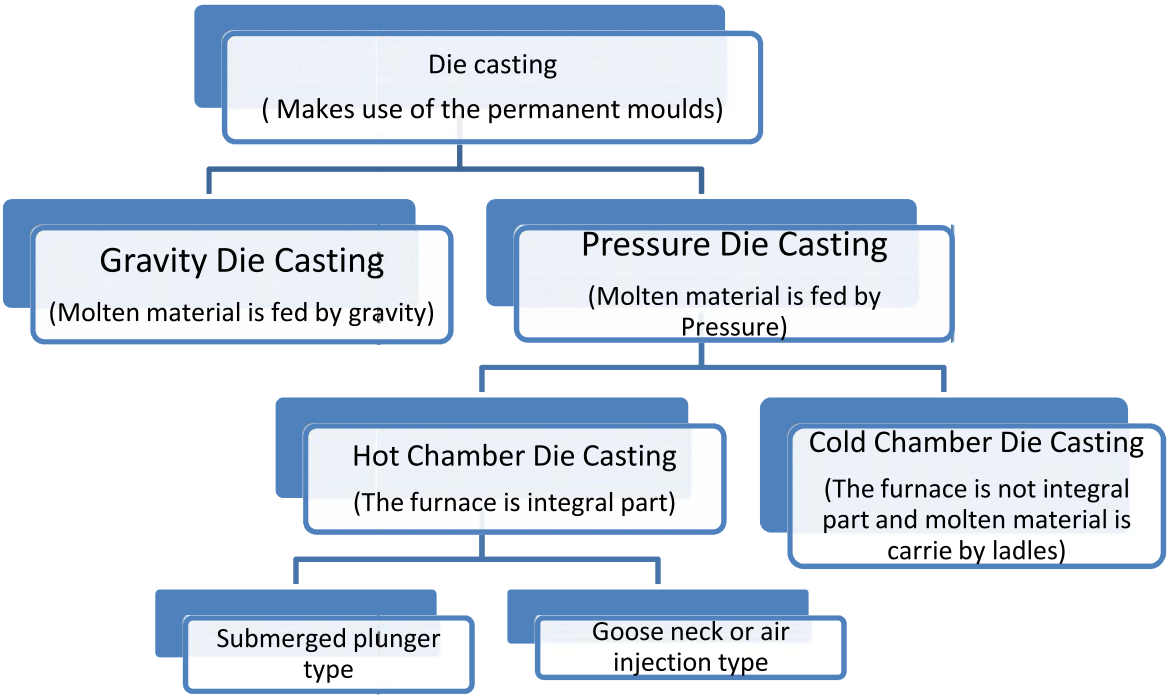
a) Goose neck or air injection type (or direct air pressure).
b) Submerged plunger type.

Submerged plunger type

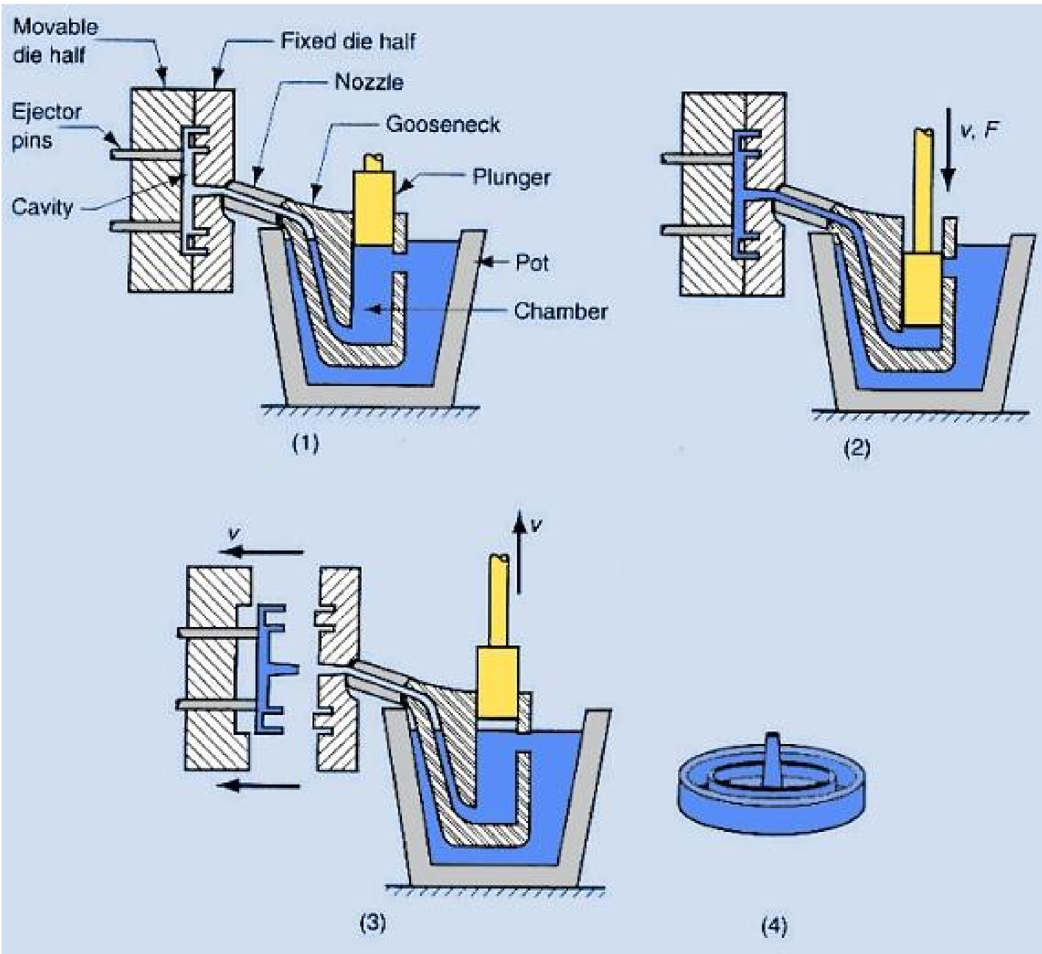
In this machine, the goose neck type container always remains immersed in the metal pot. The molten metal from the metal container is forced inside the die with the help of a plunger submerged in the molten metal and operates hydraulically. When the plunger moves up, the molten metal comes up and fills the cylinder and when the plunger moves down, the metal is forced into the die. The movable die platen is synchronized such that when plunger is moving up, the movable die platen moves away and the casting is removed. The figure presents the steps involved the hot chamber die casting.



Gravity die casting



Hot chamber die casting showing the different steps



13. ***What are different foundry equipments, explain cupola furnace and its operation. What are the different zones of cupola furnace? Explain with a neat sketch.**

*Write short notes on any three of following: a) Plastics b) Ceramics c) MIG d) Cast Iron e) Cupola Furnace f) Carbon steels. 2010, Sem-I/II, Spl-carry

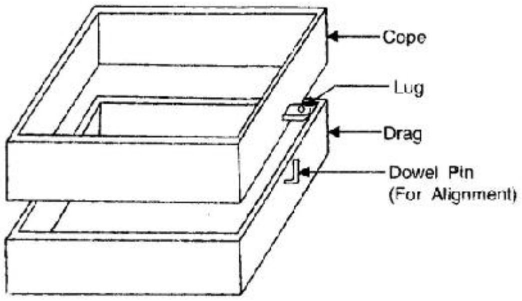
* Classify and describe different tools and equipments used in the foundries. 2010, Sem-I/II, Spl-carry

With the help of neat diagram, explain the working of cupola. Also write its limitations. 2009-10, Sem-I

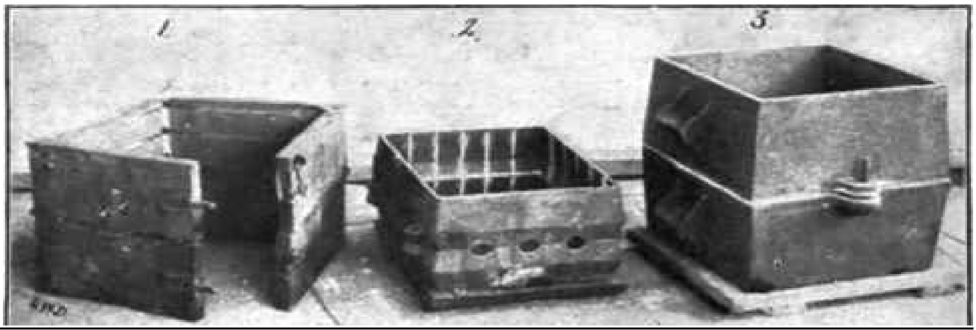
* Draw a neat sketch of cupola furnace and explain working. 2011-12 Spl-Carry

ANSWER

A foundry is a place where castings are produced, and for performing different operations of mould making, like pattern making, machining, lifting, shifting, inspecting, testing etc., a variety of hand tools and equipments are needed. The tools and equipments can be classified as:



Two piece molding flask OR box



Molding flasks

Cupola Furnace

Cupola is a furnace generally used for production and melting of cast iron and other metals can also be melted. The **advantages** of cupola are as:

a) The cost of melting is low.
b) The control of chemical composition is better.
c) Temperature control is easier.
d) Molten metal can be tapped from the cupola at regular intervals.
e) It consumes the easily available and less expensive fuels.
f) Cupola furnace has low initial cost as compared to other furnace of same capacity.
g) Continuous production can be obtained from the cupola furnace once started.
h) Less floor space requirements as compared to other furnaces of same capacity,
i) It has nigh degree of efficiency.

The main disadvantage of Cupola is that it is not possible to produce iron below 2.8% carbon in this furnace. So for producing white cast iron (containing below 2.7% carbon) the duplex process is employed. Moreover, molten iron and coke comes in contact with each other, certain elements such as Si, Mn are lost while others are included in the metal.

Foundry Eqipments

Hand tools

1. Showel
2. vent wire
3. Trowels
4. lifters
5. Swab
6. Rammers
7. Sprue pin
8. Clamps, etc.

Moulding boxes OR Flask

The boxes used in sand moulding may be made of wood, cast iron or steel.

It is a container in which sand is packed and rammed.

Moulding boxes consists of One, two or more parts. The upper part is called 'cope'. The lower part is called 'drag' and intermediate parts are called 'cheeks'. These are provided with suitable clamps to help in locating the right position during casting.

Pouring equipments

1. Ladles
2. Crucible

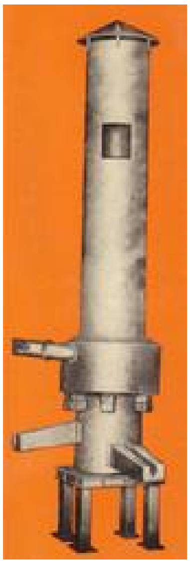
Ladles are used to transport molten metal from the melting furnace to the mould.

Melting equipments

1. Cupola
2. Induction furnace etc.

Moulding machines

1. Jolt Machine
2. Squeezing Machine



Construction and description of Cupola Furnace (Shown in the figure below)

Shell and refractory brick lining: Shell is a vertical and cylindrical in shape and made of steel. It is lined inside with refractory bricks and clay. Refractory bricks and clay used for cupola lining consist of silica (SiO_2) and Alumina (Al_2O_3). Cupola diameter varies from 1 to 2 meters and the height is 4 to 6 times of the diameter.

Foundation: The shell is mounted either on a brick works foundation or on steel columns. The bottom of the shell consists of a **drop bottom door**, through which debris consisting of coke, slag etc. can be discharged at the end of a melting.

Tuyere: Air for combustion of fuel is delivered through the tuyeres which are provided at the height of between 0.6 to 1.2 meters above the working bottom or sand bed.

Wind Belt or box: The air is delivered to the tuyere from a wind belt which is a steel plate duct mounted on the outer shell of the cupola.

Blower: A high pressure fan or blower supplies the air to the wind belt through a blast pipe.

Slag Hole: It is located at a level below (about 250 mm) the centers of the tuyeres. It is used to remove or tap the slag.

Charging Door: It is situated above (3 to 4 meters) the tuyere level. Through this hole, metal, coke and flux are fed into the furnace in layers.

Chimney or Stack: The shell is usually continued for 4 meters to 5 meters above the charging hole to form a chimney.

Zones in a Cupola

The entire section OR height of the cupola is divided into the following zones:

Crucible Zone OR Well: It is between top of the sand bed and bottom of the tuyeres. The moltenmetal accumulates here

Combustion or Oxidizing Zone: It is situated normally above (150 to 300 mm) the tuyere zone. Heat is evolved in this zone because of the following oxidation reactions:

$$C + O_2 \rightarrow CO_2 + Heat$$
$$Si + O_2 \rightarrow SiO_2 + Heat$$
$$Fe + O \rightarrow FeO + Heat$$
$$2Mn + C_2 \rightarrow 2MnO + Heat$$

Reducing zone: This zone starts from the top of the combustion zone and isupto the top of the coke bed. In this zone, the reduction of CO_2 to CO occurs and temperature drops to about 1200°C.

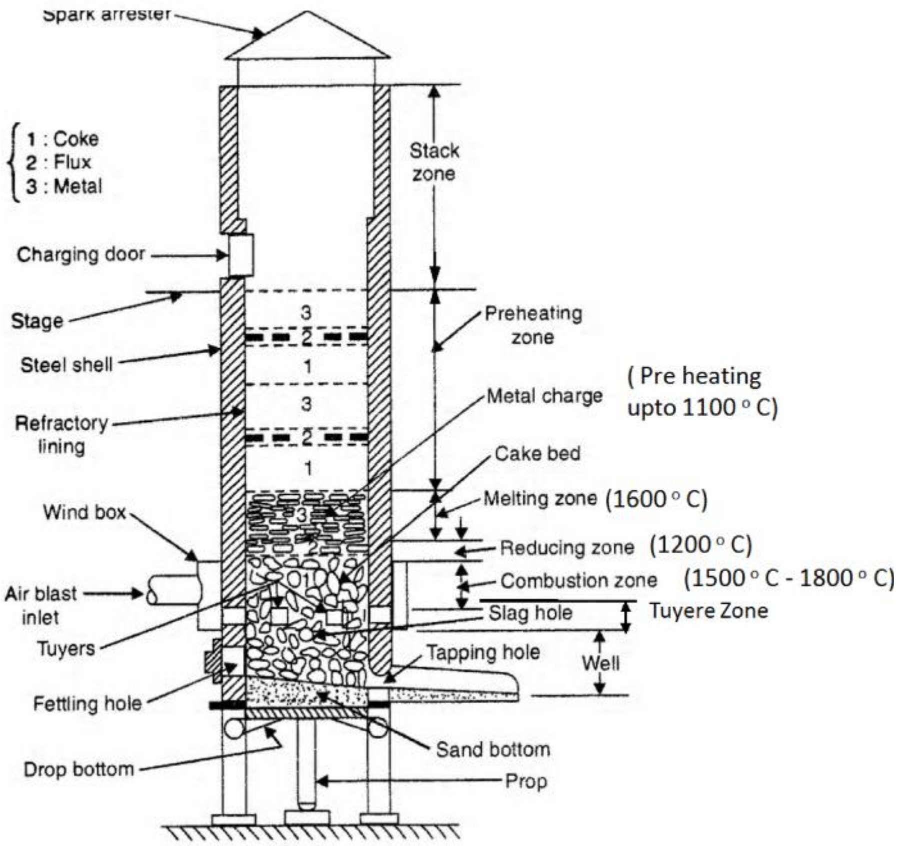
$$CO_2 + C\,(Coke) \rightarrow 2CC - Heat$$
$$(In this reaction heat is absorbed thus temperature falls)$$

Melting Zone: The zone starts from the top of the coke bed and extends upto a height of 900 mm. The temperature in this zone is very high approx. 1600-1800^{O}C.

$$3Fe + 2CO \rightarrow Fe_3C + Co_2$$

Preheating Zone or Charging Zone: It starts from the top of the melting zone and extends upto the charging door. Charging materials are fed in this zone and get preheated.

Stack Zone: It starts from the charging zone and extends upto the top of the cupola. The gases generated within the furnace are carried to the atmosphere by this zone through chimney.



Cupola furnace: showing internal cross section details temperatureswith zones

Operation of Cupola Furnace

Preparation of Cupola: Clean out the slag and repair the damaged lining with the mixture of fire clay and silica sand. After this bottom doors are raised and bottom sand is introduced. The surface of the sand bottom is sloped from all directions towards the tap hole. Slag hole is also formed to remove the slag.

Firing the Cupola: A fire of soft wood is ignited on the sand bottom. After proper burning of wood, coke is added to a level slightly above the tuyeres. Air blast at a slower rate is turned on. After having red spots over the fuel bed, extra coke is added to the predetermined height.

Charging the cupola: Once proper burning of fire starts in the cupola, alternate layers of pig iron (scrap), coke and flux (limestone) areadded from the charging door. Flux will be added to prevent the oxidation as well as to remove the impurities. (Flux is 2 to 3% of the metal charge by weight). Metal (pig iron, steel scrap) flux and coke are added in alternate layers until the cupola is full to the charging door.

Soaking of iron: After the furnace is charged fully the metal charge starts heating slowly.

Opening of Air Blast: At the end of the soaking period, the air blast is opened. Tap hole is closed to accumulate the sufficient amount of metal. The rate of charging should be equal to the rate of melting so that the furnace remains full.

Pouring of Molten Iron: When sufficient metal collects in the well, the slag hole is opened, and the slag is removed;After this tap hole is opened to collect the molten metal.

Closing the Cupola: At the end of the operation, the charge feeding is stopped, air supply is cut off and the prop is removed (when the cupola is in operation, the bottom door is supported by a bottom prop so that it may not collapse due to the large weight of the charge, coke etc., it carries). As soon as the prop is removed the door swing down providing a clear space for the coke fire, residue of the molten metal with slag and the sand bed to fall down and, thus, the fire inside ceases gradually.

The ashes can be cooled by water.

14. *What are the desirable properties of molding sand, explain all.

*What are the important properties which are essential in good molding sand? Explain in detail.
2010-11, Sem-II

*Explain different properties of molding sand. 2010-11, Sem-I

*What are the main ingredients of molding sand? List the important properties of molding sand.
2011-12, Spl-Carry

*List various important properties of molding sand. Explain the importance of each property.
2011-12, Sem-I

ANSWER

Good and propermolding sand must possess the following properties:

a. **Porosity or permeability**: This is the property of sand because of which the sand allows the gasses to pass through it.Molten metal always contains a certain amount of dissolved gases which are evolved when the metal freezes. Molten metal also coming in contact with the moist sand; generates steam or water vapors. Thus to provide a path for free escape of the gases, the molding sand should be permeable or porous. If these gases and water vapors evolved by the molding sand don't find opportunity to escape completely through the mould, they will form gas holes and pores in the casting called porosity defect. Sands which are coarse or have rounded grains exhibit more permeability. Soft ramming and clay addition in lower amount also improves permeability. Hard ramming and addition of more binder decreases permeability. Addition of more water decreases the permeability.

b. **Flow-ability (Plasticity)** is the ability of the molding sand to get compacted to a uniform density. Flow-ability assists molding sand to flow and pack all around the pattern and take up the required shape. Flow ability increases as clay and water content increases. The sand must retain its shape when the pressure is removed.

c. **Refractoriness**: It is the ability of the molding sand to withstand high temperature of the molten metal without fusion, cracking or buckling.Refractoriness is measured by the sinter point of the sand rather than its melting point.The degree of refractoriness depends upon the quartz content and the shape and grain size of the particles. The higher the quartz content, rougher the grain shape, higher is the refractoriness of the sand.

d. **Adhesiveness**: It is that property of the sand due to which it adheres or clings to another body or material (i.e., sides of the molding box). It is due to this property that the sand mass can be successfully held in a molding box and it does not fall out of the box when it is tilted (roll over).

e. **Cohesiveness**: This is the ability of sand particles to stick together. It may be defined as the strength of themolding sand. It is of three types : *

    I. **Green Strength**: The property (strength) of the sand in its green or moist state is known as green strength.

    II. **Dry Strength**: The strength of the sand that has been dried or baked is called dry strength.

    III. **Hot Strength**: After the moisture has evaporated, the sand may be required to possess strength at some elevated temperature (above 100°C). The strength of the sand at elevated temperature is called hot strength.

f. **Collapsibility:**It is that property of the sand due to which the sand mould breaks (collapse) automatically (or with very less forces) after the solidification of the casting occurs.If the mould or core does not collapse easily, it may restrict free contraction of the solidifying metal and cause the same (casting) to tear or crack.If the molding sand have more strength, then breaking of molding sand around the casting becomes difficult or in other sense molding sand have a poor collapsibility.Addition of binders increases the adhesiveness and cohesiveness i.e., strength of the molding sand but decreases the collapsibility of the molding sand. So the molder has to add the optimum amount of the binder in the molding sand so that molding sand have required strength as well as required collapsibility.

g. **Durability:**The molding sand should possess the capacity to withstand repeated cycles of heating and cooling during casting operations. This ability of sand is known as durability.

h. **Fineness**: Finer sand mould (grain size small) resists metal penetration and produces smooth casting surface.Fineness and permeability are inversely proportional. They must be balanced for good results.

i. **Bench Life**: It is the ability of the molding sand to retain its properties during storage or while standing (i.e., in case of any delay).Sometimes molding sand gets hardened because of the exposure to the atmospheric air i.e., molder is not able to use that sand. So sand should have good bench life i.e., once it is prepared, it can be used for long hours.

j. **Co-efficient of expansion**: Molding sand should possess low coefficient of expansion.

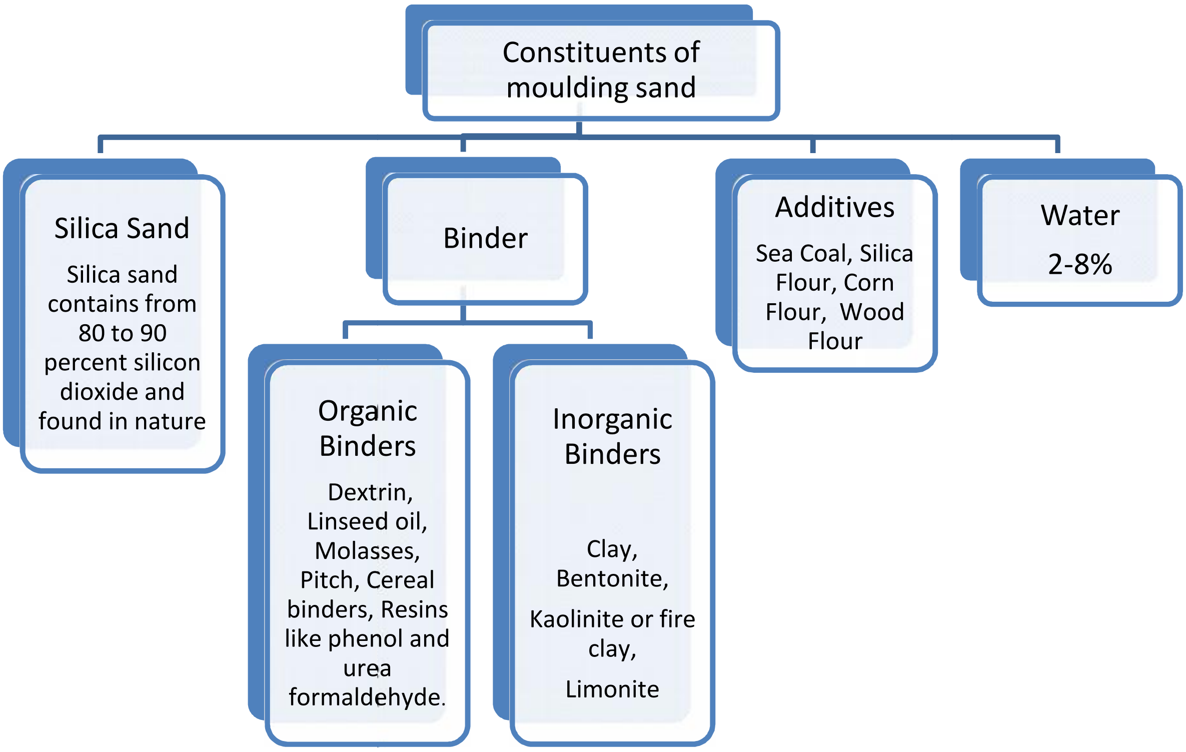
k. **Chemical stability**: Molding sand should be chemically stable/ neutral.

l. **Reusability**: Molding sand should be reusable.

m. **Cheap** and **Easy Availability.**

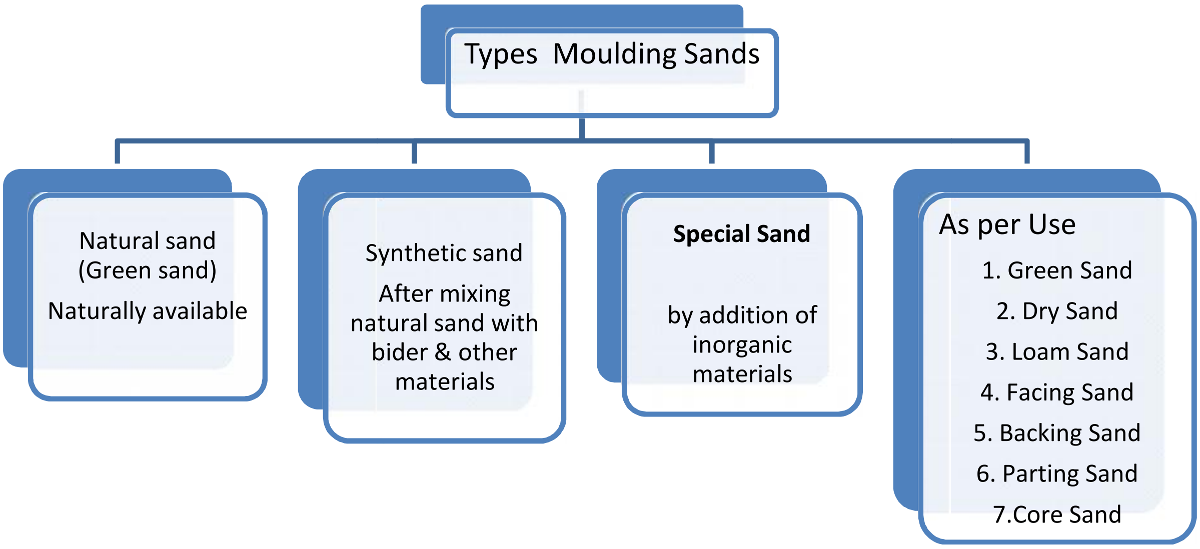
The principle **constituents OR ingredients** of molding sand are:

Silica Sand: The silica sand is found in nature on the bottoms and bank of rivers, lakes and large bodies of water.It is a product of the breaking up of quartz rocks or the decomposition of granite, which is composed of quartz and feldspar.
Binder: The purpose of adding a binder to the molding sand is to impart the sufficient strength and cohesiveness. However, it produces an adverse effect on the permeability of sand mould. Cement, linseed oil, clay, etc.
Additives: Additives are those materials which are added to the molding sand to improve the existing properties of sand.Corn flour, graphite, wood flour, etc.**Water**: Naturally available and is present from 2-8%.



Effect of particle size on surface quality of casting

Fine grains of sand produce good surface finish but give low permeability. These are use full for small and intricate castings. Medium size sand is suitable for normal casting in bench working. Coarse grained sand is used for large castings and it posses good refractoriness but the surface quality is not good.



Types of molding sand

1. **Natural Sand (Green sand)**
   These sands are taken from river beds and are dug from pits and purely natural. They possess an appreciable amount of clay (acts as a binder) and moisture.Natural molding sands are also obtained by crushing and milling soft yellow sand stones. During milling operation, clay aggregates breaks down and are uniformly distributed over the sand grains.Due to their low cost and easy availability, these are used for most of the ferrous and non-ferrous castings.
2. **Synthetic Sand**
   It is artificial sand obtained by mixing relatively clay free sand, binder and other materials as required. It is better molding sand as its properties can be easily controlled by varying the mixture content.
3. **Special Sand**
   It contains the mixtures of inorganic compounds. Cost of these sands are more but they offer high temperature stability, better cast surfaces etc.Special sands used are zircon, olivine.

The **molding sands according to their use**, are further classified as below:

1. **Green Sand**: The sand in its natural or moist state is called green sand. It is a mixture of silica sand with 18 to 30 percent clay, having total amount of water 6 to 8 percent.The molten metal is poured in the green sand moulds without any prior baking (Heating).It is used for simple, small and medium size castings.
2. **Dry Sand**: The green sand moulds when baked or dried before pouring the molten metal are called dry sand mould. The sand in this condition is called dry sand.
   Dry sand has more strength, rigidity and thermal stability as compared to green sand.
   These moulds are used for large and heavy castings.
3. **Loam Sand:**Loam sand contains much more clay as compared to ordinary molding sand. The clay content is of the order of 50%.Sweep or skeleton patterns may be used for loam molding.It is used for loam molding of large grey iron castings.
4. **Facing Sand**:
   This sand is used directly next to the surface of the pattern and comes in contact with the molten metal when the mould is poured.It is fresh sand i.e., without the addition of used

sand.It must possess high strength and refractoriness.The layer of facing sand in a mould usually ranges from 20 to 30 mm.

5. **Backing Sand**:It is the sand which backs up the facing sand. It is the floor sand which is repeatedly used.Backing sand has black colour due to the addition of coal dust and burning on coming in contact with molten metal.Before use, the backing sand should, however, be cleaned off the foreign matter like fins, nails etc.

6. **System Sand**:System sand is one which is used in a mechanical sand preparation and handling system (mechanized foundries).In mechanized foundries, no facing sand is used, rather the complete otherwise used sand is cleaned and reactivated by the addition of waters, binders and special additives.Since the whole mould is made of this system sand, the strength, permeability and refractoriness of this sand must be higher than those of backing sand.

7. **Parting Sand**:This sand is clay free sand and consists of dried silica sand, sea sand or burnt sand.It is used to keep the green sand from sticking to the pattern and also to allow the sand on the parting surface of the cope and drag to separate without clinging.

8. **Core Sand**:The sand which is used for the preparation of the cores is called core sand. It is also called oil sand.It is the silica sand mixed with linseed oil or any other oil as binder.

******* UNIT-IIENDS ********

UNIT-III

1. *Describe the basic working principle and important parts of Lathe machine. What are the different operations performed on lathe machine? Explain each of them.

*Differentiate between shaper and planer. With the help of schematic sketch, explain the basic components of lathe machine. 2009-10, SEM-I

*Draw a labeled diagram of lathe machine. List various operations performed on lathe. 2011-12, Sem-I

*List the various types of lathes available giving salient features of each. What are the uses of:
a) Lead screw b) Feed rod c) Tailstock d) Half nut e) Compound slide in lathe
2010-11, Sem-I, Spl-Carry

*Explain the five main parts of a lathe. 2010, Sem-I/II, Spl-Carry

With help of neat sketch, explain the basic components of lathe machine and various operations performed on it.
2008-09, Sem-I/II, Spl-Carry,2009-10, Sem-II

*How Taper turning is done lathe machine? Explain in detail. 2011-12, Spl-Carrry

ANSWER

Machining may be defined as the operation or process of removing the excess metal by means of a cutting tool, in the **machine tool;** to obtain the desired shape, size and surface finish.

A machine, which performs the material removal operation with tools, to produce desired shape and size of the work-piece, is known as **machine tool**.

Purpose of Machine tools:

a) To improve production rates
b) To reduce cost of production
c) To reduce fatigue of workers
d) To achieve better quality
e) To reduce wastage.

Basic Conditions for machining (Machining Principle)

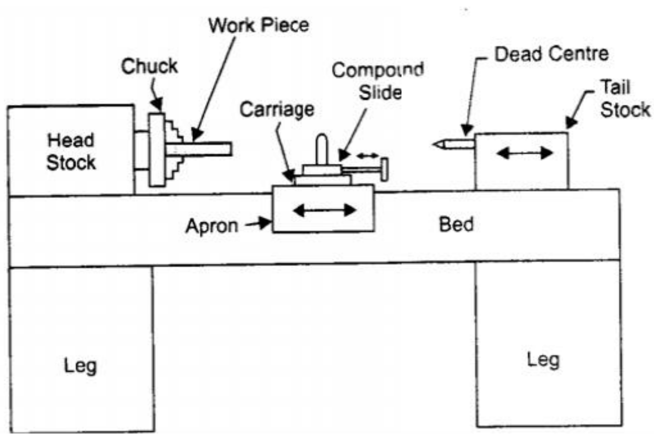
a) The material of tool should be harder than metal to be machined
b) Tool should be strong and held rigidly
c) Shape of tool is designed properly
d) There must be a relative movement between the tool and work piece

Basic relative movements/ motions the tool and work-piece must a have relative movement against each other for the machining to take place and these movements/ motions may be Circular (Rotary) or Reciprocating (Straight line).

Lathe machine

The lathe machine is one of the earliest machine tools and one of the most versatile and widely used as machine tool for performing the machining operations.

Principle: The job to be machined is held and rotated in a lathe chuck; a single point cutting tool is advanced which is stationary against the rotating job. Since the cutting tool material is harder than the work-piece, so metal is easily removed from the job.



The principal parts of lathe are:
a) Bed b) Head stock c) Tail stock d) Carriage e) Feed mechanism f) Legs

1) Bed

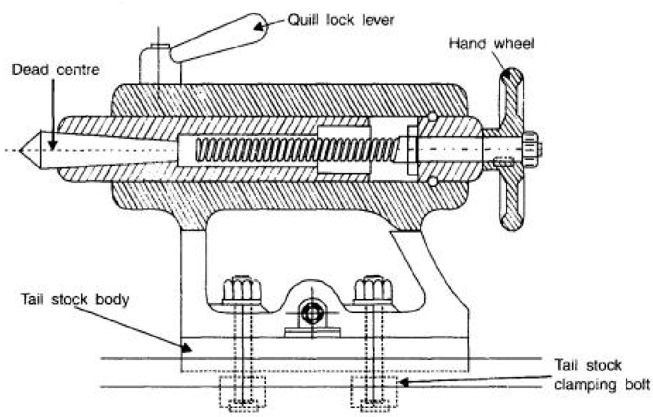
It is the base or foundation of the lathe. It is heavy, rugged and single piece casting made to support the working parts of the lathe. On the top of the bed, there are two sets of guide ways—outer ways and inner ways. Outer ways is for the carriage and the inner ways for the tailstock. The guide ways are of two types wide flat guide ways and inverted V-guide ways. With flat guide ways, chip accumulation is a problem but life is more but for V-guide ways combination of both the flat and inverted V-guide ways are used.

2) Headstock

The headstock is permanently fastened on the inner ways at the left side of the bed. The headstock spindle, a hollow cylindrical shaft supported by bearings, provides a drive from the motor to the work holding device. A live centre and sleeve, a face plate, or a chuck can be fitted to the spindle nose to hold and drive the work. All lathes receive their power with the help of a head stock. The power transmission device may be step cone pulleys or a geared head drive.

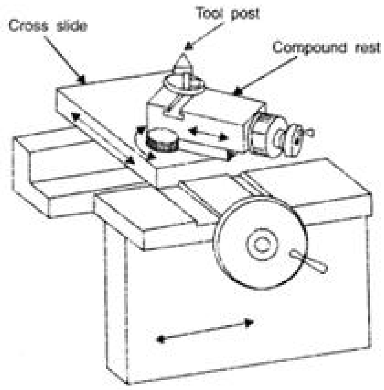
3) Tailstock

It is situated at the right hand end of the bed and is mounted on the inner guide ways. It can be moved towards or away from the operator. Tailstock can be locked in any position along the bed of the lathe by tightening the clamp lever or nut. The tailstock spindle is a hollow tapered shaft (left side end). It can be used to hold the dead centre or other tools having the same tapers such as drills and reamers. The tailstock hand wheel is used to move the tail stock spindle in or out of the tailstock casting and a spindle binding (clamping) lever or lock handle is used to hold the tailstock spindle in a fixed position.



4) Carriage

The carriage controls and supports the cutting tool. By the help of this, tool moves away or towards the headstock. It has five major parts



Carriage

a. **Saddle**: It is an H-shaped casting mounted on the top of the lathe ways so it slides along the ways between the headstock and tailstock. On the top it supports the cross slide.
b. **Cross Slide**: It is mounted on the saddle. The cross slide has a dovetail that fits over the saddle
c. **Dovetail**. It provides the cross movement (towards or away from the operator) to the cutting tool. It supports the compound rest.
d. **Compound Rest**: It is mounted on the top of the cross-slide and is used to support the cutting tool. It can be swiveled to any angle for taper turning operations.
e. **Tool Post**: It is mounted above the compound rest. A T-slot is machined in the compound rest to accommodate the tool post. It clamps the cutting tool or cutting tool holder in a desired position.
f. **Apron**: It is fastened to the saddle and contains the feeding mechanism. The apron hand wheel can be turned by hand to move the carriage along the bed of the lathe. The automatic feed lever is used to engage power feeds to the carriage and the cross slide.

5) Feed Mechanism

The movement of the tool relative to the work is termed as **feed**. The combination of different parts to ensure the feed is known as feed mechanism. A lathe tool may have three types of feed.

a) **Longitudinal Feed**: When the tool moves parallel to the work i.e. towards or away from the headstock.

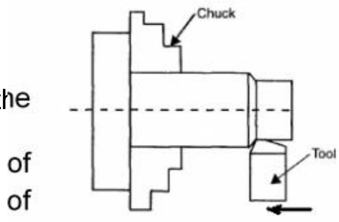
b) **Cross Feed**: When the tool moves perpendicular to the work i.e. towards or away from the operator.
c) **Angular Feed**: When the tool moves at an angle to the work. It is obtained by swiveling the compound slide.

Cross and longitudinal feed are both hand and power operated but angular feed is only hand operated.

a) **Lead screw** is used for cutting of the threads in combination with the split nut. Split nut **(Half nut)** ensures that carriage moves without any slippage.
b) **Feed Rod** is used for powered longitudinal movement of the carriage and cross slide.

6) Legs

Legs support the entire weight of the machine. These are made of cast iron and may be with the lathe bed. These are firmly secured to the foundation by bolts.

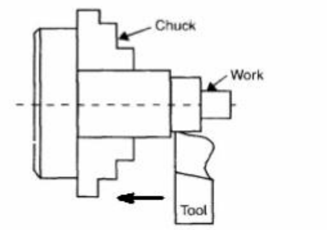


Plain Turning.

Lathe machine operations

The most common operations which can be performed on a lathe machine are described below:

a. **Plain Turning**: It is an operation of removing excess amount of material from the surface (cylindrical surface or circumference) of the cylindrical workpiece. This operation is done to reduce the diameter of the workpiece.
b. **Step Turning**: It is an operation of producing various steps of different diameters in the workpiece.

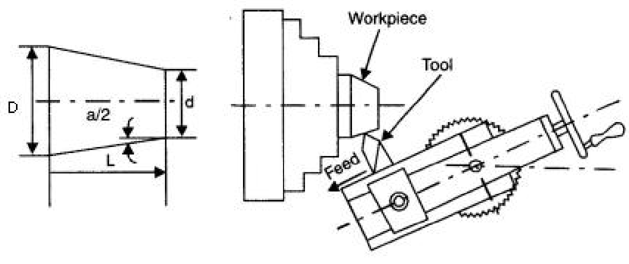


Step Turning.

c. **Taper Turning**: It is an operation of producing an external conical surface on a work-piece. Taper turning can be performed by the tail stock set over method, by swiveling the compound rest, or using the taper turning attachment. Most commonly used is by swiveling the compound rest.

$$\tan \propto = \frac{(D-d)}{2L}$$

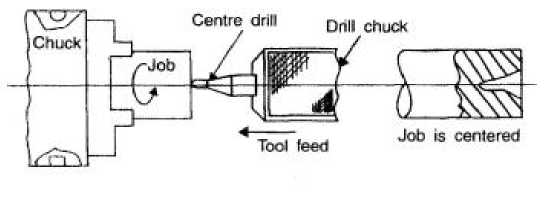
Where, $\propto$ = angle of swiveling of compound slide
D= Larger diameter
d= small diameter
L= Length of the bar



Taper Turning.

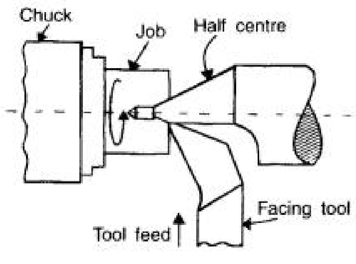
Steps Involved In the Taper Turning of a bar(How taper turning is done?)

(ii) Fix the bar in the chuck of head stock
(iii) Fix the single point cutting tool on the tool post
(iv) Adjust the taper angle on the compound rest by loosening the two nuts on the cross slide and tighten them
(v) Now adjust the depth of cut and start the lathe machine
(vi) Move the wheel on the compound rest to give the feed to the cutting tool
(vii) Repeat the procedure (iv and v)till the required taper is obtained



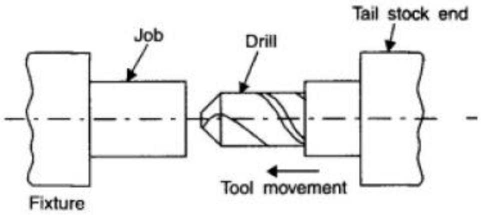
Centering.

d. **Centering**: If the chuck is three jaws type, then centering is not required because it is self-centered chuck. But for four jaws chuck, centering is needed. Centre is located by means of using a combination set or using a bell centre punch. After locating the centre, centre holes are produced by using a countersunk tool or drill.



Facing.

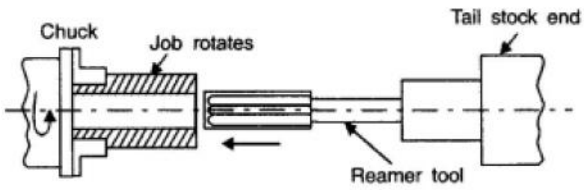
e. **Facing**: Facing is the operation of machining the ends of a piece of work to produce the flat surface. The facing tool is fed from the centre of the workpiece towards the outer surface or from the outer surface to the centre, with the help of a cross slide.



Drilling.

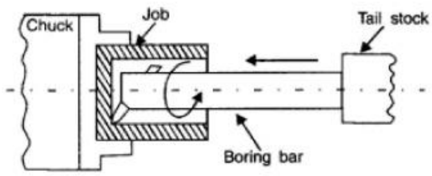
f. **Drilling**: It is an operation of making a round hole in the workpiece with the help of a drill. The workpiece is held in a chuck and the drill is held in the tailstock.

The drill is fed manually, into the rotating workpiece, by rotating the tailstock handwheel.



Reaming.

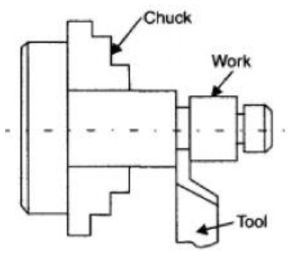
g. **Reaming**: It is an operation of finishing the previously drilled role. In this case, reamer is held in the tailstock and is fed into the hole by rotating the tailstock hand wheel.



Boring.

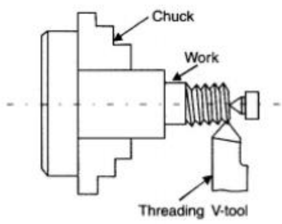
h. **Boring**: It is an operation of enlarging a hole already made in a workpiece. In this, boring tool is held in the tool post and is fed into the work similarly as in plain turning.

i. **Undercutting or Grooving**: It is an operation of reducing the diameter of a workpiece over a very narrow surface. In this case, the proper cutting tool is fed into the revolving work upto the desired depth at right angle to the workpiece.



Undercutting or Grooving.

j. **Threading**: Both external and internal threads can be cut on lathe. For this operation some lathes are provided with quick change gear box, which enables the establishment of the required speed ratio very quickly. A chart is provided on the gearbox, which carries the complete information of speed and recommended feed. With the help of gear change lever, required speed and feed can be obtained.



Threading.

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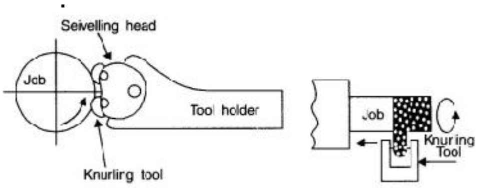


Knurling

k. **Knurling**: Knurling produces a regularly shaped, roughened surface on a workpiece. The knurling tool is pressed against the workpiece, which causes the slight outward and lateral displacement of the metal so as to form the knurl, a raised diamond pattern.

2. **With the help of schematic sketch, describe the basic working principle milling machine. Differentiate between up-milling and down milling.** 2008-09, SEM-II

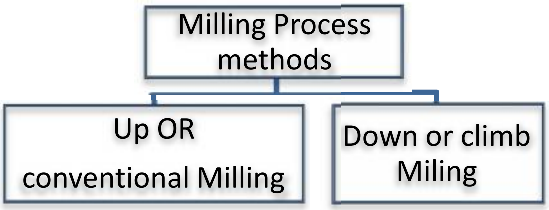
Draw a labeled diagram of universal milling machine. Also list various operations performed on it. 2010-11, Sem-II

Explain the working principle and operations of a milling machine with neat diagram. 2010-11, Sem-I

What do you mean by gang milling? 2011-12, Sem-II

Differentiate between down milling and up milling. What are the work holding devices used in milling? Explain their relative application and disadvantages. 2011-12, Sem-II

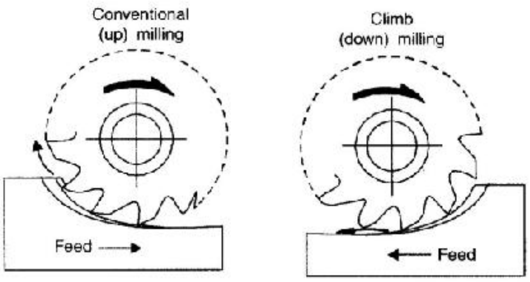
ANSWER



<u>Milling</u> <u>is a process of metal removal/ cutting by means of a multi-teeth (point) rotating tool called milling cutter. The form of each tooth of cutter is same as that of the single point cutting tool, used in the lathe machine</u>. Milling process is of two types:

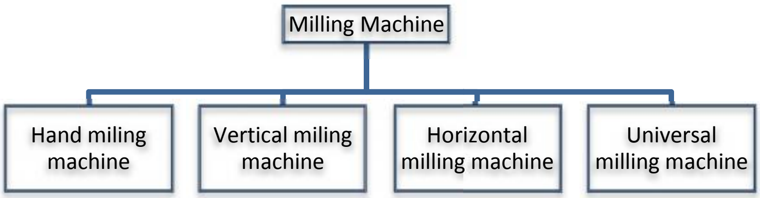
<u>Up Milling</u><u>: In up milling also known as conventional milling, the cutter rotates against the direction in which the work is being fed.</u>

<u>Down Milling</u><u>: In down milling also known as climb milling; the cutter rotates in the same direction in which the work is being fed.</u>



Up Milling and Down Milling.

Working principle of milling process is that the work is rigidly held by the clamps (Vice) on the table and a revolving milling cutter mounted on the arbor OR spindle removes the metal. The cutter revolves at high speed and each tooth of the milling cutter removes the metal in the form of chips. The work may be fed to the cutter, longitudinally, transversely or vertically, the cutter is set to a certain depth of cut by raising the table.

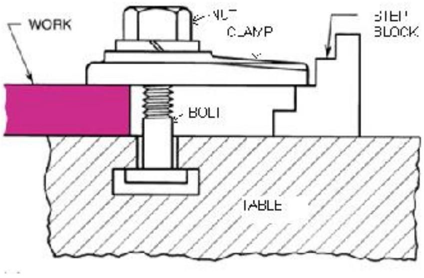


Milling machine is a machine tool in which metal is removed by means of a revolving cutter with many teeth (multipoint cutting tool known as **milling cutter**). Milling machines are of many types and the **universal milling machine** has a swivel-able housing on which the table is mounted.

<u>Differentiation / Comparison between up milling and down milling</u>

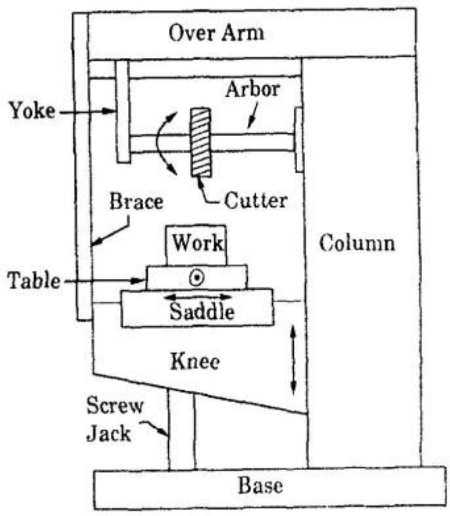
UP MILLING	DOWN MILLING
The cutter rotates against the direction in which the work is being fed.	The cutter rotates in the same direction as that in which the work is being fed
It is also known as conventional milling.	It is also known as climb milling.
Job-tool motion is in the opposite direction.	Job-tool motion is in the same direction.
Chip thickness varies from minimum to maximum.	Chip thickness varies from maximum to minimum.

Cutting forces vary from zero to maximum.	Cutting forces vary from maximum to zero.
Surface finish is poorer compared to down milling.	Surface finish is better, if it is free from backlash error.
Use of cutting fluid is difficult.	Use of cutting fluid is easy.
There is tendency to lift the job so more clamping forces are needed to fix the job on the table.	Forces are sufficient on the job to press down-ward. So clamping problem is not so much.



Work holding Devices: These are the devices used for holding and fixing the workpiece on the table of milling machine for performing the milling operations.

In case of simple shape, size and weight many work-pieces can be directly held conveniently with help of ***vices*** but in case of complex shapes the work-pieces are secured to the machine table with help of the Vice (used to hold round and square work-pieces)***Clamps***, ***strapclamps (are cheap,easy to use, flexible force can be applied by tightening a nut by hand or wrench), jacks, step blocks (to provide support to outer end of the strap clamps) and clamping bolts***, **etc.** All these clamps, straps contain a hole which is aligned and clamping bolt is passed through it to fix the work-piece. *Toggle clamps can accommodate small variation in thickness and provide excellent and consistent clamping force*. Toggle clamps are fast, adjustable, inexpensive, provide high ratio of leverage and can be automated.



Horizontal knee type milling machine

In general a milling machine has the following **Principal parts**:

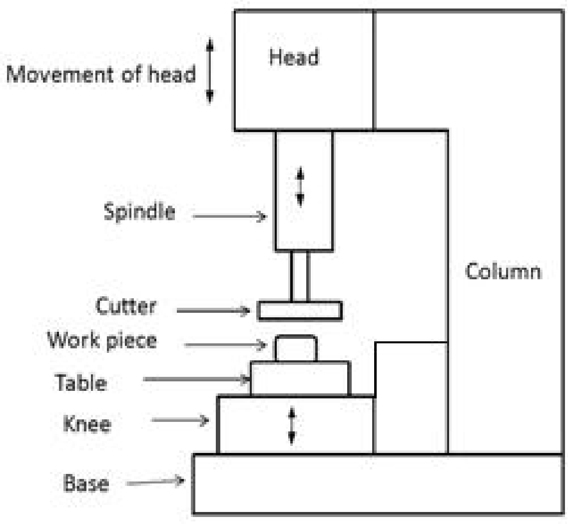
a) Base b) Column c) Knee d) Saddle e) Table f) Over Arm g) Spindle h) Arbor

Base: It is the foundation of the machine upon which all other parts are mounted. It is generally made of gray cast iron to absorb shock and vibration. Sometime it also serves as a reservoir for cutting fluid.

Column: It is the main supporting frame mounted vertically on one side of the base. The motor and other driving mechanisms are contained in it. It supports and guides the knee in its vertical travel. It carries the jack for elevating the knee.

Knee: The knee projects from the column and slides up and down on its face. It supports the saddle and table. It is partially supported by the elevating screw which adjusts its height. It carries the table feed mechanism and controls to feed in longitudinal, cross, vertical and rotation etc. by hand power or machine power.

Saddle: The saddle supports and carries the table and is adjustable transversely on ways on top of the knee. It is provided with graduation for exact movement and can be operated by hand or power.

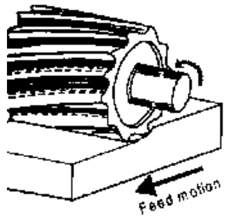


Vertical Knee type Milling Machine

Table: The table rests on ways on the saddle and travels longitudinally in a horizontal plane. It supports the workpiece, fixtures etc.

Over-arm: The over arm is mounted on and guided by the top of the column. It is adjusted in and out by hand to the position of maximum support for the arbor and then clamped. (Not in the vertical type of milling machines)

Spindle: The spindle is mounted on the upper part of the column. It receives power from the motor through belts, gears, clutches etc. and can be rotated at different speeds by the step cone pulley drive or by gearing arrangement and transmits it to arbor or sub-arbor. (In the vertical type of milling machines)

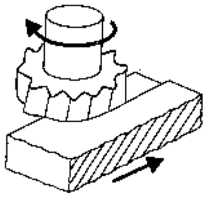


Slab milling

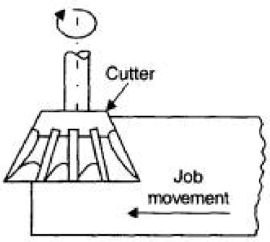
Arbor: The arbor is the extension of the spindle on which all the various cutters are mounted. It is tapered at one end to fit the spindle nose and has two slots to fit the nose keys for locating and driving it.

Operations carried out on the milling machine are:

Plain or Slab Milling: The plain milling operation is the production of flat or horizontal surface parallel to the axis of the cutter.


Face milling

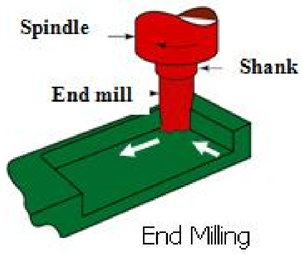
Face Milling: The face milling operation is also the production of flat surface which is at right angle to the axis of rotation of the face milling cutter.



Angular or Bevel Milling

Angular or Bevel Milling: The angular milling operation is production of flat surface, which is at an angle to the axis of the cutter.

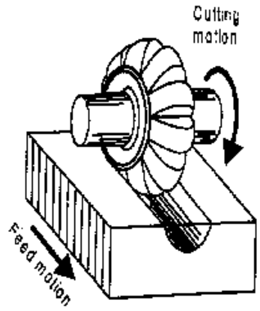
Side Milling: The side milling operation is the production of a vertical flat surface on the side face of a job by using a side milling cutter.



End Milling

End Milling: The End milling operation is the production of **both peripheral and face milling** operations simultaneously, generates vertical, horizontal or angular surfaces by using an end milling cutter.

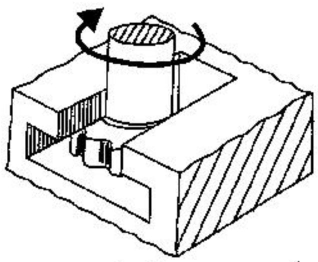
Gang Milling: Gang milling is operation of producing many surfaces of on a job simultaneously by feeding the table against a number of required cutters. The surfaces produced may be flat horizontal or vertical surfaces and are produced simultaneously.



Form milling

Form Milling: The form milling operation is the production of irregular contours by using the cutters having the same profile corresponding to the surface to be generated.

T-Slot milling refers to the formation of T-Slots.


T- Slot milling

3. *With the help of schematic sketch describe the basic working principle of drilling machine. What are the different operations performed on drilling machine?

*With the help of schematic diagram, describe the basic working principle and important parts of drilling machine. Also describe drilling operations. 2010-11, Sem-I

ANSWER

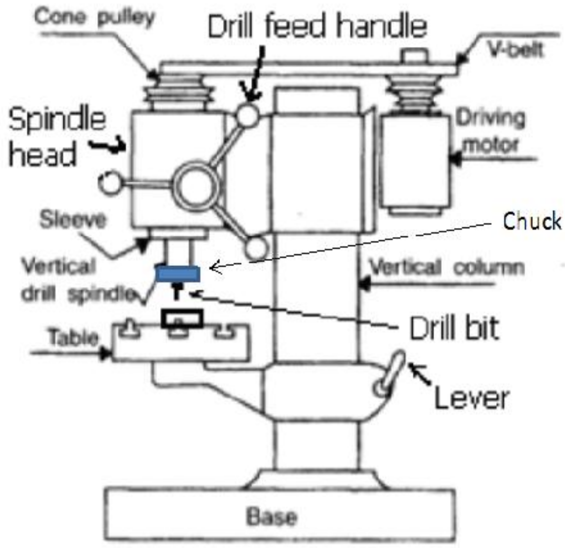
Drilling/ drilling process: It is an operation of producing a circular hole in a workpiece by forcing a drill also called drill bit, in the workpiece.
Drilling machine is a machine tool designed for drilling round holes in metallic and nonmetallic materials. The cutting tool is a multi-point cutting tool, known as drill or drill bit.

Types of drilling machines: the various types of drilling machines are

Portable drilling machines are very small, compact and self contained units with an electric motor inside.

Bench drilling machines are commonly used for light and precision work and available in training workshops. This type of machine is discussed next.

Radial drilling machines have radial arm with a capacity of tool movement, and used for the job which cannot be manipulated easily.



Drill machine

Principal Parts of the Drilling Machine

1.**Head or spindle head**: Head contains the electric motor, V- pulleys and V- belt which transmit rotary motion to the drill spindle from the motor.

2.**Spindle**: Spindle is made up of alloy steel. It rotates as well as moves up and down in a sleeve.
3. **Drill Chuck**: It is held at the end of the drill spindle and in turn it holds the drill bit.

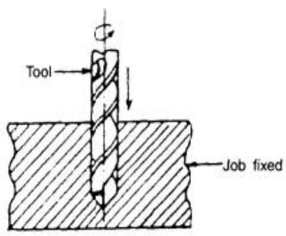
4.**Adjustable Table**: It is supported on the column of the drilling machine and can be moved vertically and horizontally. It also carries slots for bolts clamping.

5.**Base**: It supports the column, which, in turn, supports the table, head etc. and made of cast iron.

6.**Column**: It is a vertical round or box section, which rests on the base and supports the head and the table.

Working Principle and Operation of a Drilling Machine
Drilling machine is used to produce round holes in the workpiece. The end cutting tool (with two or more cutting edges) used for drilling holes in the workpiece is called the **drill or drill bit**.

1. The drill is held in the chuck and workpiece is fixed in the vice on the table.
2. On switching 'ON' the machine, the drill rotates.
3. The linear motion is given to the drill towards the workpiece by drill feed handlewhich is called feed.
4. In order to remove the chips from the hole, drill is taken out from the hole frequently and coolant is used to keep the drill cool. The combination of rotary and linear motion produces the round hole in the workpiece.

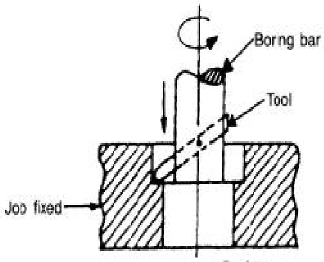


Drilling.

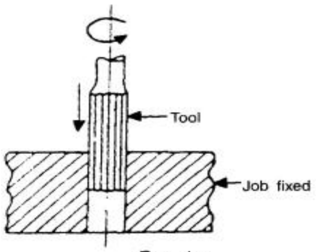
Operations performed on Drilling machine

1. **Drilling**: It is an operation of producing a circular hole in a workpiece by forcing a drill in the workpiece.

2. **Boring**: It is an operation of enlarging a hole that has already been drilled. Single point cutting tool is used in boring.

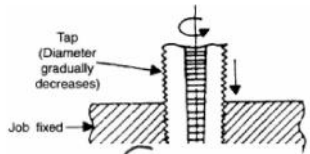


Boring.

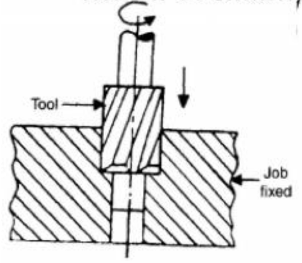


Reaming.

3. Reaming: Reaming is done with reamers. It is done to generate the hole of proper size and finish after drilling.

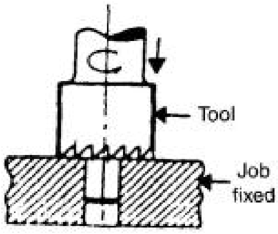


4. Tapping: It is an operation of producing internal threads in a hole by means of a tap.



Counter Boring.

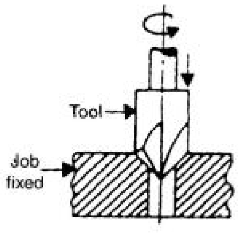
5. Counter Boring: It is an operation of enlarging the entry of a drilled hole to accommodate the bolt head etc. Counter boring tool does it.



Spot Facing.

6. Spot Facing: It is an operation done on the drilled hole to provide smooth seat for bolt head.

7. Counter Sinking: It is an operation to bevel the top of a drilled hole for making a conical seat. A counter sunk drill as shown in Fig is used in this operation.



Counter Sinking.

4. ***With the help of neat sketch explain the basic components of shaper machine and various-operations performed on it.** 2008-09,Sem-I

Differentiate between shaper and planer. With the help of neat sketch explain the basic components of lathe machine. 2009-10, Sem-I

With the help of schematic sketch, describe the basic working principle and important parts of shaper machine. Also describe the difference between shaper and planer. 2008-09, Sem-II

What are the main differences between a shaper and planer? Which are the drive mechanisms used in the shaper? Discuss any one in brief with neat sketch. 2011-12, Sem-II

ANSWER

The shaper is a machine tool in which the plane and flat surfaces are produced by a single point cutting tool by a reciprocating motion, in which the ram moves the cutting tool backward and forward in a straight line to generate the flat surface. The flat surface may be horizontal, inclined or vertical.The **shaperis** also called **shaping machine**,

Working Principle and Operation

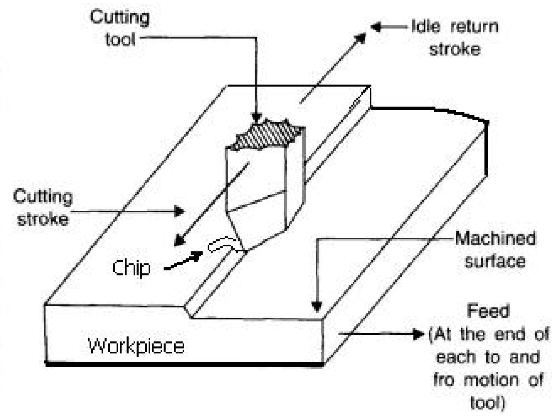
*In a **shaper machine**, a single point cutting tool reciprocates over the stationary work piece. The workpiece is rigidly held in a vice or clamped directly on the table. The tool is held in the tool head mounted on the ram of the machine. When the ram moves forward, cutting of material takes place. So, it is called cutting stroke. When the ram moves backward, no cutting of material takes place so called idle stroke. The time taken during the return stroke is less as compared to forward stroke and this is obtained by quick return mechanism. The depth of cut is adjusted by moving the tool downward towards the work piece.*

Principal Parts of a Shaper machine or shaper

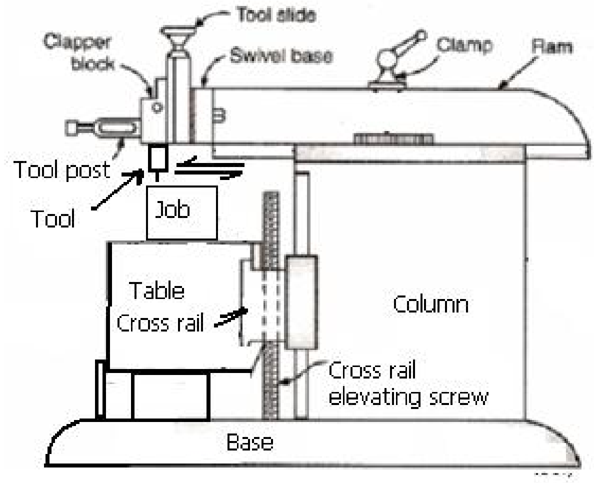
Base: It is a heavy and robust cast iron body which acts as a support for all other parts of the machine which are mounted over it.

Column (Body or **frame**): It is a box type iron body mounted upon the base. It acts as housing for the operating mechanism of the machine, electrical motor, **quick return mechanism**, cross rail and ram. On the top it is having two guide-ways on which the ram reciprocates.

Cross-rail: It is a heavy cast iron construction, attached to the column in front of the machine & on the vertical guide-ways. It carries two mechanisms, one for elevating the table and the other for cross travel of the table.



Cutting Action of a Shaper.



Shaper Machine

Table: It is made of cast iron and used for holding the work piece. T slots are provided on its top and sides for securing the work on to it. It slides along the cross rail to provide feed to the work.

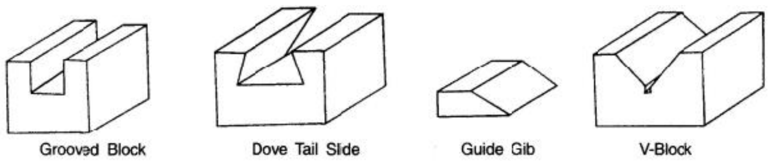
Ram: It reciprocates on the guide-ways provided above the column. It carries the tool head and mechanism for adjusting the stroke length.

Tool Head: It is attached to the front portion of the ram and is used to hold the tool rigidly. It also provides the vertical and angular movement to the tool for cutting.

Vice: It is job holding device and mounted on the table, job can be directly clamped to table also

Operations performed or Surfaces Produced by a Shaper machine

All type of flat surfaces which may be horizontal, inclined or vertical can be produced by shaper machine. Some of the products are shown in the figure.

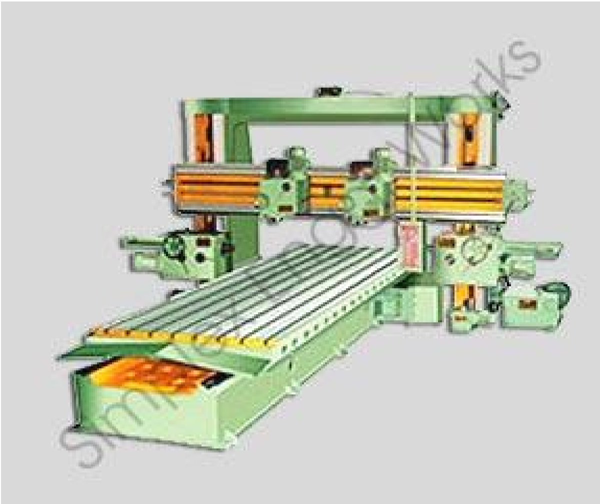


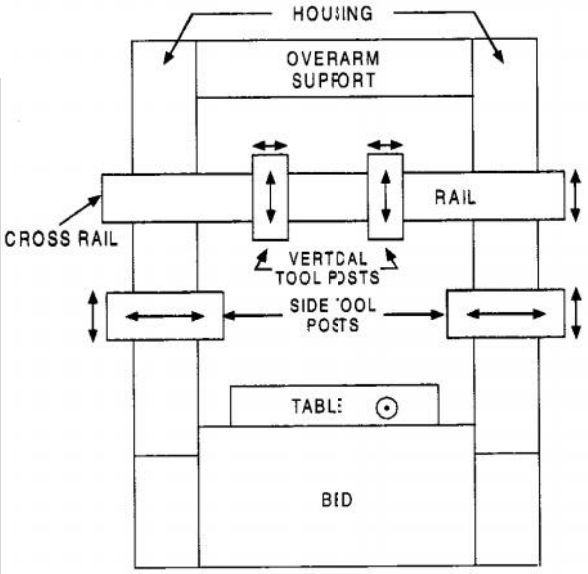
Surface Produced by a Shaper.

Planer or planer machine

The planer (also called **planning machine**) is used to produce plane and flat surfaces by a single point cutting tool when the work piece is **very large** in size. It is similar to shaper but its size is very large so used for producing flat surfaces on much larger work than a shaper. The major difference between shaper and planer is that in a planer, the tool remains stationary and the work reciprocates whereas in the shaper, the work remains stationary and the tool reciprocates.

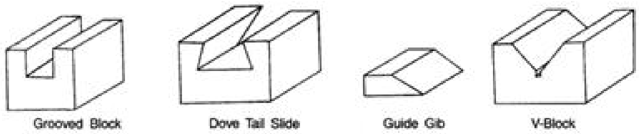
A **planer** consisting of following main parts is shown in block diagram below.
Bed: The bed of the planer is the heavy cast iron structure which provides the foundation for the machine and supports the housing and all other moving parts. At its top, V- type guide-ways are provided on which the table slides.
Table: It is a box type structure made up of cast iron. It reciprocates along the ways of the bed and supports the work. At its top, it carries longitudinal T-slots and holes to accommodate the clamping bolts and other devices.





Housing or Columns: The housings are rigid castings placed on each side of the bed in case of double housing planer and on one side only in case of open side planer. It carries cross rail elevating screws, vertical feed shaft and cross feed bar to transmit the power to the upper parts of the machine. The front face carries the vertical ways along which the cross rail slides up and down.
Cross Rail: The cross rail is mounted on the vertical guide-ways of the two housings. It can be raised or lowered. Accurately finished ways are provided at the front of the cross rail for two vertical tool heads.
Tool Heads: Two tool heads are mounted on the cross rail and the other two on the vertical columns. Each column carries one side tool head. All the four tool heads work independently, such that they can operate separately or simultaneously, as desired.

Operations performed on planer



Surfaces which can be produced by planer

The common operations performed on planer are as follows:

a) Machining horizontal flat surfaces.
b) Machining vertical flat surfaces.
c) Machining angular surfaces, including dovetails.
d) Machining different types of slots and grooves.
e) Machining curved surfaces.
f) Machining along contours.

Differences between shaper and planer

PLANER	SHAPER
1. It is heavier, more rigid and costlier machine. 2. It requires more floor area. 3. It is adopted for large works.	1. It is a comparatively lighter and cheaper machine. 2.It requires less floor area.

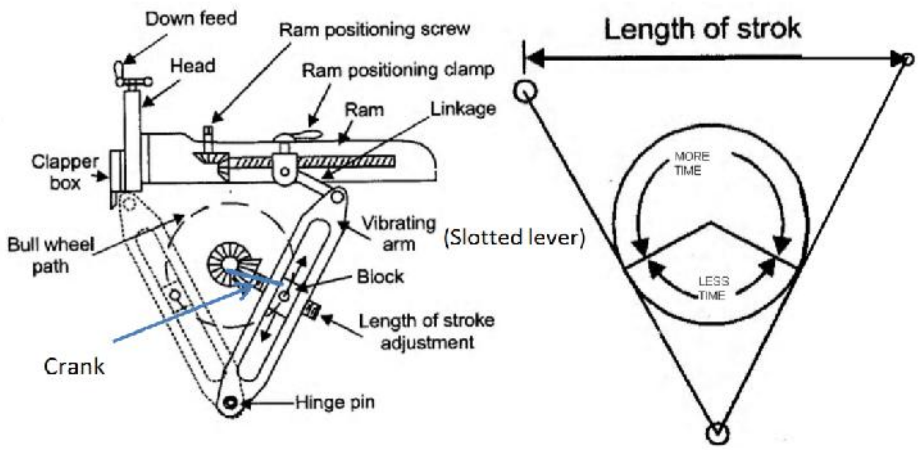
4. Tool is fixed and work moves.	3. It is used for small works.
5. More than one cutting tool can be used at a time.	4. Work is fixed and the tool moves.
	5. Only one cutting tool is used at a time.
6. The tools used on a planer are larger, heavier and stronger.	6. The tool used on a shaper is small in size as compared to planer tool.
7. Heavier feeds are applied.	7. Lighter feeds are applied.
8. It can take deep cut.	8. It cannot take deep cuts.
9. Work setting requires much of skill and time.	9. Work may be clamped easily and quickly.
10. Indexed feed is given to the tool during theidle stroke of the work table.	10. Indexed feed is given to the work during theidle stroke of the ram.

Drive mechanisms

The reciprocating movement of ram and quick return mechanisms of the shaper machine is obtained by any of the following mechanisms:

1. Crank and slotted link mechanism
2. Whitworth quick return mechanism
3. Hydraulic

Crank and slotted link mechanism



The figure shows the crank and slotted link mechanism, the motor drives the crank and crank is connected to sliding block, engaged in the slotted lever. The block can slide in the slotted lever.

Let us consider that the arm is in the right side end and the crank is rotating anti-clock-wise with uniform angular speed. The timer taken by the arm or the slotted lever to reach towards left side will be more (Forward stroke), and the further rotation of the crank will bring the arm back in less time (Return stroke). The rotation angle for forward stroke is more and for return stroke is less.

5. **With the help of schematic sketch, describe the basic working principle of grinding process**.

2009-10, Sem-I

*With the help of schematic sketch, describe the basic working principle of grinding machine and also mention the various applications of grinding process. 2008-09, Sem-I/II, Spl-carry

*How are grinding wheels specified? Clearly differentiate between grade and structure of a grinding wheel.

2010-11,Sem-I, Spl-carry

ANSWER

*Grinding is a process of removing material by the abrasive action of a Revolving Wheel (called as **grinding wheel**) from the surface of a workpiece, in order to bring it to the required shape and size. It consists of Sharp Crystals, called **Abrasives**, held together by a Binding material or Bond*. The Wheel may be a Single piece or Solid type or may be composed of Several Segments of Abrasive Blocks joined together. In most cases, it is a **Finishing Operation** and a **very small** amount of material is removed from the surface during the operation.

A Grinding Wheel essentially consists of the following two materials:

1. **Bond**: This material of the grinding wheel acts as a binder to hold the Abrasive grains together.
2. **Abrasives**: It is that material of the Grinding Wheel which does the cutting action. These are extremely hard materials consisting of very small particles called grains, which carry a number of sharp Cutting Edges and Corners. Examples are silicon carbide, aluminium oxide, etc.

A **grinding wheel** is an expendable wheel that is composed of an abrasive compound used for various grinding (abrasive cutting) and abrasive machining operations. They are used in grinding machines. The wheels are generally made from a matrix of coarse particles pressed and bonded together to form a solid, circular shape, various profiles and cross sections are available depending on the intended usage for the wheel. They may also be made from a solid steel or aluminum disc with particles bonded to the surface.

Characteristics
There are five characteristics of a cutting wheel: **material, grain size, wheel grade, grain pacing, and bond** type. They will these are indicated by codes on the wheel's label.

Material, for the actual abrasive, is selected according to the hardness of the material being cut. The frequently used materials are: Aluminium Oxide, Silicon Carbide, Diamond, etc.

Grain size (Grit), from 8 (**coarsest**) 600 (**finest**), determines the physical size of the abrasive grains in the wheel. A larger grain will cut freely, allowing fast cutting but poor surface finish. Ultra-fine grain sizes are for precision finish work.

Wheel grade, from A (**soft**) to Z (**hard**), determines how tightly the bond holds (strength) the abrasive. Softer wheels are preferred for harder materials and vice-versa.

Grain spacing, or **structure**, from 1 (densest) to 16 (least dense). Density is the ratio of **bond and abrasive** to **air space**. A less-dense wheel will cut freely, and has a large effect on surface finish. It is also able to take a deeper or wider cut with less coolant, as the chip clearance on the wheel is greater.

Wheel bond, indicates that the material by which the wheel holds the abrasives, this affects finish, coolant, and minimum/maximum wheel speed.
Vitrified (V), Resinoid (B), Silicate (S), Shellac (E), Rubber (R), Metal (M).

Difference between grade and structure
Grade represents the strength of the bond whereas the structure represents the spacing between the grains or the density of the abrasive particles (i.e dense (1) to least dense (16). Brittle and hard materials need a grinding wheel with dense structure.
Types/ Classification of grinding wheels

Straight wheel
To the right is an image of a **straight wheel**. These are by far the most common style of wheel and can be found on bench or pedestal grinders. They are used on the periphery only and therefore produce a slightly concave surface (*hollow ground*) on the part. This can be used to advantage on many tools such as chisels. Straight Wheels are generally used for cylindrical, centre-less, and surface grinding operations. Wheels of this form vary greatly in size, the diameter and width of face naturally depending upon the class of work for which is used and the size and power of the grinding machine.

Cylinder or wheel ring
Cylinder wheels provide a long, wide surface with no center mounting support (hollow). They can be very large, up to 12" in width. They are used only in vertical or horizontal spindle grinders.

Cylinder or wheel ring is used for producing flat surfaces, the grinding being done with the end face of the wheel.

Tapered wheel
A straight wheel which tapers towards the center of the wheel is called tapered wheel. This arrangement is stronger than straight wheels and can accept higher lateral loads. Tapered face straight wheel is primarily used for grinding thread, gear teeth etc.

Grinding Machines (Grinders)

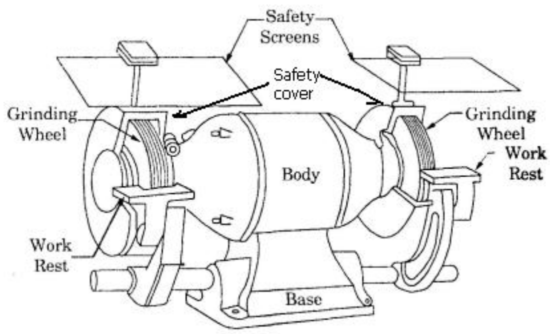
- Roughing or non-precision grinder
  1. Bench grinder
  2. Pedestal grinder
  3. Portable grinder
- Precision grinder
  1. Cylindrical grinder
  2. Surface grinder
  3. Internal grinder

Diamond wheel
Diamond wheels are grinding wheels with industrial diamonds bonded to the periphery.
They are used for grinding extremely hard materials such as carbide cutting tips, gemstones or concrete. The saw pictured to the right is a slitting saw and is designed for slicing hard materials, typically gemstones.

Cut off wheels
Cut off wheels, also known as *parting wheels*, are self-sharpening wheels that are thin in width and often have radial fibers reinforcing them. They are often used in the construction industry for cutting reinforcement bars, protruding bolts or anything that needs quick removal or trimming.

Grinder or grinding machine
These are the machines to perform the grinding operations. These may be of different types as shown.

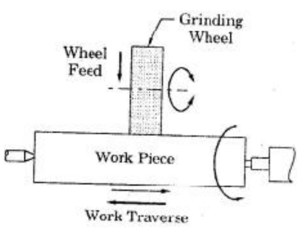
Bench grinder consists of body having electrically driven motor, base to fix on the table or bench, grinding wheels mounted on the motor shaft, safety cover & screen and work rest. The figure below shows the bench grinder.



Bench Grinder

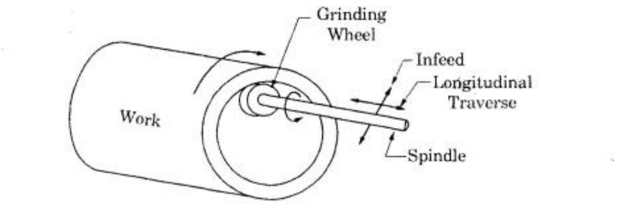
The different operations performed by the grinders as follows:

a-Cylindrical grinding: It is used for Grinding of Outside cylindrical and tapered surfaces.



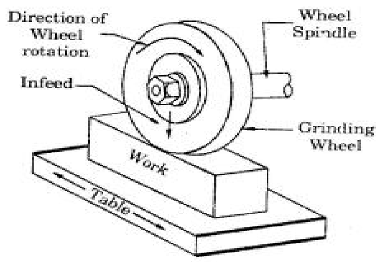
Principle of cylindrical grinding.

b-Internal grinding: It means a method of grinding the internal surfaces of cylindrical and tapered holes.

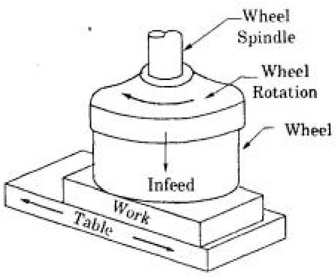


Principle of Internal Grinding on a Plain Internal Grinding Machine

c-Surface grinding: It is a method of grinding Horizontal flat surfaces. The wheel spindle can be horizontal or vertical.

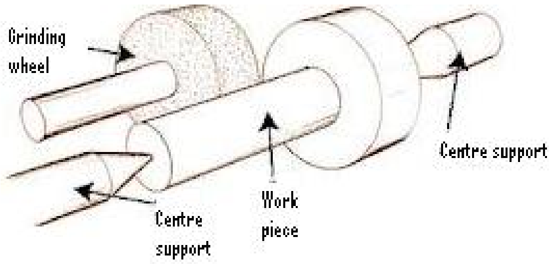


Working principle of a Horizontal spindle Reciprocating table, Surface Grinder.



Working principle of a Vertical spindle Reciprocating table Surface grinder.
table, Surface Grinder.

d-Face grinding: It is a method of grinding Vertical flat surface.

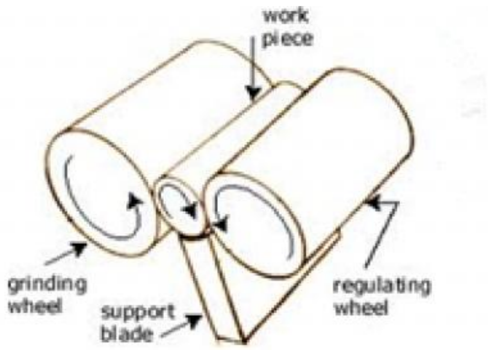


Centred Grinding

e-Form grinding. The formed surfaces can be produced by this method of grinding using a formed wheel.

f-Centered Grinding: In this method the work piece is held from the sides between the supports and grinding wheel is brought in the contact for machining operation.

g-Centre-less grinding: In this method the external cylindrical surfaces are generated by supporting the work on the regulating wheel, grinding wheel and work rest (support)blade.

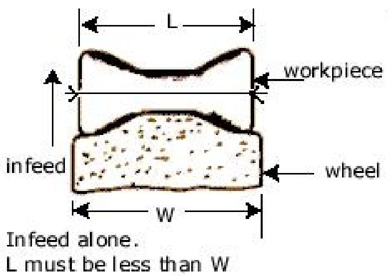


Example of cetre-less grinding (Through feed grinding)

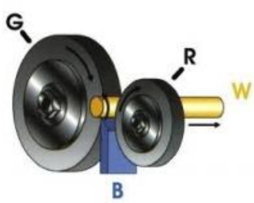
Centre- less grinding is of three types:

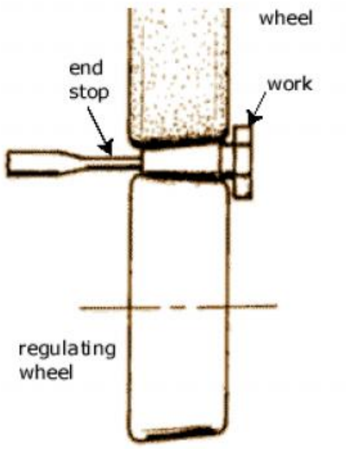
(viii) *Through-feed grinding*,
(ix) *In-feed grinding*
(x) *End-Feed Grinding*

h-Off-hand grinding: It is roughening operation. In this method thework is held by hands and grinding is performed on the items on which accuracy is not of primary importance.



In-feed grinding





End feed grinding

6. *Explain fusion as it relates to welding operations. How will you classify the welding processes? Explain with neat sketch the features and uses of neutral, reducing and oxidizing flames in case of oxy-acetylene gas welding.

* Explain fusion as it relates to welding operations. How will you classify the welding processes? Explain the features of neutral, reducing and oxidizing flames. 2008-09, Sem-I
* What do you understand by classification of welding processes? Explain in detail. 2011-12, Sem-I
*Draw labeled diagram of three types of flames used in Oxy-acetylene gas welding. Also give their uses. 2010-11, Sem-II
* What is the principle of gas welding? Explain different types of oxyacetylene flames. 2010-11, Sem-I
* What do you understand by gas welding? How neutral, oxidizing and reducing flames are obtained in a welding torch? Draw neat sketches of flames. 2010, Sem-I/II, Spl-carry
* Describe the various types of flames in welding. Explain with suitable applications, the working principle of electric arc welding. 2008-09, Sem-I/II, Spl-carry
*How is an arc obtained in arc welding? What are the different power sources used in the welding? What are the limitations and advantages of each. 2011-12, Sem-II
* Draw a labeled diagram of three types of Oxy-acetylene gas welding flames. Also give their applications. 2011-12, Spl-Carry
* Briefly explain gas welding process. 2012-13 SEm-II

ANSWER

The **welding** is a process of joining two similar or dissimilar metals by **fusion** (application of heat), with or without the application of **pressure** and with or without the use of **filler metal**.

Weld-ability of a metal is the ability (or the ease) of the metals with which two similar or dissimilar metals are joined by fusion with or without the application of pressure and with or without the use of filler metal.

Fuse: meaning: 1. To mix (constituent elements) together by or as if by melting; blend.
The **fusion,** (*means:* The act or procedure of liquefying or melting by the application of heat OR the act or operation of melting or rendering fluid by heat; the act of melting together; as, the fusion of metals), of metal takes place by application of heat. The heat may be obtained from electric arc, electric resistance, chemical reaction, friction or radiant energy. The importance of fusion is clear from the observation that without melting and mixing of the two metals pieces the joining will not be successful.

Base Metal: The metal to be joined or cut is termed as the base metal.

Filler metal: It is the metal (in the form of wire or rod) added to supplement the molten metal pool to make a good and strong joint.

Heat sources

The sources of heat for welding operation may be combustion of gas and coal, electric arc, electric resistance, chemical reaction. The fuel gas and electricity are most used power sources. The gas welding can be performed for thin section and without much expenditure. In case of electric power source welding is suitable for thick sections and provides clean joints but heavy and costly equipment is required. The welding process using the chemical reaction as power source can be carried out at remote locations where it is not practicable to carry heavy equipments i.e. railway track welding.

Classification of welding process

The welding processes may be classified on the basis of

(i) **Metals joined and filler material**,

Autogenous Welding

The process of joining similar metals by melting the edges together, without the addition of filler metal, is called Autogenous welding.

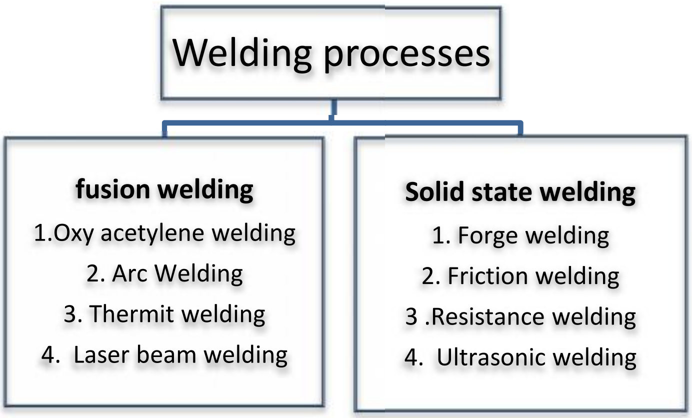
Homogeneous Welding

The process of joining similar metals with the help of filler rod of the same metal is called homogeneous welding.

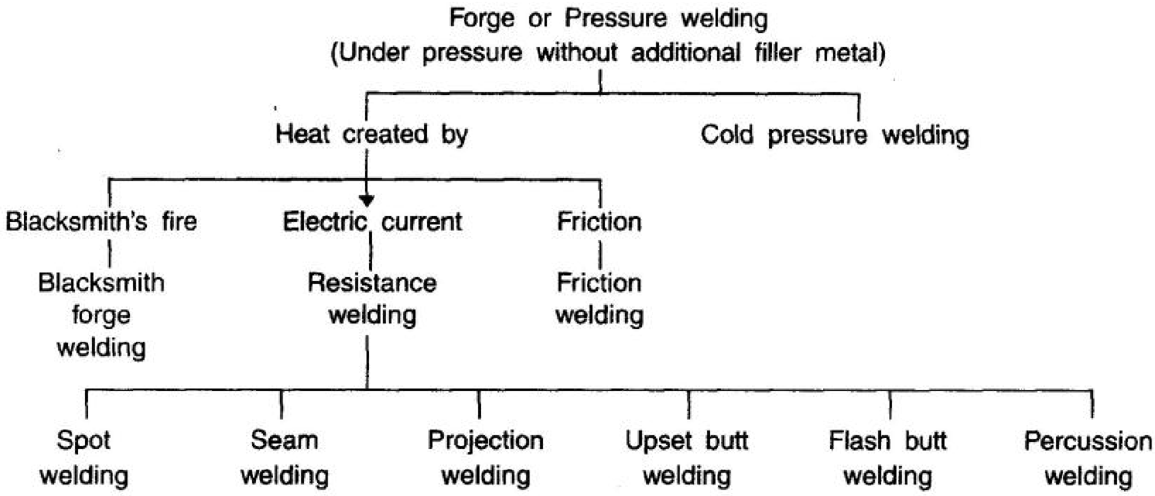
Heterogeneous Welding

The process of joining dissimilar metals using filler rod is called heterogeneous welding.

(ii) **The state of metals at the time of welding**, i.e. if the metals are heated to the melting temperature then the welding is called as **fusion welding**, and in case the metal is heated only upto such a temperature to bring it to plastic state then welding is called as **solid state** or **pressure welding**.



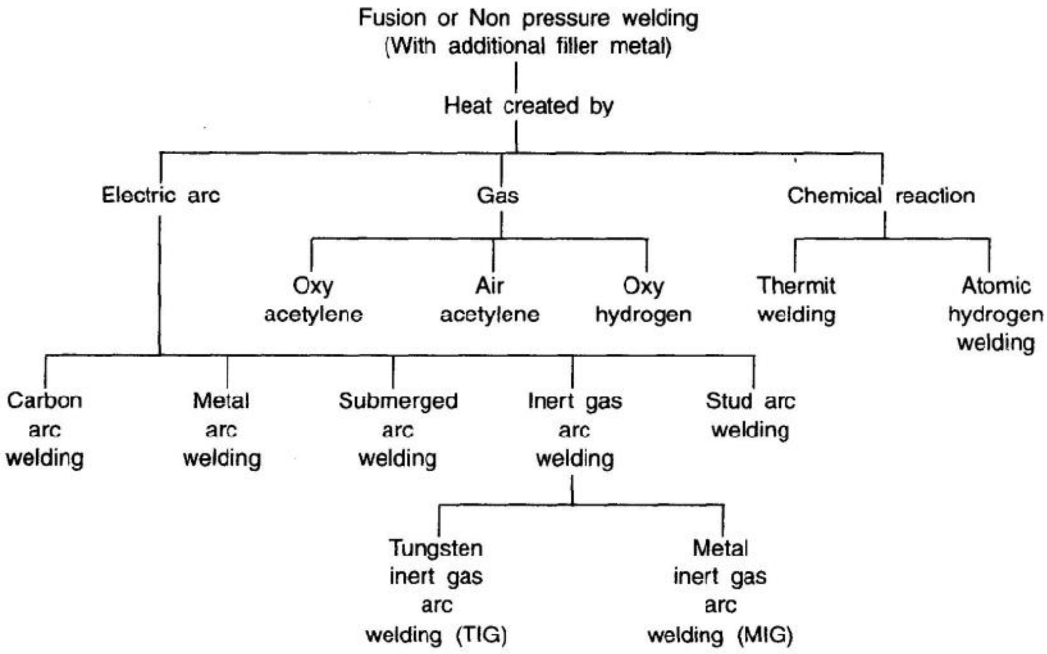
Solid state welding: In forge or pressure welding, the work-pieces are heated to plastic state and then, the work-pieces are joined together by applying external pressure on them. The examples are:
1. Forge welding, 2. Friction welding, 3.Ultrasonic welding, and 4.Spot welding, 5. Seam welding, 6. Projection welding, 7. Resistance butt welding, 8. Flash butt welding9.Percussion welding, etc.



Fusion or Non-pressure Welding: In this welding, the material at the joint is heated to a molten state and then allowed to solidify. The filler material may or may not be added. The examples are:
1. Air-acetylene welding, 2. Oxy acetylene welding, 3. Arc Welding, 4. Carbon arc welding, 5. Shielded metal arc welding, 6. TIG (Tungsten Inert Gas) welding, and 7.MIG (Metal Inert Gas) 8.Thermitwelding 9. Laser beam welding, etc

ADVANTAGES OF WELDING

a) A good weld is as strong as the base metal.
b) A large number of metals/alloys can be joined by welding.
c) Repair by welding is very easy.
d) Welding can be easily mechanized.
e) Portable welding equipment is available.
f) General welding equipment is not very costly.
g) Total joining cost is less in case of welding joint.



DISADVANTAGES OF WELDING

a) Welding produces the harmful radiation, fumes and spatter.
b) A skilled welder is required.
c) Welding heat produces metallurgical changes.
d) Cost of equipment (initial cost) is high.
e) Edge preparation is required before welding.
f) More safety devices are required.
g) Jigs and fixtures are required to hold the parts to be welded

WELDING AS COMPARED TO RIVETING AND CASTING

a) Welding is more economical and is a much faster process as compared to both casting and riveting.
b) As compared to riveting and casting, fewer persons are involved in a fabrication process.
c) Welding involves less cost of handling.
d) Welding produces less noise as compared to riveting.
e) Welding designs involve less cost and are flexible also (we can change easily).
f)Cost of pattern making, storing, maintenance, repairs is eliminated.
g) Welding structures are comparatively lighter.
h) Welding can be carried out at any point on a structure, but riveting requires enough clearance.
i) Drilling holes to accommodate rivets weakens a riveted structure.
j) Welding can produce a 100% efficient joint, which is difficult to make by riveting.

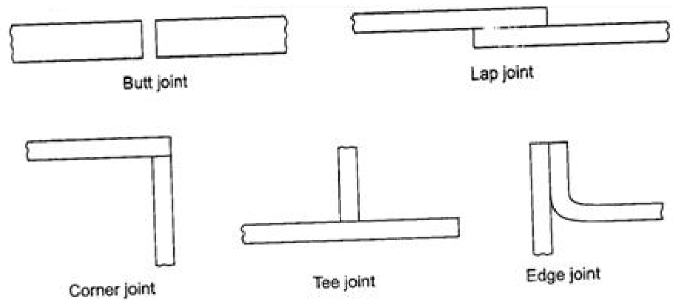
Applications of welding

a) Automobile construction.
b) Railroad equipment.
c) Ships.
d) Aircraft construction.
e) Building construction.
f) Bridges construction.
g) Pressure vessels.

h) Storage tanks.
i) Piping and pipe lines.
j) Fabrication of jigs, fixtures and machine tools.
k) Repair of broken and damaged parts.
l) Household furniture.
m) Material handling equipments etc.

Types of welded joints

The following are the five basic types of joints commonly used in fusion welding:



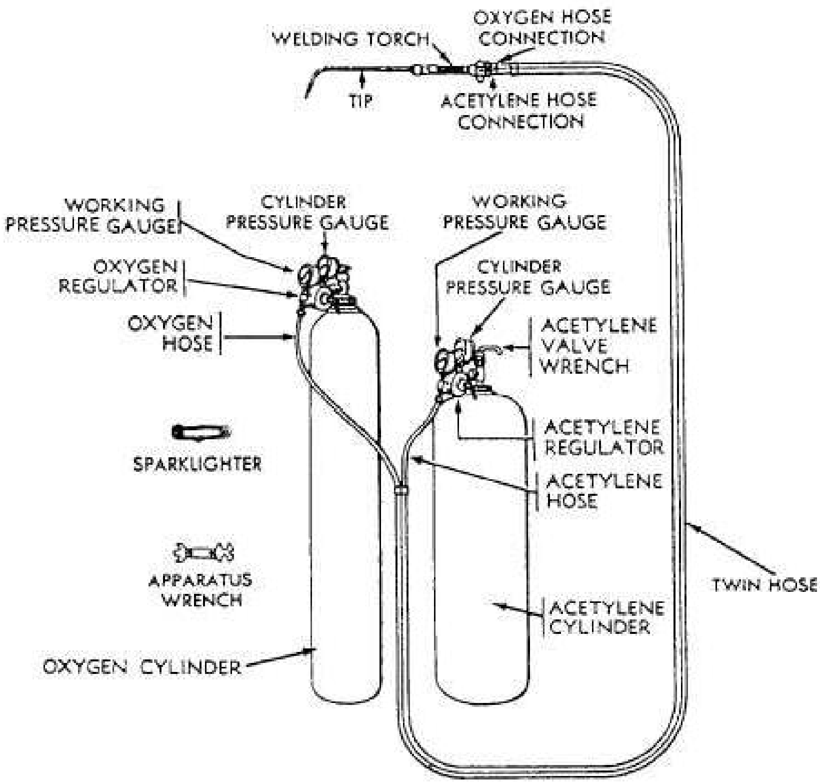
1. **Lap Joint**. The lap joint is obtained by overlapping the plates and then welding the edges of the plates.

2. **Butt Joint**. The butt joint is obtained by welding the ends or edges of the two plates.

3. **Corner Joint**. The corner joint as shown in Fig. is obtained by joining the edges of two plates whose surfaces are at an angle of approx. 90 degrees to each other.

4. **Edge Joint**. The edge joint as shown in Figure is obtained by joining two parallel plates. It is economical for plates having thickness less than 6 mm.

5. **T-Joint**. The T-joint as shown in Figure, is obtained by joining two plates whose surfaces are approximately at right angles to each other. These joints are suitable upto 3 mm thickness.



Gas welding

Gas welding also called an oxy-fuel gas welding, and it obtains the heat for welding from the combustion of a fuel gas such as acetylene in combination with oxygen. <u>The process is a fusion welding process wherein joint is completely melted to obtain the fusion</u>.

Principle of operation

<u>The acetylene gas is mixed with oxygen in correct proportions in the welding torch and ignited, the flame is produced which is sufficiently hot to melt and join (upon cooling) the parent metal. Temperature of flame is about 2800-3400°C. A filler rod is generally added to build up the seam for greater strength</u>.

Oxy-acetylene welding may be classified as:

High Pressure Oxy-acetylene Welding: In case of high pressure Oxy-acetylene gas welding, the acetylene gas is supplied from the acetylene cylinder (Painted maroon) in compressed form. The acetylene is dissolved in the porous mass soaked in acetone. The oxygen gas is supplied from the commercial cylinders (Painted black) in both types of gas welding.

Gas Welding Torch

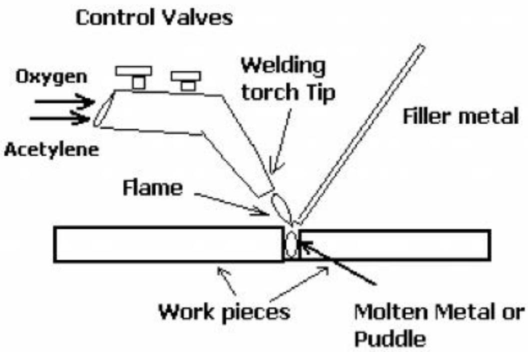
Low Pressure Oxy-acetylene Welding:
In case of low pressure Oxy-acetylene gas welding, the acetylene gas is supplied from the generator at low pressure. In the generator calcium carbide stone is added in the chamber in which water is already present. Calcium carbide stone reacts with the water and produce acetylene gas. This gas can be easily collected from the top of the water and can be used for welding purpose.

Chemical reactions: In welding process the acetylene gas reacts with oxygen in two stages and produces heat. The reactions are written as:

1. First reaction: $2C_2H_2 + 2O_2 \longrightarrow 4CO +$:

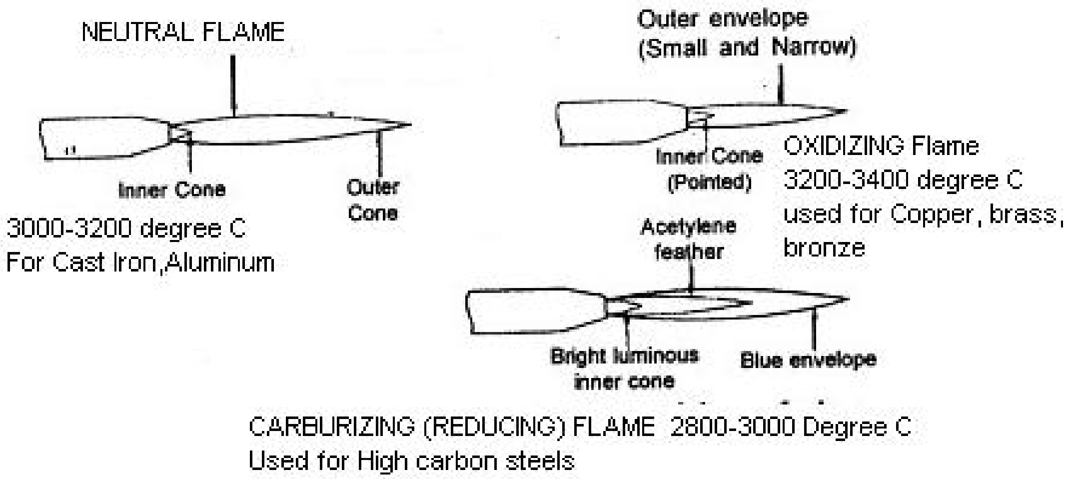
2. Second reaction: $4CO + 2H_2 + 3O_2 \longrightarrow 4C($

3. The combination of above two reactions is



Types of welding flames: depending upon the proportions of acetylene and oxygen the three types of flames are:

1. Neutral flame



a) A neutral flame is produced when oxygen to acetylene ratio is 1.1 to 1.
b) The temperature is of the order of about (3000-3200°C).
c) The flame has nicely defined inner cone (light blue in colour) and is surrounded by outer envelope which is dark blue in colour than the inner cone.
d) It is called neutral because it will **not oxidize or carburize** the metal.
e) It is used for welding ofCopper, Cast iron, Al.

2. Oxidizing flame

After the neutral flame, if the supply of oxygen is further increased, the result will be an oxidizing flame.

a) Its inner cone is more pointed and outer flame envelope is much shorter.
b) It burns with a loud roar.
c) The temperature is of the order of about 3400°C (because of excess of O_2 so complete combustion takes place).
d) This flame is harmful for steels, because it oxidizes the steels.
e) Only in the welding of **copper and copper based alloys**, oxidizing flame is desirable, because in those cases a thin protective layer of slag forms over the molten metal

3. Reducing flame

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

a) In this flame, **acetylene feather** exists between the **inner cone** and **outer envelope**.
b) Temperature is of the order of about 2800°C (less because it does not completely consume the available carbon).
c) Metals that tend to absorb carbon should not be welded with reducing flame.
d) Carburizing flame contains more acetylene than a reducing flame.
e) Carburizing flame is used for the welding of lead and for carburizing (surface hardening) purposes.
f) Reducing flame is used, with low alloy steel rod, for **welding high carbon steel**.

Flux is a chemical cleaning agent, flowing agent, or purifying agent. Fluxes may have more than one function at a time. They are used in both extractive metallurgy and metal joining. During welding process the metal is heated/ melted in air, oxygen from the air combines with the metal to form oxides which results in poor quality, low strength welds and in some cases may even make welding impossible.

Purpose of flux The role of a flux in **joining processes** (welding, soldering & brazing) is multiple as:

a) It dissolves of the oxides on the metal surface, which facilitates wetting by molten metal, and
b) Acts as an oxygen barrier by coating the hot surface, preventing its oxidation.
c) In some applications molten flux also serves as a heat transfer medium, facilitating heating of the joint by the soldering tool or molten solder.
d) It improves the fluidity of the metal and capillary action
e) Examples of flux are sodium carbonate, borax and ammonium chloride.

Advantages of Gas Welding	Disadvantages of Gas Welding
It can be applied to a wide variety of manufacturing and maintenance situations	Flame temperature is less than the temperature of the arc
Rate of heating and cooling of weld deposit and job is slow.	Refractory metals (e.g. tungsten, molybdenum, tantalum etc.) and reactive metals (titanium and zirconium) cannot be gas welded.
No electric current is required	Gas flame takes a long time to heat up the metal than an arc
Equipment is having less cost	Heat affected zone is wider
Operator is having better control because sources of heat and filler metals are separate	
Cost and maintenance of the welding equipment is low	

7. Differentiate between welding soldering and brazing. Explain the purpose and uses of the flux in case of gas welding.

*Differentiate between soldering and brazing. Give their composition and uses. 2011-12, Sem-I

* Write short notes on (i) Soldering (ii) Brazing (iii) Centrifugal casting (iv) Die casting process 2010-11,Sem-I

*Distinguish between welding, brazing and soldering processes. Write about the importance of fluxes being used in welding. 2009-10, Sem-I

* Explain soldering process, How it differs from brazing and welding? Write the uses of soldering and brazing.

ANSWER

Soldering and brazing provide permanent joint to metal pieces. Soldering and brazing process lie in between fusion welding and solid state welding. These processes have some advantages over welding process. These can join the metal having poor weld-ability, dissimilar metals, very less amount of heating is needed.

The major disadvantage is joint made by soldering and brazing has low strength as compared to Joints made by welding.

Brazing

Brazing is the metal joining process with the help of filler metal called as brass (**an alloy of copper 60% and Zinc 40%).** Filler metal is melted and distributed by capillary action between the mating surfaces of the metallic parts being joined. In this case only filler metal melts. There is no melting of workpiece metal. The filler metal (brazing metal) has the melting point more than 450^{o}C. Its melting point should be lesser than the melting point of workpiece metal. The metallurgical bonding between work and filler metal and geometric constrictions imposed on the joint by the workpiece metal make the joint stronger than the filler metal out of which the joint has been formed.

Soldering

Soldering is metal joining process with help of solder (filler metal). (**Solder is an alloy of lead 60% and tin 40%**). Filler metal has the melting temperature lower than 450^{o}C. The surfaces to be soldered must be pre-cleaned so that these are faces of oxides, oils, etc. An appropriate flux must be applied to the mating surfaces and then surfaces are heated. Filler metal called solder is added to the joint, which distributes between the closely fitted surfaces. Strength of soldered joint is much lesser than welded joint and lesser than a brazed joint.

Soldering Procedure

Following sequential steps should be carried out as soldering procedure.

1.Work Preparation Workpieces which are to be joined together should be perfectly clean. There should not be any dirt, dust, rust, paint or grease. This is so that the solder or spelter can stick to the joint with proper strength. Cleaning is done with the help of a file or sandpaper

2.Preparation of Joint Workpieces should be clamped to avoid any relative movement between them that may disturb the joint making. At the joint smaller grooves are made on the workpieces to facilitate better flow of molten solder and so good strength of the joint.

3.Fluxing The flux is applied.

4.Tinning In this step of soldering procedure, the bit of solder iron is cleaned, application of flux is done over it. It is brought in contact of solder wire so the bit carries sufficient amount of molten solder over it. After that it is used to make tags of solder at various places throughout the joint.

5.Cooling The joint is filled with molten solder and allowed to cool and solidify.

The differences between soldering brazing and welding

Welding	Soldering	Brazing
In welding filler metal melting point is same as that of base metal	In soldering the filler metal is solder and melting point is below 450oC	In brazing the filler metal is brass and melting point is above 450oC
NO capillary action between the base and filler metal and the joint takes place due to fusion of metals.	Joint takes place due to capillary action between the base and filler metal	Joint takes place due to capillary action between the base and filler metal.
These are the strongest joints used to bear the load. Strength of a weldedjoint may be more than the strength ofbase metal.	These are weakest joint out of three. Not meant to bear the load. Use to make electrical contacts generally.	These are stronger than soldering but weaker than welding. These can be used to bear the load upto some extent.
Temperature required is upto 3800oC of welding zone.	Temperature requirement is upto 450oC or below.	It may go from 450oC to 600oC in brazing.
Workpiece to be joined need to be heated till their melting point.	No need to heat the workpieces till melting point.	Workpieces are heated but below their melting point.
Mechanical properties of base metal may change at the joint due to heating and cooling.	No change in mechanical properties after joining.	May change in mechanical properties of joint but it is almost negligible
High cost is involved and high skill level is required.	Cost involved and skill requirements are very low.	Cost involved and skill required are in between others two.
Heat treatment is generally required to eliminate undesirable effects of welding.	No heat treatment is required.	No heat treatment is required after brazing.
No preheating of workpiece is required before welding as it is carried out at high temperature.	Preheating of workpiece before soldering is good for making good quality joint.	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature.
Distortion is more	Distortion is least	Distortion is less
Used for joining steel , mild steel, aluminium, etc	Used for electrical applications, radiator tubes, utensils, etc	Used for carbide tools, pipe fittings, dissimilar metals, tubes, utensils, etc

8. *Explain the resistance welding. What are the different types of resistance welding? Draw neat sketches of each process.

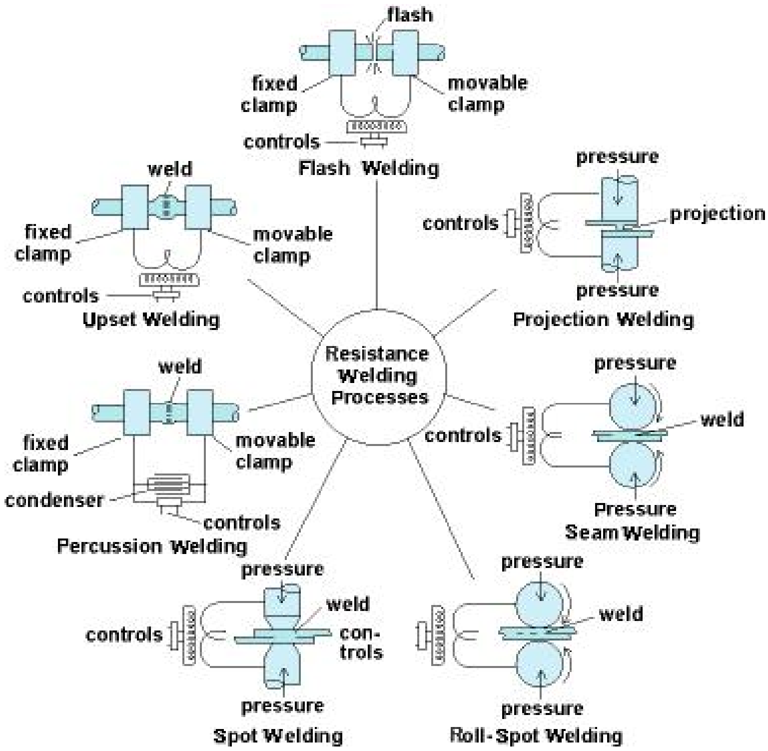
*How will you classify the welding processes? Explain with suitable applications, the working principle of resistance welding. 2009-10, Sem-II, 2008-09, Sem-II

* Briefly explain the projection welding process. Also give its advantages and disadvantages.
2010-11, Sem-I,Spl-Carry

* Explain the working principle of resistance welding. Briefly discuss the advantages and disadvantages of it.
2012-13 Sem-II

ANSWER:

Resistance welding is a group of welding processes in which heat for welding is obtained from the resistance of the work-piece (metal) to the flow of electric current and with the application of pressure. No filler metal or flux is added.
In resistance welding both heat and pressure are used to make the joint or establish the coalescence.

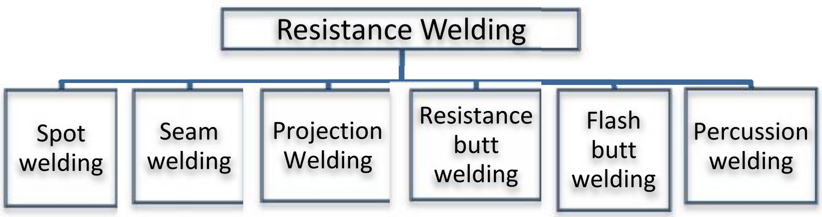


Types of Resistance Welding

a. Spot welding
b. Seam welding
b) Projection Welding
c) Resistance butt welding
d) Flash butt welding
e) Percussion welding.

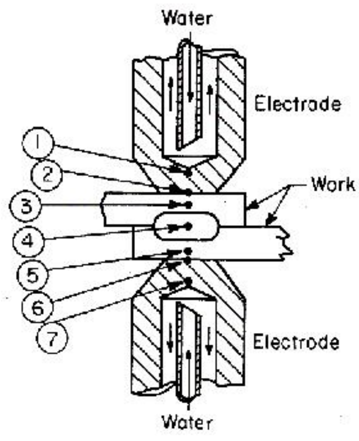
Principle of Resistance Welding

In resistance welding, a low voltage (typically 0.5 to 10 volt) and very high current (typically 15000 A) is passed through the joint for a very short time (typically .25 sec). This high amperage heats the joint. The heat generated in resistance welding can be expressed as:



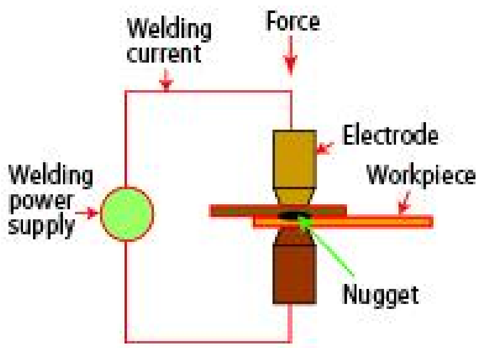
Where, H= Total heat generated in the work, Joules
I = Electric current, Amp.
T=Time for which the electric current is passing through the joint, sec.
R=Resistance of the joint in ohms.

The electric resistance spot welding process is shown in Figures, electrodes 1 and 7 presses against work-pieces 3 and 5. A current is then passed through these components. Because of the electrical contact resistance, heat will be generated at electrode/work-piece interfaces 2 and 6 and faying/ mating surface 4. The heat at the faying face melts the work-pieces to form a nugget, 4. To prevent melting at the electrode/work-piece interface, water is circulated in the cooling chamber of the electrodes.



Schematic figure for electric resistance welding

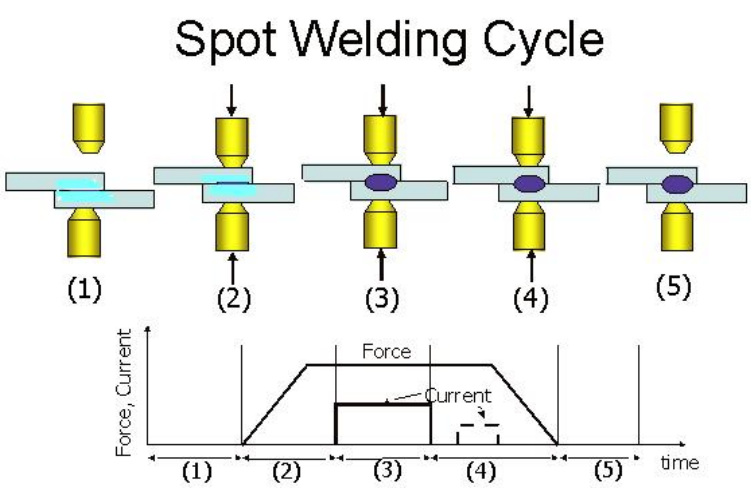
Electrodes for Resistance Welding
The electrodes in resistance welding have to carry large amount of current, pressure and also help to remove the heat from the weld zone thus preventing overheating and surface fusion of work. The electrodes should have higher electrical conductivity as well as higher hardness. Hence, **copper in** alloyed form is used for making electrodes. The electrodes may be water cooled internally.



Advantages of Resistance Welding	Disadvantages of Resistance Welding
Very little skill is required to operate the resistance welding machine	The initial cost of equipment is high.
High production rate so well suited for mass production.	Certain resistance welding operations are limited only to lap joints
Heating of the work-piece is confined to a very small part, which results in less distortion	Skilled persons are needed for maintenance
No filler rod and flux is needed.	Bigger job thicknesses cannot be welded
It is possible to weld dissimilar metals as well as metal plates of different thickness.	
Semi-automatic equipments are available.	
Very little skill is required to operate the resistance welding machine.	
There are no consumables used in this process except for the electrical power and a relatively small electrode wear. As a result, it is a very economical process.	

Applications of Resistance Welding
Joining of sheets, bars, tubes, making of metal furniture.Making fuel tanks of cars, tractors, Making of containers. Welding aircraft and automobile parts

Spot welding
Spot welding is a resistance welding process in which overlapping sheets are joined by local fusion at one or more spots by the heat and pressure is applied by the electrodes one above and other below the work-pieces. The heat is generated because of the resistance to the flow of electric current through work-piece.

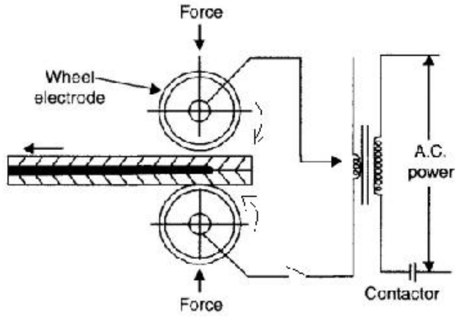


Procedure: (The steps involved in spot welding are represented by the figure**)**
a) The job should be clean.
b) It should be free from grease, dirt, paint, scale, oxide etc.
c) Clean the electrode tip surface. Very fine emery cloth may be used for routine cleaning.
d) Water is kept running through the electrodes in order to cool the weld and save the electrodes from getting overheated.
e) Proper welding current is set. Proper time has been set on weld timer.

f) Electrodes are brought together against the overlapping work-pieces and pressure is applied so that the surfaces of the two work-pieces come in physical contact with each other.
g) Welding current is switched on for a definite period of time.
h) As the current passes, a small area where the work-pieces are in contact is heated and spot weld takes place. The temperature of this weld zone is approx. 815°C to 930°C.
i) After the welding takes place, the welding current is cut off. Extra electrode force is then applied or the original force is prolonged. Hold until the metal cools down and gains strength.
j) After that, electrode pressure is released to remove the spot welded work-pieces.

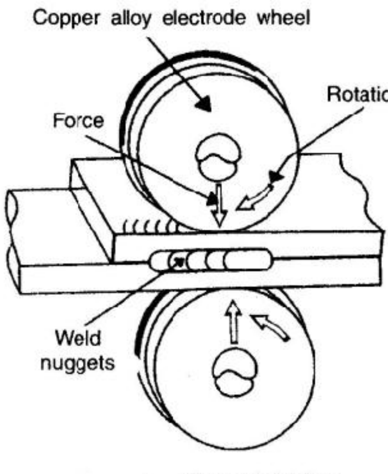
Advantages of Spot Welding:
Low cost.
Less skilled worker can perform this welding.
Higher productivity
Operation may be made automatic or semiautomatic.
No edge preparation is needed.

Application of Spot Welding:
Welding of low carbon steels, high speed steels, stainless steels, nickel, nickel alloys, automobile, aircraft industry, household furniture, Containers, etc.



Principle of Seam Welding

Seam Welding
Seam welding is a resistance welding process in which overlapping sheets are joined by local fusion progressively, along a joint, by two rotating the circular electrodes. Fusion takes place because of heat, which is generated, from the resistance to electric current flow through the work parts which are held together under pressure by electrodes.



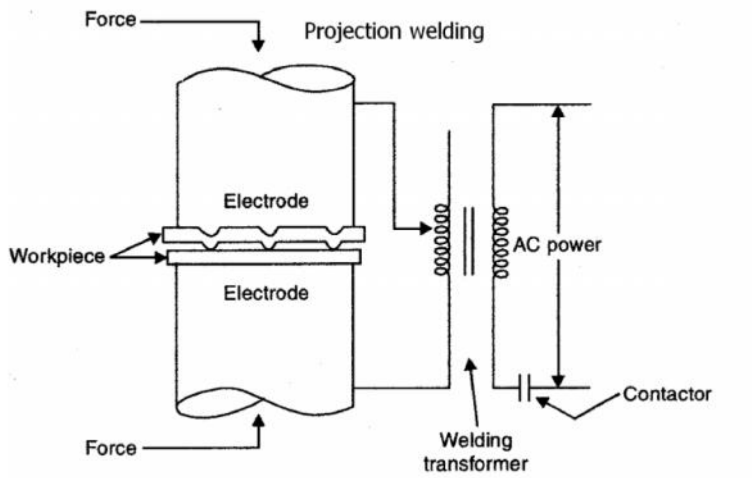
Seam Welding.

Principle of Operation (Procedure)
a) The work-pieces to be seam welded are cleaned, overlapped suitably and placed between the two circular electrodes which hold the work-pieces together by the pressure on electrode force.
b) Switch on the coolant supply (in some machines, the electrodes are cooled by external spray of water; in others, the electrodes are cooled by refrigerant fluid that flow inside the working electrodes).
c) Switch on the current supply. As the first current impulse is applied, the power driven circular electrodes are set in rotation and the work-pieces steadily move forward.
d) If the current is **put off and on quickly**, a continuous fusion zone made up of overlapping nuggets is obtained. It is known as stitch welding.
e) If individual spot welds are obtained by constant and regularly timed interruption of the welding current, the process is known as **roll (spot) welding**.

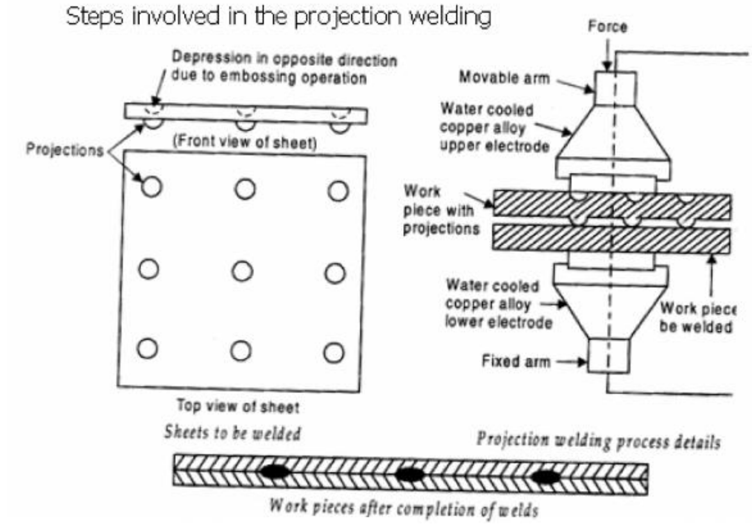
Advantages of Seam Welding	**Disadvantages of Seam Welding**
It can produce gas tight or liquid tight joints.	Cost of equipment is high as compared to spot welding set
Overlap can be less than spot or projections welds	Welding can be done only along a straight or uniformly curved line.
Several parallel seams may be produced	It is difficult to weld thickness greater than 3 mm.

Applications of Seam Welding:
It is used for welding of stainless steels, steels alloys, nickel and its alloys, magnesium alloys etc.

Projection Welding
Projection welding is another advancement of spot welding, where one of the sheets to be joined is provided with a number of projections to help localise the current at a predetermined spot. Thus, the surfaces of the workpieces are in contact with each other only at the projections.



Steps involved in the projection welding



Projection Welding Procedure
a) The projections are made in one of the sheet
b) Thee sheets are placed between the electrodes
c) As the current is switched on, it will pass through these projections. Because of heat produced due to resistance to the flow of electric current, these projections are melted.
d) The electrodes are pressed together to complete the weld, by pressing the upper electrode downward. The melted projections form the weld.
e) Welding can be done at several points simultaneously.
f) This completes one cycle of welding. The projections are generally very small of the order of 0.8 mm and are obtained by means of embossing.

Advantages of Projection Welding	Disadvantages of Projection Welding
It is possible to weld more than one spot at a given time	Making of projections is an extra operation
The welds may be placed closer than spot welding	All projections should be of same height
Proper heat balance can be easily obtained	Metals, which cannot support projections, cannot be welded satisfactorily
Projections are to be made in thicker plate or in the plate which is having higher electrical conductivity	
Life of electrode is much longer than the life of electrode in spot welding	
The uniformity and appearance of the weld is better as compared to spot welding	

Application of Projection Welding

a) Small fasteners, nuts etc. can be welded to larger components.

b) It is used for welding of refrigerator condensers, joining of wires etc.

c) Welding of stainless steel parts, titanium alloys, etc.

d) Used for joining and making of utensils.

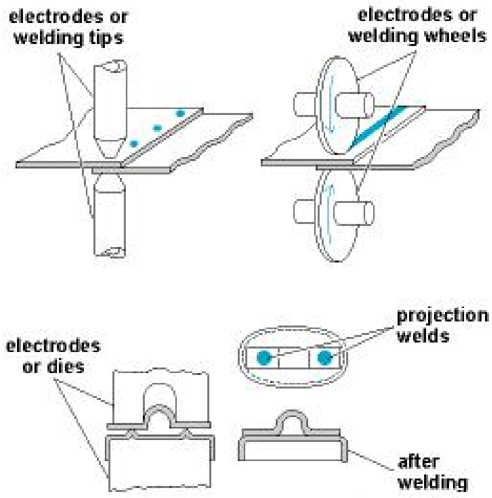
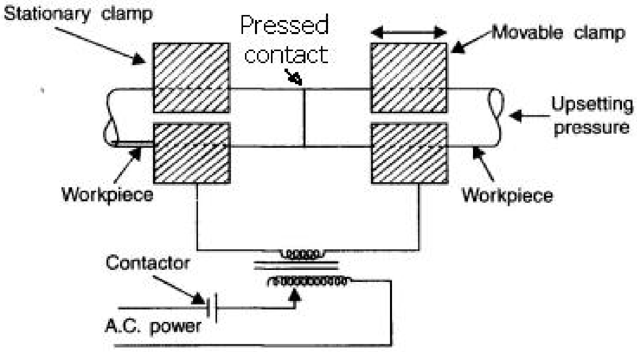


Figure showing spot, seam and projection welding



Principle of Resistance Butt Welding (UPSET)

Resistance Butt Welding (Upset)

This is used for joining the rods or bars face to face using the electric resistance or heat generation.

Resistance Butt Welding (Upset) Procedure

a) One workpiece to be joined is clamped in stationary clamping block and other is clamped in moving clamping block.

b) The two workpieces are brought together (butt joint) by pressure.

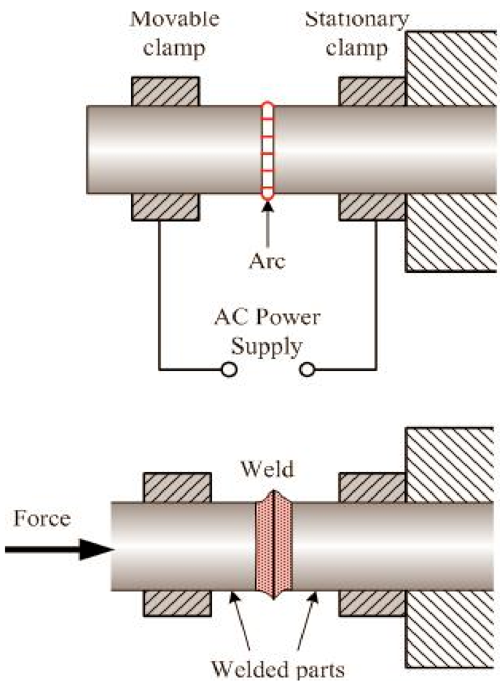
c) A heavy current is passed through these workpieces. The heat is generated because of resistance to the flow of electric current.

d) When the welding temperature has been reached, the pressure is increased so that proper joint takes place.

e) After that welding current is cut off.

f) Force is released when the welded joint has reached the desired temperature (normal temperature).

g) After that workpieces are unclamped.



Application of Resistance Butt Welding:

a) Used in wire drawing industries.

b) Used for producing butt joints in tubes, pipes, rods etc.

Flash Butt Welding

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

Procedure

a) One workpiece to be joined is clamped in moving platen while other is mounted on fixed platen.

b) Current is switched 'ON'

c) The workpiece held in the movable platen is moved towards the workpiece which is held in stationary platen as they come closer, flashing is established.

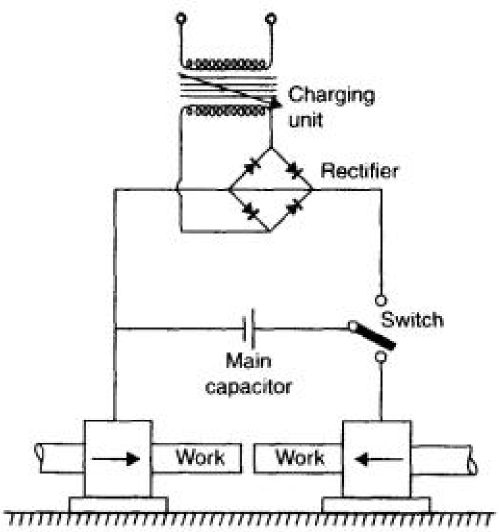
d) This flashing produces the welding heat. When sufficient heat is produced, more pressure is applied so that sound joint takes place.
e) After that, welding current is cut 'OFF' and workpieces are unclamped.

Advantages of Flash Butt Welding	Disadvantages of Flash Butt Welding
It consumes less welding current than upset butt weld process.	Concentricity and straightness of workpieces during welding is difficult to maintain
Flash welding offers strength factor upto 100%.	The shapes of the workpieces should be similar which is not always possible
Preparation of weld surface is not required.	Chances of fire hazards are there
The process is cheap	Flashes may cause eye trouble
It is a faster process	

Applications of Flash Butt Welding
a) It is used for the welding of bars, rods and tubes.
b) It is also used for the welding of saw blades into continuous loops, taps and reamers to alloy steel shanks.

Percussion Welding
In this resistance welding, welding heat is obtained from an arc produced by a rapid discharge of stored electrical energy. Pressure is applied rapidly during and immediately following the electric discharge. The electrostatic capacitors/ condensers are used to store the electrical energy.

Procedure
a) In this welding process, workpieces to be joined are clamped in moving platens.
b) Workpieces are brought near to each other.
c) The two workpieces are brought nearer.
d) An arc is produced by sudden discharge of the Condensers/ capacitors and rapidly pressure is applied.
e) At this stage arc is extinguished. Pressure is released when the weld cools.
f) After that workpieces are unclamped.



Percussion welding

Advantages of Percussion Welding	Disadvantages of Percussion Welding
Arc temperature is more as compared to flash butt welding	The process is limited to butt welds only
Strong joints are produced	The equipment used for this purpose is quite expensive
In this welding, there is no or very less upsetting	The equipment must be extremely rugged and provided with accurate holding fixtures and sensitive timing devices etc
Can be used for joining different metals	

Applications of Percussion Welding:
a) It is used for welding stellite tips to tools, silver contact tips to copper, copper to aluminium etc.
b) It is used in telephone industries.
c) It is also used for welding **fine wire** leads to filaments in lamps, bulbs, etc.

9. **Explain the process and principle of electric arc welding with a neat sketch.

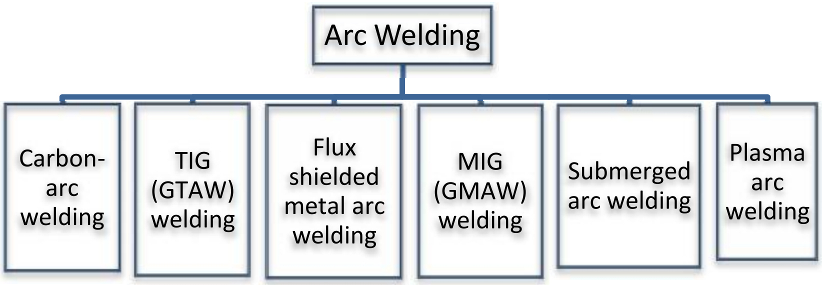
*Define weld-ability. Explain in brief the electric arc welding and different equipment used in electric arc welding. Also explain its advantages and disadvantages. 2010-11, Sem-I

*What is the principle of operation of electric arc welding? 2010, Sem-I/II, Spl-carry

*How is an arc obtained in arc welding? What are the different power sources used in the welding? What are the limitations and advantages of each. 2011-12, Sem-II

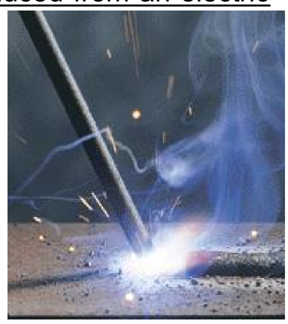
ANSWER

Arc welding is a metal joining process, in this process the heat is obtained from an electric arc. Arc welding is carried out without the application of pressure and with or without the use of filler metal, depending upon the base plate thickness.



<u>What is Arc Welding?</u>

<u>The fusing of two or more pieces of metal together by using the heat produced from an electric arc welding machine.</u>



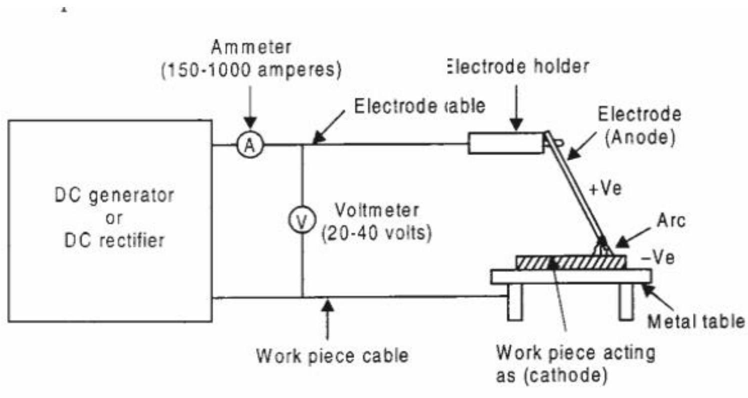
Basics of Arc Welding

The arc is struck between the electrode and the metal. It then heats the metal to a melting point. The electrode is then removed, breaking the arc between the electrode and the metal. This allows the molten metal to "freeze" or solidify.

What is arc and How an arc is formed?

The arc is like a flame of intense heat that is generated as the electrical current passes through a highly resistant air gap.

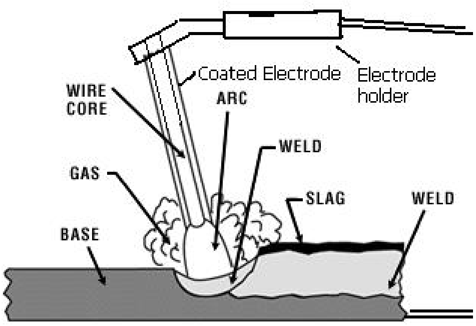
Procedure: The arc is formed (after switching ON the electric arc welding machine and connecting the electrodes) by striking the end of the welding rod on the work piece and a spark is produced, simultaneously the gap (approximately 0.8 to 2 mm) is maintained between the welding rod and work piece, this result in the continuous arc and heats the workpiece.



(a)

Arc Welding Principle

In arc welding, arc is generated between the electrode and the workpiece connected to electric supply which may be DC or AC. When these two poles are brought together, and separated for a small distance (0.8 to 2 mm) then the current starts to flow through a path of **ionized particles**, called plasma, and an **electric arc** is formed. Heat is generated as the ions strike the cathode (Negative). <u>About 60% heat is librated at positive terminal (Anode).</u>



Metal Arc welding with coated electode

Various arc welding processes are:

a) Carbon-arc welding

b) Metal arc welding
c) Shielded metal arc welding (SMAW)
d) TIG (Gas Tungsten Arc Welding) welding
e) MIG (Gas Metal Arc Welding) welding
f) Submerged arc welding
g) Plasma arc welding

Carbon-arc welding
In carbon arc welding the arc is established between the work piece and the carbon electrode the filler material may be used separately.

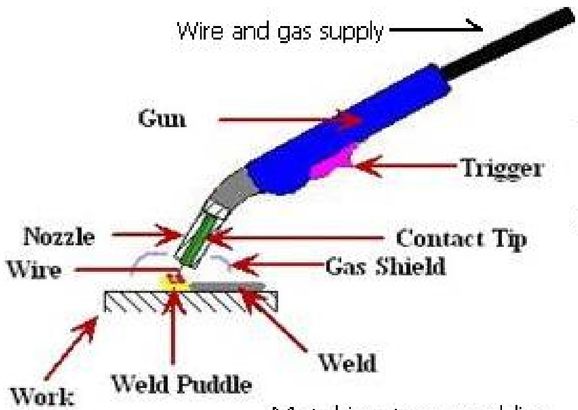
Metal arc welding
In metal arc welding the arc is established between the work piece and the metal electrode which acts as the filler material also.

Metal arc welding Procedure
a) The work piece is connected to one terminal of the welding machine.(Positive terminal in case of straight polarity)
b) The electrode is attached to the electrode holder.
c) The machine is switched 'ON' and current adjusted.
d) The metal electrode is struck to the workpiece and a gap of 0.8-1.2 mm is maintained to establish the arc.
e) The developed arc melts the metals and forms a pool of molten metal, called puddle. The molten metal forms a joint on cooling and solidification.
f) The joint is complete on solidification.

Shielded metal arc welding (SMAW)
a) Also referred to as "Stick Welding"
b) Commonly used method and can be seen in the local market and small workshops, for everything from pipeline welding, farm repair and complex fabrication processes.
c) Uses a "stick" shaped coated electrode.
d) The procedure is same as that of metal arc welding but the electrodes or the stick is coated with flux which shields and protects the weld pool or heated metal from oxidation.
e) Can weld: steel, cast iron, stainless steel, etc.

MIG (Metal Inert gas welding)

The welding is performed by electric arc using a continuously fed metal wire and the work piece. An inert gas is continuously supplied on the weld pool to make the protective atmosphere, such as argon or helium.



Metal inert gas welding

Applications of arc welding
a) Used for fabrication work and repairs
b) Used in ship building, pipe lines, bridge construction, tanks, boilers, etc
c) Domestic repairs and making of doors/ gates.
d) Manufacturing of domestic equipments such as chair, table, etc.

Advantages and disadvantages of **arc welding**

Advantages	**Limitations or disadvantages**
Most efficient way to join metals	Manually applied, therefore high labor cost.
Lowest-cost joining method	Need high energy causing danger
Affords lighter weight through betterutilization of materials	Not convenient for disassembly.
Joins all commercial metals	Defects are hard to detect at joints
Provides design flexibility	

Comparison of **A.C. and D.C. power sources** in arc welding

Alternating Current (from Transformer)	**Direct Current (from Generator)**
More efficiency	Less efficiency
Power consumption less	Power consumption more
Cost of equipment is less	Cost of equipment is more
Higher voltage – hence not safe	Low voltage – safer operation
Not suitable for welding non ferrous metals	suitable for both ferrous non ferrous metals
Not preferred for welding thin sections	preferred for welding thin sections
Any terminal can be connected to the work or electrode	Positive terminal connected to the work

Arc welding equipments:

The equipments required for arc welding are:

a) Power Source is a welding machine or generator (D.C.) or Transformer (A.C.)
b) Two cables- one for work and one for electrode
c) Electrode holder
d) Electrode
e) Protective shield
f) Gloves
g) Wire brush
h) Chipping hammer
i) Goggles or Safety Mask/ glass

******** UNIT-3 ENDS*********

UNIT-IV

1. What is quality?

Quality is a relative term and Quality can be defined as an inherent or distinguishing characteristic; a property of any object, product or service.

In manufacturing, a measure of excellence or a state of being free from defects, deficiencies and significant variations. It is brought about by strict and consistent commitment to certain standards that achieve uniformity of a product in order to satisfy specific customer or user requirements. ISO 8402-1986 standard defines quality as "the totality of features and characteristics of a product or service that bears its ability to satisfy stated or implied needs." If an automobile company finds a defect in one of their cars and makes a product recall, customer reliability and therefore production will decrease because trust will be lost in the car's quality.

If a product fulfils the customer’s expectations, the customer will be pleased andconsider that the product is of acceptable or even high quality. If his or her expectationsare not fulfilled, the customer will consider that the product is of low quality.This means that the quality of a product may be defined as “its ability to fulfill thecustomer’s needs and expectations”.Quality needs to be defined firstly in terms of parameters or characteristics, which varyfrom product to product.

For example, for a mechanical or electronic product theseare performance, reliability, safety and appearance. For pharmaceutical products,parameters such as physical and chemical characteristics, medicinal effect, toxicity,taste and shelf life may be important. For a food product they will include taste,nutritional properties, texture, shelf life and so on.

How the quality of any product can be improved?

The quality of any product or service can be improved by considering the following factors aspects:

Eight Dimensions or measures or factors effecting the Quality can be identified as a framework for thinking about the basic elements of product quality:

1. Performance: refers to the primary operating characteristics of a product. For an automobile, these would be traits like acceleration, handling, cruising speed, and comfort; for a television set, they would include sound and picture clarity, color, and ability to receive distant stations.
2. Features: automatic tuners on a color television set, blue tooth in mobile.
3. Reliability: It reflects the probability of a product’s failing within a specified period of time.
4. Conformance:The degree to which a product’s design and operating characteristics match pre established standards.
5. Durability: durability can be defined as the amount of use one gets from a product before it physically deteriorates. A light bulb provides the perfect example: after so many hours of use, the filament burns up and the bulb must be replaced.
6. Serviceability: Consumers are concerned not only about a product breaking down, but also about the elapsed time before service is restored, the timeliness with which service appointments are kept, the nature of their dealings with service personnel, and the frequency with which service calls or repairs fail to resolve outstanding problems.
7. Aesthetics:signifies that how a product looks, feels, sounds, tastes, or smells.This is clearly matters of personal judgment, and reflections of individual preferences.
8. Perceived Quality: Perceptions of quality can be as subjective as assessments of aesthetics. In these circumstances, products will be evaluated less on their objective characteristics than on their images, advertising, or brand names.

What do you understand by Quality circles?

A Quality Circle typically is a small group of volunteers consisting of first-line employees who meet regularly to identify, analyze and solve problems in their area of work to continually improve the quality, productivity and related issues of their work, products and services.Quality circle teams meet voluntarily on a regular basis toidentify, investigate, analyze and solve their work-related problems. It has been theexperience of Japanese industries that 95 per cent of problems at the workplace canbe solved by using the above seven quality circle tools and by the effective work ofquality circles.

Conformance: Fixing product specifications

A specification is the minimum requirement according to which a producer or serviceprovider makes and delivers the product and service to the customer. In settingspecification limits, the following should be considered:

a) The user's and/or customer's needs.
b) Requirements relating to product safety and health hazards provided for in the statutory and regulatory requirements.
c) Requirements provided for in national and/or international standards.
d) The competitor's product specifications, in order to gain marketing advantages.
e) In designing the product, the capacity of processes and machines should be kept in mind. It is also necessary to maintain a balance between cost and value realization.
f) The clearer the specification, the better the possibility of creating and delivering quality products.

Preparing product design

The specifications and drawings produced by the designer should show the qualitystandard demanded by the customer or marketplace in clear and precise terms. Everydimension should have realistic tolerances and other performance requirementsshould have precise limits of acceptability so that the production team can manufacturethe product strictly according to specification and drawings.

To achieve the above, those responsible for design, production and quality should beconsulted from the sales negotiation stage onwards. The overall design of any productis made up of many individual characteristics. For example these may be:

a) *Dimensions*, such as length, diameter, thickness or area;
b) *Physical properties*, such as weight, volume or strength;
c) *Electrical properties*, such as resistance, voltage or current;
d) *Appearance*, such as finish, colour or texture;
e) *Functional qualities*, such as output or kilometer per litre;
f) *Effects on service*, such as taste, feel or noise level.

Manufacturing drawings and specifications are prepared by the designers and theseshould indicate to the production team precisely what quality is required and whatraw materials should be used.

Correction of quality deficiencies

In spite of all the efforts made, the required quality will sometimes not be attainedand one may be faced with a pile of scrap and rework. This means that somethinghas gone wrong during the quality planning and maybe also during the manufacturingprocess. The reason for the trouble must be located and permanently corrected sothat it cannot happen again. The following are obvious possibilities:

a) The shop-floor operators had no clear idea what standard of quality was required.
b) The method was such that it was very difficult to get the job right, but very easy to get it wrong.
c) The machine and equipment were incapable of achieving the tolerances required.
d) The incoming materials and components were unsatisfactory.
e) The operators were untrained and not up to the job.
f) Shop-floor quality control was either not properly planned or not properly executed, or both.

Coordination
It is obvious from the above that everybody in the company the salesmen,designers, purchasing, stores and methods staff, plant engineers, jigs and toolpersonnel, production planning and production staff, operators, inspection and testingstaff, packaging, dispatch and so on, are responsible for product quality. Indeed,quality is everybody's business. Unfortunately, if care is not taken, it ends up beingnobody's business. It is therefore important to ensure that everyone is quality-conscious and that they all work together on matters related to quality.

2. ***Elaborate the factors governing the selection of plant location. What are the different types of the plant layouts? Explain fixed position layout.**

* Describe with suitable examples, plant layout and its different types and applications. 2009-10, Sem-II, 2009-10, Sem-I

* What are the differences between production and productivity? Also discuss the product layout and process layout with suitable examples. 2011-12, Sem-II

* What do you understand by plant layout? Explain in detail. 2011-12, Spl-Carry

* What do mean by plant layout? Discuss its objectives and advantages. 2012-13 Sem-II

ANSWER

Plant Location

The term Plant Location includes the ***decision as to where and how large*** a Plant should be setup. When a Large Industrial Undertaking is initially planned a number of Important Considerations are made before taking a final decision.

Plant Layout is a systematic and effective functional arrangement of different departments, machines, equipment and services of an organization that will facilitate the processing of the proposed or undertaken product in the most efficient and economical manner in the minimum possible time.

The term Plant Layout incorporates all the aspects connected with the enterprise, for example, grounds, buildings, machinery, equipment, departments, methods of manufacturing, factory services, material handling, flow of production, working conditions, hygiene, labor and shipment of goods, etc. The term 'Plant Layout' does not necessarily mean **planning a New Enterprise only**. It implies to all the following:

a) Minor improvements, here and there, in the existing layout.
b) Expansion of the existing plant.
c) Re-layout of the existing plant.
d) Layout of a new (proposed) plant.

Principles of Plant Layout
A good plant layout is based on the following principles:

a) **Integration.** It means the integration of production centre facilities like workers, machinery, raw material etc. in a logical and balanced manner.
b) **Minimum movement and Material handling**. The movement of workers and materials should be minimum.
c) **Smooth and continuous flow**. Means bottlenecks, congestion points and tracking should not exist in a workshop.
d) **Space utilization**. The total space available should be utilized properly. Raw material and products should be stored in racks, if possible.
e) **Flexibility**. The plant layout must be flexible to facilitate changes in production as and when required.
f) **Environment.** The workplace should be free from pollution and safe. It should have proper light, ventilation and other amenities.

Objectives of Plant Layout
Whenever a new or old plant layout is considered, the attempt is always to arrange the buildings, men and materials, in such a way that the following objectives are efficiently served:

a) The material has to move a minimum distance.
b) There is a smooth flow of the product in the plant.
c) The entire space of the plant is fully utilized.
d) The layout provides adequate safety and satisfaction to the plant workers.
e) It provides for enough flexibility in the arrangement of the above factors, so as to suit minor future changes, if any.
f) It facilitates an effective supervision.
g) Over and above all, it integrates all the above factors in such a way that the best compromise and coordination is achieved among them

Advantages of a Good Plant Layout
A good layout has many advantages and benefits are offered by a good Plant Layout, of which a few prominent ones are given below:

a) The floor area is effectively and economically utilized.
b) The rate of production is increased and less men and machine hours are used per unit of production.
c) The material handling time is minimized.
d) The usual production delays are avoided.
e) The men, machinery and factory services are more effectively utilized.
f) The overall production time is reduced.
g) A fairly large amount of paper work is eliminated.
h) The indirect expenses are considerably reduced

Important Considerations (*Factors governing the selection of plant Location*)
When a large industrial undertaking is initially planned a number of important considerations are made before taking a final decision. The common factors affecting this decision are:

a) Availability of space.
b) Availability of road, train, airport, electricity
c) Availability of power.
d) Availability of water.
e) Availability of raw material.
f) Climatic conditions. Means of communication. Marketing facilities for the planned product. Possibility of utilization and sale of the process wastes and by-products of the planned industry.
g) Effect of ancillary industries.
h) Availability of skilled and unskilled labor locally.
i) Local taxes and similar other economic considerations.

Internal Layout
Once a final decision has been taken, regarding the **size and location of the enterprise**, the next step is to plan the Internal Layout of the factory i.e., to plan-out the sequence of different shops and their locations accordingly. The same is generally affected by the following:

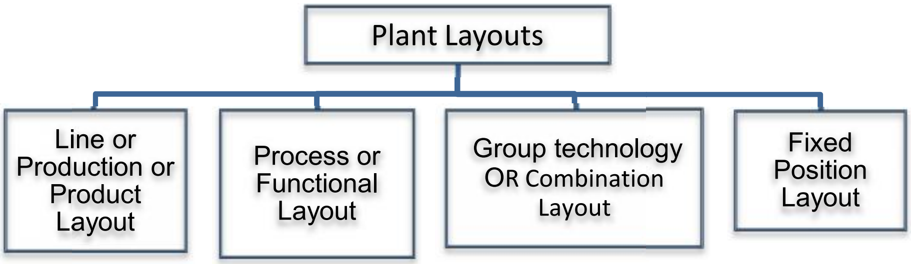
a) Specifications of material and product
b) Manufacturing processes.
c) Type of production
d) Material handling facilities
e) System and facilities for storing
f) Inter-dependability of one shop over the other
g) Service facilities
h) Lighting and ventilation

After finalizing the above sequence, the **internal arrangement of the equipment of different shops** is decided next. This is called Shop Layout. The following factors affect this layout:

a) Size and type of equipment.
b) Number of machines to be installed.
c) Floor area required for working on each machine. Use of individual machine.
d) Power requirements for the machines.
e) Requirements of factory services.
f) Sequence of operations to be followed.
g) Sound and uniform get-up.
h) Accessibility to all the machines.
i) Proper supervision and control.
j) Type of drive used—i.e., group or individual.
k) Safe working conditions.
l) Provision of stores within the shop, i.e., for tools, instruments, finished parts and consumable materials, etc.

Types of Layouts

The above conditions and requirements have led to different types of Plant Layouts which may be broadly classified as follows:

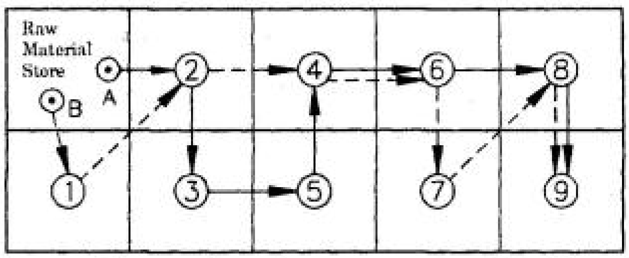


1. Line or Production or Product Layout

In this type of layout all the machines are arranged in a line according to the sequence of operations, i.e., each following machine or section is arranged to perform the next operation to that performed by its preceding machine or section. It is an ideal form of layout in which the handling time is least.

A sample Product Layout showing different Departments and Continuous Product flow.
1. Raw material store 2. Forging 3. Turning 4. Drilling 5. Milling 6. Grinding 7. Inspection 8. Finished goods store

This type of layout is commonly used in Continuous Production, which involves a continuous flow of material from Raw material stage to the Finished Product stage. An example product (or line) layout is shown in Figure. In this, the operations required in sequence are Forging, Turning, Drilling, Milling, Grinding and Inspection before the product is sent to the finished goods store for packing and shipment.



Process Layout showing movements of Products A and B
1. Forging 2. Turning 3. Milling 4. Shaping 5. Broaching 6. Drilling 7. Heat treatment 8. Inspection and 9. Finished parts store

Process or Functional Layout

In this type of layout, *similar machines or operations* are grouped together, so that all the operations of same type are performed at the same place always. *For example,* all the lathesmay be grouped together to do turning and threading etc. all Drilling machinesin one area to do *drilling work,* allBuffingand Polishing machinesat one place to do *Surface finishing* work, and so on.

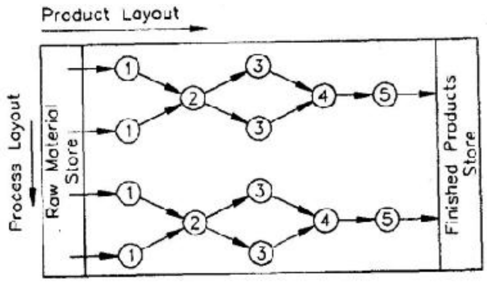
This type of layoutis usually preferred for the industries involved in 'Job order'type of productionand manufacturingand/or maintenance activities of *non-repetitive* type. This type of layoutis shown in Figure**,** which illustrates the movement for two products A and B.The operations required for these products in order *of sequence* are as follows:

Product A—Turning, Milling, Broaching, Shaping, Drilling, Inspection

Product B—Forging, Turning, Shaping, Drilling, Heat treatment, Inspection

Combination or (or Group Layout)

By taking advantages of both the Process Layout as well as Product Layout the best results can be obtained by combining the advantageous features of both these layouts into a single one, and this is known as a **Combination Layout**. In this type of layout, a set of machinery or equipment is grouped together in a section, and so on, so that each set (or group) of machines or equipment is used to perform similar operations to produce a Family of Components. Since this type of Process Layout incorporates the principle of Group Technology, this layout is also known as Group Layout as well. The flow of product follows a Product Layout sequence.

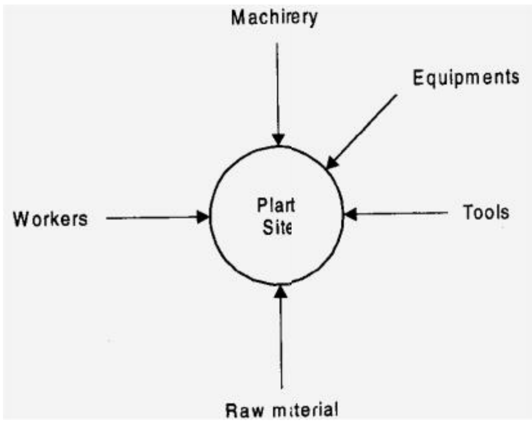


A Combination Layout for manufacturing different sizes of Crankshafts.
1. Forging hammers, 2. Inspection 3. Journal ginding 4. Heat treatment 5. Final inspection

A sample Combination Layout for manufacturing forged Crankshafts is shown in Figure wherein the combination of both Process Layout and Product Layout is quite clear.

Fixed Position or (Project) Layout

In this type of layout the major part of an assembly or material remains at a fixed position and all its accessories, auxiliary material, machinery and equipment needed, tools required and the labour are brought to it to work at site. Thus, the location of the major component or material is not disturbed till the product is ready for dispatch.**Merits and Demerits:** This type of layout is mostly adopted for extremely large items manufactured in very small numbers, e.g., ships, aero-planes, etc.

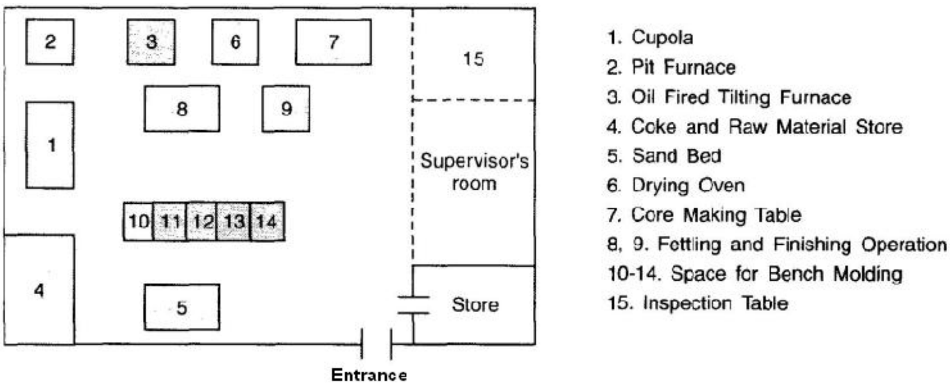


Comparison of different types of plant layouts

Product Layout	**Process or Functional Layout**	Combination	**Fixed Position Layout**
Advantages	**Advantages**	**Has advantages of both**	**Advantages**
Relatively less floor area is required.	Better utilization of the available equipments.		The movement of material is reduced to a minimum.
Material handling is less.	Less number of machines are needed as compared to other layouts.		There is maximum flexibility to change in the product.
Work in process inventory is less.	Wide flexibility exists.		All members of the team are responsible for quality work. So better coordination can be achieved.
Production control is better.	Operations performed in one section don’t affect the workers of the other		Continuity of operations is ensured.

	section.		
Manufacturing time is less.	Experience can be utilized properly.		Minimum capital investment.
Workflow is smooth and continuous.	New workers have better training facilities.		Production control is easy.
Automation can be easily applied.	Provision of standby units.		Better space utilization.
Requires less inspection as compared to process layout.			Risk factors associated with heavy material handling are reduced
Disadvantages	**Disadvantages :**		**Disadvantages**
More number of machines are needed, so higher capital investment.	Requires more floor area.		There is low utilization of labour and equipment and space.
Less flexibility in layout.	More movement of materials.		Equipment handling cost is high.
The rate of production is largely affected by the rate of the slowest machine.	Production control is difficult.		It is limited to large items only.
Specialized facilities also require a high initial investment	Large in process inventory (*i.e.* work in process is more).		Highly skilled workers are required.
Manufacturing cost increases, if the production is limited	Total job completion time is more.		Complicated jigs and fixtures are required for fixing tools and jobs.
The breakdown of a single machine may effect the whole production.	Inspection of work after each operation is essential as the material passes to the next department.		Not suitable for mass production.
	Routing and scheduling is more difficult.		
Application	Application		Application
This type of layout is used for repetitive types	This type of layout is used for job order production or manufacturing/maintenance activities of non-repetitive types.		This type of layout is used in shipbuilding, automobile industry, railway wagon industry, and aeroplane.

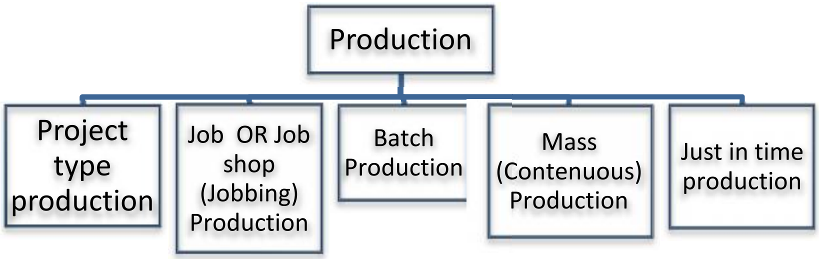
Lay out of a foundry shop is a type of layout and, the figure below indicates the layout of a foundry shop.



Layout of a foundry shop showing arrangement of different equipments & Facilities

3. **Explain with suitable examples, the types of production**. 2008-09, Sem-I

Production: It can be defined as the transformation of the raw materials into valuable and useful items, with the use of different Manufacturing Processes, which are required by the society for various purposes.



Types of Production

a. **Project Type Production:**

It is also known as **One-off Production** because it is the Production of a Single, Large and Complicated Product, such as Construction of a Bridge, a Hospital, a Mail, a Factory, an Airport, a Ship, etc. Such a production is considered as an independent Project, in which various categories of workmen and the required Machinery are usually hired, **specifically for that Project**, and the Production work is carried out at the site.

b. Job OR Job shop OR Jobbing Production

It is also known as Job shop Production or simply Job Production. It involves production of a ***single unit or a single lot of items or Services against a specific Order***. Another lot of similar items may or may not be ordered again, but such a repetition of order normally does not occur. Some examples of this type of Production can be the production of special type of Machines, making of house doors, construction of Aeroplanes, undertaking ship repairs and other repair jobs, etc. Evidently, such jobs require special skills and, therefore, a highly skilled workforce is employed for them. Consequently, the Unit Costs in this type of production are quite high.

c. Batch Production

It is also known as Intermittent Production. In this type of production the jobs or services are produced in Batches or Groups, in which the products or services carry similar designs. The complete order is usually large, but the production is in relatively small groups or batches intermittently to makeup the large order or a Continuing Order.

Once a Group or Batch of a particular design has been produced, the Plant Facilities are utilised for producing another batch of Products of different design and this process continues like this intermittently. The quantity of products, produced in a batch, is normally more than the instant requirement, to store for future.

d. Mass Production

It is also known as Flow Production or Continuous Production or Line Production. In this type of Production the Products or Services are of similar design and are produced on a continuous basis and normally they are manufactured on Interchangeable basis. The production machines are installed in a row (line), such that they carry out the operations in a specified sequence one after the other. The production rate is almost equal to the demand. Mass Production is normally used when a large number of identical items are required to be produced and their demand is expected to continue for a long time. Some examples of this type of Production are Bicycle manufacturing, Car Manufacturing, Cement industries, Sugar Industries, Oil Refineries, etc. Depending upon the nature of products, the machinery used may be special Purpose Machines and Automatic or Semi-Automatic Machines, together with some Standard Machines and Tools, and accordingly the required workforce may be an amalgam of skilled, unskilled and semiskilled workers.

e. Just in time production: In this case the items are produced as per the demand only and as and they are needed or required.

Comparison of types of production

Project Type Production	Job Production	Batch Production	Mass Production
Used for specific and independent project	Used for a specific Order	Used to meet continuing demand and production is carried out in batches or groups	Used for the products with continuous demand
Man power is highly skilled	Man power is highly skilled to semiskilled	Man power is semiskilled	Man power is low to semi-skilled
Production is carried out at site	Production is carried in the shop with general purpose machines	Production is carried in the factory with general purpose machines and semi automatic machines	Production is carried in the factory with special purpose and automatic machines
The workers are hired only for the project	Workers are permanent employees	Workers are permanent employees	Workers are permanent employees
Ex: bridge, airport, etc	Ex: doors, gates, etc.	Ex: tooth paste, medicines,etc.	Ex: sugar, cement, refinery, etc.
Cost is very high	Cost is high	Cost is medium	Cost is very low
			Production unit runs for 24 hours

4. *What do you understand by production and productivity and types of production?

*What are the differences between production and productivity? 2010-11, Sem-I, 2011-12, Sem-II

ANSWER

Production: It can be defined as the transformation of the raw materials into valuable and useful items/ product, with the use of different Manufacturing Processes, which are required by the society for various purposes.

Production also refers to the absolute number or measure of the items or services produced in the plant or organisation. *(Types of production is covered in earlier pages)*

Productivity. It is defined as the ratio of the Input facilities to the Output of goods and Services. In general, it is the quantitative relationship between the produce and the resources utilised in their production and represents the efficiency of the factory/organisation.

$$Productivity = \frac{Measure\ of\ Output}{Measure of Input}$$

Productivity is "The Ratio between the Volume of Output, as measured by Production Indices, and the Corresponding Volume of Labour Input, as measured by Employment Indices.

Comparison of production and productivity

Production	Productivity
It is the volume of products	It is relative measure efficiency of factory (Ratio of output to input)
It can be increased by increasing Input material, manpower and working hours	It increases by decreasing input and keeping output same
It can be increased by decreasing wastage	It increases by increasing output and keeping input same
	It can be increased by good plant layout

5. **Describe, step by step, manufacturing of components by powder metallurgy process. What are the advantages of Powder metallurgy?

*List various advantages of powder metallurgy. Explain the process in detail. 2011-12, Sem-I

*What is meant by "Powder metallurgy"? Describe briefly the various powder production methods. 2010, Sem-I/II, Spl-Carry

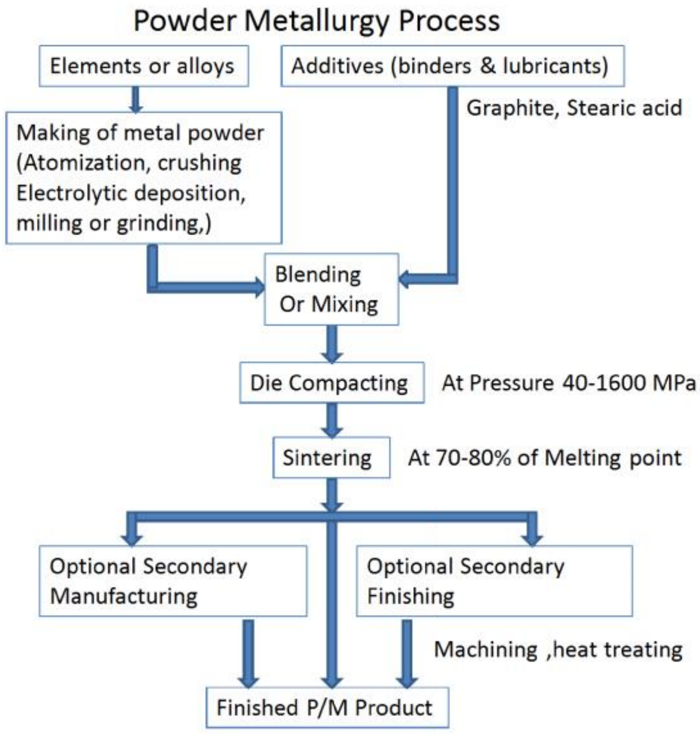
*Explain powder metallurgy process. Also give its advantages and applications. 2010-11, Sem-II

*Explain the different properties of the metal powder suitable for powder metallurgy process. Also discuss the applications of powder metallurgy. 2011-12, Sem-II

*Write a short note on powder metallurgy giving its applications. 2011-12, Spl-Carry

ANSWER

Powder Metallurgy Process



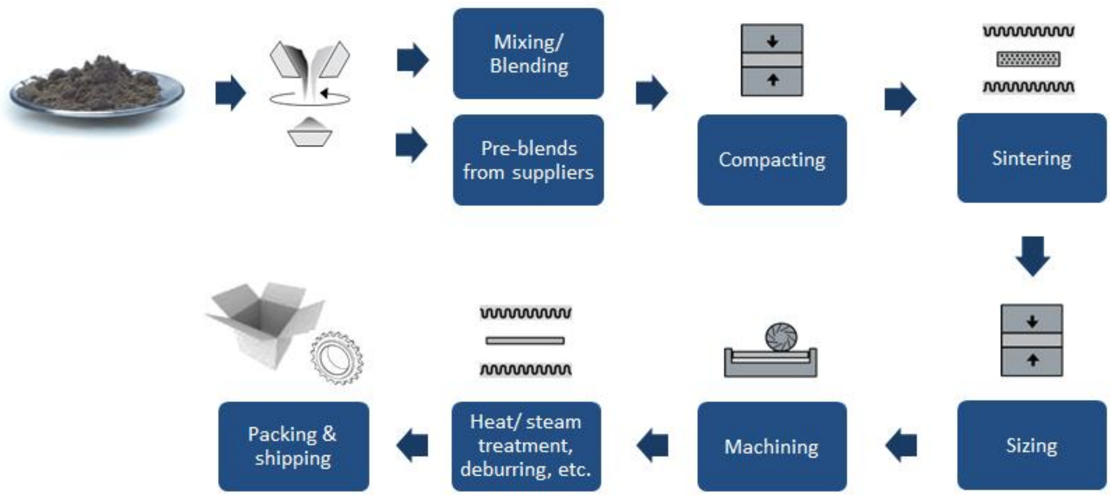
Powder Metallurgy can be described as process or technique of *manufacturing commercial articles* from *powdered metals* by placing these powders in moulds and applying Pressure.

These compressed parts are then heated to bind the particles together and improve their strength and other properties. This process is known as **Sintering.** The temperature during this process is kept below the melting point of the powder.

The Products made through this process are very costly on account of the high cost of metal powders as well as of the dies used. A few typical examples of such products are Tungsten carbide Cutting Tools, Oil-less Self Lubricating Bearings, special Electrical Contacts and Turbine-Blades, having high temperature strength. The Components made through this technique may be made from a single Metal powder or alloyed Metal powders.

Powder Metallurgy Process

The entire Powder metallurgy process mainly consists of the following **basic steps**:

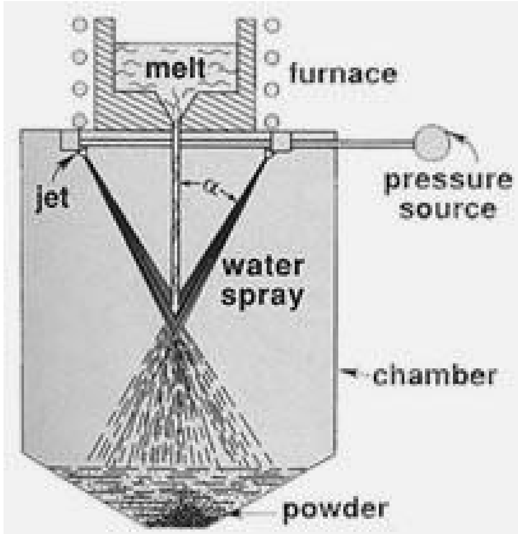


a. Production of metal powders.
b. Mixing or Blending of the metal powders in required proportions.
c. Pressing and compacting the powders into desired shapes and sizes.
d. Sintering the compacted parts in a furnace of controlled atmosphere.
e. Subjecting the sintered parts to Secondary Processing, if required.
f. Heat treat the components if, required

The complete powder metallurgy process of making components from the powders is shown in the above figures.

a. Production of Metal Powders

The following Processes are commonly used for producing these powders:



Atomization: It consists of forcing the Molten Metal through a Nozzle into a stream of **Air** or **Water**. As it comes in contact with the stream, the metal solidifies into small particles of various irregular shapes and sizes. Size of Nozzle, Rate of flow of metal and Temperature and Pressure of the air or water stream control the size of these particles. The Powders produced through this method are normally of Spherical or Pear shape.

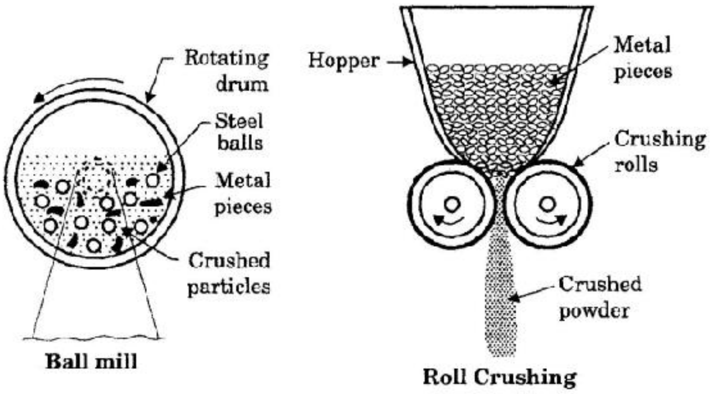
The maximum amount of Metal powders is produced through Water Atomization Process, shown in Figure, the setup is shown in the diagram consists of a Hopper like Container, called **Tundish**with a furnace, at the top. It carries a small Orifice at its bottom. This Container (Tundish) is fitted on the top of a larger container, which carries provision for Water jets inside. Molten metal is poured into **Tundish from a Ladle at the top of** it. As this metal flows down in the form of a stream through the nozzle, Water Streams from both sides impinge on it. This results in instantaneous cooling of the flowing metal in the form of small metal particles, which fall down and are collected at the bottom.

In **Air Atomization**, an air stream replaces the Water jets. In either case, the particles will be oxidized. If, however, oxidized particles are not acceptable, an Inert gas stream can be used, the process then being known as **Gas Atomization**

Electrolysis or Electrolytic Process: Metal powders may be deposited electrolytically under controlled conditions. The deposited material is Mulled or Ground for fineness, Pulverized for desired grain size and Annealed to drive out hydrogen and remove the effect of work hardening. The Powders produced through this process are the Purest,

Milling and Grinding or Mechanical Pulverization :

It consists of breaking down the metal into small particles by Crushing and Impact through Ball Mills, Stampers, Crushers, etc. The process involves pulverize (grind/ crush) the metal mechanically so that it will disintegrate into small particles, as shown in Figure. Brittle materials suit best to this method. It is also used for Malleable and Ductile metals.



Ball mill and roll crushing methods of powder making

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.

Properties/ characteristics desirable in the metal powders

i. **Particle shape**: particles may be angular, flat or spherical and this will affect the compactness, porosity & strength of part. A mixture of all shape type of particle is desirable.
ii. **Particle size and distribution**: it may be fine and coarse. The mixture of both is desirable for good part production.

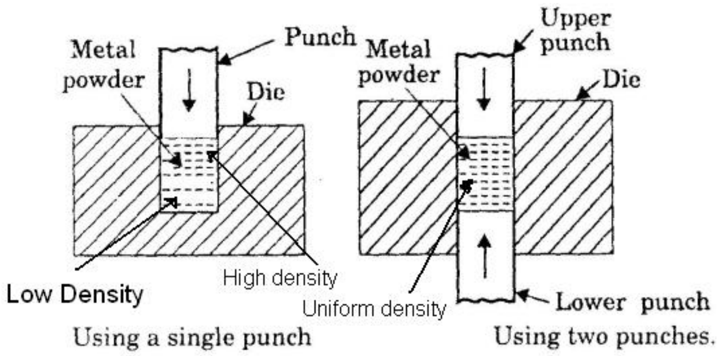
iii. **Flow-ability**: the powders must be flow-able to occupy the each corner of the mould easily.
iv. **Compressibility**: The powders should possess good compressibility which is the ratio initial volume to the final volume after compaction.
v. **Purity**: the powders should not have any impurity as this will lowers the quality and mechanical properties of the parts.
vi. **Sintering ability:** It should sufficiently high for good products.

b. Blending or Mixing

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 and enable easy ejection of pressed parts. Common lubricants are Graphite, Stearic acid and Lithium stearate. Blending also facilitates uniform distribution of particle size.

c. Compacting

It is the process of converting **loose powder** into a Green Compact of accurate shape and size. It is done in steel dies and punches. Due to inter particle friction, the pressure applied from one side is not uniformly distributed throughout the mass. Two punches are, therefore, employed, one from the top and the other from the bottom of the powder, as shown in Figure. The lower punch also works as an Ejector for the compressed part. Due to low flow-ability of metal powders, the density variation is kept at a minimum by both-side pressing.



Compacting of metal powders using one and two punches

d. Sintering

Sintering of compacted parts is the process of heating to high temperatures, but below the melting points of the materials being sintered it may be carried out in two steps, using pre-sintering to a lower temperature. The actual values of sintering temperatures for most materials range between 70 to 80 per cent of their melting temperatures.

The main objectives of Sintering can be summarized as follows:

a) Achieving high strength
b) Achieving good bonding of powder particles
c) Producing a dense and compact structure
d) Producing parts free of oxides
e) Causing metallurgical diffusion and facilitate alloying of constituent materials.
f) Obtaining desired structure and improved mechanical properties.

e. Secondary Processes

Sizing: It consists of placing the sintered part in a Die, made to correct dimensions, and repressing the same to bring it to the required size. It also takes care of certain distortions which might have occurred during Sintering.

Machining

In most of the cases, the parts produced through powder metallurgy are finished to required dimensions and tolerances and no further machining is required on them. However, sometimes, in order to hold very close tolerances or for producing such features like Small holes, Threads, Undercuts and Grooves, etc., which cannot be produced through Powder Metallurgy process, machining may have to be done.

Impregnation
The process is performed to provide Self-Lubricating Properties to the sintered parts. For this, the parts are placed in a tank, carrying the lubricant, and heated to about 93°C for about 15 to 20 minutes. The lubricant enters the pores of the part through capillary action and is retained there.

Heat Treatment
All sintered metal parts can be Heat-Treated through the usual methods, although the results are not as impressive as with solid metal parts.

Applications of powder metallurgy
Some Typical applications of metal powder parts are

a. Porous Metal Bearings, made from Brass, Iron, Aluminum, Bronze, etc. which are later impregnated with lubricants.
b. Machine parts are produced from powders of Iron, Brass and Bronze.
c. Filament wire for electric bulbs is made from Tungsten Carbide Powders with Cobalt as binder.
d. Products where metals and non-metals are combined
e. Combination of metals and ceramics
f. Used for making the grinding wheels
g. Used for making electrical contacts
h. Used in medical services for medicine and making of equipments

Advantages and Disadvantages of Power Metallurgy

Advantages	Disadvantages and Limitations
It facilitates production of many such parts which cannot be produced through other methods, such as Sintered carbides and Self lubricating bearings	The metal powders and the equipment used are very costly
It also facilitates mixing of both metallic and non-metallic powders to give products of special characteristics	There is a limitation to the size of the product as the same will depend on the capacity of the press used and the compression ratio of the powders
The products carry very high dimensional accuracy, thus eliminating the need for further machining in most cases. If at all needed, it is not much	Storing of powders offers great difficulties because of the possibilities of fire and explosion hazards
Layers of different metal powders can be molded together to obtain multi-metallic products	Design restrictions, due to low flowability of metal powders, restrict the production of intricate shapes
The products of powder metallurgy are highly pure	Sintering of low melting point metal powders, like those of lead, zinc and tin etc. offers serious difficulties
The process facilitates saving in material as no material loss occurs during fabrication	
It is possible to ensure uniformity of composition, since exact proportions of constituent metal powders can be used	A completely dense and compact metal structure cannot be produced through this process.
The rate of production is quite high	
It enables production of parts from such alloys which possess poor cast-ability	
The process does not require highly skilled workmen	The process is not found economical for small scale production
Hard to process materials, like diamond and ceramics, can be converted into usable components and tools through this process	Physical properties of parts produced through this method are generally not comparable to cast or wrought parts

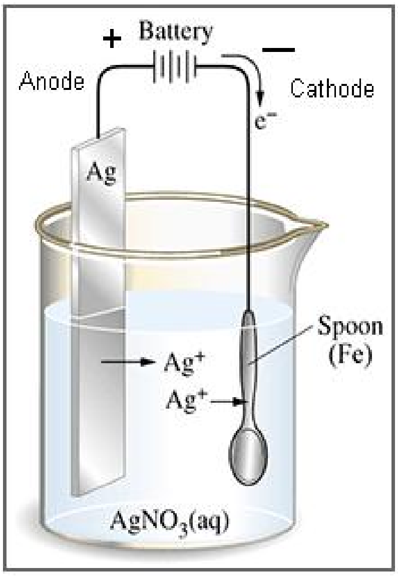
6. *** Explain the following:**

a) Electroplating 2009-10, Sem-II, 2008-09,Sem-II

b) Galvanizing 2009-10, Sem-II, 2008-09,Sem-II, 2008-09, Sem-I
c) Ceramics
d) Ceramics and their applications 2009-10, Sem-I , 2009-10, Sem-II, 2008-09,Sem-II
e) Plant Layout
f) What is galvanizing? 2011-12,Spl-Carry
g) Explain the purpose of galvanizing. Discuss the hot dip galvanizing process. 2012-13, Sem-II

ANSWER

a. Electroplating

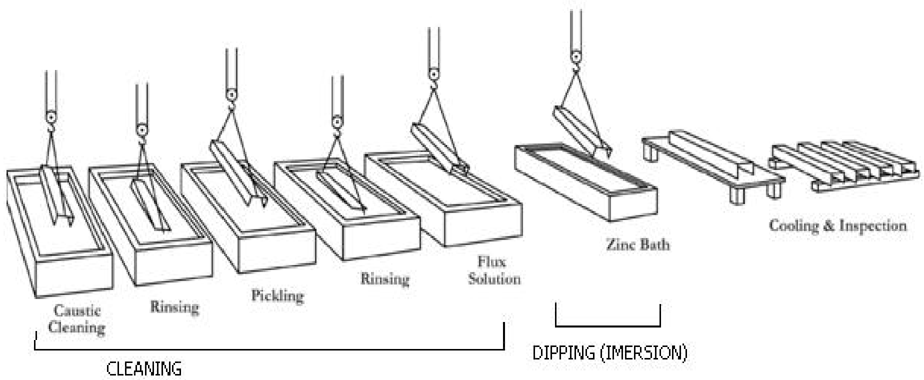


Electroplating is a very popular process of providing metallic coatings by means of Electrolysis. The article to be coated may be metallic or non-metallic (Plastics). If metallic, the Base metal and the coated metal may be same or different. Coatings of several different Metals and Alloys can be provided through this technique. Some common metals and alloys, of which coatings can be provided on metallic and non-metallic surfaces, include Chromium, Tin, Nickel, Copper, Cadmium, Silver, Gold, Platinum, Brass, Bronze, etc.

The **Basic Principle** involved in Electroplating of all metals is the same. The main elements involved in this process are an Electrolyte, a Tank containing this electrolyte, an Anode (+ve terminal), a ***Cathode (-ve terminal)*** and a low voltage Direct Current (d.c.) supply. The Electrolyte used is a metallic salt solution i.e.,dissolved salts of the Plating Metal. ***The Work-pieces to be plated are suspended and immersed in the electrolyte filled in the tank and electrically, they are connected to the Negative Terminal so as to act as Cathode in the circuit.*** The material to be deposited to provide the Coating is connected to the Positive terminal, so as to act as Anode. When plastics are to be plated, a primary coat of an electrically conductive material is first provided over them and then they are electroplated.

b. Galvanizing

Galvanizing or galvanization is a process which employs an **Electrochemical** Action for providing a Coating of a highly corrosion resistant material on the surface of another metal.This process (Galvanizing) is largely used for providing a coating of **Zinc** on Iron and Steel. It is a fairly low-cost process and is widely used for corrosion resistant Coatings on sheet metal, house hold items of daily use made from iron and steel i.e. buckets, tubs and other containers, machine parts, tools, ships, tanks, wires, different threaded fasteners, etc. Galvanized metal sheets, pipes and wires are probably the most popular galvanized items and find application both in industrial work as well as in articles made for domestic use, i.e. hand pump or submersible pump pipes.



Hot-dipping Galvanizing Procedure

a) The first step in applying this process is **cleaning** of the parts or items to be galvanized. This may involve degreasing, acid rinsing in cold water, etc. depending upon the condition of the work-surfaces. The basic idea is to obtain an absolutely clean surface. If the item to be galvanized is sheet metal, it is annealed after surface cleaning and then cooled in an oxide free atmosphere.

a) The sheet is then **dipped in the molten zinc** bath consisting of a minimum of 98% pure molten zinc. The bath temperature is maintained at about 449 ^{o}C.

b) If perfect and uniform thickness is an important consideration, the sheets are drawn through a set of rollers, immediately following the coating process. This process drives away the Excess Zinc and allows only the required amount of zinc to remain on the surface, which is just enough to provide the coating of desired thickness.

c) This is followed by drying & inspection.

d) The sheets are ready for shipment.

e) The complete procedural steps are shown with help of the figure above.

c. Ceramics

Ceramic is a compound which consists of metallic and non- metallic constituents. This word is derived from a Greek word Keramicos, which means Potter Earth or Clay. It is found that they carry more than one type of bond in a single material, i.e., an ionic bond as well as the covalent Bond. Due to these bonds, Ceramics are characterized by their: High Brittleness, High hardness, high Electrical insulation, Chemical inertness and High melting points.

Examples: Common Ceramic Materials include Glasses, Insulating Materials, Enamels, Abrasives, etc. All metal oxides, nitrides, silicates, borides and Carbides are also considered as Ceramics.

Classification of Ceramics: Ceramics may be considered as materials made from naturally occurring clay or earth. Ceramics are non-metallic and inorganic materials which are processed at high temperature. Ceramics may be classified as natural ceramics (Silica, Silicates) and manufactured ceramics (Silicon carbide, Aluminium oxide, etc.)

Properties of Ceramics

a. They are hard.
b. They are brittle.
c. Ceramics have high melting point.
d. Ceramics have low electrical and thermal conductivity.
e. They have good creep resistance.
f. They have high corrosion resistance.
g. Ceramics have good chemical and thermal stability.
h. Ceramics have high compressive strength.
i. Ceramics have excellent resistance to wear.
j. Porous ceramics are resistant to thermal shocks.
k. Ceramics have low density.
l. Ceramics have low tensile strength.

Applications of Ceramics

a) Clay Products :
   1) Earthen-ware : Porous drainage pipes, ceramic filter, wall, tiles and bricks.
   2) Fine China : Table ware.

3) Stone ware : Glazed pipes, roofing tiles and table ware.
4) Porcelain :Fine table ware, scientific equipment and spark plug insulators for automobiles

b) Refractory bricks
c) Cutting tool materials
d) Abrasives
e) Electrical switches and capacitors

7. Write short notes on the following:

a) Plastics and their applications 2008-09,Sem-I/II, Spl-Carry, 2011-12, Sem-I, 2010-11, Sem-II, 2010, Sem-I/II, Spl-Carry
b) Process type plant layout 2011-12, Sem-I
c) Types of plant layout 2008-09,Sem-II, 2 010-11,Sem-II
d) Cement concrete 2010-11,Sem-II
e) Composite materials & applications 2009-10, Sem-I, 2009-10, Sem-II, 2010-11, Sem-II, 2010, Sem-I/II, Spl-Carry
f) What is composite material? Discuss their types along with their relative importance over conventional materials. 2012-13, Sem-II
g) Write a brief note on cement indicating its properties and applications. 2012-13, Sem-II
h) Explain the following with neat sketches: (i) Extrusion moulding (ii) Blow moulding. 2012-13, Sem-II

ANSWER

a. Plastics: Plastics are the organic materials and derived from the materials which consist of carbon combined with hydrogen oxygen and other non-metallic substances.

Also the Plastics are synthetic organic materials termed as ***polymers****, which are formed from monomers after the process of polymerization.*

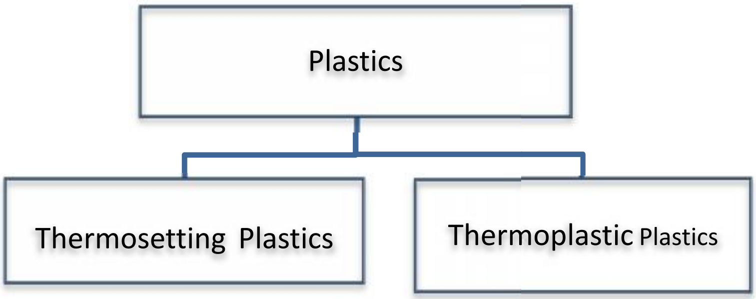
Properties of Plastics and Advantages

a) They are light weight having low density and at the same time possess good strength and rigidity.
b) They are less brittle when compared to glass and yet can be made equally transparent and smooth.
c) The high heat and electric insulation make them suitable to be applied in the radio and electrical engineering industries as dielectrics and as substitutes for porcelain, ebonite, mica, shellac etc.
d) They possess good toughness.
e) They have good chemical stability, when exposed to the action of solvents, and certain oxidizing agents i.e., they resist corrosion and action of chemicals.
f) Plastics have good damping capacity.
g) Plastics have good surface finish.
h) They possess the property of low moisture absorption.
i) They can be easily molded to desired shapes.
j) Simple processing of plastics is required to obtain machine parts.
k) Plastics possess low melting point and can easily flow into a mould.
l) They possess high strength to weight ratio.
m) Mass production of plastics is easy and so they are extensively used as wrappers and bags.
n) Plastics possess weather-ability, colour-ability, heat resistance and deformability

Disadvantages of Plastics

1. Comparatively higher costs of materials.
2. Inability of most of the plastics to withstand moderately high temperature

Types of Plastics



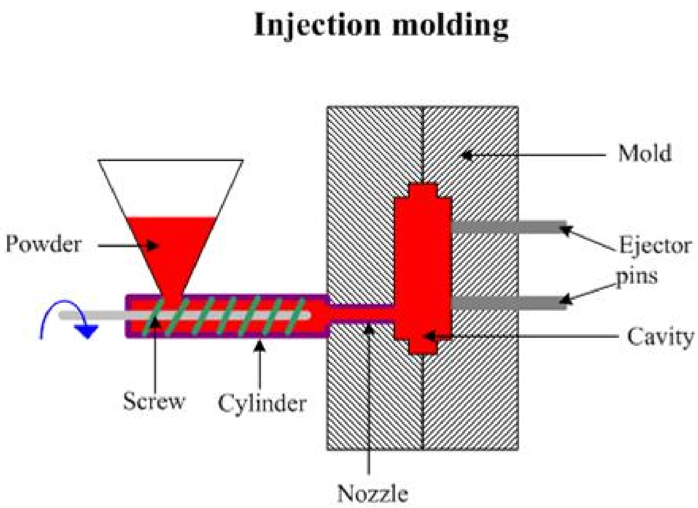
Thermosetting Plastics: These plastics, when subjected (once only) to heat and pressure required for forming, change into hard and rigid substances. Once these Thermosetting Resins are changed into rigid substance they cannot be softened again by application of heat.

Thermoplastic Plastics: These plastics can be re-softened and re-molded by application of heat and pressure. These plastics harden on cooling and can be re-softened under heat. Thus, they retain their fusibility, solubility and capability of being repeatedly shaped. Thermoplastic resins are linear and branched linear polymers and are sensitive to temperature and sunlight.

Plastic Products Manufacturing

The following methods are commonly employed for manufacturing of plastics into various usable articles:

a) Extrusion
b) Injection molding
c) Reaction Injection molding
d) Blow molding
e) Casting
f) Slush molding

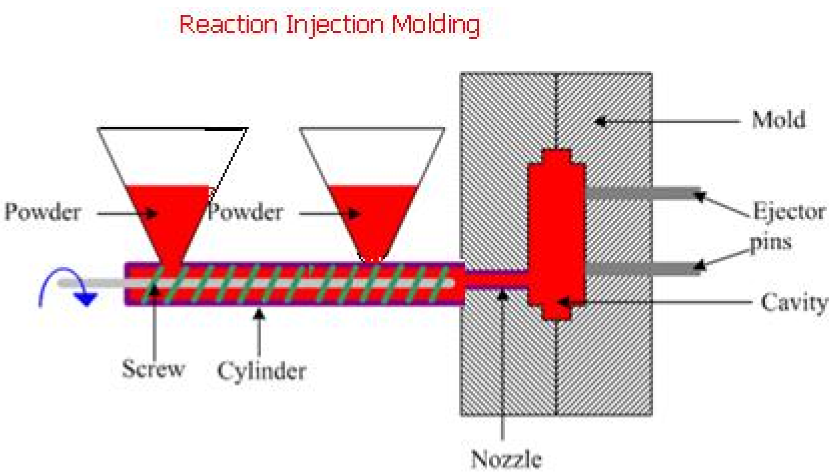


Injection Molding

It is very commonly used for Thermoplastic Plastics. The process is illustrated in Figure. The Powdered plastic Compound is first heated to drive off Moisture and then fed into the Hopper. The material (Plastic) is fed into the cavity by the screw. This compresses the material and forces it forward into the water cooled mould through the Nozzle. During heating in the Chamber, the temperature of the material rises to between 177°C and 274°C. After the Plastic has been cooled and sufficiently hardened in the mould, the mould is opened and the produced part knocked out. It is a faster process and suits best for large-quantity Production.

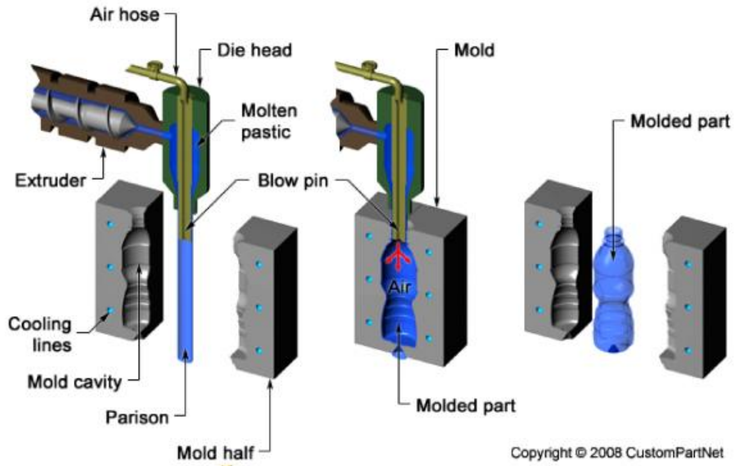
Reaction injection molding

This method is used for thermosetting plastics and the arrangement is similar to injection molding. The powders of two materials are heated and mixed and forced in the cavity. The arrangement uses two hoppers.



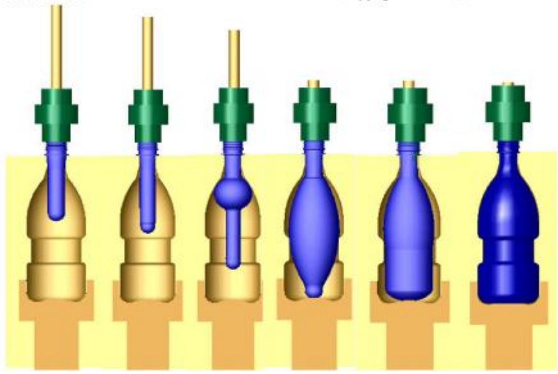
Blow moulding

Blow moulding a shape is a common industrial process. The example shown below is of the production of a plastic bottle. The plastics normally used in this process are; polythene, PVC and polypropylene.



The process is similar to injection moulding and extrusion.

a) The plastic is fed in granular form into a 'hopper' that stores it.
b) A large thread is turned by a motor which feeds the granules through a heated section.
c) In this heated section the granules melt and become a liquid and the liquid is fed into a mould.
d) Air is forced into the mould which forces the plastic to the sides, giving the shape of the bottle.
e) The mould is then cooled and is removed.



b. Cement-Concrete

Cement Concrete is a mixture of Cement, Sand, Brick or Stone Ballast and Water. On hardening, the mixture forms a stone like material known as Cement Concrete. Mixture of Cement and Water forms a paste and it binds the aggregates to a permanent mass after hardening. Sometimes some, chemicals are also added in it to reduce porosity at the optimum mortar cement ratio and to avoid failure of the structure. Cement Concrete Produces excellent resistance to compressive stress, shear stress and abrasion.

Cement basically contains materials of Calcium Carbonate origin, such as Limestone. The Cement normally used in construction work is commonly known as Portland cement due to its resemblance with Portland Stone.

When mixed with water, it forms a Paste. If allowed to remain like this for some time. It starts setting, and gets stiff and finally it becomes hard and strong. The colour of commonly used Portland cement is Grey. Cement is also production in White Colour, which is known as White Cement. It's strength is less than that of Grey Portland/ Cement and it is generally used in decorative flooring, fixing of tiles and repair work. Portland cement is commonly used in all construction works, such as Building construction, Road construction, Construction of Docks and Airports, etc.

c. **Composite Materials**

Composite Material is *"Macroscopic combination of two or more distinct materials, having a recognizable interface between them"*.

Composite materials form a material system, composed of a *mixture or a combination of two or more macro constituents that differ in form and chemical composition and are insoluble in each other*. These constituents maintain their identity even after mixing and being together and give entirely different properties to the mixture.

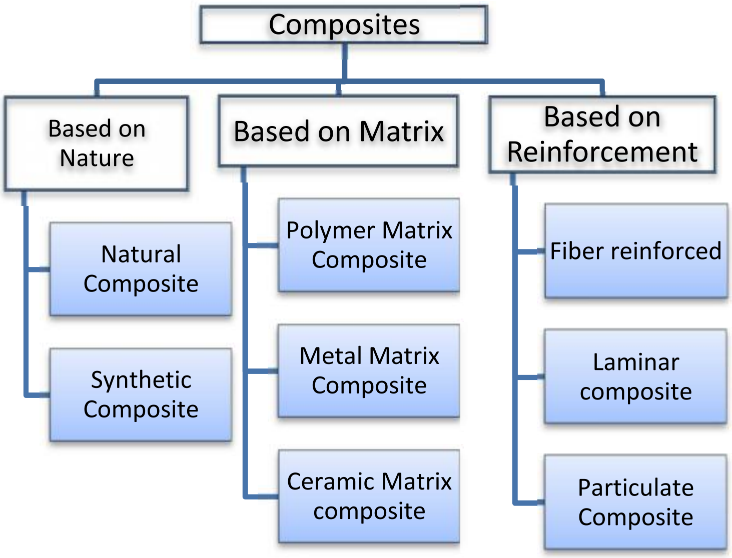
Components (Parts or Constituents)of Composites

<u>There are TWO major components:</u>

a) <u>Reinforcement, i.e., material that provides strength to the matrix</u>

b) <u>Matrix, i.e., material that holds the reinforcements in place</u>

Classification of Composite Materials



Properties and Advantages of Composites

- **a.** Low density and very light weight with high strength, hardness and stiffness
- **b.** Corrosion resistance
- **c.** Weather resistance
- **d.** Low thermal conductivity
- **e.** Low coefficient of thermal expansion
- **f.** High dielectric strength
- **g.** Non-magnetic
- **h.** Radar transparency
- **i.** They can withstand elevated temperatures in the corrosive environment.
- **j.** Exceptional formability.
- **k.** Outstanding durability.
- **l.** Inherent damping.

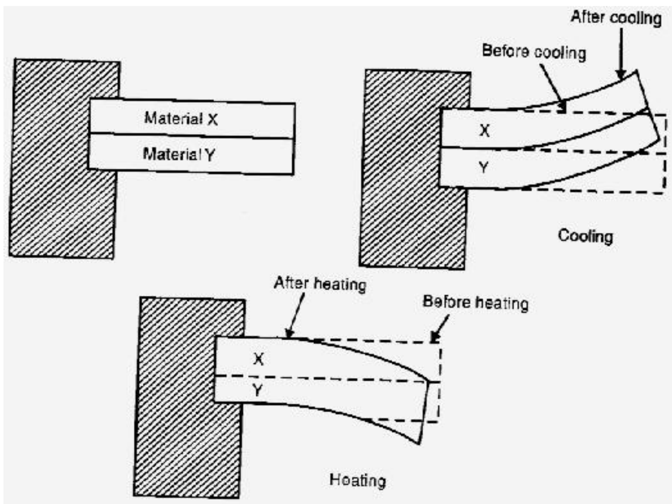
Disadvantages of Composites

(a) High cost of raw materials and fabrication.

(b) Composites are more brittle than wrought iron and thus are more easily damaged.

(c) Matrix is weak, therefore, low toughness.

(d) Matrix is subject to environment degradation.



Behavior of a composite metal strip with heating and cooling

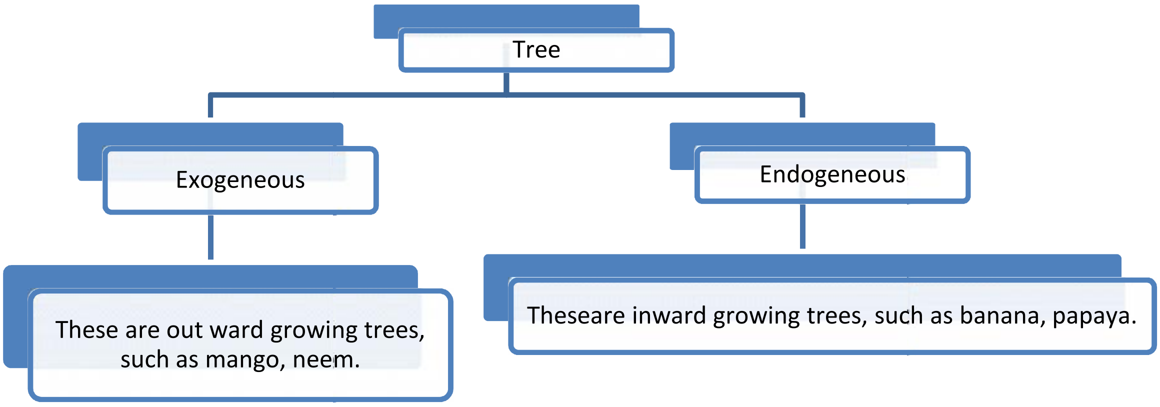
Applications

a) Used as a replacement material in various engineering applications such as for cylinder block liners, vehicle drive, shafts, automotive pistons, bicycle frames, etc.

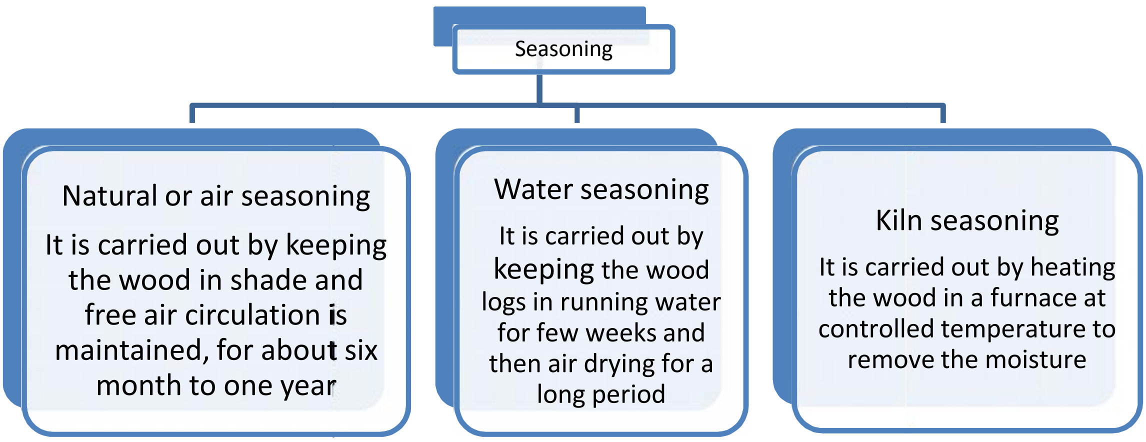
b) Hockey sticks, vaulting poles, golf carts etc.
c) Fuel and chemical storage tanks.
d) Aerospace applications: helicopter blades, engine couplings, ducts etc.
e) Marine: Boats, ships, hulls etc.
f) Electronic and recreational industries.
g) High voltage power transmission lines and heat sinks for electronic components.
h) As bio-compatible materials
i) Used in electrical appliance as thermal switch.

8. Discuss the common types of wood and its applications.

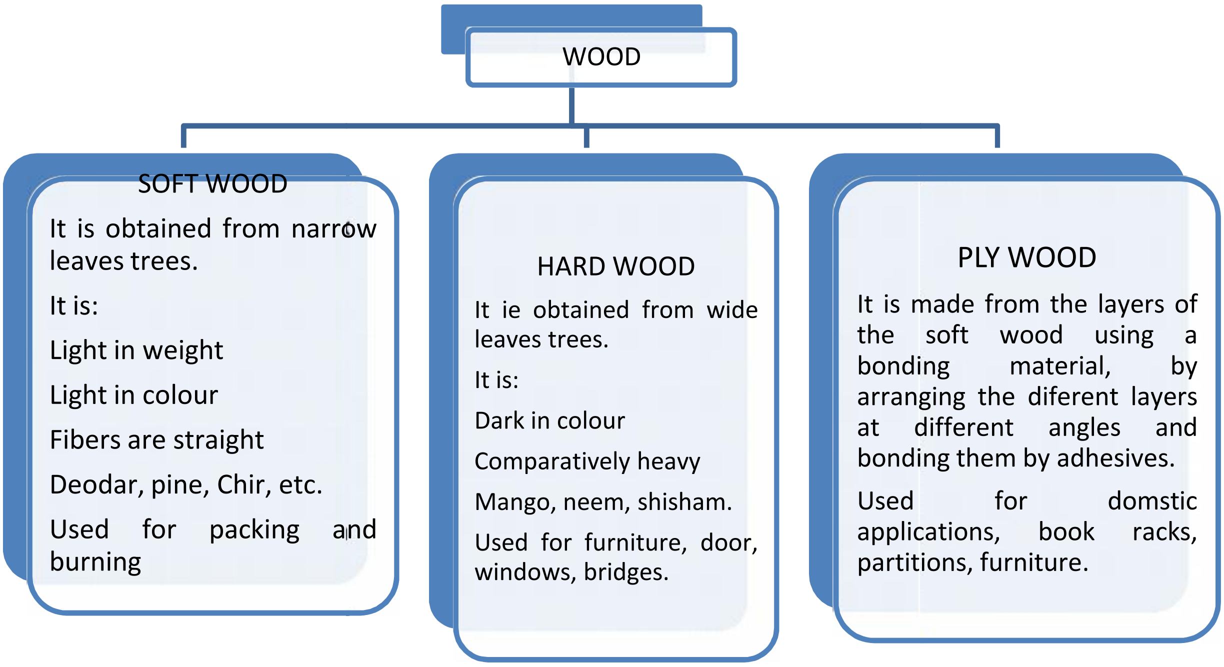
Wood: Wood is natural organic material and also used for engineering applications. The wood received from tree is cut and shaped to be used and after cutting to size and shape it is called as Timber. The wood may be obtained from trees and trees are classified as:



Seasoning: the wood is seasoned before putting into actual use and during seasoning the extra moisture is removed from the wood, so that later on it is not getting warped and twisted.

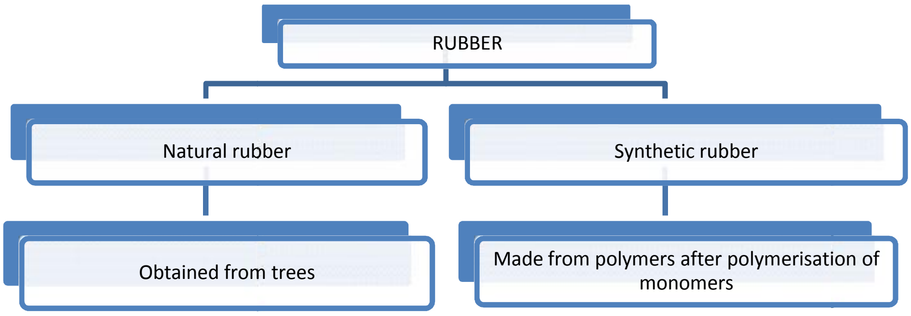


Types of Wood: Wood may be classified as



9. Write a short note on rubber.

Rubber: Rubber is a polymer material and is very elastic in nature. It is obtained from tree known as heveabrasilliensis in the form of emulsion called as Latex. Rubber may be classified as:



Properties: Rubber has the following properties:

1. Good elasticity
2. Good texture
3. Good resilience
4. Good insulator of electricity

Uses: Rubber finds application/uses in the following:

1. Automobiles
2. Rubber hoses for water and air
3. Rain coats, floor mats, belts, electrical insulators, tyre and tubes, etc

Vulcanization: Vulcanization is the process of heating rubber with sulpher to provide the durability and strength to rubber. The vulcanized rubber is used for making of tyre and tubes.

*****************UNIT-4 ENDS**********************

Wish you good luck