SPINTRONIC TECHNOLOGY & ADVANCE RESEARCH

LECTURE NOTE

ON

PRODUCTION TECHNOLOGY

SEMESTER-3RD

DEPARTMENT OF MECHANICAL ENGINEERING

BY

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TH-1 PRODUCTION TECHNOLOGY

Name of the Course: Diploma in **Mech/Auto/Aero & Other Mechanical Allied Branches**

Course code:		Semester	3rd
Total Period:	60	Examination	3 hrs
Theory periods:	4 P/W	I.A	20
Maximum marks:	100	End Semester Examination:	80

A. RATIONALE :

Production Technology involves a working knowledge in the field of product design, product development and rapid part production. It deals with the production methodology and its management to make a complete analysis on the products.

B. COURSE OBJECTIVES

At the end of the course the students will be able to

1. Understand the different components and processes involved in press tool operation.
2. Understand how to minimize the job setting and tool setting times in mass production.
3. Understand the industrial requirements of fabrication systems.
4. Understand the manufacturing processes like casting and powder metallurgy.

C. CHAPTER WISE DISTRIBUTION OF PERIODS

Sl. No.	Topic	Periods
01	Metal Forming Processes	07
02	Welding	16
03	Casting	16
04	Powder Metallurgy	07
05	Press Work	07
06	Jigs and fixtures	07
	Total Period:	60

D. COURSE CONTENTS

1.0 Metal Forming Processes

- 1.1 Extrusion: Definition & Classification
- 1.2 Explain direct, indirect and impact extrusion process.
- 1.3 Define rolling. Classify it.
- 1.4 Differentiate between cold rolling and hot rolling process.
- 1.5 List the different types of rolling mills used in Rolling process.

2.0 Welding

- 2.1 Define welding and classify various welding processes.
- 2.2 Explain fluxes used in welding.
- 2.3 Explain Oxy-acetylene welding process.
- 2.4 Explain various types of flames used in Oxy-acetylene welding process.
- 2.5 Explain Arc welding process.
- 2.6 Specify arc welding electrodes.
- 2.7 Define resistance welding and classify it.
- 2.8 Describe various resistance welding processes such as butt welding, spot welding, flash welding, projection welding and seam welding.

2.9 Explain TIG and MIG welding process
2.10 State different welding defects with causes and remedies.

3.0 Casting

3.1 Define Casting and Classify the various Casting processes.
3.2 Explain the procedure of Sand mould casting.
3.3 Explain different types of molding sands with their composition and properties.
3.4 Classify different pattern and state various pattern allowances.
3.5 Classify core.
3.6 Describe construction and working of cupola and crucible furnace.
3.7 Explain die casting method.
3.8 Explain centrifugal casting such as true centrifugal casting, centrifuging with advantages, limitation and area of application.
3.9 Explain various casting defects with their causes and remedies.

4.0 Powder Metallurgy

4.1 Define powder metallurgy process.
4.2 State advantages of powder metallurgy technology technique
4.3 Describe the methods of producing components by powder metallurgy technique.
4.4 Explain sintering.
4.5 Economics of powder metallurgy.

5. 0 Press Work

5.1 Describe Press Works: blanking, piercing and trimming.
5.2 List various types of die and punch 7
5.3 Explain simple, Compound & Progressive dies
5.4 Describe the various advantages & disadvantages of above dies

6. 0 Jigs and fixtures

6.1 Define jigs and fixtures
6.2 State advantages of using jigs and fixtures
6.3 State the principle of locations
6.4 Describe the methods of location with respect to 3-2-1 point location of rectangular jig
6.5 List various types of jig and fixtures.

Syllabus to be covered up to IA- Chapters 1, 2&3

LEARNING RESOURCES

Sl. No.	Author	Title of the book	Publisher
01	O.P. Khanna	Production Technology, Vol- I& II	Dhanpat Rai Publication
02	B.S Raghuwanshi	Workshop technology, Vol- I& II	Dhanpat Rai & Co
03	P.N. Rao	Manufacturing technology, Vol- I&II	TMH
04	P.C.Sharma	Manufacturing technology, Vol- I	S. Chand

FORMING PROCESS

Cold working

The process is usually performed at room temperature, but mildly elevated temperatures may be used to provide increased ductility and reduced strength

For example: Deforming lead at room temperature is a hot working process because the recrystallization temperature of lead is about room temperature.

Effects of Cold Working

Deformation using cold working results in

- Higher stiffness, and strength, but
- Reduced malleability and ductility of the metal.
- Anisotropy

Advantages

- No heating is required
- Strength, fatigue and wear properties are improved through strain hardening
- Superior dimensional control is achieved, so little, if any, secondary machining is required
- Better surface finish is obtained
- Products possess better reproducibility and interchangeability
- Directional properties can be imparted
- Contamination problems are minimized

Disadvantages

- Higher forces are required to initiate and complete the deformation
- Less ductility is available
- Intermediate anneals may be required to compensate for the loss of ductility that accompanies strain hardening
- Heavier and more powerful equipment is required
- Metal surfaces must be clean and scale-free
- Imparted directional properties may be detrimental
- Undesirable residual stresses may be produced

Hot working

Hot working is the deformation that is carried out above the recrystallization temperature.

Effects of hot working

- At high temperature, scaling and oxidation exist. Scaling and oxidation produce undesirable surface finish. Most ferrous metals needs to be cold worked after hot working in order to improve the surface finish.
- The amount of force needed to perform hot working is less than that for cold work.
- The mechanical properties of the material remain unchanged during hot working.

· The metal usually experiences a decrease in yield strength when hot worked. Therefore, it is possible to hot work the metal without causing any fracture.

Quenching is the sudden immersion of a heated metal into cold water or oil. It is used to make the metal very hard. To reverse the effects of quenching, tempering is used (reheated of the metal for a period of time)

To reverse the process of quenching, tempering is used, which is the reheat of the metal.

Cold-working Processes

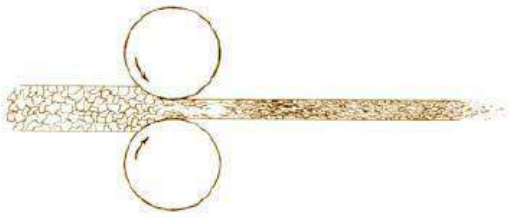
- Squeezing
- Bending
- Shearing
- Drawing
- Presses

Classifications of Squeezing Processes

- Rolling
- Cold Forging
- Sizing
- Staking
- Staking
- Coining
- Burnishing
- Extrusion
- Peening
- Hubbing
- Riveting
- Thread Rolling

ROLLING

Process used in sheets, strips, bars, and rods to obtain products that have smooth surfaces and accurate dimensions; most cold-rolling is performed on four-high or cluster-type rolling mills



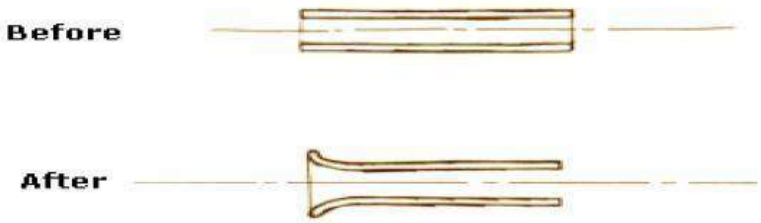
ROLLING PROCESS

Flat Rolling

A sheet or block or strip stock is introduced between rollers and then compressed and squeezed. Thickness is reduced. The amount of strain (deformation) introduced determines the hardness, strength and other material properties of the finished product.
Used to produce sheet metals predominantly

Swaging

Process that reduces/increases the diameter, tapers, rods or points round bars or tubes by external hammering



SWAGING

Cold Forging

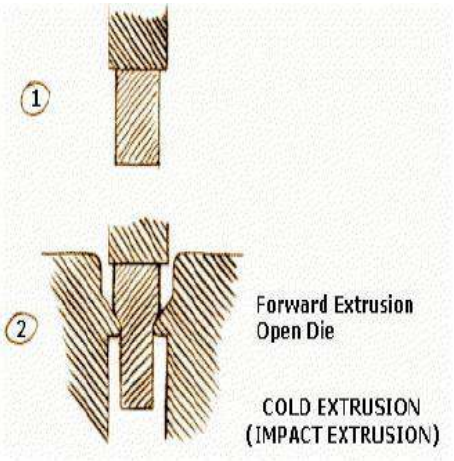
Process in which slugs of material are squeezed into shaped die cavities to produce finished parts of precise shape and size.



COLD HEADING/COLD FORGING

Extrusion

Process which is commonly used to make collapsible tubes such as toothpaste tubes, cans usually using soft materials such as aluminum, lead, tin. Usually a small shot of solid material is placed in the die and is impacted by a ram, which causes cold flow in the material.



Sizing

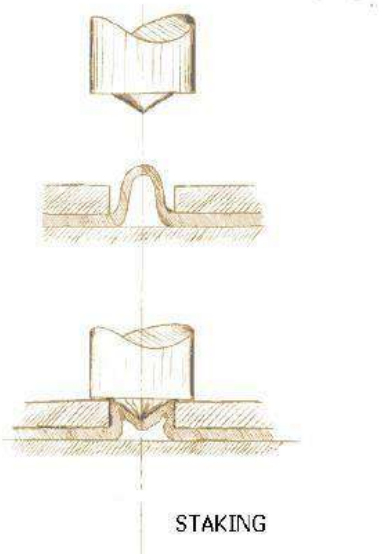
Process of squeezing all or selected areas of forgings, ductile castings, or powder metallurgy products to achieve a desired thickness or precision

Riveting

Process where a head is formed on the shrank end of a fastener to permanently join sheets or plates of material;

Staking

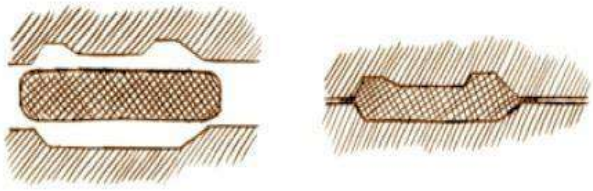
Process of permanently joining parts together when one part protrudes through a hole in the other; a shaped punch is driven into the end of the protruding piece where a deformation is formed causing a radial expansion, mechanically locking the two pieces together



STAKING

Coining

Process where metal while it is confined in a closed set of dies; used to produce coins, medals, and other products where exact size and fine details are required, and thickness varies about a well-defined average



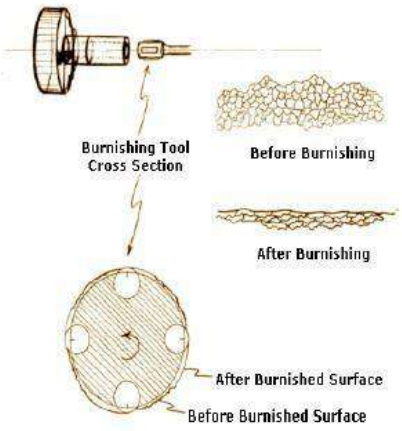
COINING

Peening

Process where the surface of the metal is blasted by shot pellets; the mechanical working of surfaces by repeated blows of impelled shot or a round-nose tool

Burnishing

Process by which a smooth hard tools is rubbed on the metal surface and flattens the high spots by applying compressive force and plastically flowing the material



BURNISHING

Hubbing

Process is used to form recessed cavities in various types of female tooling dies. This is often used to make plastic extrusion dies in an economical manner

Thread Rolling

Process is used for making external threads; in this process, a die, which is a hardened tool with the thread profile, is pressed on to a rotating workpiece

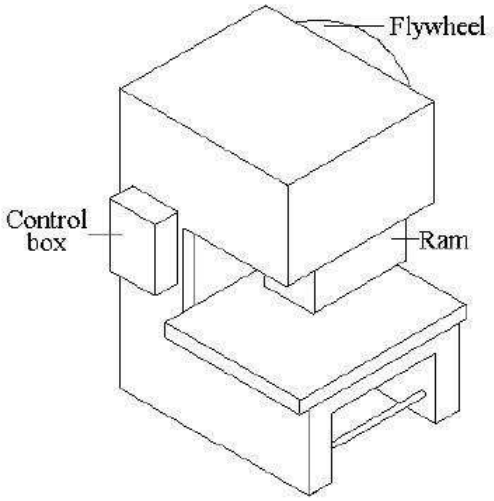


THREAD ROLLING

The Presses

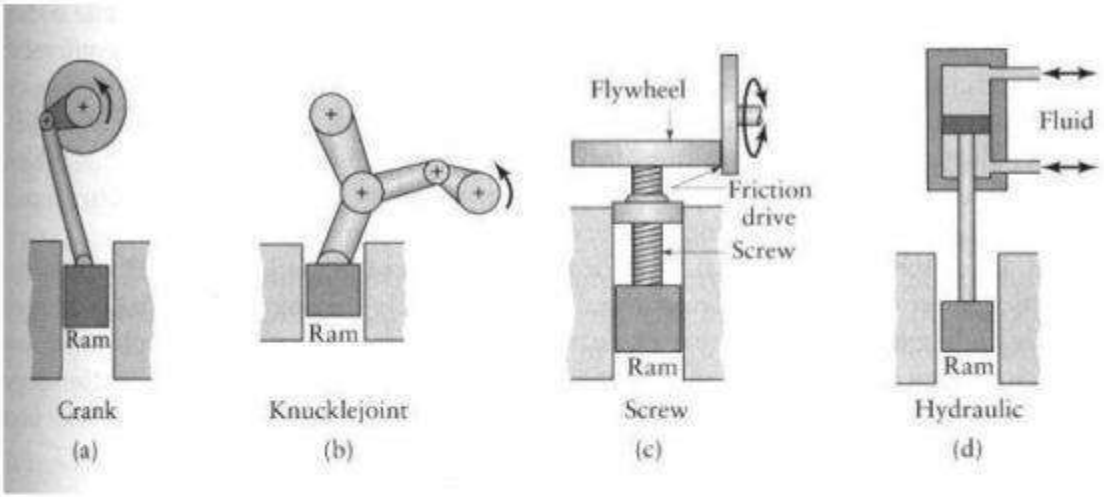
There are many kinds of machines

- Hydraulic presses
- Mechanical presses
  - C frame
  - Straight sided
- Others

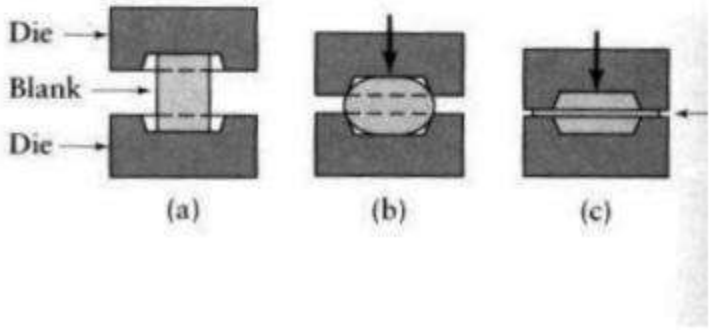


C-frame mechanical press

Types of Forging Presses



Impression Die Forging



Forging operations

Forging is a process in which the workpiece is shaped by compressive forces applied through various dies and tools. It is one of the oldest metalworking operations. Most forgings require a set of dies and a press or a forging hammer.

A Forged metal can result in the following: -

- Decrease in height, increase in section - open die forging
- Increase length, decrease cross-section, called drawing out.
- Decrease length, increase in cross-section on a portion of the length - upsetting
- Change length, change cross-section, by squeezing in closed impression dies - closed die forging. This results in favorable grain flow for strong parts

Types of forging

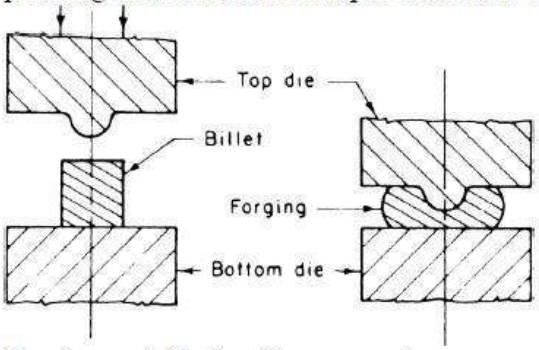
- Closed/impression die forging
- Electro-upsetting
- Forward extrusion
- Backward extrusion
- Radial forging
- Hobbing
- Isothermal forging
- Open-die forgig
- Upsetting
- Nosing
- Coining

Commonly used materials include

- Ferrous materials: low carbon steels
- Nonferrous materials: copper, aluminum and their alloys

Open-Die Forging

Open-die forging is a hot forging process in which metal is shaped by hammering or pressing between flat or simple contoured dies.



Equipment. Hydraulic presses, hammers.

Materials. Carbon and alloy steels, aluminum alloys, copper alloys, titanium alloys, all forgeable materials.

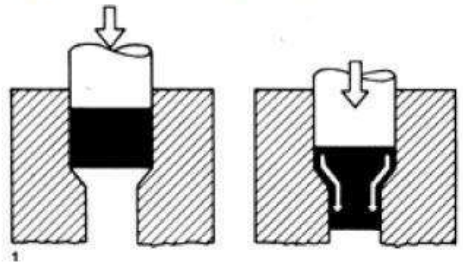
Process Variations. Slab forging, shaft forging, mandrel forging, ring forging, upsetting between flat or curved dies, drawing out.
Application. Forging ingots, large and bulky forgings, preforms for finished forgings.

Closed Die Forging

In this process, a billet is formed (hot) in dies (usually with two halves) such that the flow of metal from the die cavity is restricted. The excess material is extruded through a restrictive narrow gap and appears as flash around the forging at the die parting line.
Equipment. Anvil and counterblow hammers, hydraulic, mechanical, and screw presses.
Materials. Carbon and alloy steels, aluminum alloys, copper alloys, magnesium alloys, beryllium, stainless steels, nickel alloys, titanium and titanium alloys, iron and nickel and cobalt super alloys.
Process Variations. Closed-die forging with lateral flash, closed-die forging with longitudinal flash, closed-die forging without flash.
Application. Production of forgings for automobiles, trucks, tractors, off-highway equipment, aircraft, railroad and mining equipment, general mechanical industry, and energy-related engineering production.

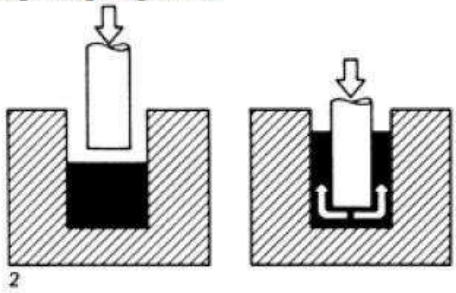
Forward extrusion

Forward extrusion reduces slug diameter and increases its length to produce parts such as stepped shafts and cylinders.



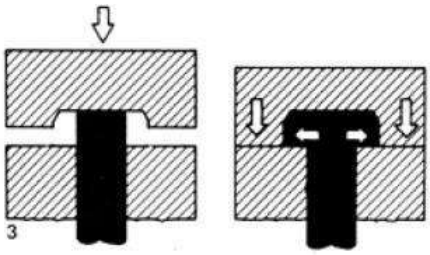
backward extrusion

In backward extrusion, the steel flows back and around the descending punch to form cup-shaped pieces.



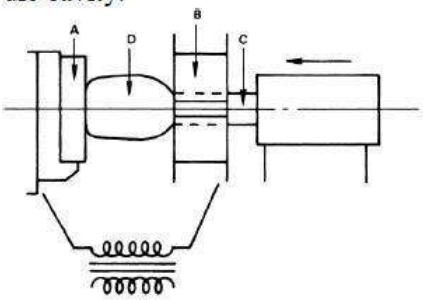
Upsetting, or heading

Upsetting, or heading, a common technique for making fasteners, gathers steel in the head and other sections along the length of the part.



Electro-Upsetting (Fig. 2.4)

Electro-upsetting is the hot forging process of gathering a large amount of material at one end of a round bar by heating the bar end electrically and pushing it against a flat anvil or shaped die cavity.



A, anvil electrode; B, gripping electrode; C, workpiece; D, upset end of workpiece

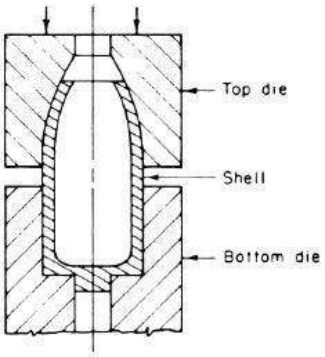
Equipment. Electric upsetters.
Materials. Carbon and alloy steels, titanium.
Application. Preforms for finished forgings.

Hobbing

Hobbing is the process of indenting or coining an impression into a cold orhot die block by pressing with a punch.
Equipment. Hydraulic presses, hammers.
Materials. Carbon and alloy steels.
Process Variations. Die hobbing, die typing.
Application. Manufacture of dies and molds with relatively shallow impressions.

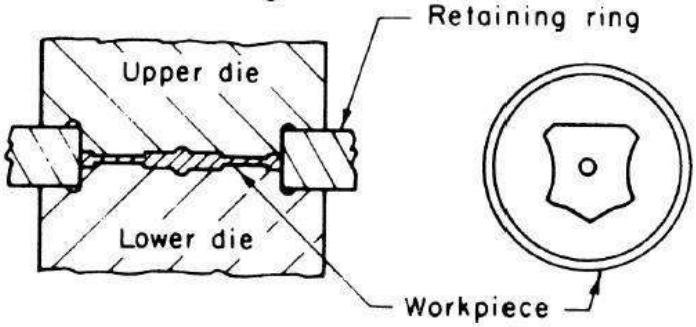
Nosing

Nosing is a hot or cold forging process in which the open end of a shell or tubular component is closed by axial pressing with a shaped die.
Equipment. Mechanical and hydraulic presses, hammers.
Materials. Carbon and alloy steels, aluminum alloys, titanium alloys.
Process Variations. Tube sinking, tube expanding.
Applications. Forging of open ends of ammunition shells; forging of gas pressure containers.



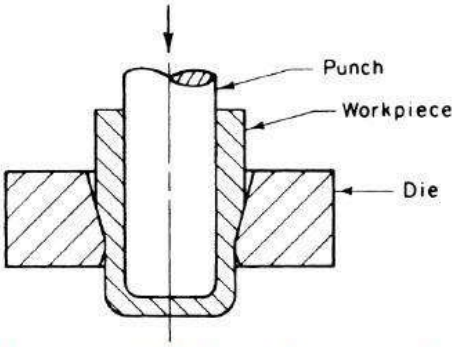
Coining

In sheet metal working, coining is used to form indentations and raised sections in the part. During the process, metal is intentionally thinned or thickened to achieve the required indentations or raised sections. It is widely used for lettering on sheet metal or components such as coins. Bottoming is a type of coining process where bottoming pressure causes reduction in thickness at the bending area.



Ironing

Ironing is the process of smoothing and thinning the wall of a shell or cup (cold or hot) by forcing the shell through a die with a punch.



Equipment. Mechanical presses and hydraulic presses.
Materials. Carbon and alloy steels, aluminum and aluminum alloys, titanium alloys.
Applications. Shells and cups for various

Swaging

Uses hammering dies to decrease the diameter of the part

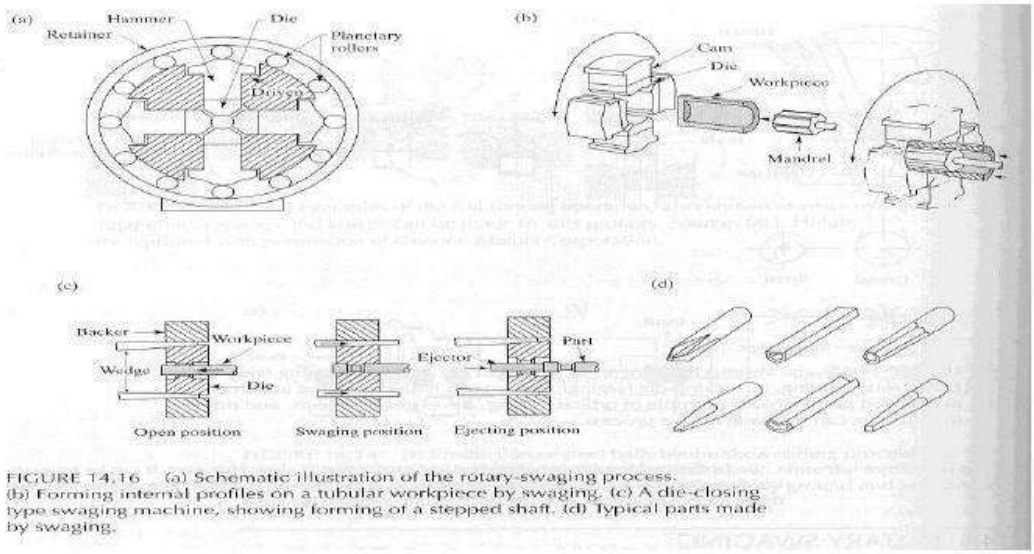
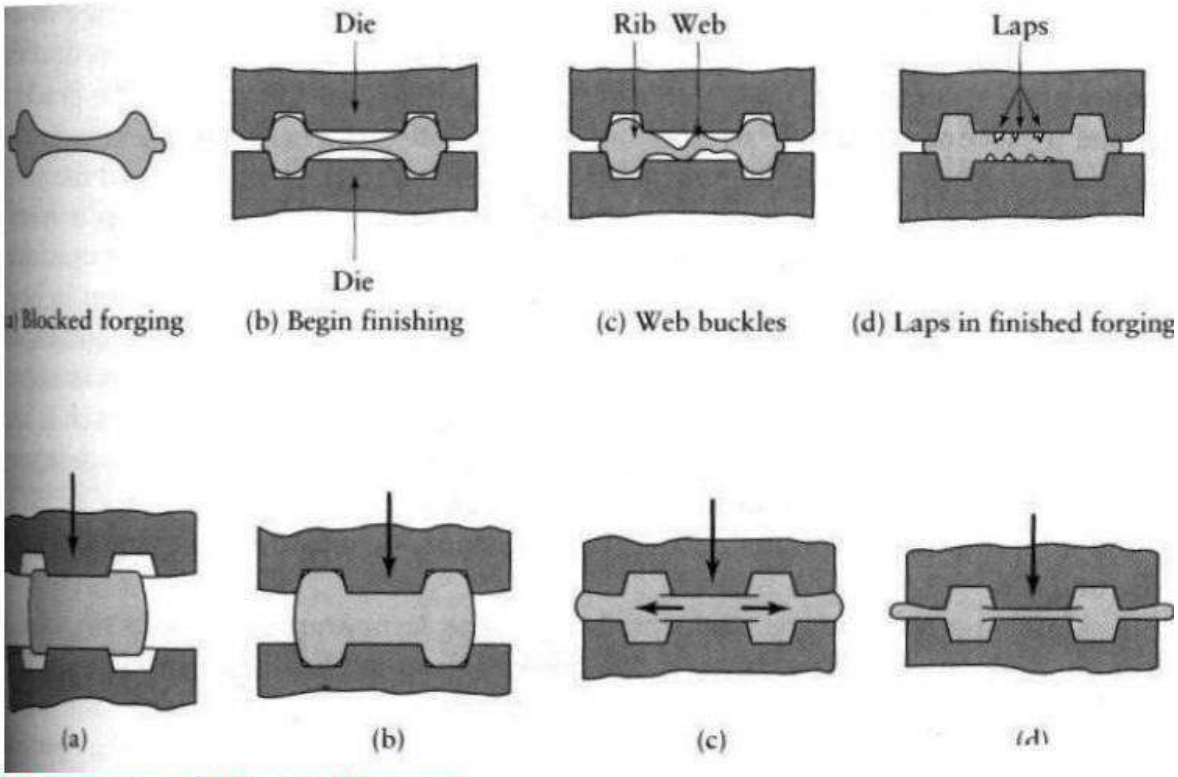


FIGURE 14.16 (a) Schematic illustration of the rotary-swaging process. (b) Forming internal profiles on a tubular workpiece by swaging. (c) A die-closing type swaging machine, showing forming of a stepped shaft. (d) Typical parts made by swaging.

Defects in Forging



Extrusion and Drawing Processes

Extrusion

Process by which long straight metal parts can be produced.
Cross-sections that can be produced vary from solid round, rectangular, to L shapes, T Shapes, tubes and many other different types
Done by squeezing metal in a closed cavity through a die using either a mechanical or hydraulic press.
Extrusion produces compressive and shear forces in the stock.
No tension is produced, which makes high deformation possible without tearing the metal.
Can be done Hot or cold

Drawing

Section of material reduced by pulling through die.
Similar to extrusion except material is under TENSILE force since it is pulled through the die
Various types of sections: - round, square, profiles

Tube Drawing

Utilizes a special tool called a MANDREL is inserted in a tube hollow section to draw a seamless tube

- Mandrel and die reduce both the tube's outside diameter and its wall thickness. The mandrel also makes the tube's inside surface smoother

Sheet Metal Forming

Involves methods in which sheet metal is cut into required dimensions and shape; and/or forming by stamping, drawing, or pressing to the final shape

A special class of metal forming where the thickness of the piece of material is small compared to the other dimensions

Cutting into shape involve shear forces

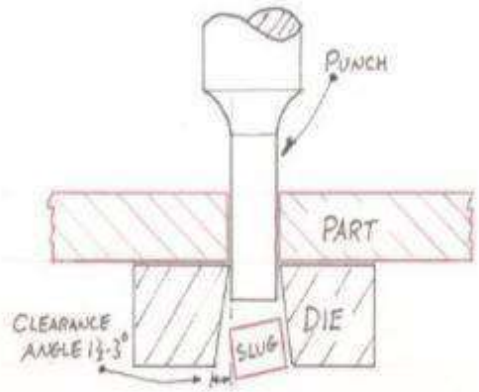
Forming Processes involve tensile stresses

The Major operations of sheet Metal are:

1) Shearing,
2) Bending,
3) Drawing and
4) Squeezing

Shearing

The mechanical cutting of materials without the information of chips or the use of burning or melting for straight cutting blades: shearing for curved blades: blanking, piercing, notching, trimming



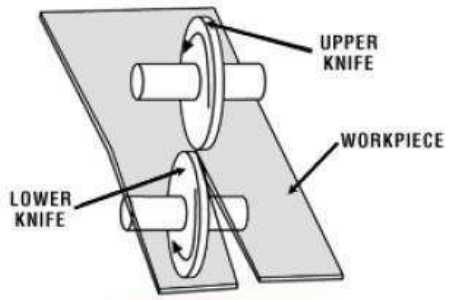
Classifications of Shearing Processes

- Slitting
- Piercing
- Blanking
- Notching
- Shaving
- Trimming
- Cutoff
- Dinking

Slitting

3. Discuss the various forging operations and its types. (16)

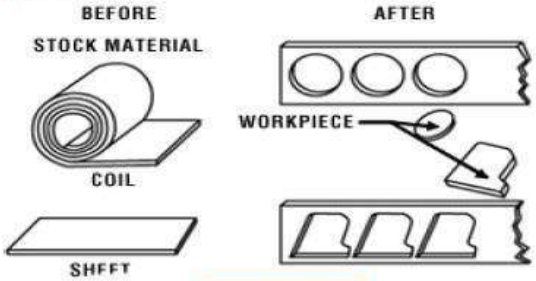
shearing process used to cut rolls of sheet metal into several rolls of narrower width
used to cut a wide coil of metal into a number of narrower coils as the main coil is moved through the slitter.



SLITTING PROCESS

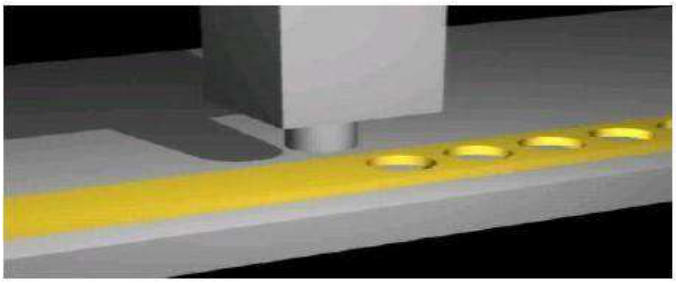
Blanking

during which a metal workpiece is removed from the primary metal strip or sheet when it is punched.



WORKPIECES

Piercing



Notching

same as piercing
- edge of the strip or black forms part of the punch-out perimeter

Nibbling

Produces a series of overlapping slits/notches

Shaving

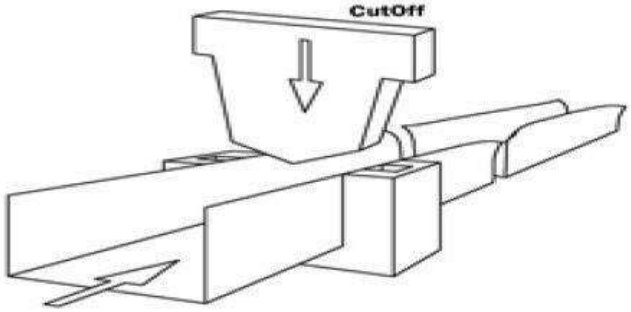
- finishing operation in which a small amount of metal is sheared away from the edge of an already blanked part
- can be used to produce a smoother edge

Trimming



Cutoff

Punch and die operation used to separate a stamping or other product from a strip or stock



Dinking

Used to blank shapes from low-strength materials such as rubber, fiber and cloth

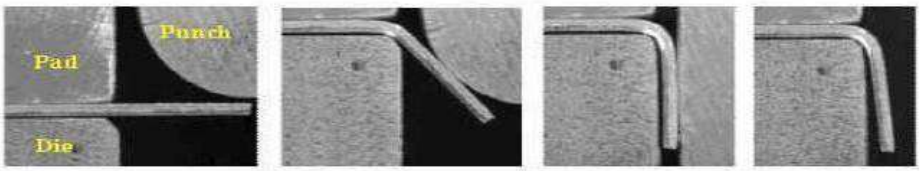
Bending

The plastic deformation of metals about a linear axis with little or no change in the surface area.

The purpose of bending is to form sheet metal along a straight line

Springback

The elastic recovery of the material after unloading of the tools



To compensate with the unbending action of the springback, the metal should be slightly overbent.

Classifications of Bending Processes

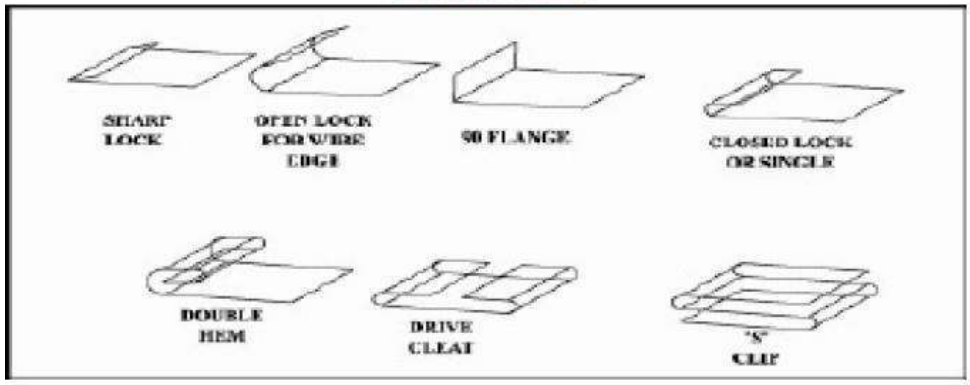
- Angle
- Straightening
- Roll Forming
- Draw and Compression
- Seaming
- Roll
- Flanging

Roll Bending

Bending where plates, sheets and rolled shapes can be bent to a desired curvature
Roll bending toll can bend plate up to 6 inches thick

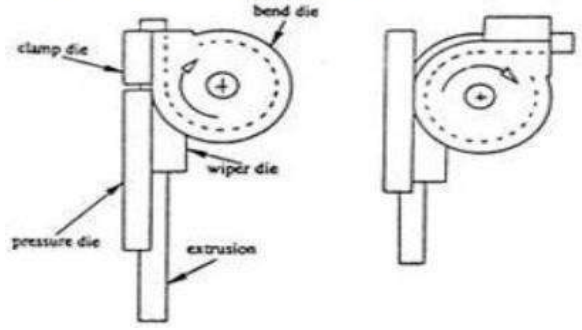
Angle Bending

Profiles:



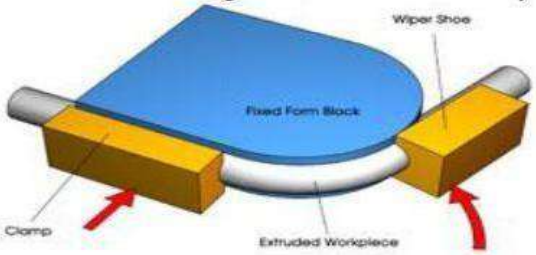
Drawing Bending

Workpiece is clamped against a bending form and the entire assemble rotates to draw the workpiece across a stationary tool



Compression Bending

The bending form remains stationary and the pressure tool moves along the workpiece



Roll Forming

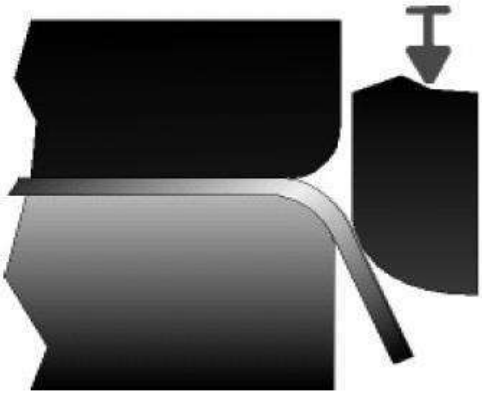
Involves the progressive bending of metal strip as it passes through a series of forming rolls
Any material that can be bent can be roll- formed

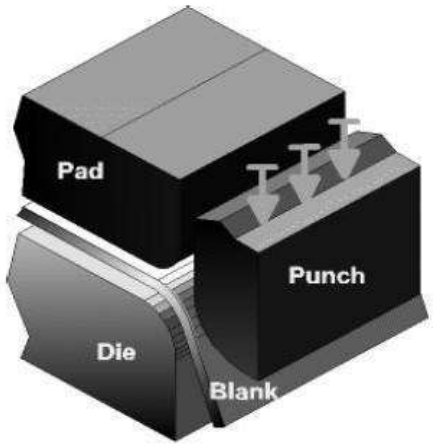
Seaming

- bending operation that can be used to join the ends of sheet metal to form containers such as cans, pails and drums

Flanging

-the process of rolling on sheet metal in essentially the same manner as seaming





Straightening

- also known as flattening
- opposite of bending

Drawing- Stretch forming

Sheet metal clamped along its edges and stretched over a die or form block in required directions.

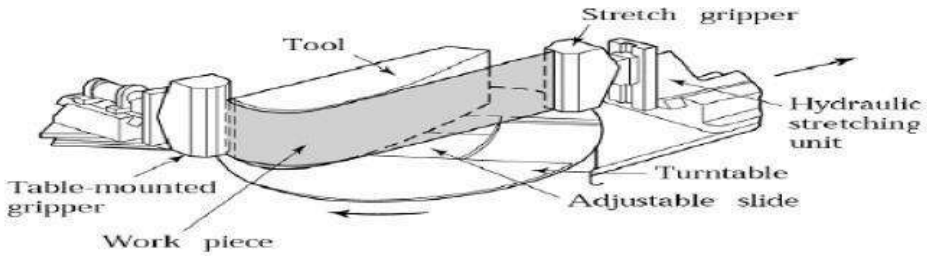


Fig: Schematic illustration of a stretch forming process. Aluminum skins for aircraft can be made by this process

Special Forming Process

There are a great variety of sheet metal forming methods, mainly using shear and tensile forces in the operation.

- Progressive forming
- Rubber hydroforming
- Bending and contouring
- Spinning processes
- Explosive forming
- Shearing and blanking
- Stretch forming
- • Deep drawing

Progressive forming

• Punches and dies are designed so that successive stages in the forming of the part are carried out in the same die on each stroke of the press.
• Progressive dies are also known as multi-stage dies.

Rubber forming

In bending and embossing of sheet metal, the female die is replaced with rubber pad

Hydro-form (or) fluid forming process

The pressure over rubber membrane is controlled throughout the forming cycle ,with max pressure up to 100 Mpi

As a result the friction at the punch-cup interface increases, this increase reduces the longitudinal tensile stresses in the cup and delays fracture

Spinning

Shaping thin sheets by pressing them against a form with a blunt tool to force the material into a desired form

Conventional spinning

A circular blank if flat or performed sheet metal hold against a mandrel and rotated ,while a rigid metal is held against a mandrel and rotated ,wile a rigid tool deforms and shapes the material over the mandrel.

Shear Spinning

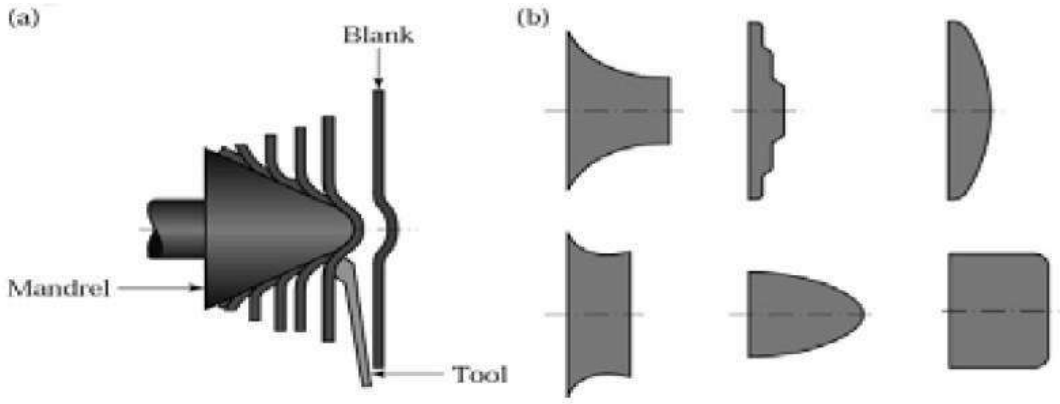
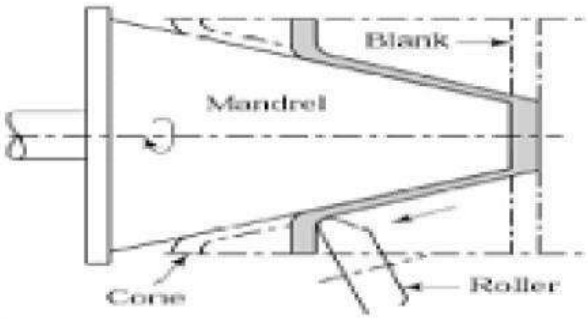


Fig .(a) Schematic illustration of the conventional spinning process (b) Types of parts conventionally spun.

All parts are antisymmetric

- Known as power spinning, flow turning, hydro-spinning, and spin forging
- Produces axisymmetric conical or curvilinear shape
- Single rollers and two rollers can be used
- It has less wastage of material
- Typical products are rocket-

motor casing and missile nose cones.

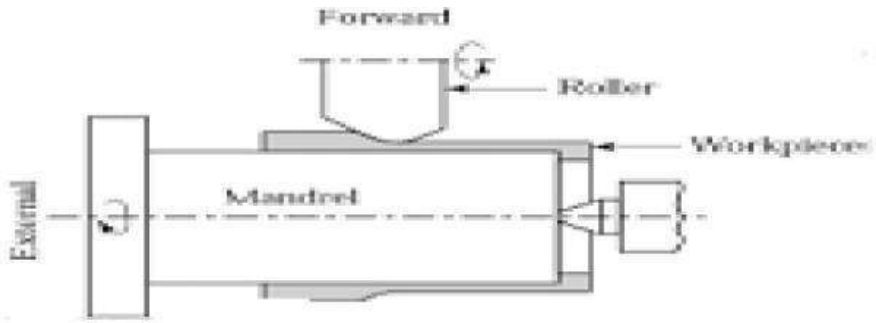


Tube spinning

Thickness of cylindrical parts are reduced by spinning them on a cylindrical mandrel rollers

Parts can be spun in either direction

Large tensile elongation up to 2000 % are obtained within certain temperature ranges and at low strain rates.



Advantages

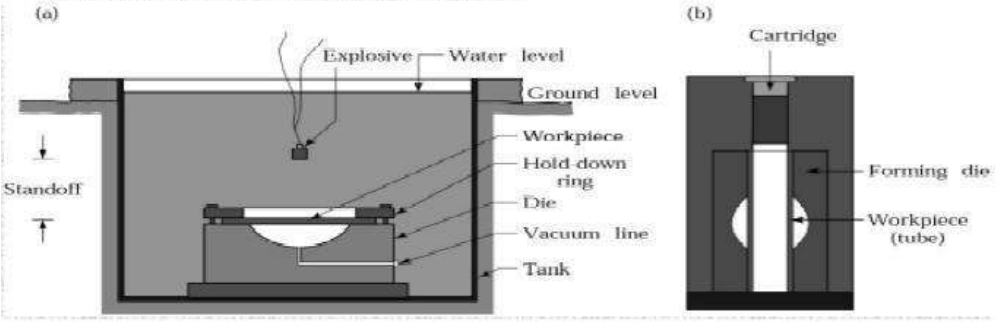
Lower strength is required and less tooling costs
Complex shapes with close tolerances can be made
Weight and material savings
Little or no residual stress occurs in the formed parts

Disadvantages

Materials must not be super elastic at service temperatures
Longer cycle times

Explosive forming

Explosive energy used s metal forming
Sheet-metal blank is clamped over a die
Assembly is immersed in a tank with water
Rapid conversion of explosive charge into gas generates a shock wave .the pressure of this wave is sufficient to form sheet metals



Beading

The periphery if the sheet metal is bent into the cavity of a die

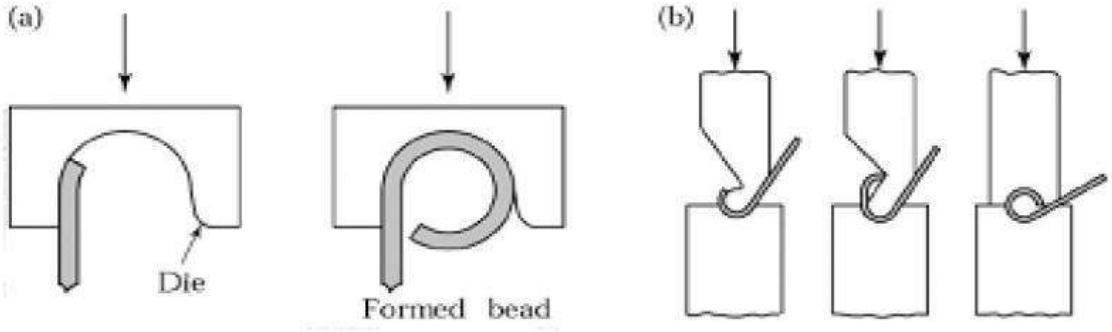


Fig .(a) Bead forming with a single die (b) Bead forming with two dies,in a press brake

Hemming

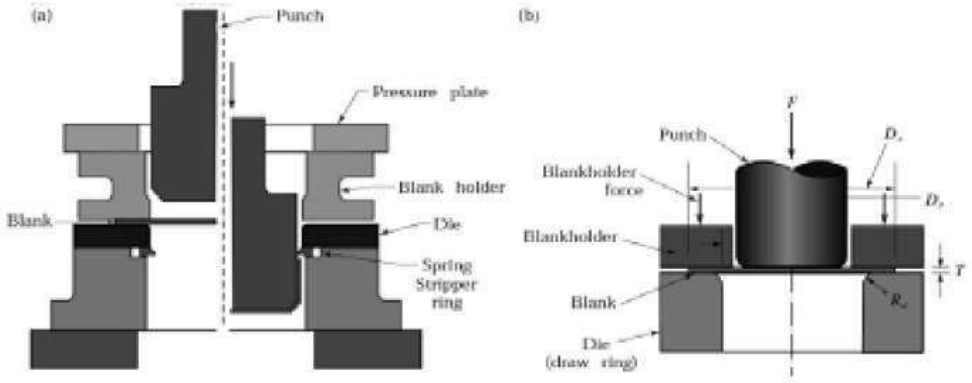
- The edge of the sheet is folded over itself
- This increases stiffness of the part
- The metal strip is bent in stages by passing it through a series of rolls

Seaming

Joining two edges of sheet metal by hemming.Specifically shaped rollers used for watertight and airtight joints

Deep drawing

- Punch forces a flat sheet metal into a deep die cavity.
- Round sheet metal block is placed over a circular die opening and held in a place with blank holder & punch forces down into the die cavity



Flanging

Flanging is a process of bending the edges of sheet metals to 90o
Shrink flanging – subjected to compressive hoop stress.
Stretch flanging –subjected to tensile stresses

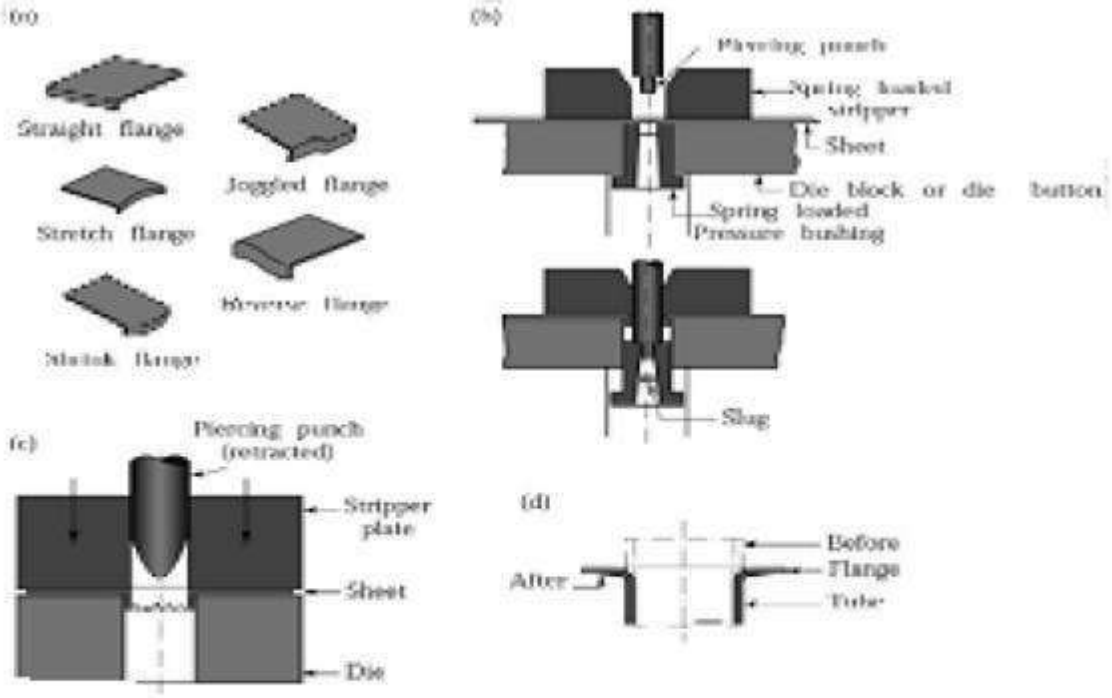


Fig .Various flanging operations (a) Flanges on a flat sheet. (b) Dimpling. (c) The piercing of the sheet metal to form a flange.

In this operation,a hole does not have to be prepunched before the bunch descends .Note however,the rough edges along the circumference of the flange. (d) The flanging of a tube; note the thinning of the edges of the flange

WELDING

Welding

Welding is a materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone, and with or without the use of filler material.

Welding is used for making permanent joints.

It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

Classification of welding processes

(i) Arc welding

- Carbon arc
- Metal arc
- Metal inert gas
- Tungsten inert gas
- Plasma arc
- Submerged arc
- Electro-slag

(ii) Gas Welding

- Oxy-acetylene
- Air-acetylene
- Oxy-hydrogen

iii) Resistance Welding

- Butt
- Spot
- Seam
- Projection
- Percussion

(iv)Thermit Welding

(v)Solid State Welding

Friction
Ultrasonic
Diffusion
Explosive

(vi) Newer Welding

Electron-beam
Laser

(vii)Related Process

Oxy-acetylene cutting
Arc cutting
Hard facing
Brazing
Soldering

Welding practice & equipment

STEPS :

- Prepare the edges to be joined and maintain the proper position
- Open the acetylene valve and ignite the gas at tip of the torch
- Hold the torch at about 45deg to the work piece plane
- Inner flame near the work piece and filler rod at about 30 – 40 deg
- Touch filler rod at the joint and control the movement according to the flow of the material

Two Basic Types of AW Electrodes

- Consumable – consumed during welding process
  - Source of filler metal in arc welding
- Nonconsumable – not consumed during welding process
  - Filler metal must be added separately

Consumable Electrodes

Forms of consumable electrodes

- Welding rods (a.k.a. sticks) are 9 to 18 inches and 3/8 inch or less in diameter and must be changed frequently
- Weld wire can be continuously fed from spools with long lengths of wire, avoiding frequent interruptions

In both rod and wire forms, electrode is consumed by arc and added to weld joint as filler metal.

Nonconsumable Electrodes

- Made of tungsten which resists melting
- Gradually depleted during welding (vaporization is principal mechanism)
- Any filler metal must be supplied by a separate wire fed into weld pool

Flux

A substance that prevents formation of oxides and other contaminants in welding, or dissolves them and facilitates removal

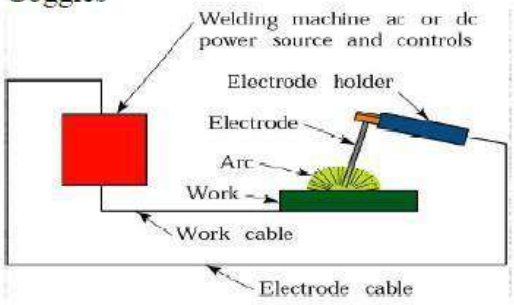
- Provides protective atmosphere for welding
- Stabilizes arc
- Reduces spattering

Arc welding

Uses an electric arc to coalesce metals
Arc welding is the most common method of welding metals
Electricity travels from electrode to base metal to ground

Arc welding Equipments

- A welding generator (D.C.) or Transformer (A.C.)
- Two cables- one for work and one for electrode
- Electrode holder
- Electrode
- Protective shield
- Gloves
- Wire brush
- Chipping hammer
- Goggles



Advantages

- Most efficient way to join metals
- Lowest-cost joining method
- Affords lighter weight through better utilization of materials
- Joins all commercial metals
- Provides design flexibility

Disadvantages

- Manually applied, therefore high labor cost.
- Need high energy causing danger
- Not convenient for disassembly.
- Defects are hard to detect at joints.

GAS WELDING

- Sound weld is obtained by selecting proper size of flame, filler material and method of moving torch
- The temperature generated during the process is 33000c.
- When the metal is fused, oxygen from the atmosphere and the torch combines with molten metal and forms oxides, results defective weld
- Fluxes are added to the welded metal to remove oxides
- Common fluxes used are made of sodium, potassium. Lithium and borax.
- Flux can be applied as paste, powder, liquid. solid coating or gas.

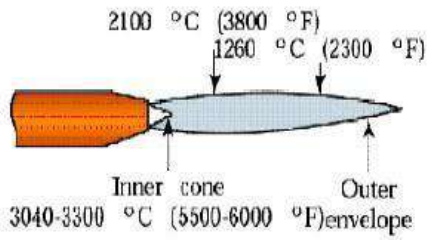
GAS WELDING EQUIPMENT

1.Gas Cylinders
Pressure
Oxygen – 125 kg/cm2
Acetylene – 16 kg/cm2
2. Regulators
Working pressure of oxygen 1 kg/cm2
Working pressure of acetylene 0.15 kg/cm2
Working pressure varies depends upon the thickness of the work pieces welded.
3. Pressure Gauges
4. Hoses
5. Welding torch
6. Check valve
7. Non return valve

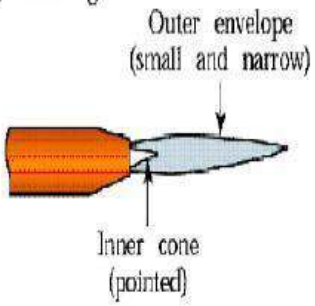
Types of Flames

- Oxygen is turned on, flame immediately changes into a long white inner area (Feather) surrounded by a transparent blue envelope is called **Carburizing flame** (30000c)
- Addition of little more oxygen give a bright whitish cone surrounded by the transparent blue envelope is called **Neutral flame** (It has a balance of fuel gas and oxygen) (32000c)
- Used for welding steels, aluminium, copper and cast iron
- If more oxygen is added, the cone becomes darker and more pointed, while the envelope becomes shorter and more fierce is called **Oxidizing flame**
- Has the highest temperature about 34000c
- Used for welding brass and brazing operation

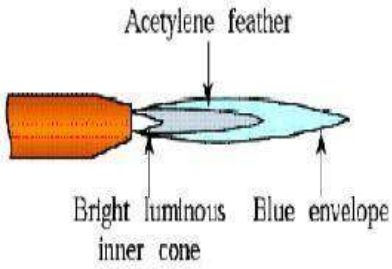
(a) Neutral flame



(b) Oxidizing flame



(c) Carburizing (reducing) flame



Three basic types of oxyacetylene flames used in oxyfuel-gas welding and cutting operations:

(a) neutral flame; (b) oxidizing flame; (c) carburizing, or reducing flame.

Fusion welding processes

- Definition : Fusion Welding is defined as melting together and coalescing materials by means of heat
- Energy is supplied by thermal or electrical means
- Fusion welds made without filler metals are known as autogenous welds

Filler Metals:

- Additional material to weld the weld zone
- Available as rod or wire
- They can be used bare or coated with flux
- The purpose of the flux is to retard the

Shielded metal arc welding process

- An electric arc is generated between a coated electrode and the parent metal
- The coated electrode carries the electric current to form the arc, produces a gas to control the atmosphere and provides filler metal for the weld bead
- Electric current may be AC or DC. If the current is DC, the polarity will affect the weld size and application

Process

- Intense heat at the arc melts the tip of the electrode
- Tiny drops of metal enter the arc stream and are deposited on the parent metal
- As molten metal is deposited, a slag forms over the bead which serves as an insulation against air contaminants during cooling
- After a weld 'pass' is allowed the cool, the oxide layer is removed by a chipping hammer and then cleaned with a wirebrush before the next pass.

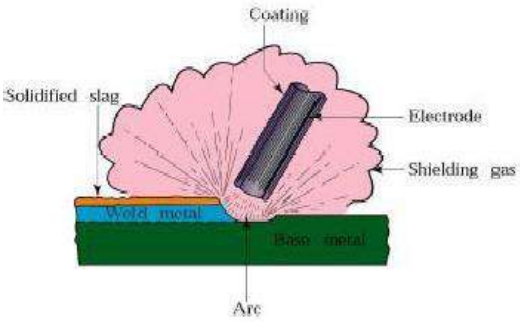


Fig : Schematic illustration of the shielded metal-arc welding process. About 50% of all large-scale industrial welding operations use this process.

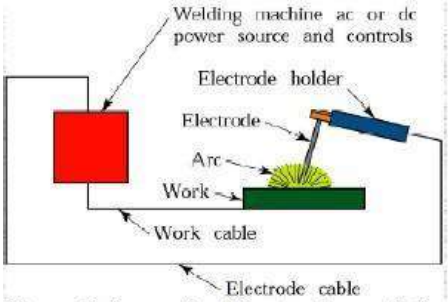


Fig : Schematic illustration of the shielded metal-arc welding process (also known as stick welding, because the electrode is in the shape of a stick).

Submerged arc welding

- Weld arc is shielded by a granular flux , consisting of silica, lime, manganese oxide, calcium fluoride and other compounds.
- Flux is fed into the weld zone by gravity flow through nozzle

- Thick layer of flux covers molten metal

- Flux acts as a thermal insulator ,promoting deep penetration of heat into the work piece
- Consumable electrode is a coil of bare round wire fed automatically through a tube
- Power is supplied by 3-phase or 2-phase power lines

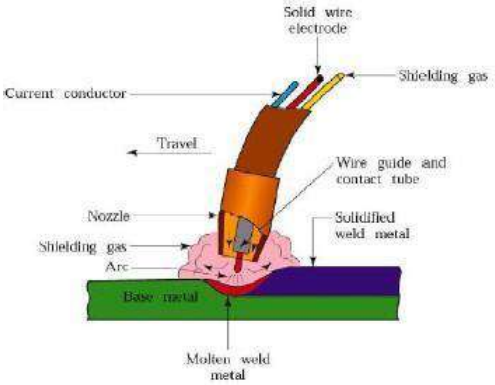


Fig : Schematic illustration of the submerged-arc welding process and equipment. The unfused flux is recovered and reused.

Gas metal arc welding

- GMAW is a metal inert gas welding (MIG)
- Weld area shielded by an effectively inert atmosphere of argon,helium,carbon dioxide,various other gas mixtures
- Metal can be transferred by 3 methods :
- Spray transfer
- Globular transfer
- Short circuiting

Process capabilities

- GMAV process is suitable for welding a variety of ferrous and non-ferrous metals
- Process is versatile ,rapid, economical, welding productivity is double that of SMAW

Flux cored arc welding

- Flux cored arc welding is similar to a gas metal arc welding
- Electrode is tubular in shape and is filled with flux
- Cored electrodes produce more stable arc improve weld contour and produce better mechanical properties
- Flux is more flexible than others

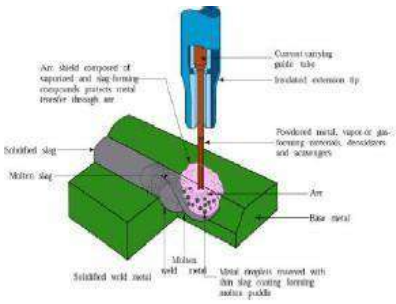


Fig : Schematic illustration of the flux-cored arc-welding process. This operation is similar to gas metal-arc welding.

Electro gas Welding

- EGW is welding the edges of sections vertically in one pass with the pieces placed edge to edge
- Similar to Electro gas welding
- Weld metal is deposited into weld cavity between the two pieces to be joined
- Difference is Arc is started between electrode tip and bottom part of the part to be welded
- Flux added first and then melted by the heat on the arc
- Molten slag reaches the tip of the electrode and the arc is extinguished
- Heat is then continuously produced by electrical resistance of the molten slag
- Single or multiple solid as well as flux-cored electrodes may be used

Process capabilities

- Weld thickness ranges from 12mm to 75mm
- Metals welded are steels, titanium, aluminum alloys
- Applications are construction of bridges, pressure vessels, thick walled and large diameter pipes, storage tanks and ships.

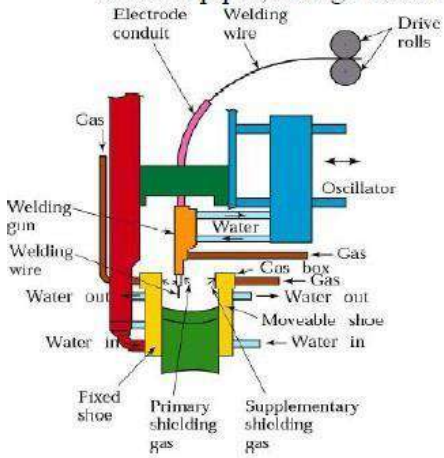


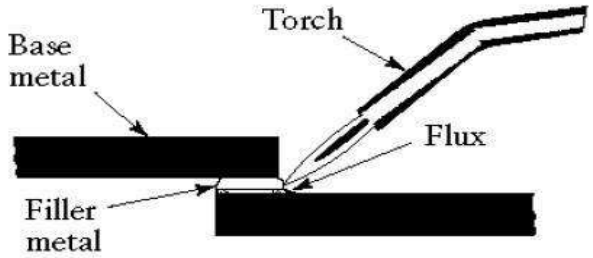
Fig : Schematic illustration of the electrogas welding process

Brazing

It is a low temperature joining process. It is performed at temperatures above 840° F and it generally affords strengths comparable to those of the metal which it joins. It is low temperature in that it is done below the melting point of the base metal. It is achieved by diffusion without fusion (melting) of the base

Brazing can be classified as

Torch brazing
Dip brazing
Furnace brazing
Induction brazing



Advantages

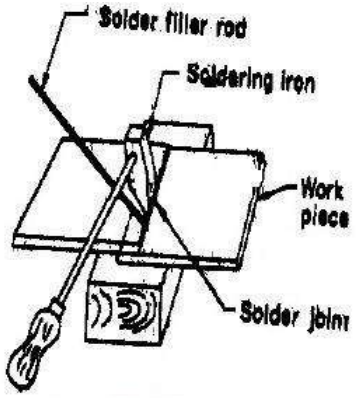
- Dissimilar metals which canot be welded can be joined by brazing
- Very thin metals can be joined
- Metals with different thickness can be joined easily
- In brazing thermal stresses are not produced in the work piece. Hence there is no distortion
- Using this process, carbides tips are brazed on the steel tool holders

Disadvantages

- Brazed joints have lesser strength compared to welding
- Joint preparation cost is more
- Can be used for thin sheet metal sections

Soldering

- It is a low temperature joining process. It is performed at temperatures below 840°F for joining.
- Soldering is used for,
    - Sealing, as in automotive radiators or tin cans
    - Electrical Connections
    - Joining thermally sensitive components
    - Joining dissimilar metals



Inert Gas Welding

For materials such as Al or Ti which quickly form oxide layers, a method to place an inert atmosphere around the weld puddle had to be developed

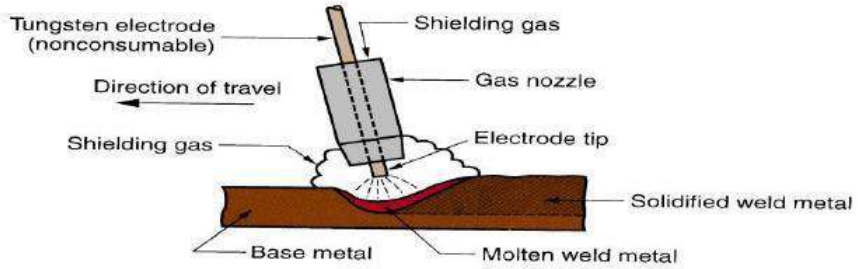
Metal Inert Gas (MIG)

- Uses a consumable electrode (filler wire made of the base metal)
- Inert gas is typically Argon

Gas Tungsten Arc Welding (GTAW)

Uses a non-consumable tungsten electrode and an inert gas for arc shielding

- Melting point of tungsten = 3410°C (6170°F)
- A.k.a. Tungsten Inert Gas (TIG) welding
  - In Europe, called "WIG welding"
- Used with or without a filler metal
  - When filler metal used, it is added to weld pool from separate rod or wire
- Applications: aluminum and stainless steel most common



Advantages

- High quality welds for suitable applications
- No spatter because no filler metal through arc
- Little or no post-weld cleaning because no flux

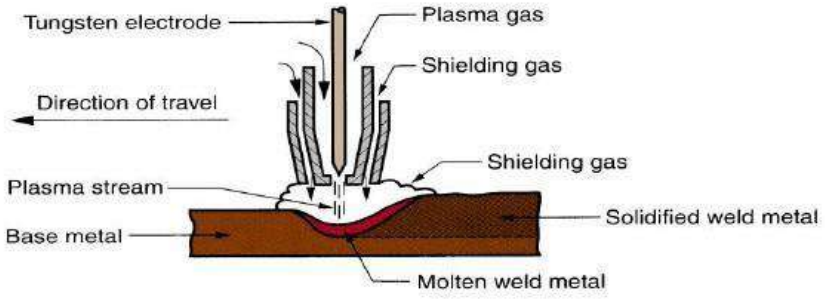
Disadvantages

- Generally slower and more costly than consumable electrode AW processes

Plasma Arc Welding (PAW)

Special form of GTAW in which a constricted plasma arc is directed at weld area

- Tungsten electrode is contained in a nozzle that focuses a high velocity stream of inert gas (argon) into arc region to form a high velocity, intensely hot plasma arc stream
- Temperatures in PAW reach 28,000°C (50,000°F), due to constriction of arc, producing a plasma jet of small diameter and very high energy density



Resistance Welding (RW)

A group of fusion welding processes that use a combination of heat and pressure to accomplish coalescence

- Heat generated by electrical resistance to current flow at junction to be welded
- Principal RW process is resistance spot welding (RSW)

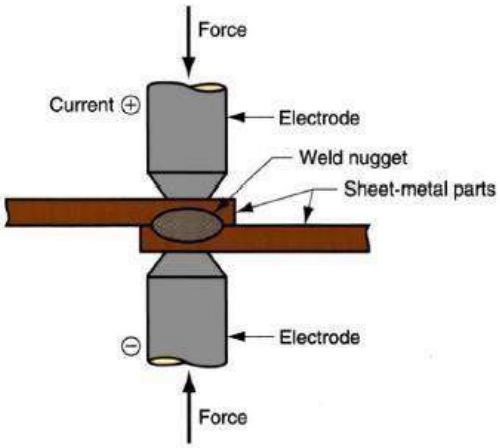


Fig: Resistance welding, showing the components in spot welding, the main process in the RW group.

Components in Resistance Spot Welding

- Parts to be welded (usually sheet metal)
- Two opposing electrodes
- Means of applying pressure to squeeze parts between electrodes
- Power supply from which a controlled current can be applied for a specified time duration

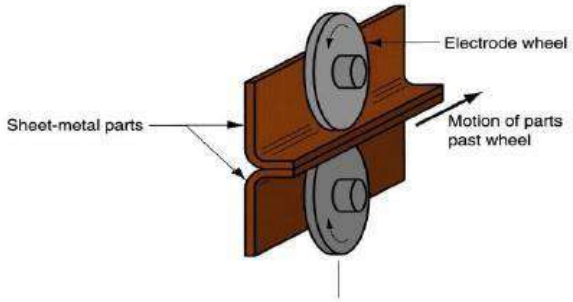
Advantages

- No filler metal required

- High production rates possible
- Lends itself to mechanization and automation
- Lower operator skill level than for arc welding
- Good repeatability and reliability

Disadvantages
- High initial equipment cost
- Limited to lap joints for most RW processes

Resistance Seam Welding



Electron Beam Welding (EBW)

Fusion welding process in which heat for welding is provided by a highly-focused, high-intensity stream of electrons striking work surface

- Electron beam gun operates at:
  - High voltage (e.g., 10 to 150 kV typical) to accelerate electrons
  - Beam currents are low (measured in milliamps)
- Power in EBW not exceptional, but power density is

Advantages
- High-quality welds, deep and narrow profiles
- Limited heat affected zone, low thermal distortion
- High welding speeds
- No flux or shielding gases needed

Disadvantages
- High equipment cost
- Precise joint preparation & alignment required
- Vacuum chamber required
- Safety concern: EBW generates x-rays

Laser Beam Welding (LBW)

Fusion welding process in which coalescence is achieved by energy of a highly concentrated, coherent light beam focused on joint

- Laser = "light amplification by stimulated emission of radiation"
- LBW normally performed with shielding gases to prevent oxidation

- Filler metal not usually added
- High power density in small area, so LBW often used for small parts

Comparison: LBW vs. EBW

- No vacuum chamber required for LBW
- No x-rays emitted in LBW
- Laser beams can be focused and directed by optical lenses and mirrors
- LBW not capable of the deep welds and high depth-to-width ratios of EBW
    - Maximum LBW depth = ~ 19 mm (3/4 in), whereas EBW depths = 50 mm (2 in)

Thermit Welding (TW)

FW process in which heat for coalescence is produced by superheated molten metal from the chemical reaction of thermite

- Thermite = mixture of Al and Fe3O4 fine powders that produce an exothermic reaction when ignited
- Also used for incendiary bombs
- Filler metal obtained from liquid metal
- Process used for joining, but has more in common with casting than welding

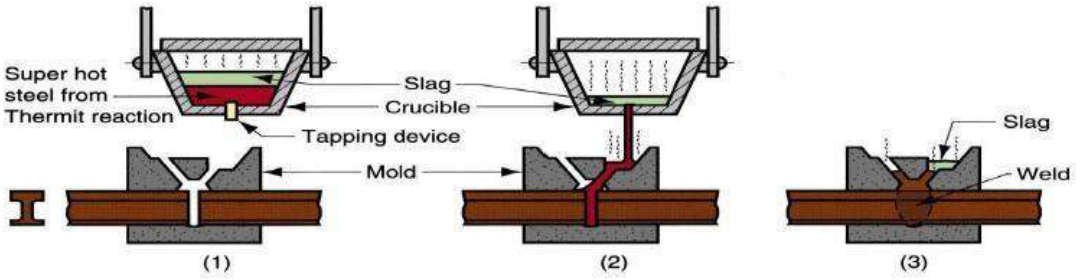


Fig: Thermit welding: (1) Thermit ignited; (2) crucible tapped, superheated metal flows into mold; (3) metal solidifies to produce weld joint.

Applications

- Joining of railroad rails
- Repair of cracks in large steel castings and forgings
- Weld surface is often smooth enough that no finishing is required

Diffusion Welding (DFW)

SSW process uses heat and pressure, usually in a controlled atmosphere, with sufficient time for diffusion and coalescence to occur

- Temperatures ≤ 0.5 Tm
- Plastic deformation at surfaces is minimal
- Primary coalescence mechanism is solid state diffusion
- Limitation: time required for diffusion can range from seconds to hours

Applications

- Joining of high-strength and refractory metals in aerospace and nuclear industries
- Can be used to join either similar and dissimilar metals
- For joining dissimilar metals, a filler layer of different metal is often sandwiched between base metals to promote diffusion

Friction Welding (FRW)

SSW process in which coalescence is achieved by frictional heat combined with pressure

- When properly carried out, no melting occurs at faying surfaces
- No filler metal, flux, or shielding gases normally used
- Process yields a narrow HAZ
- Can be used to join dissimilar metals
- Widely used commercial process, amenable to automation and mass production

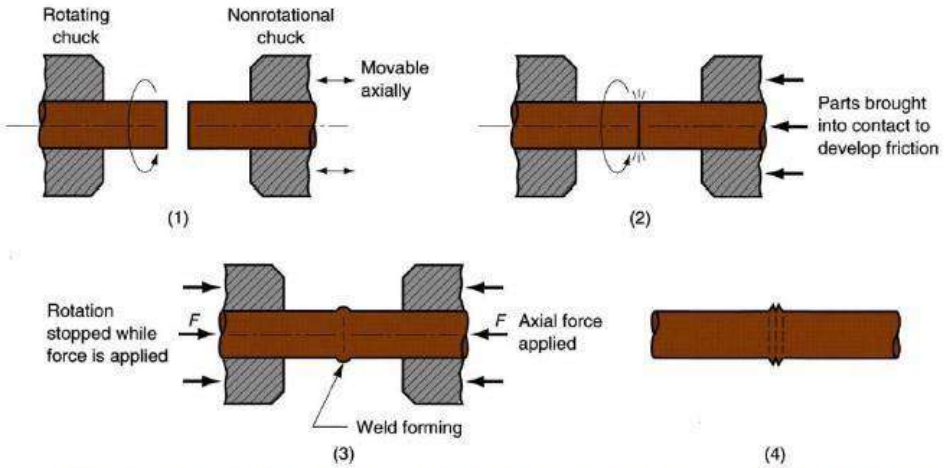


Fig: Friction welding (FRW): (1) rotating part, no contact; (2) parts brought into contact to generate friction heat; (3) rotation stopped and axial pressure applied; and (4) weld created.

Applications

- Shafts and tubular parts
- Industries: automotive, aircraft, farm equipment, petroleum and natural gas

Limitations

- At least one of the parts must be rotational
- Flash must usually be removed
- Upsetting reduces the part lengths (which must be taken into consideration in product design)

Weld Defects

- Undercuts/Overlaps
- Grain Growth

A wide ΔT will exist between base metal and HAZ. Preheating and cooling methods will affect the brittleness of the metal in this region

- Blowholes

Are cavities caused by gas entrapment during the solidification of the weld puddle. Prevented by proper weld technique (even temperature and speed)

- Inclusions

  Impurities or foreign substances which are forced into the weld puddle during the welding process. Has the same effect as a crack. Prevented by proper technique/cleanliness.

- Segregation

  Condition where some regions of the metal are enriched with an alloy ingredient and others aren't. Can be prevented by proper heat treatment and cooling.

- Porosity

  The formation of tiny pinholes generated by atmospheric contamination. Prevented by keeping a protective shield over the molten weld puddle.

Metal Casting Process

Manufacturing

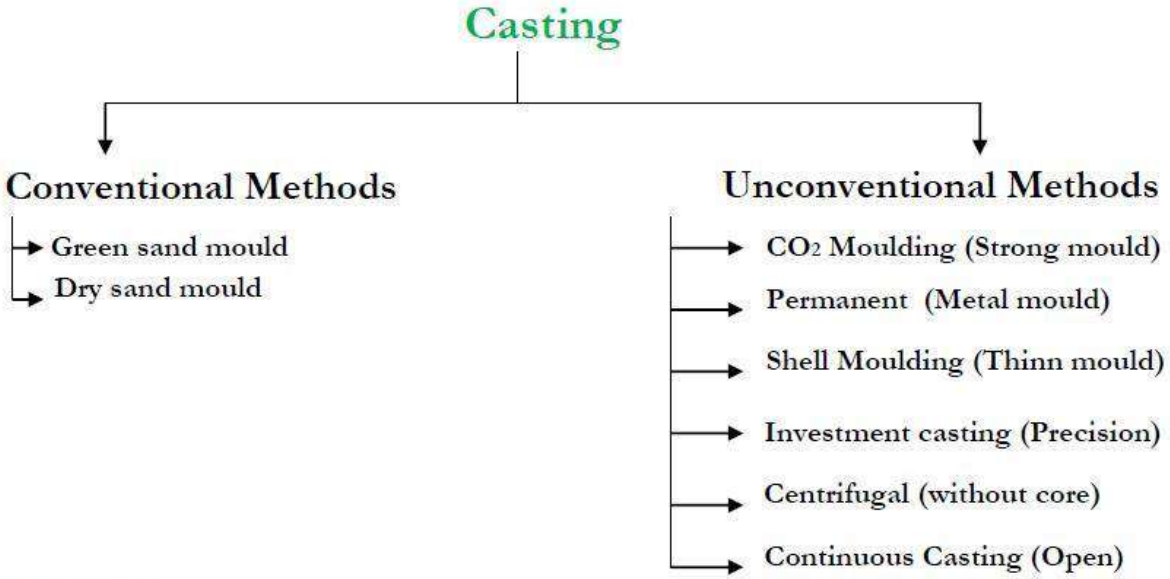
- Manufacturing in its broadest sense is the process of converting raw materials into useful products.
- It includes

i) Design of the product
ii) Selection of raw materials and
iii) The sequence of processes through which the product will be manufactured.

Casting

Casting is the process of producing metal parts by pouring molten metal into the mould cavity of the required shape and allowing the metal to solidify. The solidified metal piece is called as "casting".

Types of casting



Advantages

- Design flexibility
- Reduced costs
- Dimensional accuracy
- Versatility in production

Disadvantages

- Lot of molten metal is wasted in riser & gating
- Casting may require machining to remove rough surfaces

Sand Casting is simply melting the metal and pouring it into a preformed cavity, called mold, allowing (the metal to solidify and then breaking up the mold to remove casting. In sand casting expandable molds are used. So for each casting operation you have to form a new mold.

- Most widely used casting process.
- Parts ranging in size from small to very large
- Production quantities from one to millions
- Sand mold is used.
- Patterns and Cores
  - Solid, Split, Match-plate and Cope-and-drag Patterns
  - Cores – achieve the internal surface of the part

Molds

- Sand with a mixture of water and bonding clay
- Typical mix: 90% sand, 3% water, and 7% clay
- to enhance strength and/or permeability

Sand – Refractory for high temperature

Size and shape of sand

Small grain size -> better surface finish
Large grain size -> to allow escape of gases during pouring
Irregular grain shapes -> strengthen molds due to interlocking but to reduce permeability

Types of sand

a) Green-sand molds - mixture of sand, clay, and water; "Green" means mold contains moisture at time of pouring.
b) Dry-sand mold - organic binders rather than clay and mold is baked to improve strength
c) Skin-dried mold - drying mold cavity surface of a green-sand

- mold to a depth of 10 to 25 mm, using torches or heating

Steps in Sand Casting

The cavity in the sand mold is formed by packing sand around a pattern, separating the mold into two halves

- The mold must also contain gating and riser system
- For internal cavity, a core must be included in mold
- A new sand mold must be made for each part

1. Pour molten metal into sand mold
2. Allow metal to solidify
3. Break up the mold to remove casting
4. Clean and inspect casting
5. Heat treatment of casting is sometimes required to improve metallurgical properties

Testing of Mould & Core sand

1) Preparation of standard test specimen
2) Mould hardness test
3) Core hardness test
4) Moisture content test on foundry sand
5) Sieve analysis
6) Clay content test
7) Permeability test
8) Compression, shear test

Other Expendable Mold Casting

- Shell Molding
- Vacuum Molding
- Expanded Polystyrene Process
- Investment casting
- Plaster and Ceramic Mold casting

Steps in shell-molding

Shell-mold casting yields better surface quality and tolerances. The process is described as follows:

The 2-piece pattern is made of metal (e.g. aluminum or steel), it is heated to between 175°C- 370°C, and coated with a lubricant, e.g. silicone spray.

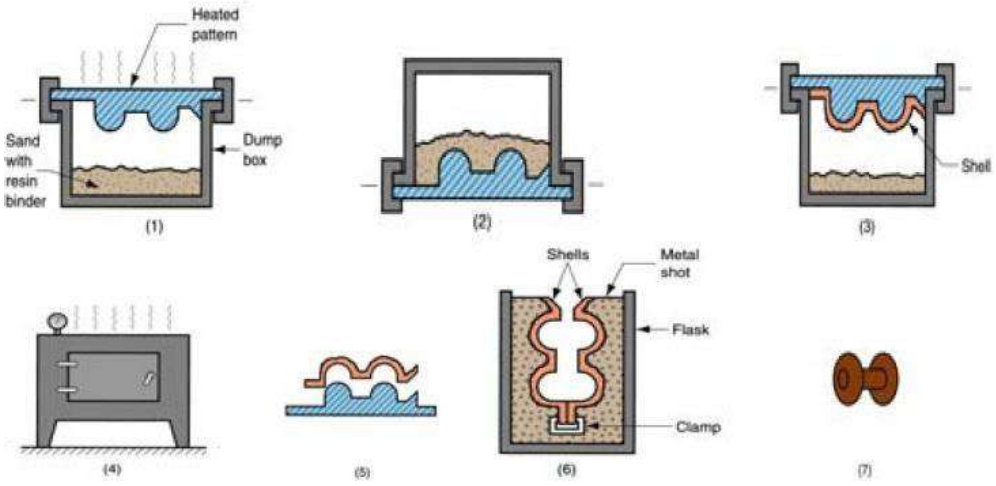
Each heated half-pattern is covered with a mixture of sand and a thermoset resin/epoxy binder.

The binder glues a layer of sand to the pattern, forming a shell. The process may be repeated to get a thicker shell.

The assembly is baked to cure it.

The patterns are removed, and the two half-shells joined together to form the mold; metal is poured into the mold.

When the metal solidifies, the shell is broken to get the part.



Advantages

- Smoother cavity surface permits easier flow of molten metal and better surface finish on casting
- Good dimensional accuracy
- Machining often not required
- Mold collapsibility usually avoids cracks in casting
- Can be mechanized for mass production

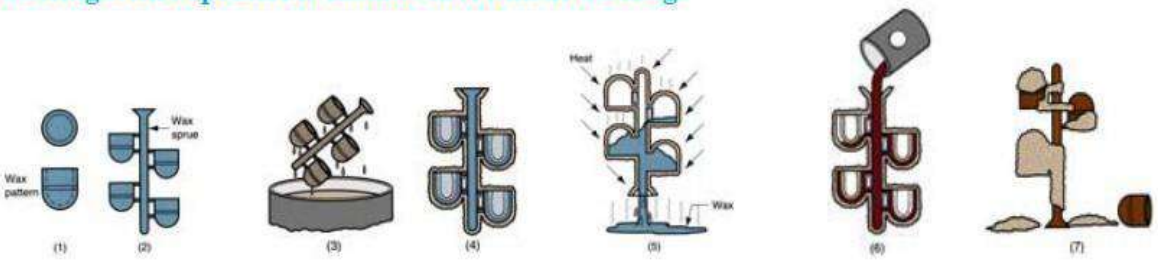
Disadvantages

- More expensive metal pattern
- Difficult to justify for small quantities

Investment Casting

- Investment casting produces very high surface quality and dimensional accuracy.
- Investment casting is commonly used for precision equipment such as surgical equipment, for complex geometries and for precious metals.
- This process is commonly used by artisans to produce highly detailed artwork.
- The first step is to produce a pattern or replica of the finished mould. Wax is most commonly used to form the pattern, although plastic is also used.
- Patterns are typically mass-produced by injecting liquid or semi-liquid wax into a permanent die.
- Prototypes, small production runs and specialty projects can also be undertaken by carving wax models.
- Cores are typically unnecessary but can be used for complex internal structures. Rapid prototyping techniques have been developed to produce expendable patterns.
- Several replicas are often attached to a gating system constructed of the same material to form a tree assembly. In this way multiple castings can be produced in a single pouring.

Casting with expendable mould: Investment Casting



Advantages

– Parts of great complexity and intricacy can be cast
– Close dimensional control and good surface finish
– Wax can usually be recovered for reuse
– Additional machining is not normally required - this is a net shape process

Disadvantages

– Many processing steps are required
– Relatively expensive process

Plaster Molding

• Similar to sand casting except mold is made of plaster of Paris (gypsum - CaSO4-2H2O)
• Plaster and water mixture is poured over plastic or metal pattern to make a mold

Advantages

– Good dimensional accuracy and surface finish
– Capability to make thin cross-sections in casting

Disadvantages

- Moisture in plaster mold causes problems:
- Mold must be baked to remove moisture
- Mold strength is lost when is over-baked, yet moisture content can cause defects in product
- Plaster molds cannot stand high temperatures

Permanent Mold Casting

Basic Permanent Mold Process
– Uses a metal mold constructed of two sections designed for easy, precise opening and closing
– Molds for lower melting point alloys: steel or cast iron and Molds for steel: refractory material, due to the very high pouring temperatures

Permanent Mold Casting Process

- The two halves of the mold are made of metal, usually cast iron, steel, or refractory alloys. The cavity, including the runners and gating system are machined into the mold halves.
- For hollow parts, either permanent cores (made of metal) or sand-bonded ones may be used, depending on whether the core can be extracted from the part without damage after casting.
- The surface of the mold is coated with clay or other hard refractory material – this improves the life of the mold. Before molding, the surface is covered with a spray of graphite or silica, which acts as a lubricant. This has two purposes – it improves the flow of the liquid metal, and it allows the cast part to be withdrawn from the mold more easily.
- The process can be automated, and therefore yields high throughput rates.
- It produces very good tolerance and surface finish.
- It is commonly used for producing pistons used in car engines; gear blanks, cylinder heads, and other parts made of low melting point metals, e.g. copper, bronze, aluminum, magnesium, etc.

Advantage

- Good surface finish and dimensional control and Fine grain due to rapid solidification.

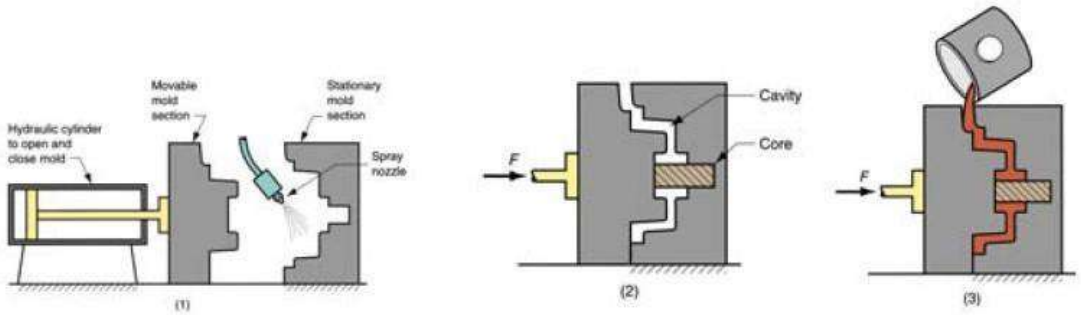
Disadvantage

- Simple geometric part, expensive mold.

Example

It is commonly used for producing pistons used in car engines; gear blanks, cylinder heads, and other parts made of low melting point metals, e.g. copper, bronze, aluminum, magnesium, etc.

Basic Permanent Mold Process



Advantages

– Good dimensional control and surface finish

– More rapid solidification caused by the cold metal mold results in a finer grain structure, so stronger castings are produced

Limitations

- Generally limited to metals of lower melting point
- Simple part geometries compared to sand casting because of the need to open the mold
- High cost of mold
- Due to high mold cost, process is best suited to automated high volume production

Testing of Mould & Core sand

1) Preparation of standard test specimen
2) Mould hardness test
3) Core hardness test
4) Moisture content test on foundry sand
5) Sieve analysis
6) Clay content test
7) Permeability test
8) Compression, shear test

Die Casting

• Die casting is a very commonly used type of permanent mold casting process.

• It is used for producing many components of home appliances (e.g rice cookers, stoves, fans, washing and drying machines, fridges), motors, toys and hand-tools

• The molten metal is injected into mold cavity (die) under high pressure (7-350MPa). Pressure maintained during solidification.

• Hot Chamber (Pressure of 7 to 35MPa)

• The injection system is submerged under the molten metals (low melting point metals such as lead, zinc, tin and magnesium)

• Cold Chamber (Pressure of 14 to 140MPa)

• External melting container (in addition aluminum, brass and magnesium)

Molds are made of tool steel, mold steel, maraging steel, tungsten and molybdenum.

• Single or multiple cavity

• Lubricants and Ejector pins to free the parts

• Venting holes and passageways in die
• Formation of flash that needs to be trimmed

Properties of die-casting

1) Huge numbers of small, light castings can be produced with great accuracy.
2) Little surface finishing is required.
3) Permanent mold (dies can be used over and over)

Advantages

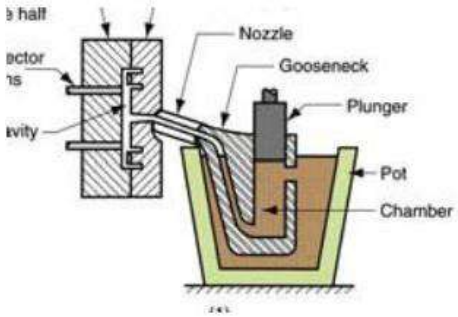
– High production, Economical, close tolerance, good surface finish, thin sections, rapid cooling

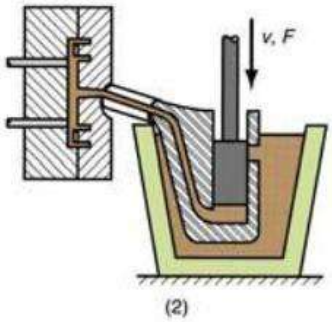
Hot-Chamber Die Casting

In a hot chamber process (used for Zinc alloys, magnesium) the pressure chamber connected to the die cavity is filled permanently in the molten metal.
The basic cycle of operation is as follows:

(i) die is closed and gooseneck cylinder is filled with molten metal;
(ii) plunger pushes molten metal through gooseneck passage and nozzle and into the die cavity; metal is held under pressure until it solidifies;
(iii) die opens and cores, if any, are retracted; casting stays in ejector die; plunger returns, pulling molten metal back through nozzle and gooseneck;
(iv) ejector pins push casting out of ejector die. As plunger uncovers inlet hole, molten metal refills gooseneck cylinder.

The hot chamber process is used for metals that (a) have low melting points and (b) do not alloy with the die material, steel; common examples are tin, zinc, and lead.



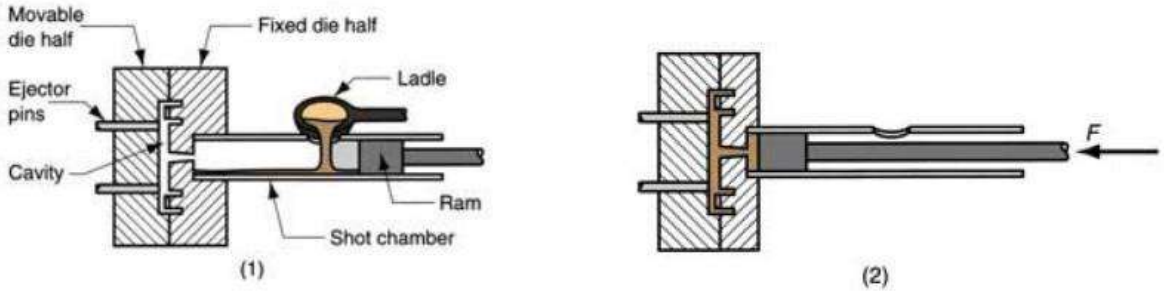


Cold Chamber Die Casting

In a cold chamber process, the molten metal is poured into the cold chamber in each cycle. The operating cycle is

(i) Die is closed and molten metal is ladled into the cold chamber cylinder;
(ii) plunger pushes molten metal into die cavity; the metal is held under high pressure until it solidifies;
(iii) die opens and plunger follows to push the solidified slug from the cylinder, if there are cores, they are retracted away;
(iv) ejector pins push casting off ejector die and plunger returns to original position

This process is particularly useful for high melting point metals such as Aluminum, and Copper (and its alloys).



Advantages

– Economical for large production quantities
– Good dimensional accuracy and surface finish
– Thin sections are possible
– Rapid cooling provides small grain size and good strength to casting

Disadvantages

– Generally limited to metals with low metal points
– Part geometry must allow removal from die cavity

Centrifugal casting

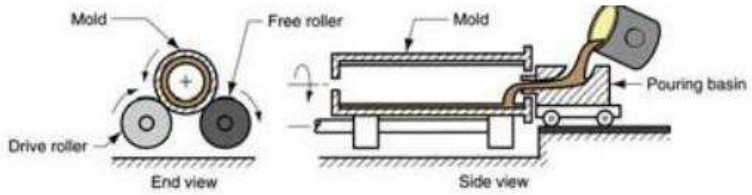
Centrifugal casting uses a permanent mold that is rotated about its axis at a speed betwe 300 to 3000 rpm as the molten metal is poured.

Centrifugal forces cause the metal to be pushed out towards the mold walls, where solidifies after cooling.

Centrifugal casting has greater reliability than static castings. They are relatively free fro gas and shrinkage porosity.

Surface treatments such as case carburizing, flame hardening and have to be used when wear resistant surface must be combined with a hard tough exterior surface.

One such application is bimetallic pipe consisting of two separate concentric layers different alloys/metals bonded together.



Carbon Dioxide Moulding

- This sand is mixed with 3 to 5 % sodium silicate liquid base binder in muller for 3 to 4 minutes. Additives such as coal powder, wood flour sea coal, dextrine may be added to improve its properties.
- Aluminium oxide Kaolin clay may also added to the sand .

- Patterns used in this method may be coated with Zinc of 0.05 mm to 0.13 mm and then spraying a layer of aluminium or brass of about 0.25 mm thickness for good surface finish and good results.

Advantages

- Operation is speedy since we can use the mould and cores immediately after processing.
- Heavy and rush orders
- Floor space requirement is less
- Semi skilled labour may be used.

Disadvantages

Difficult in reusing the moulding sand.

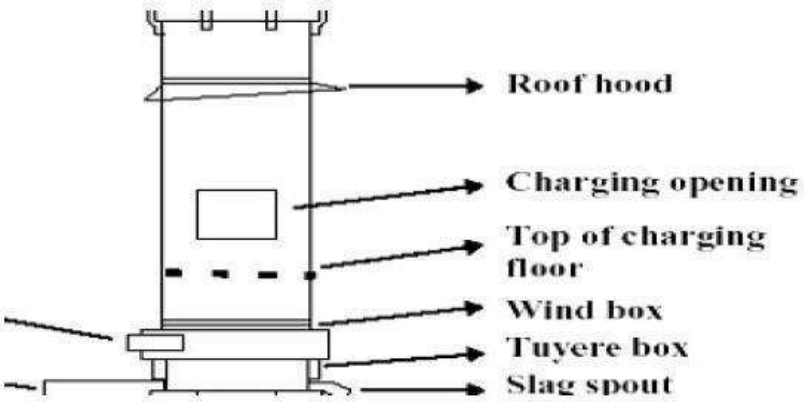
Process	Advantages	Disadvantages	Examples
Sand	Wide range of metals, sizes, shapes, low cost	poor finish, wide tolerance	engine blocks, cylinder heads
Shell mold	better accuracy, finish, higher production rate	limited part size	connecting rods, gear housings
Expendable pattern	Wide range of metals, sizes, shapes	patterns have low strength	cylinder heads, brake components
Plaster mold	complex shapes, good surface finish	non-ferrous metals, low production rate	prototypes of mechanical parts
Ceramic mold	complex shapes, high accuracy, good finish	small sizes	impellers, injection mold tooling
Investment	complex shapes, excellent finish	small parts, expensive	jewellery
Permanent mold	good finish, low porosity, high production rate	Costly mold, simpler shapes only	gears, gear housings
Die	Excellent dimensional accuracy, high production rate	costly dies, small parts, non-ferrous metals	precision gears, camera bodies, car wheels
Centrifugal	Large cylindrical parts, good quality	Expensive, limited shapes	pipes, boilers, flywheels

Furnaces

Cupola Furnace

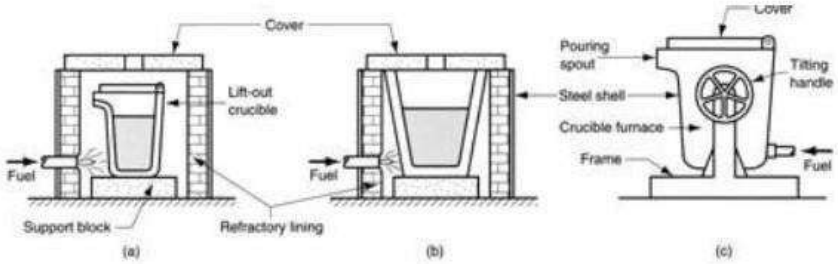
- A continuous flow of iron emerges from the bottom of the furnace.
- Depending on the size of the furnace, the flow rate can be as high as 100 tonnes per hour.

At the metal melts it is refined to some extent, which removes contaminants. This makes this process more suitable than electric furnaces for dirty charges.

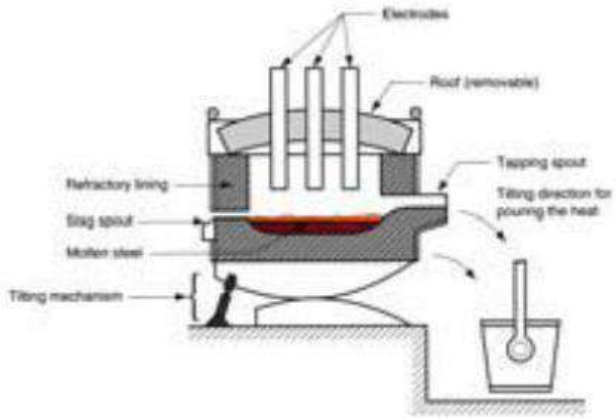


Direct Fuel-fired furnace

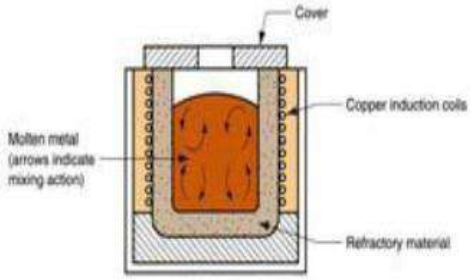
–Crucible Furnace
– Electric-arc Furnace
– Induction Furnace
• Pouring with ladle
• Solidification – watch for oxidation
• Trimming, surface cleaning, repair and heat treat, inspection



Three types: (a) lift-out crucible, (b) stationary pot, from which molten metal must be ladle (c) tilting-pot furnace



Induction Furnace:



Casting defects

Defects may occur due to one or more of the following reasons:

- Fault in design of casting pattern
- Fault in design on mold and core
- Fault in design of gating system and riser
- Improper choice of moulding sand
- Improper metal composition
- Inadequate melting temperature and rate of pouring

Some common defects in castings:

a) Misruns b) Cold Shut c) Cold Shot d) Shrinkage Cavity e) Microporosity f) Hot Tearing

Misruns:

a)Misruns

It is a casting that has solidified before completely filling the mold cavity.

Typical causes include

1) Fluidity of the molten metal is insufficient,
2) Pouring Temperature is too low,
3) Pouring is done too slowly and/or
4) Cross section of the mold cavity is too thin.

b) Cold Shut

A cold shut occurs when two portion of the metal flow together, but there is lack of fusion between them due to premature freezing. Its causes are similar to those of a Misruns.

c) Cold Shots

When splattering occurs during pouring, solid globules of the metal are formed that become entrapped in the casting. Poring procedures and gating system designs that avoid splattering can prevent these defects.

d) Shrinkage Cavity

This defects is a depression in the surface or an internal void in the casting caused by solidification shrinkage that restricts the amount of the molten metal available in the last region to freeze.

e) Microporosity

This refers to a network of a small voids distributed throughout the casting caused by localized solidification shrinkage of the final molten metal in the dendritic structure.

f) Hot Tearing

This defect, also called hot cracking, occurs when the casting is restrained or early stages of cooling after solidification.

Powder Metallurgy

Powder Metallurgy–Engineering and technology of producing metal powders and making finished / semifinished objects from mixed or alloyed powders with or without the addition of nonmetallic constituents

Basic Processes In Powder Metallurgy:

Powder production, Compaction, Sintering, & Secondary operations

Powder production:

Raw materials: Powder

Powders can be pure elements, pre-alloyed powders.

Methods for making powders –

- Atomization: Produces powders of both ferrous and non-ferrous powders like stainless steel, superalloys, Ti alloy powders.
- Reduction of compounds: Production of iron, Cu, tungsten, molybdenum
- Electrolysis: for making Cu, iron, silver powders.

Powders along with additives are mixed using mixers. Lubricants are added prior to mixing to facilitate easy ejection of compact and to minimize wear of tools; Waxes, metallic stearates, graphite etc.

Powder characterization –

size, flow, density, compressibility tests.

Compaction:

compaction is performed using dies machined to close tolerances.Dies are made of cemented carbide, die/tool steel; pressed usinghydraulic or mechanical presses.The basic purpose of compaction is to obtain a green compact with sufficient strength to withstand further handling operations.The green compact is then taken for sintering

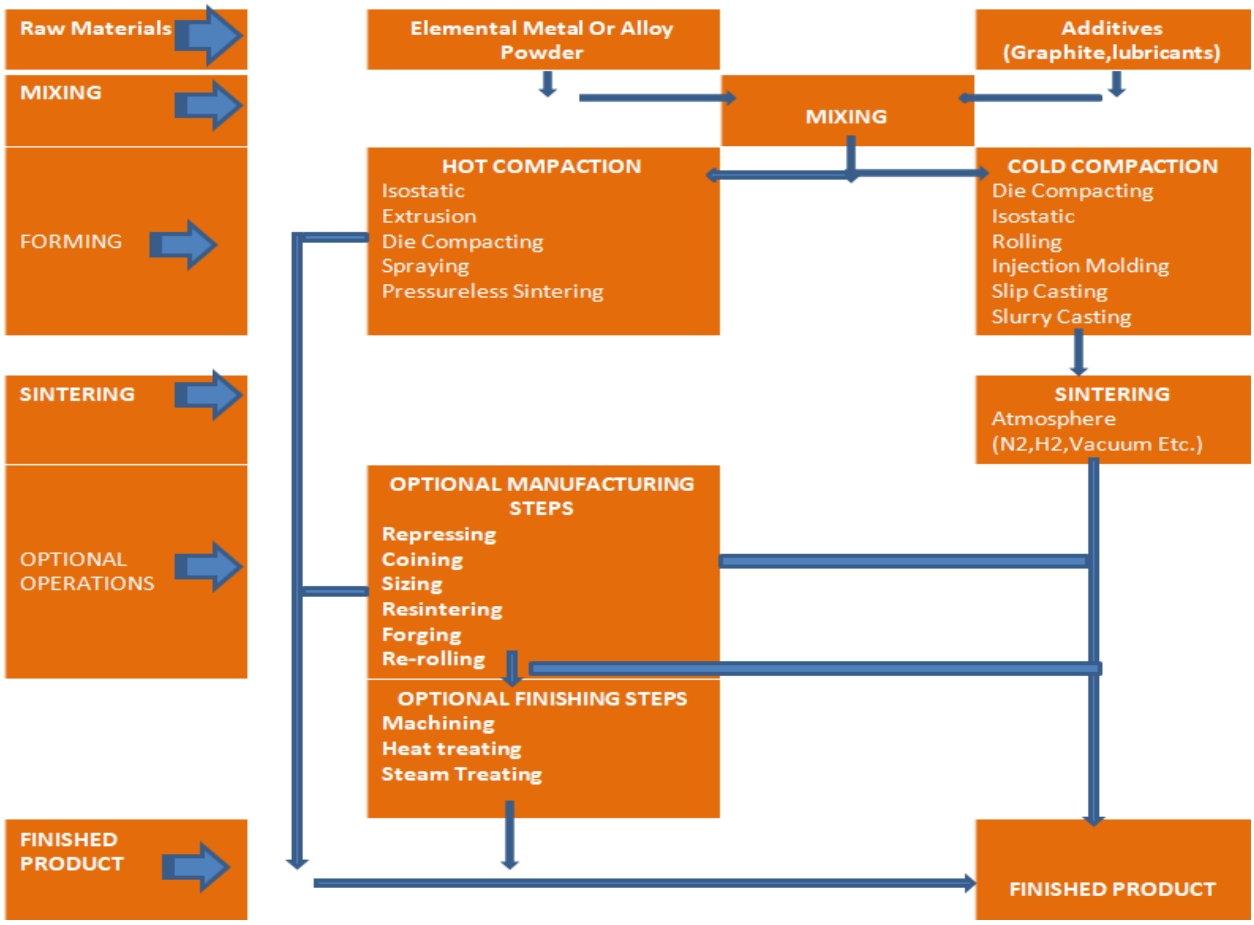
Hot extrusion, hot pressing, hot isostaticpressing - consolidation at high temperatures

Sintering:

Performed at controlled atmosphere to bond atoms metallurgically; Bonding occurs by diffusion of atoms; done at 70% of abs. melting point of materials. It serves to consolidate the mechanically bonded powders into a coherent body having desired on service behavior.Densification occurs during the process and improvement in physical and mechanical properties are seen.

Furnaces –mesh belt furnaces (up to 1200C), walking beam, pusher type furnace, batch type furnaces are also used
Protective atmosphere: Nitrogen

Secondary operations:
Operations include repressing, grinding, plating can be done; They are used to ensure close dimensional tolerances, good surface finish, increase density, corrosion resistance etc.



Flow Chart For Making P/M Components

Advantages & Limitations

- Efficient material utilization
- Enables close dimensional tolerances –near net shape possible
- Good surface finish
- Manufacture of complex shapes possible
- Hard materials used to make components that are difficult to machine can be readily made –tungsten wires for incandescent lamps
- Environment friendly, energy efficient
- Suited for moderate to high volume component production
- Powders of uniform chemical composition - reflected in the finished part
- wide variety of materials - miscible, immiscible systems; refractory metals
- Parts with controlled porosity can be made
- High cost of powder material & tooling
- Less strong parts than wrought ones
- Less well known process

Production of powders

•Metal powders - Main constituent of a P/M product; final properties of the finished P/M part depends on size, shape, and surface area of powder particles
•Single powder production method is not sufficient for all applications
Powder production methods: 1. Mechanical methods, 2. Physical methods, 3. Chemical methods
1. **Mechanical methods-** Cheapest of the powder production methods; These methods involve using mechanical forces such as compressive forces, shear or impact to facilitate particle size reduction of bulk materials;
Eg.:Milling-illing:During milling, impact, attrition, shear and compression forcesare acted upon particles. During impact, striking of one powder particle against another occurs. Attritionrefers to the production of wear debris due to the rubbing action between two particles. Shearrefers to cutting of particles resulting in fracture. The particles are broken into fine particles by squeezing action in compression force type.
Main objective of milling:Particle size reduction (main purpose),Particle size growth, shape change, agglomeration (joining of particles together), solid state alloying, mechanical or solid state mixing, modification of material properties

Mechanism of milling: Changes in the morphology of powder particles during milling results in the following events.
1.Microforging, 2. Fracture, 3. Agglomeration, 4. Deagglomeration
Microforging- Individual particles or group of particles are impacted repeatedly so that they flatten with very less change in mass
Fracture- Individual particles deform and cracks initiate and propagate resulting in fracture
Agglomeration - Mechanical interlocking due to atomic bonding or vandeWaals forces
Deagglomeration- Breaking of agglomerates

The different powder characteristics influenced by milling are shape, size, texture, particle size distribution, crystalline size, chemical composition, hardness, density, flowability, compressibility, sinterability, sintered density

Milling equipment:The equipments are generally classified as crushers & mills
Crushing- for making ceramic materials such as oxides of metals;
Grinding- for reactive metals such as titanium, zirconium, niobium, tantalum

Ball mills:

•This contains cylindrical vessel rotating horizontally along the axis. Length of the cylinder is more or less equal to diameter. The vessel is charged with the grinding media. The grinding media may be made of hardened steel, or tungsten carbide, ceramics like agate, porcelain, alumina, zirconia. During rolling of vessel, the grinding media & powder particles roll from some height. This process grinds the powder materials by impact/collision & attrition.
•Milling can be dry milling or wet milling. In dry milling, about 25 vol% of powder is added along with about 1 wt% of a lubricant such as stearicor oleic acid. For wet milling, 30-40 vol% of powder with 1 wt% of dispersing agent such as water, alcohol or hexane is employed.
•Optimum diameter of the mill for grinding powders is about 250 mm

Vibratory ball mill:

•Finer powder particles need longer periods for grinding

•In this case, vibratory ball mill is better - here high amount of energy is imparted to the particles and milling is accelerated by vibrating the container

•This mill contains an electric motor connected to the shaft of the drum by an elastic coupling. The drum is usually lined with wear resistant material. During operation, 80% of the container is filled with grinding bodies and the starting material. Here vibratory motion is obtained by an eccentric shaft that is mounted on a frame inside the mill. The rotation of eccentric shaft causes the drum of the vibrating mill to oscillate.

•In general, vibration frequency is equal to 1500 to 3000 oscillations/min.The amplitude of oscillations is 2 to 3 mm. The grinding bodies is made of steel or carbide balls, that are 10-20 mm in diameter.The mass of the balls is 8-10 times the charged particles.Final particle size is of the order of 5-100 microns

Attrition mill: In this case, the charge is ground to fine size by the action of a vertical shaft with side arms attached to it. The ball to charge ratio may be 5:1, 10:1, 15:1. This method is more efficient in achieving fine particle size.

Rod mills:Horizontal rods are used instead of balls to grind. Granularityof the discharge material is 40-10 mm. The mill speed

varies from 12 to 30 rpm.

Planetary mill:High energy mill widely used for producing metal, alloy, and composite powders.

Fluid energy grinding or Jet milling:

The basic principle of fluid energy mill is to induce particles to collide against each other at high velocity, causing them to fracture into fine particles

•Multiple collisions enhance the reduction process and therefore, multiple jet arrangements are normally incorporated in the mill design. The fluid used is either air about 0.7 MPa or stream at 2 MPa. In the case of volatile materials, protective atmosphere of nitrogen and carbon-di-oxide is used.

•The pressurized fluid is introduced into the grinding zone through specially designed nozzles which convert the applied pressure to kinetic energy. Also materials to be powdered are introduced simultaneously into the turbulent zone.

•The velocity of fluid coming out from the nozzles is directly proportional to the square root of the absolute temperature of the fluid entering the nozzle. Hence it is preferable to raise the temperature of fluid to the maximum possible level without affecting the feed material.

•If further powdering is required, large size particles are separated from the rest centrifugal forces and re-circulated into the turbulent zone for size reduction. Fine particles are taken to the exit by viscous drag of the exhaust gases to be carried away for collection.

•This Jet millingprocess can create powders of average particle size less than 5 μm

Machining:Mg, Be, Ag, solder, dental alloy are specifically made by machining; Turning and chips thus formed during machining are subsequently crushed or ground into powders

Shotting: Fine stream of molten metal is poured through a vibratory screen into air or protective gas medium. When the molten metals falls through screen, it disintegrates and solidifies as spherical particles. These particles get oxidized. The particles thus obtained depends on pore size of screen, temperature, gas used, frequency of vibration. Metal produced by the method are Cu, Brass, Al, Zn, Sn, Pb, Ni. (this method is like making Boondhi)

Graining: Same as shottingexcept that the falling material through sieve is collected in water; Powders of cadmium, Bismuth, antimony are produced.

2. Physical methods

Electrolytic deposition

•In this method, the processing conditions are so chosen that metals of high purity are precipitated from aqueous solution on the cathode of an electrolytic cell. This method is mainly used for producing copper, iron powders. This method is also used for producing zinc, tin, nickel, cadmium, antimony, silver,lead, beryllium powders.

•Copper powder Solution containing copper sulphateand sulphuricacid; crude copper as anode

•Reaction: at anode: Cu --> Cu++ e-; at cathode: Cu++ e-->Cu

•Iron powder- Anode is low carbon steel; cathode is stainless steel. The iron powder deposits are subsequently pulverized by milling in hammermill. The milled powders are annealed in hydrogen atmosphere to make them soft

•Mg powder-Electrodeposition from a purified magnesium sulphateelectrolyte using insoluble lead anodes and stainless steel cathodes

•Powders of thorium, tantalum, vanadium - fused salt electrolysis is carried out at a temperature below melting point of the metal. Here deposition will occur in the form of small crystals with dendriticshape

Atomization

This uses high pressure fluid jets to break up a molten metal stream into very fine droplets, which then solidify into fine particles

High quality powders of Al, brass, iron, stainless steel, tool steel, superalloysare produced commercially

Types:

water atomization, gas atomization, soluble gas or vacuum atomization, centrifugal atomization, rotating disk atomization, ultrarapidsolidification process, ultrasonic atomization

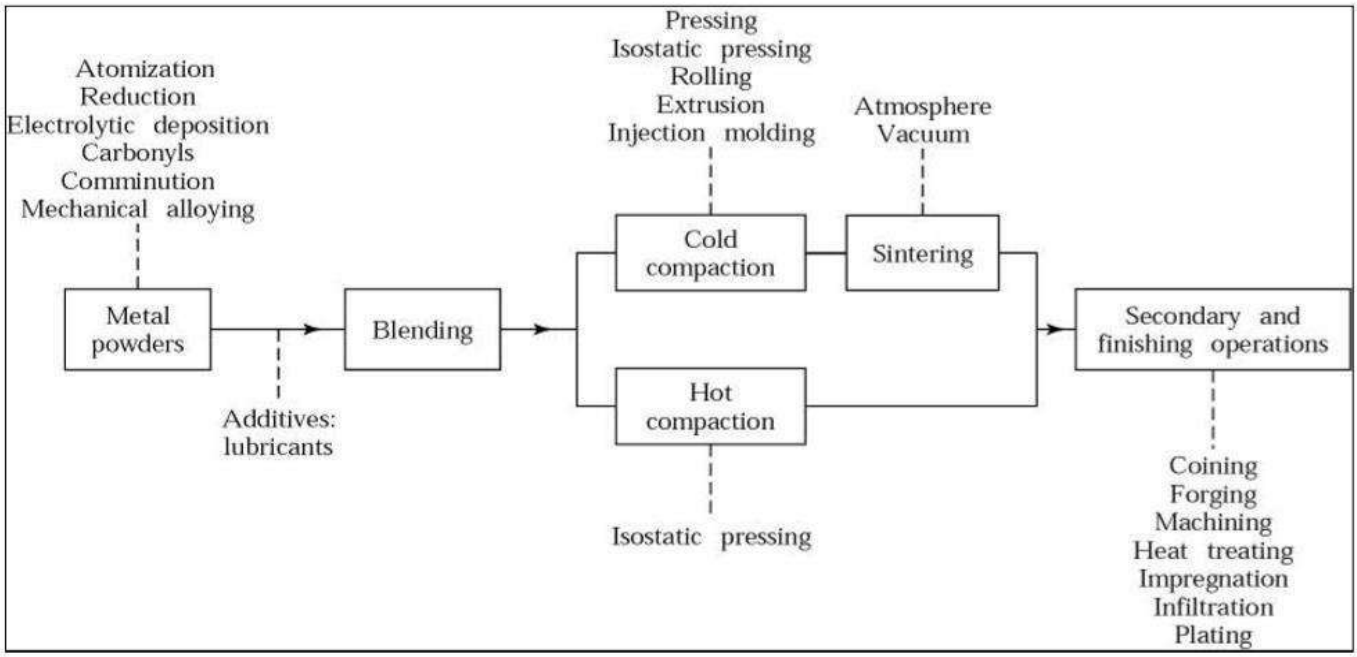
Mechanism of atomization:

In conventional (gas or water) atomization, a liquid metal is produced by pouring molten metal through a tundishwith a nozzle at its base. The stream of liquid is then broken into droplets by the impingement of high pressure gas or water. This disintegration of liquid stream is shown in fig. This has five stages

i) Formation of wavy surface of the liquid due to small disturbances
ii) Wave fragmentation and ligament formation
iii)Disintegration of ligament into fine droplets
iv)Further breakdown of fragments into fine particles
v)Collision and coalescence of particles

•The interaction between jets and liquid metal stream begins with the creation of small disturbances at liquid surfaces, which grow into shearing forces that fragment the liquid into ligaments. The broken ligaments are further madeto fine particles because of high energy in impacting jet.
•Lower surface tension of molten metal, high cooling rate - formation of irregular surface : like in water atomization
•High surface tension, low cooling rates - spherical shape formation : like in inert gas atomization
•The liquid metal stream velocity, $v = A\,[2g\,(Pi–Pg)\rho]0.5$
where Pi–injection pressure of the liquid, Pg –pressure of atomizing medium, ρ–density of the liquid

Making powder & subsequent processing



Powder treatment & Handling

In powder conditioning, the powders prepared by various methodsare subjected to a variety of treatments to improve or modify their physical, chemical characteristics

Powder treatments

Powders manufactured for P/M applications can be classified into–elemental powders, and pre-alloyed powders
Elemental powders- powdersof single metallic element; eg.: iron for magnetic applications
Pre-alloyed powders- more than one element; made by alloying elemental powders during manufacturing process itself; IN this case, all the particles have same nominal composition and each particle is equivalent to small ingot
Majority of powders undergo heat treatmentsprior to compaction like,
i) Drying to remove moisture, ii) grinding/crushing to obtain fine sizes, iii) particle size classification to obtain the desired particle size distribution, iv) annealing, v) mixing and blending of powders, vi) lubricant addition for powder compaction, vii) powder coating

a) Cleaning of Powders:

•Refers to the removal of contaminants, solid or gaseous, from the powder particles

•Solid contaminants- come from several sources like nozzles or crucible linings. They interfere during compaction and sintering preventing propermechanical bonding

•Most of these contaminants are non-reactive, but they act as sites for crack nucleation and reduce the dynamic properties of the sintered part; Non-metallic solid impurities can be removed from superalloypowders by particle separators, electrostatic

separation techniques

•Gaseous impurities like hydrogen and oxygen get into powders during processing, storage or handling if proper care is not taken. Finer the powders, contamination will be more because of large powder surface area.

•These gaseous impurities can form undesirable oxides during processing at relatively high temperatureor gets trapped inside the material as pores, reducing the in situ performance of the P/M part; Degassing techniques like cold, hotstatic or dynamic degassing methods are used to remove adsorbed gases from the powders

•Lubricants added to the powders for better compaction has to be removed for desirable final P/M part

b) Grinding:

Similar to the mechanical methods seen earlier; Milling is widely used for reducing the aggregates of powder; Milling time, speed, type canbe selected for getting required degree of grinding

c) Powder classification & screening:

Powder size and shape, size distribution varied within specified range is required for better behavior of P/M parts; In this method, the desired particle size distributions with particle sizes within specific limits can be obtained; These variation depends on lot also.

d) Blending & mixing:Blending–

Process in which powders of the same nominal composition but having different particle sizes are intermingled. This is done to (i) obtain a uniform distribution of particle sizes, i.e. powders consisting of different particle sizes are often blended to reduce porosity, (ii) for intermingling of lubricant with powders to modify metal to powder interaction during compaction

Mixing–Process of combining powders of different chemistries such as elemental powder mixes (Cu-Sn) or metal-nonmetal powders. This may be done in dry or wet condition. Liquid medium like alcohol, acetone, benzene or distilled water are used as milling medium in wet milling. Ball mills or rod mills are employed for mixing hard metals such as carbides

Mixing methods

The various types of mixing methods are, (i) convective mixing: transfer of one group of particles from one location to another, (ii) diffusive mixing: movement of particles on to newly formed surface, (iii) shear mixing: deformation & formation of planes within the powders

Depending on the extent of mixing, mixing can be classified as (i) perfectly mixed or uniform mixing, (ii) random mixed, & (iii) totally un-mixed. The mixing should be stopped when random mixture is achieved. Overmixingleads to reduced flow characteristics of the mix

Heat Treatment Of Powders

Heat treatment is generally carried out before mixing or blending the metal powders. Some of the important objectives are,

i)Improving the purity of powder:Reduction of surface oxides from powders by annealing in hydrogen or other reducing atmosphere. Dissolved gases like hydrogen and oxygen, other impurities are removed by annealing of powders. Lowering impurities like carbon results in lower hardness of thepowder and hence lower compaction pressures & lower die wear during compaction. For eg., atomized powders having a combined carbon and oxygen content as high as 1% can be reduced after annealing to about 0.01% carbon and 0.2% oxygen. Heat treatment is done at protective atmosphere like hydrogen, vacuum.

ii)Improving the powder softness:Aim is to reduce the work hardening effect of powders that has be crushed to obtain fine powders; while many powders are made by milling, crushing or grinding of bulk materials. Powder particles are annealed under reducing atmosphere like hydrogen. The annealing temperature is kept low to avoid fusion of the particles.

iii)Modification of powder characteristics: The apparent density of the powders can be modified to a higher or lower value by changing the temperature of treatment.

Toxicity Of Powders

- Toxicity leads to undesirable health effects like eye, skin irritation, vomiting, respiratory problems, blood poisoning etc.
- powder like lead, nickel are highly toxic & Al, iron are less toxic
- Precautions: Use of protective gloves, respiratory masks, protective clothing etc.; use of well ventilated storage, workplace; careful handling, disposal of wastes
- flammability & reactivity data is required
- Health effects: Inhalation –disturbs the respiratory track; remedial measures include moving the person to fresh air. Artificial breathing is requiredif patient not breathing properly.

Skin, eyes –Brushing, washing skin and eyes with water and soap. Clean eyeswith fresh water for 15mts.

Compaction of Metal Powders

•Compaction is an important step in powder processing as it enables the forming of loose metalpowders into required shapes with sufficient strength to withstand till sintering is completed.

•In general, compaction is done without the application of heat.Loose powders are converted intorequired shape with sufficient strength to withstand ejection from the tools and subsequent sintering process. IN cases like cemented carbide, hot compaction is done followed by sintering.

One can not call this as compaction strictly, as sintering is also involved in this.

Powder Compaction MethodsPowder

compaction techniques can be classified as,

1. Methods without application of pressure–i) loose powder sintering in mould, ii) vibratory compaction, iii) slip casting, iv) slurry casting, v) injection moulding
2. Methods with applied pressure–i) cold die compaction (single action pressing, double action pressing, floating die pressing), ii) isostaticpressing, iii) powder rolling, iv) powder extrusion, v)explosive compaction

Pressurelesscompaction techniques

-Used for the production of simple and low density parts such as filters, other parts that are porousin nature; these techniques involve no external force and depend upon gravity for powder packing

I) Loose powder sintering:-Also known as loose powder shaping, gravity sintering, pressurelesssintering. In this method, the metal powder is vibrated mechanically into the mould, which is the negative impression of the product and heated to sintering temperature.This is the simplest method and involve low cost equipment. Themain reasons for not using this method for part production are, difficulty of part removal from the mould after sintering, & considerable shrinkage during sintering.

-Applications:Amount of porosity ranges from 40 vol% to as high as 90 vol%; Highly porous filtermaterials made of bronze, stainless steel, and monel, porous nickel membrane for use as electrodes in alkaline storage batteries andfuel cells are typical examples.

II) Slip casting:-Used for compacting metal and ceramic powders to make large & complex shapes for limited production runs

-A slip is a suspensionof metal or ceramic powder (finer than 5 μm) in water or other soluble liquidwhich is pored into a mould, dried and further sintered.

-Slip is usually made of, 1) a dispersion agentto stabilize the powder against colloidal forces, 2) a solventto control the slip viscosity and facilitate casting, 3) a binderfor giving green strength to thecast shape, 4) plasticizerto modify the properties of the binder

-For successful slip casting, formation of appropriate and a consistent slip is important. This is achieved by proper control of particle size, size distribution, order of component addition, their mixing time, addition of proper deflocculant-to prevent the settling and aggregation of powdersand maintains the desirable viscosity of the slip.

-Mostly water is used as suspending medium, but absolute alcoholor other organic liquids may also be employed. Additives like alginates –ammonium and sodium salts of alginic acids, serve three foldfunctions of deflocculant, suspension agent & binding agent to improve green strength of the compact.

-The slip to be cast is obtained in a form of suspension of powder in a suspending medium. The slipshould have low viscosity & low rate of setting so thatit can be readily poured. The slip cast should be readily removable from the mould. Low shrinkage and high strength after drying is expected.

-To obtain these properties, 5 μm powder particles should be used. In the case of fine molybdenumpowders, a slip can be prepared by suspending the powder in 5% aqueous polyvinyl alcohol with a minimum viscosity, at a pH value of 7.

• For coarser, spherical stainless steel powder, a mixer of 80.7%metal powder, 19% water, 0.3% of sodium alginate as deflocculanthaving a pH value of 10 can be used.

•Steps in slip casting:i) Preparing assembled plaster mould, ii) filling the mould, iii) absorption ofwater from the slip into the porous mould, iv) removal of part from the mould, v) trimming of finished parts from the mould

•Sometimes mould release agents like oil, graphite can be used.

•Hollow and multiple parts can be produced

• Advantages of slip casting:Products that can not be produced by pressing operation can be made, no expensive equipment is required, works best with finest powder particles

• Disadvantage:slow process, limited commercial applications

• Applications:tubes, boats, crucibles, cones, turbine blades, rocket guidancefins; Also products with excellent surface finish like basins, water closets.

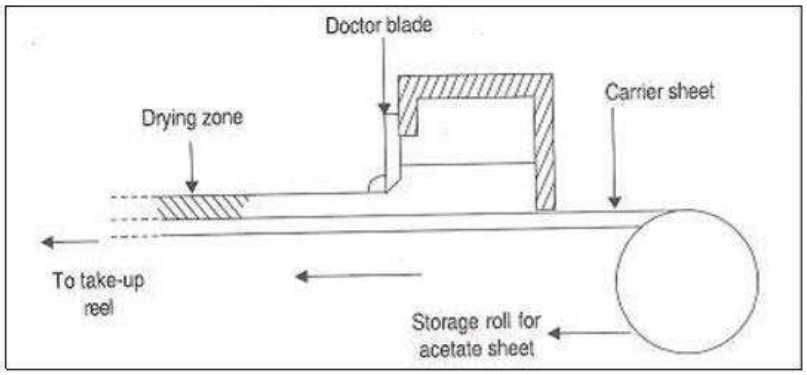
III) Slurry casting: This process is similar to slip casting except that a slurry of metal powders withsuitable liquids, various additives, and binders is poured into a mould and dried. The solvent is removed either by absorption into the POP or by evaporation. Very high porous sheet for use aselectrodes in fuel cells and nickelcadmium rechargeable batteries are produced by this method.

IV) Tape casting (doctor blade casting):-This is a variation of slurry casting process and is used toproduce thin flat sheets.

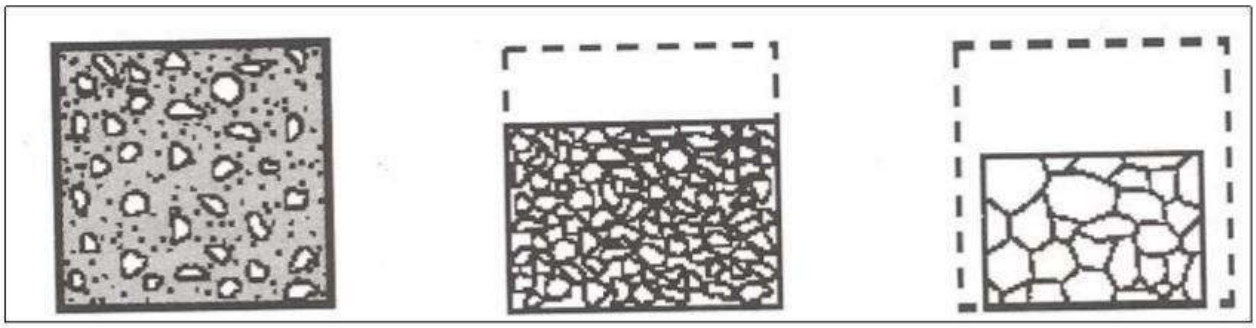
-This process involves preparing a dispersion of metal or ceramicpowder in a suitable solvent with the addition of dispersion agent (to improve the dispersion of the particles). Then a binder is addedand fed to a reservoir. Whole mixture is fed on to a moving carrier film from the bottom of the reservoir.

-This slurry layer is deposited on the film by the shearing action of a blade. The slurry should be freeof air bubbles, otherwise result in porosity. During sintering, the binder is burnt off first and densification of material occurs.

-In present days, endless stainless steel belt is used instead of carrier tape. This process can be usedfor making very thin tapes between 50 to 1000 μm thickness. This method is used for making electronic substrates, dielectrics for capacitors and piezoelectric actuators.



Schematic of tape casting



Slip Green tape Sintered tape

Stages in tape casting

V) Vibratory compaction:-

Vibratory compaction uses vibration energy to compact the powder mass. During this process, smaller voids can be filled with particles of still smaller size and this sequence is carried out till a high packing density of powder is achieved even before consolidation. Mechanical vibration facilitates the formation of nearly closed packed powder by settling particles in the voids present in the powder agglomerate. During vibration, small pneumatic pressure is usually superimposed on the powder mass.

-Brittle powders can be compacted by this method as they developcrack if done by pressure compaction

-This method is generally used when, 1) powders have irregular shape, 2) use of plasticizers for forming is not desirable, 3) sintered density is required to be very close theoretical density

-Important variables in vibratory compaction:

1. inertia of system:larger the system, more the energy required for packing
2. friction force between particles:more friction results in need of more KE for compaction
3. particle size distribution:more frequency required if more large particles are present. Vibration cycle is important and not period of vibration.

Pressure compaction techniques

•These techniques involve application of external pressure to compact the loose powder particles; Pressure applied can be unidirectional, bidirectional or hydrostatic in nature.

: Die compaction:

In this process, loose powder is shaped in a die using a mechanical or hydraulic press giving rise to densification. The mechanisms of densification depend on the material and structural characteristics of powder particles.

•Unidirectional and bidirectional compaction involves same number of stages and are described in this figure. They are, i) charging the powder mix, ii) applying load using a punch (uni-) or double punch (bi-) to compact powders, iii) removal of

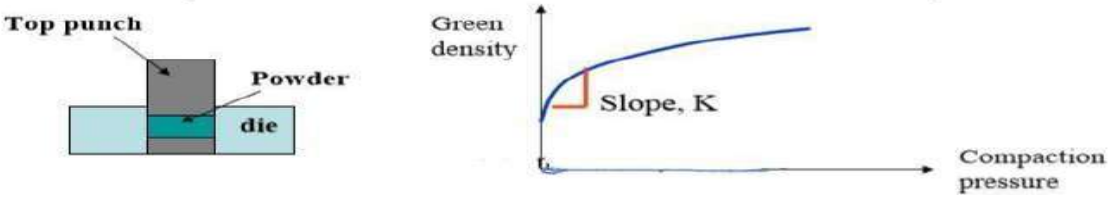
loadby retracting the punch, iv) ejection of green compact. The table gives compaction pressure ranges for metals and ceramics.

Effect of powder characteristics

For a good compaction, 1) irregular shaped particles are preferred as they give better interlocking and hence high green strength, 2) apparent density of powders decides the die fill during compaction. Hence powder size, shape & density affect the apparent density, 3) flow rate affects the die fill time, and once again powder size, shape & density affect the flow rate.

Powder behavior during compaction

- Compaction involves, 1) flow of powder particles past one another interacting with each other and with die-punch, 2) deformation of particles. In the case of homogeneous compaction, two stages are observed. **First stage** => rapid densification occurs when pressure is applied due to particle movement and rearrangement resulting in improved packing; **Second stage** => increase in applied pressure leads to elastic and plastic deformation resulting in locking and cold welding of particles. In the second stage, large increments in pressures are seen to effect a small increase in density.



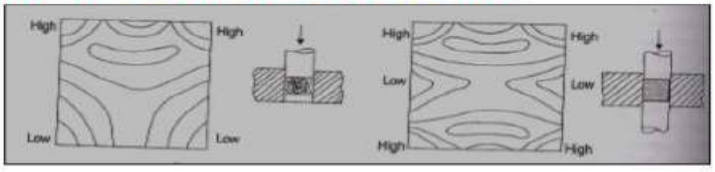
- The green compact produced can be considered as a two-phase aggregate consisting of powder particles and porosity each having own shape and size.

- Compaction can be done at low and high temperatures. Room temperature compaction employs pressures in the range of 100-700 MPa and produce density in the range of 60-90% of the theoretical density. At higher temperatures, pressures are kept low within the limits for preventing die damage.

- In **single die compaction**, powders close to the punch and die walls experience much better force than in center. This results in green density variation across the sample length. Longer the sample more the density difference. This non-uniformity can result in non-uniformity in properties of sintered part.

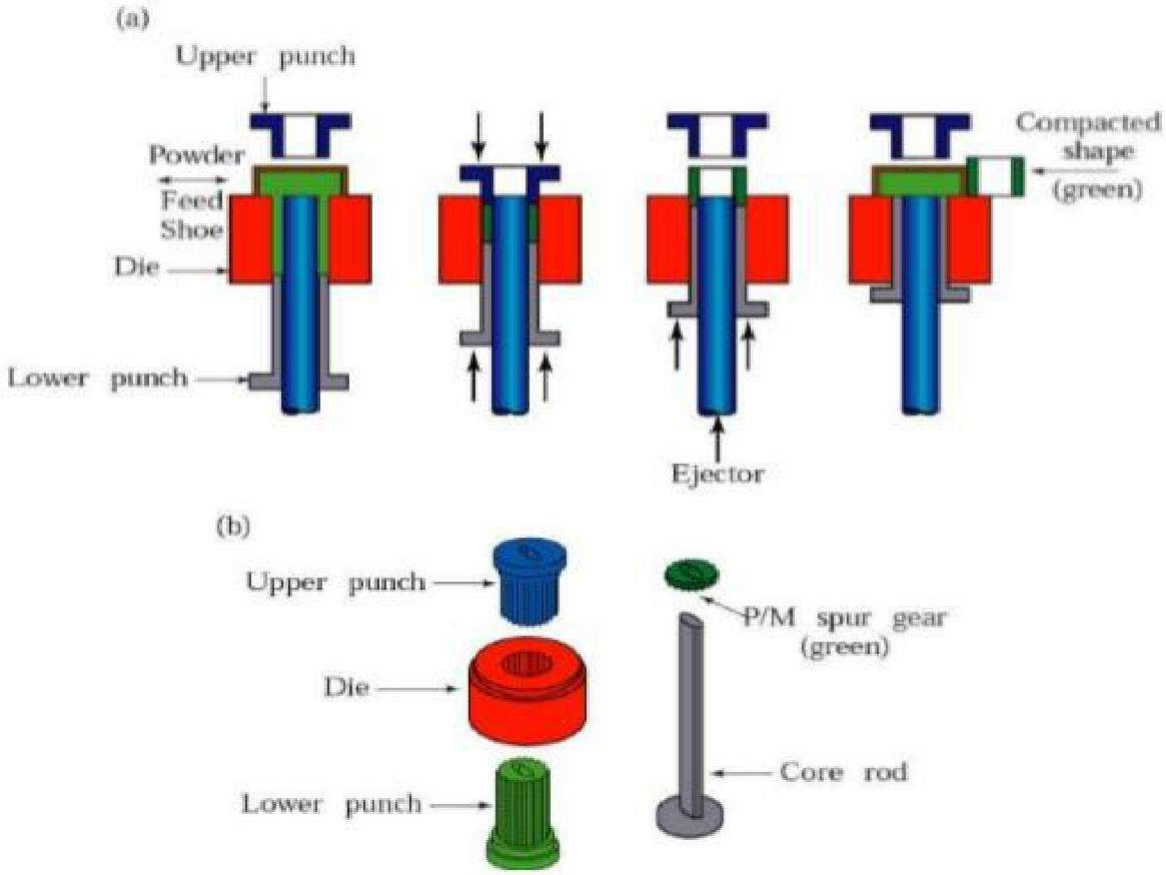
- This density variation and hence final property variation can be greatly reduced by having **double ended die compaction**. In this case, powder experiences more uniform pressure from both top and bottom, resulting in minimization of density variation. But this variation will still be considerable if the components have high aspect ratio (length to diameter ratio). This means that long rods and tubes cannot be produced by die compaction. In this case, isostatic pressing can be used.

Single ended compaction



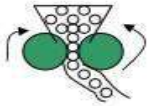
Double ended compaction

Schematic of powder compaction



Powder rolling

This process involves feeding of powders between rolls to produce a coherent and brittle green strip. This green strip is then sintered & re-rolled to obtain a dense, finished product.

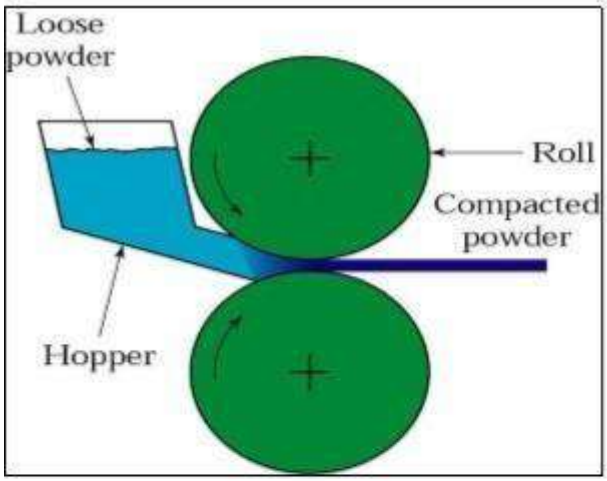


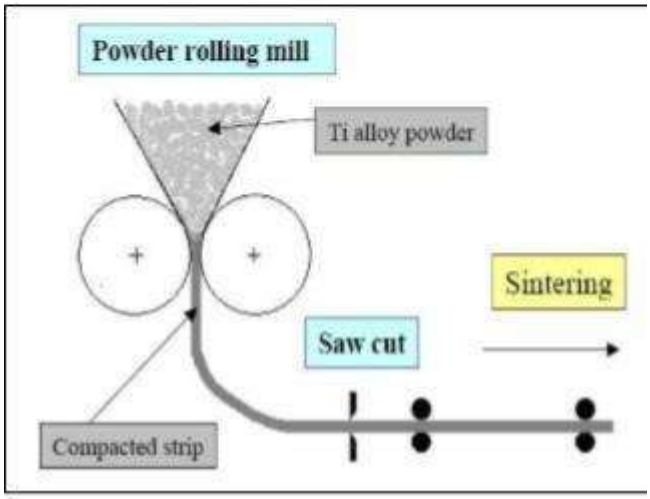
Steps: 1) preparation of green strip, 2) sintering, 3) densification of sintered strip, 4) final cold rolling and annealing

Parameters affecting powder rolling are roll gap, roll diameter, roll speed, powder characteristics; **Roll gap** => large roll gap leads to decrease in green density; very small roll gap leads to edge cracking; **roll diameter** => increase in density and strength with increase in roll dia. for a given strip thickness; **roll speed** => Kept low, 0.3-0.5 m/s; **Powder** => irregular powder with rough surfaces provide better strip density

In densification stage, either **repeated cold rolling followed by annealing** or **hot rolling of strip** can be followed

Applications: nickel strips for coinage, nickel-iron strips for controlled expansion properties, Cu-Ni-Sn alloys for electronic applications, porous nickel strip for alkaline batteries and fuel cell applications.





Hot isostatic pressing

- Ideal method for consolidation of powders of nickel and cobalt base super alloys, tool steels, maraging steels, titanium alloys, refractory metal powders, cermets. It has got variety of applications including bonding of dissimilar materials, consolidation of plasma coatings, processing hard and soft magnetic materials etc.

- HIP is the application of pressure at elevated temperatures to obtain net or near net shape parts from metal, ceramic, cermet powders.

- HIP unit consists of a pressure vessel, high temperature furnace, pressurizing system, controls and auxiliary systems (material handling, vacuum pumps, metering pumps).

- The pressure vessel is made of low alloy steel. Its function is to heat the powders while applying uniform gas pressure on all the sides. Furnaces are of radiation or convection type heating furnaces with graphite or molybdenum heating elements. Nichrome is also used. The furnace heats the powder part, while pressurizing medium (a gas) is used to apply a high pressure during the process. Generally, argon, nitrogen, helium or even air is used as pressurizing medium.

- The pressurizing gas, usually argon, is let into the vessel and then a compressor is used to increase the pressure to the desired level. The furnace is then started and both temperature and pressure are increased to a required value.

-HIP presses are available in diameters up to 2m with pressures ranges from 40 to 300 MPawith temperature range from 500to 2200 °C. The processing time can last up to 4 hours depending on the material and size of the part.
-during HIP, the pores are closed by flow of matter by diffusionand creep, but also bonded across the interface to form a continuous material.

-Commonly used heating elements:Kanthalheating element –up to 1200 °C; Molybdenum heating element –1200 to 1700 °C; Graphite heating element –2000 to 2600 °C

Sintering

• It is the process of consolidating either loose aggregate of powder or a green compact of the desired composition under controlled conditions of temperature and time.

• Types of sintering: a) solid state sintering – This is the commonly occurring consolidation of metal and alloy powders. In this, densification occurs mainly because of atomic diffusion in solid state.

b) Liquid phase sintering – The densification in improved by employing a small amount of liquid phase (1-10% vol). The liquid phase existing within the powders at the sintering temperature has some solubility for the solid. Sufficient amount of liquid is formed between the solid particles of the compact sample. During sintering, the liquid phase crystallizes at the grain boundaries binding the grains. During this stage, there is a rapid rearrangement of solid particles leading to density increase. In later stage, solid phase sintering occurs resulting in grain coarsening and densification rate slows down. Used for sintering of systems like tungsten-copper and copper-tin. Also covalent compounds like silicon nitride, silicon carbide can be made, that are difficult to sinter.

c) Activated sintering – IN this, an alloying element called 'doping' is added in small amount improves the densification by as much as 100 times than undoped compact samples. Example is the doping of nickel in tungsten compacts

d) Reaction sintering – IN this process, high temperature materials resulting from chemical reaction between the individual constituents, giving very good bonding. Reaction sintering occurs when two or more components reacts chemically during sintering to create final part. A typical example is the reaction between alumina and titania to form aluminium titanate at 1553 K which then sinters to form a densified product.

Other than mentioned above, rate controlled sintering, microwave sintering, gas plasma sintering, spark plasma sintering are also developed and practiced.

Sintering theory

- Sintering may involve, 1) single component system – here self-diffusion is the major material transport mechanism and the driving force resulting from a chemical potential gradient due to surface tension and capillary forces between particles, 2) multi-component system (involve more than one phase) – inter-diffusion occurs with the concentration gradient being the major driving force for sintering in addition to self-diffusion caused by surface tension and capillary forces. IN this sintering, liquid phase formation and solid solution formation also occurs with densification.

- First theory was proposed by Sauerwald in 1922. This theory says that two stages are involved in sintering namely *adhesion* and *recrystallisation*. Adhesion occurs during heating due to atomic attraction and recrystallisation occurs at recrystallisation temperature (above 0.5 T_m).

Solid state sintering process

Condition for sintering: 1) densification occurs during sintering and solid state sintering is carried out at temperatures where material transport due to diffusion is appreciable. Surface diffusion is not sufficient, atomic diffusion is required.

2) This occurs by replacing high energy solid-vapour interfaces (with free energy γ_{SV}) with the low energy solid-solid interface (particle-particle) of free energy γ_{SS}. This reduction in surface energy causes densification.

3) Initially free energy of solid-solid interface must be lower than free energy of solid-vapour interface. The process of sintering will stop if the overall change in free energy of the system (dE) becomes zero, i.e., $dE = \gamma_{SS}\, dA_{SS} + \gamma_{SV}\, dA_{SV} \leq 0$

Where dA_{SS} & dA_{SV} are the interfacial area of solid-solid and solid-vapour interfaces.

4) Initially, the surface area of compact represent the free surface area, since no grain boundaries have developed and hence $A_{SV} = A_{SV0}$ & $A_{SS} = 0$. As sintering proceeds, A_{SV} decreases and A_{SS} increases. The sintering process will stop when $dE = 0$,

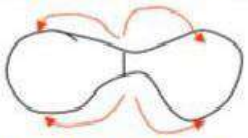
i.e., $\gamma_{SS}\, dA_{SS} + \gamma_{SV}\, dA_{SV} = 0 \Rightarrow \gamma_{SS}/\gamma_{SV} = -\, dA_{SV}/dA_{SS}$

5) Densification stops when $-\, dA_{SV}/dA_{SS}$ is close to zero. To achieve densification without grain growth, the solid-solid interface must be maximized.

Mechanism in solid state sintering

As discussed earlier, material or atom transport forms the basic mechanism for sintering process. A number of mechanisms have been proposed for sintering operation. These are,

1. Evaporation condensation, 2. diffusion (can be volume diffusion, grain boundary diffusion, surface diffusion), 3. viscous flow, 4. plastic flow



1. Evaporation and condensation mechanism

The basic principle of the mechanism is that the equilibrium vapor pressure over a concave surface (like neck) is lower compared to a convex surface (like particle surface). This creates the vapor pressure gradient between the neck region and particle surface. Hence mass transport occurs because of vapor pressure gradient from neck (concave surface) to particle surface (convex surface). The driving force of this is based on Gibbs-Thomson equation, $\mu - \mu_0 = RT \ln(p/p_0) = (-\gamma)(\Omega)/r$ where μ and μ_0 are chemical potentials of initial and final surfaces, R is universal gas constant, T is temperature in K, p and p_0 are partial pressures over the curved and flat surface respectively, γ is the surface free energy, Ω is the atomic volume

Driving force for sintering

•The main driving force is excess surface free energy in solid state sintering. The surface energy can be reduced by transporting material from different areas by various material transport mechanisms so as to eliminate pores.

•material transport during solid state sintering occurs mainly by surface transport, grain boundary transportation. This surface

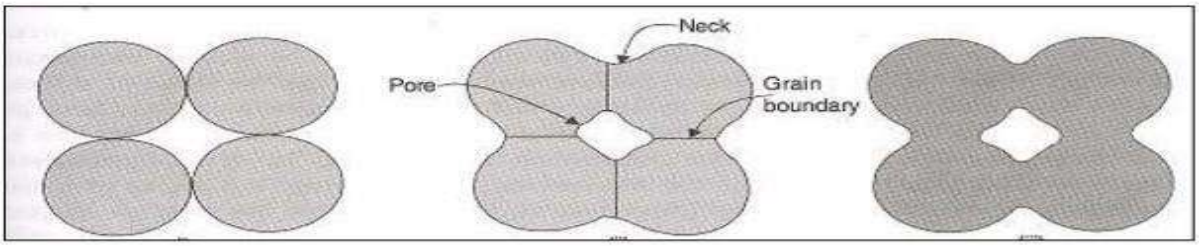
transport can be through adhesion, surface diffusion. Many models available to describe sintering process –like viscous flow, plastic flow, grain boundary and volume diffusion models. These models will be briefly described here.

Stages in solid state sintering

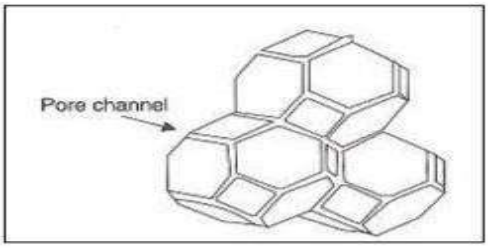
• In general, solid state sintering can be divided into three stages – 1st stage: *Necks are formed at the contact points between the particles*, which continue to grow. During this rapid neck growth takes place. Also the pores are interconnected and the pore shapes are irregular.

• 2nd stage: In this stage, with sufficient neck growth, the pore channels become more cylindrical in nature. The curvature gradient is high for small neck size leading to faster sintering. With sufficient time at the sintering temperature, the pore eventually becomes rounded. As the neck grows, the curvature gradient decreases and sintering also decreases. This means there is no change in pore volume but with change in pore shape => pores may become spherical and isolated. *With continued sintering, a network of pores and a skeleton of solid particle is formed*. The pores continue to form a connected phase throughout the compact.

• 3rd or final stage: In this stage, *pore channel closure occurs and the pores become isolated and no longer interconnected*. Porosity does not change and small pores remain even after long sintering times.



Particles in contact | Formation of necks, grain boundaries, pores | Final sintered geometry



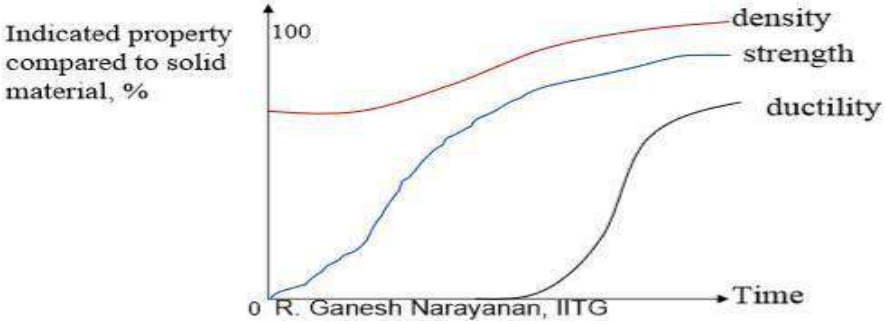
Pore channel formation

Property changes during sintering

• Densification is proportional to the shrinkage or the amount of pores removed in the case of single component system

• IN multicomponent system, expansion rather than shrinkage will result in densification and hence densification can not be treated as equal to the amount of porosity removed.

• densification results in mechanical property change like hardness, strength, toughness, physical properties like electrical, thermal conductivity, magnetic properties etc. Also change in composition is expected due to the formation of solid solution.



Mechanism during liquid phase sintering

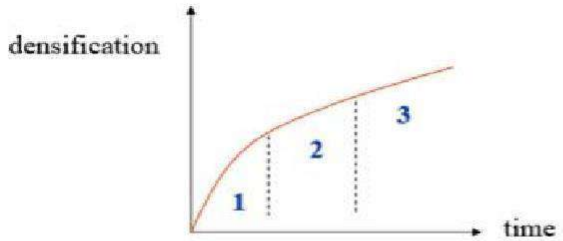
In the sintering of multi-component systems, the material transport mechanisms involve self diffusion and interdiffusion of components to one another through vacancy movement. **Sintering of such systems may also involve liquid phase formation, if the powder aggregate consists of a low melting component whose melting point is below the sintering temperature**

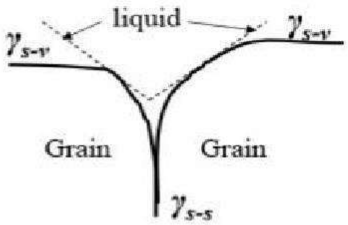
Liquid phase sintering: In this, the liquid phase formed during sintering aids in densification of the compacts. **Liquid phase sintering employs a small amount of a second constituent having relatively low melting point. This liquid phase helps to bind the solid particles together and also aids in densification of the compact.** This process is widely used for ceramics – porcelain, refractories.

Three main considerations are necessary for this process to occurs, 1. presence of appreciable amount of liquid phase, 2. appreciable solubility of solid in liquid, 3. complete wetting of the solid by liquid.

Three main stages are observed in liquid phase sintering, 1. initial particle rearrangement occurs once the liquid phase is formed. The solid particles flow under the influence of surface tension forces, 2. solution & reprecipitation process: in this stage, smaller particles dissolve from areas where they are in contact. This causes the particle centers to come closer causing densification. The dissolved material is carried away from the contact area and reprecipitate on larger particles, 3. solid state sintering

This form of liquid phase sintering has been used for W-Ni-Fe, W-Mo-Ni-Fe, W-Cu systems. The three stage densification is schematically shown in figure.





IN solid phase sintering, the solid particles are coated by the liquid in the initial stage. In liquid phase sintering, the grains are separated by a liquid film. The dihedral angle (θ) is important. For the figure shown here, the surface energy for the solid-liquid-vapour system is, $\theta = \gamma_{s\text{-}s}/2\gamma_{l\text{-}s}$ where $\gamma_{s\text{-}s}$ & $\gamma_{l\text{-}s}$ are the interfacial energies between two solid particles and liquid-solid interfaces respectively.

For complete wetting θ should be zero. This means that two liquid-solid interface can be maintained at low energy than a single solid-solid interface. This pressure gradient will make the particles to come closer. If θ is positive, grain boundaries may appear between the particles and an aggregate of two or more grains will be established.

Sintering atmosphere

Functions of sintering atmosphere: 1. preventing undesirable reactions during sintering, 2. facilitate reduction of surface oxides, 3. facilitating the addition of other sintering and alloying elements which enhance the sintering rate and promote densification, 4. aiding the removal of lubricants, 5. composition control and adjusting the impurity levels.

Eg. for sintering atmosphere: pure hydrogen, ammonia, reformed hydrocarbon gases, inert gases, vacuum, nitrogen based mixtures without carburizing addition, nitrogen based mixtures with carburizing addition

Type of transport	Material transport mechanism	Driving force
Vapour phase	Evaporation-condensation	Vapour pressure gradient between convex and concave regions
Sold state	Diffusion – surface diffusion Grain boundary diffusion, volume diffusion, viscous flow, plastic flow	Chemical potential Chemical potential Chemical potential
Liquid phase	Viscous flow	Surface tension

Selected Application Of Powder Metallurgy

P/M porous filters: porous filters made by P/M route can be classified into four types based on their applications like filtration, flow control, distribution, porosity. Filtration is the separation process involving the removal of gas, liquid or solid from another gas or liquid. Flow control involves regulation of fluid flow in a system with controlled pressure drop. Distribution involves providing a uniform flow over a wide area.

Production of porous metal filters: Typical filter shapes that can be produced from the powder include discs, cups, bushings, sheets, tubes. The major advantages of porous filters include high temperature resistance, good mechanical strength, corrosion, long service life.

Made by Gravity sintering:-Bronze filters are produced by this method. This sintering, as discussed earlier, involves pouring of graded powders in to a mould prior to sintering operation. Then sintering is performed and metallurgical bonding is achieved by diffusion.

-Bronze filters are made by gravity sintering using either atomized spherical bronze powder or from spherical Cu powder

coated with Snlayer. The powders are sintered in graphite or stainless steel moulds at temperatures near thesolidus temperature of the bronze composition. Porosities of the range 40 to 50 % can be formed

-Porous nickel filtersare made in the same fashion. Hollow, cylindrical stainless steel filterswith thin wall thickness can be fabricated by cold extrusion ofthe plasticized mixture. These products are available in corrosion resistant alloys like stainlesssteel, Ti, Ni, and nickel base alloys. Desired porosity is obtained by using specific particles size and shape. Compaction and sintering is performed under controlled atmosphere to obtain good green compact part.

Made by powder rolling: porous strips of Ni, Ti, Cu, bronze and Ti alloys are prepared by powder rolling. Strips having thicknessfrom 0.25 to 3 mm and length of several meters can be successfully made by this technique.

Made by die compaction & sintering: porous filter parts can also be made by die compaction, but with only low compaction pressures. Once achieving the green compact, the parts are heated to the desired temperature under protective atmosphereto promote bonding between atoms. Porous parts from bronze, nickel, stainless steel, titanium powders can be produced by this method.

Made by powder spraying: spraying of metal powders on a substrate under controlled conditions can be used to produce porous material.

PRESS WORK

INTRODUCTION

Metal forming is one of the manufacturing processes which are almost chipless. These operations are mainly carried out by the help of presses and press tools. These operationsinclude deformation of metal work pieces to the desired size and size by applying pressure or force. Presses and press tools facilitate mass production work. These are considered fastest and most efficient way to form a sheet metal into finished products.

Objectives

After studying this unit, you should be able to understand

- introduction of press tool,
- major components of press working system,
- different criteria of classification of presses,
- different types of presses,
- description of important parts of a press,
- specifications of a press,
- other press working tools, like punch and die,
- components of press working system,
- different types of die sets, and
- design considerations for die set design.

PRESS

A press is a sheet metal working tool with a stationary bed and a powered ram can be driven towards the bed or away from the bed to apply force or required pressure for various metal forming operations. A line diagram of a typical pres is explained in the Figure 2.1 hydraulic system. The relative positions of bed and ram in the press are decided by the structure of its frame. The punch is generally gripped into the punch

holder and punch holder is attached to ram. A balster steel plate is attached to the the press and die is mounted on the balster steel plate.

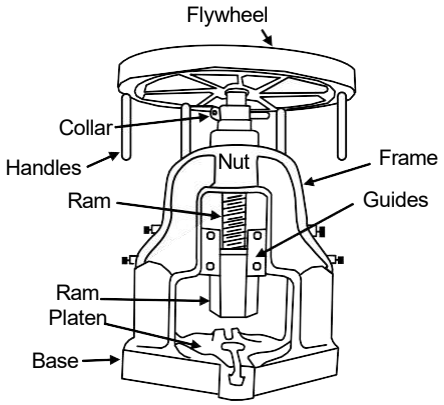


Figure 3.1 : Line Diagram of a Typical Press

Presses are available in a variety of capacities, power systems and frame type. Meaning of capacity of press is its capability to apply the required force to complete the operation.

Power and Drive System

Power systems on presses are either hydraulic presses use a large piston and cylinder to drive the ram. This system is capable to provide longer ram strokes than mechanical dries. It gives a consistent applied load. Its working is comparatively slower. These presses can be single action or double action or so on. Number of actions depends on the number of slides operating independently.

Mechanical presses are used several types of drive mechanisms. These drives includes eccentric, crankshaft, knuckle joint, etc. These drives are used to convertrotational motion given by a motor into linear motion of the ram. A fly wheel is generally used as reservoir of energy for forging operations. These presses are recommended for blanking and punching operations as the involved drives are capable to achieve very high forces at the end of their strokes.

Press working is used in large number of industries like automobile industry, aircraft industry, telecommunication electrical appliance, utensils making industryare major examples.

TYPES OF PRESSES

There are different criteria of classification of presses into different categories. These criteria, related classifications and their descriptions are discussed below.

According to the Power Source

These power source are categorized as :

Manually Operated or Power Driven

These presses are used to process thin sheet metal working operations where less pressure or force is required. These are operated by manual power. Most of manually operated presses are hand press, ball press or flypress.

Power Presses

Power presses are normally driven by mechanical mechanism or hydraulic system. Power source of these presses may be electric motor or engine.

According to the Type and Design of Frame

holder and punch holder is attached to ram. A balster steel plate is attached to the

The type and design of frame depending on the design of frame these are classified as inclinable, straight side, adjustable bed, gap frame, horning and open
end.

Its frame is called inclinable due to its capability to tilt back upto some angle. It can be locked into nay of its inclined position as shown in Figure 3.2. Its back is open to exit the scrap so it is also called open backinclinable press.

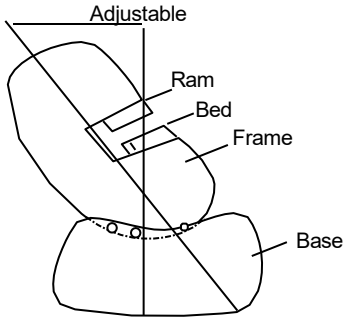
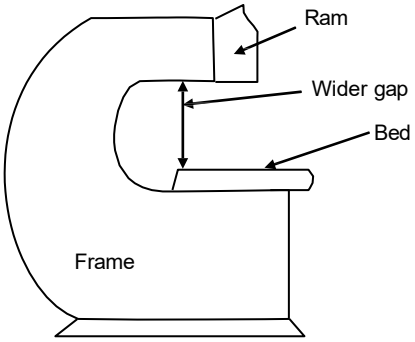


Figure 3.2 : Inclinable Frame Press

Gap Frame Press

These presses have larger frame openings, that means a wide gap between its base and ram to accommodate larger workpieces. It also has longer beds,as shown in Figure 3.3.



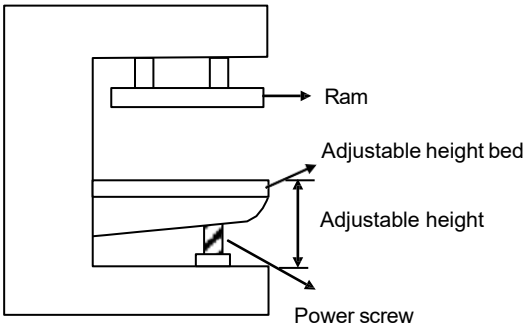
Line Diagram of a Gap Frame Press

Straight Side Press

These presses have straight side type frame which is preferred for presses having larger bed area and high tonnage. This offers greater rigidity and capable of longer strokes. The frame consists of vertical and straight sidesso it is called straight side press.

Adjustable Bed Type Press

It is also called column and knee type press because it has a knee type bed supported on its column shaped frame. Its bed (knee) can be adjusted at anydesirable height by moving it vertically up or down with the help of power screws. In this structure there is slight lack of rigidity as compared to other structures. It is shown in Figure 3.4.



Adjustable Bed Type Press

Open End Press

It has a solid type of vertical frame with all sides open. Driving mechanism is housed at the back and ram controlling mechanism at the front. It is easilyto accommodate workpiece and dies in this type of structure. Its is identifiedas light duty machine.

Horning Press

It consist of a vertical frame, top of which over hangs towards the front. Theover hanging portion serves for housing for driving mechanism and ram control. The frame consists of a front face as a work table called horn.

According to the Position of Frame

Presses can also be categorized by the position of frame as described below.

Inclinable Frame

Already described.

Vertical Frame

Vertical frame type of press is already been discussed, it cannot be adjustedlike inclinable frame. Gap, adjustable bed, straight side, open end and honing presses are the example of vertical frames.

Horizontal Frame

It has a fixed frame in horizontal position. It provides the facility of auto ejection of produced part and scrap due to gravity.

Inclined Frame

Like inclinable frame, inclined frame press has an inclined frame but fixed,it cannot be adjusted to any other angle.

According to the Actions

According to the number of actions it can be categorized as single action, double action or triple action press. Here number of actions is same as the number of ramson the press.

According to Mechanism Used to Transmit Power to Ram

Crank Press

It consists of crankshaft driven by a flywheel, rotary motion of the crankshaft is converted into reciprocating motion with the help of a connecting rod connected to ram.

Cam Driven Press

In this press, a cam is used to press the ram down words and suitably located springs restore the original position of ram when pressure applied isremoved. This mechanism has a limitation of size of the press.

Eccentric Press

In this press, the driving shaft carries an eccentric integral with it. One end of the connecting rod carried an attachment of revolving eccentric and its other end is connected to ram. As the eccentric shaft revolves, the offset between the eccentric centre and the centre of rotation of the shaft providesthe required movement.

Knuckle Press

This press is driven with the help of knuckle joint mechanism. The main advantage of this press is partial back thrust is transferred to crankshaft, its major portion is transferred to back crown which is capable to hear. This

enables the application of this press for heavier jobs with high blows. These presses are recommended for coining, squeezing, extrudingand embossing. They have a limitation of shorter stroke lengths.

Toggle Press

These presses work on toggle mechanism and used for double and triple action presses for driving the outer rams. However, crankshaft drive is usedfor the inner ram. These are used for large draw dies, in which this mechanism actuates the blank holder whereas the punch is operated by the crank driven inner ram.

Screw Press

This is known as power screw or percussion press. There is a vertical are like frame, its job forms a nut. There is a flywheel at the top of and engages the ram at its bottom. The flywheel is driven by a friction disc and the rotating screw lowers and raises the ram. The flywheel is accelerated by friction drive. Its total energy is expanded in striking the work, bringing it toa halt. The intensity of blow can be regulated by adjusting the height of the die. Higher the position of the die, lesser the speed of the flywheel and hence lower the intensity of blow. These presses have a limitation that the ram movement is slow so these are recommended for sheet metal work only.

Hydraulic Press

These presses have a piller type construction or carry the hydraulic cylinderat the top of the crown. These presses provide longer stroke than mechanical presses with adjustable intensity of blow. Their stroke length can also be adjusted with full tonnage. These are recommended for deep drawing, extruding and plastic moulding.

Rack and Pinion Press

Rack and pinion driven presses are called rack and pinion presses meant forlong strokes. Major advantage is faster operation of this press due to involvement of quick return motion. There are some limitations of this press. Load bearing capability of rack and pinion mechanism is very low sothese are light duty machines. Ram movement is slightly slower. These presses have very limited use now-a-days.

According to Number of Drive Gears

Number of drive gears means number of gears attached at the ends of crankshaft,used to drive it. Smaller presses have single drive and larger presses may be double drive crankshafts. Very large presses with longer beds, carry long crankshafts. They have risk of twisting. These crankshafts are provided with one driving gear at each ends, these presses are named as twine drive presses. If a press carries two crankshafts each having a twin drive, such presses are called quadruple drive presses.

According to Number of Crankshaft in a Press

According to the number of crankshafts used in a press, these are directly classified as single crank (having one crankshaft) double crank (having two crankshafts).

Method of transmission of power from Motor to Crankshaft

The method used for transmission of power from motor to crankshaft categorizedpresses into following categories :

Direct Drive Press

enables the application of this press for heavier jobs with high
In this case, power is directly transferred through gears pair. Smaller gear ismounted on the motor shaft, called pinion, its mating gear which is larger,
mounted on the crankshaft. The larger gear also acts as flywheel. The

flywheel is attached to the crankshaft through clutch and equipped with facility of disengaging it as per the need. Such presses have shorter strokesand these are light duty presses.

Flywheel Driven Presses

These presses consists no gears so also called “No geared presses”. For thetransmission of power motor pulley is connected to flywheel driven crankshaft by Vee belt and pulley system. A clutch is used to engage or disengage the flywheel with the crankshaft. These presses are light duty presses providing shorter and quicker strokes.

Single Geared Drive Presses

This press consists of a counter shaft between motor shaft and crankshaft. Flywheel is mounted on the countershaft. Power is transferred from motor to flywheel (countershaft) through „Vee“ belt drive and then from counter shaft to crankshaft through pinion and gear. Clutch is mounted between pinion and flywheel to disengaged the power transmission as per the requirements. In these presses there are two steps for rpm reduction and torque enhancement so these are heavy duty mechanics with longer strokes.

Double Geared Drive Presses

In these type of presses an additional shaft named as intermediate shaft is introduced between the countershaft mounted flywheel and the crankshaftof a single geared drive. Twin drive is possible in this case by having similar gear train on other sides of two shafts. This provides slow stroke with larger power.

According to the Purpose of Use

Some of the operations require low stroke strength and some lager stroke strength.In the same way requirements of stroke length is different for different operations.So depending on power and stroke length presses are classified as given below depending on their suitability of performing different operations.

(a) Shearing press
(b) Seaming press
(c) Straightening press
(d) Punching press
(e) Extruding press
(f) Caining press
(g) Forging press
(h) Rolling press
(i) Bending press.

MAIN PARTS OF A TYPICAL POWER PRESS

Different types of presses have almost common types of main parts. These parts are described below.

Base

The all machine tool, base is the one of the parts of a press. It is main supporting member for workpiece holding dies and different controlling mechanisms of press.Size of the table limits the size of workpiece that can be processed on a press. In case of some special presses the base carries mechanism for tilting the frame in any desirable inclined position too.

Frame

Frame constitute main body of the press located at one edge of its base. It housessupport for ram, driving mechanism and control mechanisms. Some of the press have column shaped frame.

Ram

This is main operating part of the press which works directly during processing ofa workpiece. Ram reciprocates to and fro within its guideways with prescribed stroke length and power. The stroke length and power transferred can be adjusted as per the requirements. Ram at its bottom end carries punch to process the workpiece.

Pitman

It is the part which connects the ram and crankshaft or ram eccentric.

Driving Mechanism

Different types of driving mechanisms are used in different types of presses like cylinder and piston arrangement in hydraulic press, crankshaft and eccentric mechanisms in mechanical press, etc. these mechanisms are used to drive ram bytransferring power from motor to ram.

Controlling Mechanisms

Controlling mechanisms are used to operate a press under predetermined controlled conditions. Normally two parameters are adjusted by controlling mechanisms length of stroke of ram and power of stroke. Transfer of power can bedisengaged with the help of clutch provided with driving mechanisms as per need. In most of the presses controlling mechanisms is in built with the driving mechanisms. Now-a-days compute controlled presses are being used in which controlling is guided by microprocessor. These presses provides reliable and accurate control with automation.

Flywheel

In most of the presses driven gear or driven pulley is made of the shape of flywheel, which is used for storing the energy reserve wire of energy) for maintaining constant speed of ram when punch is pressed against the workpiece. Flywheel is placed in the driving mechanism just before the clutch is sequence ofpower transmission.

Brakes

Brakes are very urgent in any mobile system. Generally two types of brakes are used normal brake, which can bring the driven shaft to rest quickly after disengaging it from flywheel. Other is emergency brakes which are provided as foot brake to any machine. These brakes include power off switch along with normal stronger braking to bring all motions to rest quickly.

Balster Plate

It is a thick plate attached to the bed or base of the press. It is used to clamp the die assembly rigidly to support the workpiece. The die used in press working mayhave more than one part that is why the phrase die assembly is being used at the place of die.

SPECIFICATIONS OF A PRESS

Expressing size of a machine (press) includes expressing each of the parameters pertaining to it quantitatively in appropriate units. Expressing size in the above mentioned way is the specifications of press. The following parameters are

expressed as
specifications of a press.

Frame

(a) **Maximum Force :** Maximum force that its ram can exert on the workpiece, this is expressed in tones and called tonnage. It varies from 5 to 4000 tonnesfor mechanical press. It may be up to 50,000 tonnes by hydraulic press.

(b) **Maximum Stroke Length :** Maximum distance traveled by the ram from its top most position to extreme down position. It is expressed in mm. the stroke length is adjustable so different values that can be obtained between minimum and maximum of stroke length, these are also the part of specifications.

(c) **Die Space :** Total (maximum) surface area, along with ($b \times d$), of bed, base, ram base. This the area in which die can be maintained.

(d) **Shut Height :** Total opening between the ram and base when ram is at its extreme down position. This is the minimum height of the processed workpiece.

(e) **Press Adjustments :** Different stroke lengths (already covered in point number 2). Different tonnage that can be set as per the requirement.

(f) **Ram Speed :** It is expressed as number of strokes per minute. Generally it can be 5 to 5000 strokes per minute.

PRESS TOOL

Commonly used tools which are major components of press working are punches and dies. Punch is an important part of the system which is fastened to the ram and forced into the die where workpiece to be processed is supported. Die is a work holding device,designed specifically for a particular design of a product. Die is rigidly held on the base of the press. Die carries an opening which ϕ is perfectly aligned with the punch and its movement. Both die and punch work together as a unit and this is called a die set. Punchand die both are made of high speed steel. Die is the part where strength and wear resistant both properties are required. So normally working surface of the die is made of satellite or cemented carbide. Details of the die set are described below.

Punch

Lower end of the ram holds punch holder which is equipped with the punch plate.Punch plate is generally made of stainless steel or HSS. The punch plate holds thepunch rigidly and accurately. Different ways of holding the punch are described below :

(a) Punch can be fastened by forcing it to punch plate, top end of the punch is flattened to fit in the countersunk recess as shown in Figure 3.5.

(b) Punch can be clamped to the punch plate by a set screw. The correct position of the punch is located by cutting a slot into the punch plate as shown in Figure 3.5.

(c) Shank of the punch is forced into the punch plate top end of the punch is made flat to fit into the countersunk recess as shown in Figure 3.5.

(d) Punch can be tightly secured to the punch plate with the help of grubs screws as shown in Figure 3.5.

(e) Set screws are used to fastened the punch to the punch plate as shown in Figure 3.5.

(f) Fastening of punch with the help of a set screw and it is located during fastening with the help of two dowel pins shown in Figure 3.5.

(g) Flange end of the punch is secured to the punch plate by set screws

(a) **Maximum Force :** Maximum force that its ram can exert on the workpiece, from the punch end as shown in Figure 3.5.

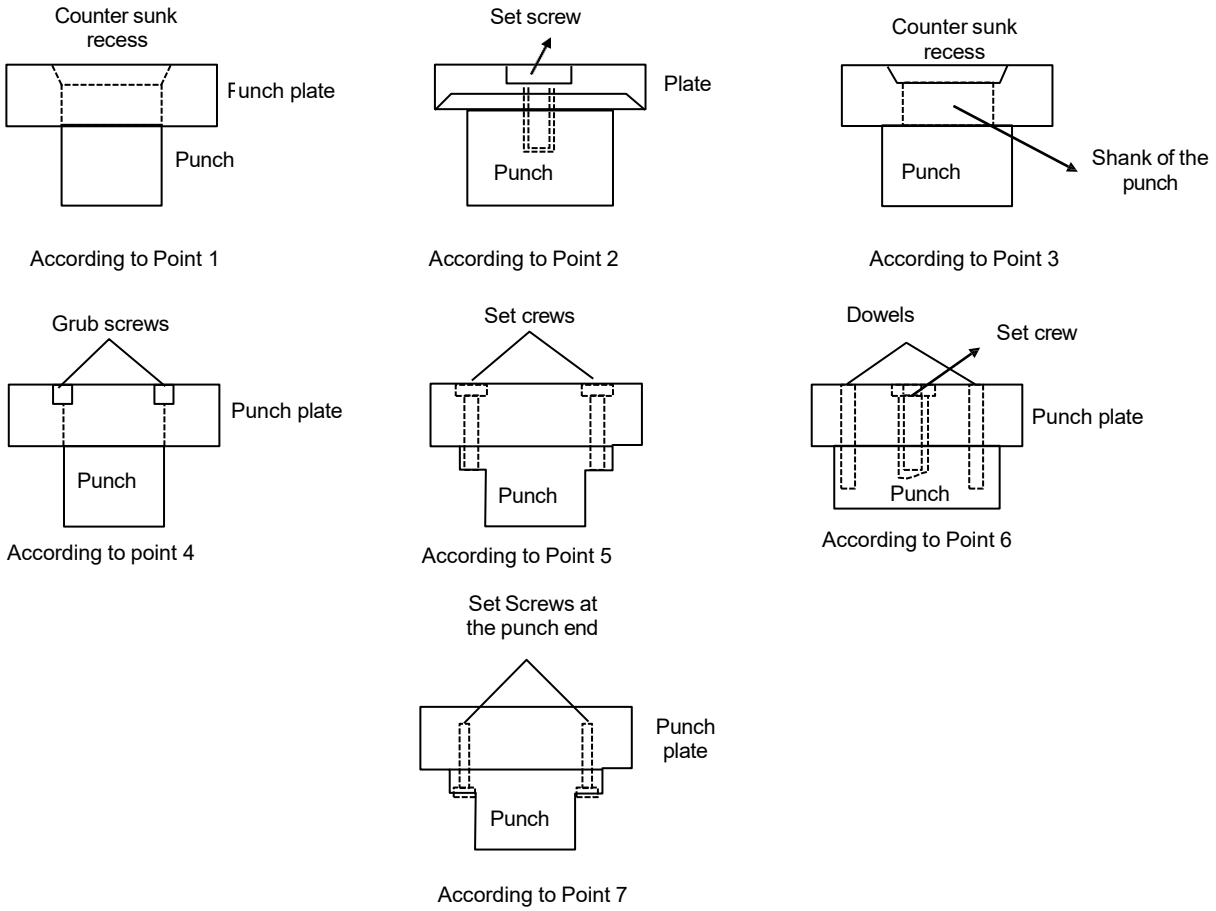


Figure 3.5 : Different Ways of Holding a Punch

DIE SET AND ITS DETAILS

The complete die set consists of a punch, die and some other accessories which are described in this section later. Perfect alignment of punch and die is most important for satisfactory working of punch. Accessories of die set provides the require alignment andrigidity to the system and improves accuracy of the system performance. These accessories are the finished parts, removal of waste. The die accessories are shown in Figure 3.6. These are described as below.

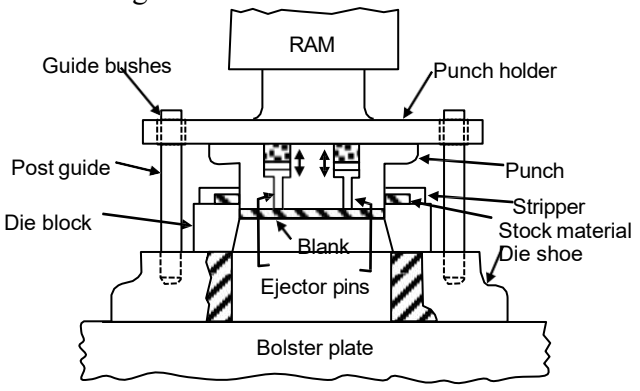


Figure 3.6 : Die Accessories

Punch Holder

It is also known by its other name upper shoe of die set. Punch holder is clampedto the ram of press. It holds the punch below it.

Punch

It is the main tool of die assembly which directly comes in contact of workpiece

during its processing, its detail have already been described.

Die Holder

It is also called die shoe. Its work as a support for the die block and it is rigidly fastened to the balster plate of the press.

Stops

Stops are used for maintaining correct spacing of the sheet metal when it is fed below the punch to maintain the quality of output. These restrict the feed of stock (workpiece) to a pre-determined length each time without doing any precise measurements. Normally two types of stops are used bottom stop and lever stop asdescribed below.

Bottom Top

Bottom stop is a tape of mechanical mechanism. This mechanism stops the movement of punch after end of each cut. A button is located in such a manner when fresh stock is fed to die, the button is pressed due to the impact of the fed stock, indicating feeding of true length of the stock. This way the mechanism alsoacts as a fixture. Pressing of button enables the system ready for next cutting action. The button stop is used in hand presses and in slow acting power presses.

Lever Stop

This mechanism operates with the help of a lever. After the completion of one cut,the stop mechanism stops the downwards movement of punch for next cut when fresh stock is fed it is stopped by a lever after feeding it up to certain length. The lever also enables the punch to move for cut.

Pilots

Pilot is used for correct location of blank when it is fed by mechanical means. Thepilot enters into the previously pierced hole and moves the blank to the correct position to be finally spaced by the stops. Normally pilots are fitted to the punch holders.

Strippers

Stripper is used to discard the workpiece out side the press after the completion ofcutting or forming operation. After the cutting when punch follows upward stroke the blank is stripped off from the punch cutting edge and prevents it from being lifted along with the punch. This action of prevention is performed by the stripper.

Knockouts

Knockout is also a type of stripper which is used generally in case of invarted dies.After the completion of cutting action, the blank is ejected by the knockout plate out of cutting edge.

Pressure Pads

Pressure pads are plates which grip the workpiece very tightly at the ends when it plastically flows between the punch and the die. This tight griping eliminates the chances of wrinkling in the process of metal forming. A spring loaded plunger acting on the bottom of workpiece plate also serve the same function. The pressurepads do a type of ironing on the sheet metal workpiece.

Guide Posts

Accurate alignment between die opening and punch movement is very important.Guide posts are used for correct alignment of punch and die shoe.

Punch Plate

Die Holder

Punch plate is also known as punch retainer. This is fixed to the punch holder. Punch plate serves as a guide way to hold the punch in right position and properlyaligned. This makes the replacement of punch quick and correct.

Backing plate is used to distribute pressure uniformly over the whole area (maintains uniform stress), it prevents the stress concentration on any portion of punch holder. This is generally made of hardened steel inserted between the punchand punch holder.

Die Retainer

The purpose of die retainer is same that is of punch plate and punch holder. Dieretainer is fixed to the bed (base) of the press to hold the die block in correct alignment with the movement of punch. In some specific cases die shoe itself works as a die retainer.

METHODS OF DIE SUPPORTING

Die is normally held in die holder which is clamped to the balster plate mounted on thetable or base of the press. Three different methods of securing die blocks to the die holder are discussed here.

Method 1

The die block is secured to the die holder by four set screws shown in Figure 3.7.Here only one screw is shown. The position of the die is correctly located by dowel pin.

Method 2

The die block is secured by the set screws at the bottom of the die holders shownin Figure 3.7.

Method 3

Die block is secured by an wedge which is clamped to the die holder by setscrews, shown in Figure 3.7.

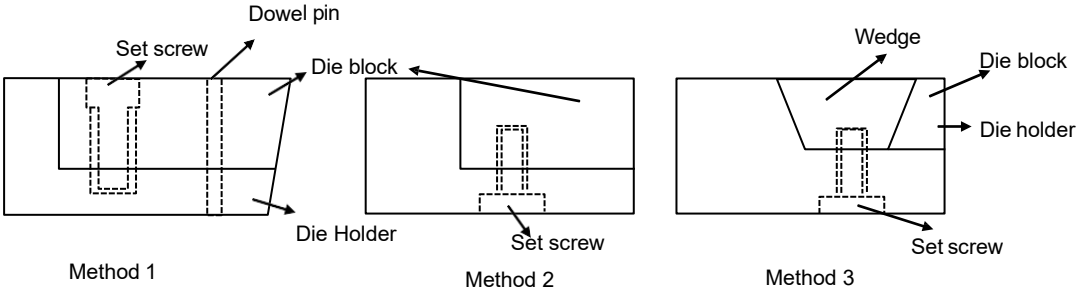


Figure 3.7 : Different Methods of Die Supporting

CLASSIFICATION OF DIES

There is a broader classification of single operation dies and multi-operation dies.

(a) Single operation dies are designed to perform only a single operation in each stroke of ram.

(b) Multi operation dies are designed to perform more than one operation in each stroke of ram.

Single operation dies are further classified as described below.

Cutting Dies

These dies are meant to cut sheet metal into blanks. The operation performed so is named as blanking operation. These dies and concerned punches are given specificangles to their edges. These are used for operation based on cutting of

metal by
shearing action.

These dies are used to change two shape of workpiece material by deformingaction. No cutting takes place in these dies. These dies are used to change theshape and size related configuration of metal blanks.

As there is a classification of single operation dies, multi-operation dies are can also be classified (further) as described below.

Compound Dies

In these dies two or more cutting actions (operations) can be executed in a single stroke of the ram.

Combination Dies

As indicated by their names these dies are meant to do combination of two or more operations simultaneously. This may be cutting action followed by formingoperation. All the operations are done in a single action of ram.

Progressing Dies

These dies are able to do progressive actions (operations) on the workpiece like one operation followed by another operation and so on. An operation is performedat one point and then workpiece is shifted to another working point in each stroke of ram.

Another classification of dies is also possible on the basis of specific operations that can be performed on them. This classification is described below.

Shearing Operations

These belong to the category of cutting dies. These are used for operations involving shearing action on the workpiece material like blanking, punching, perforating, notch making, slitting, etc.

Drawing Operations

All dies designed for flanging, embossing, bulging and cupping operations fall inthe category of drawing operation dies.

Bending Operations

Some of the dies designed for angle bending, curling, forming, folding, plunging,etc. operations fall in the category of dies based on bending operations.

Squeezing Operations

Another category of dies based on squeezing operations are capable to do operations like flattening, planishing, swaging, coining, sizing, extruding and pressing operations.

On the basis of construction, dies can be classified in the following ways :

Cut-off Die

The die designed for cutting off operation is called cut-off die. It provides a vertical surface along which punch slides to cut-off the workpiece by shearing action.

Drop through Die

As indicated by their names, these dies are made hollow where blank fall downafter being cut-off.

Return Type Die

In these dies a knockout plate is incorporated, by which the cut blank returns backto the position at which it was cut before it ejected

These are two different dies, simple dies are those dies, used for single exclusive operation in each stroke of ram. These dies have already been discussed in earlier section. In compound dies two or more operations can be done at a single workingpoint. Initial cost of such dies is more due their complicated design and difficult manufacturing. Their low operating cost makes these very economical as a single compound die is equivalent to two or three simple dies.

There is also reduction of cost of using of two or three presses because multiple operations are accomplished in a single press by a single operator.

Continental Dies

These are similar to other dies but the conceptual difference is, these are meant to do research and development work. These cannot do mass production as they maynot be very robust.

Sub-press Die

These are designed by incorporating two punch shoe in the die which is actuatedby springs to its starting position.

Follow Die

This is designed to do two operations, one followed by other operation. It is like a progressive die which have already been discussed earlier in this unit.

Transfer Die

It is also like a progressive die having more then one working points. It is different form progressive die as it has feeding fingers in the die which transfer the workpiece from one work station to other. In some cases feeding fingers are attached to press, then the press is called transfer press.

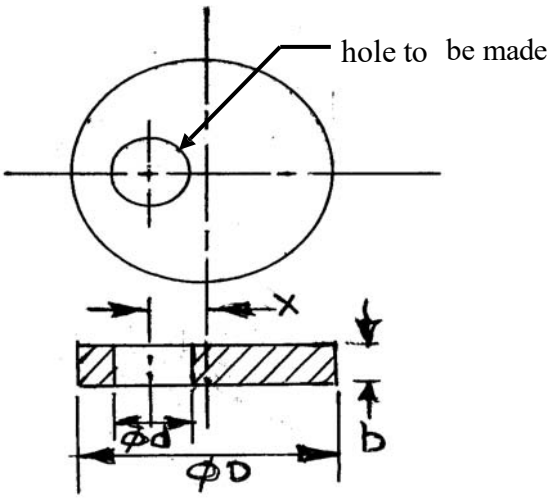
Shuttle Die

This is also a type of progressive die having bars in the die just below the workpiece position at each workstation. After the completion of one operation, liftto bear shifts the workpiece from one station to another.

Fixtures, being used in machine shop, are strong and rigid mechanical devices which enable easy, quick and consistently accurate locating, supporting and clamping, blanks against cutting tool(s) and result faster and accurate machining with consistent quality, functional ability and interchangeability.
Jig is a fixture with an additional feature of tool guidance.

(i) Purpose Of Using Fixtures And Jigs

For a machining work, like drilling a through hole of given diameter eccentrically in a premachined mild steel disk as shown in Fig. 8.1.1 in a



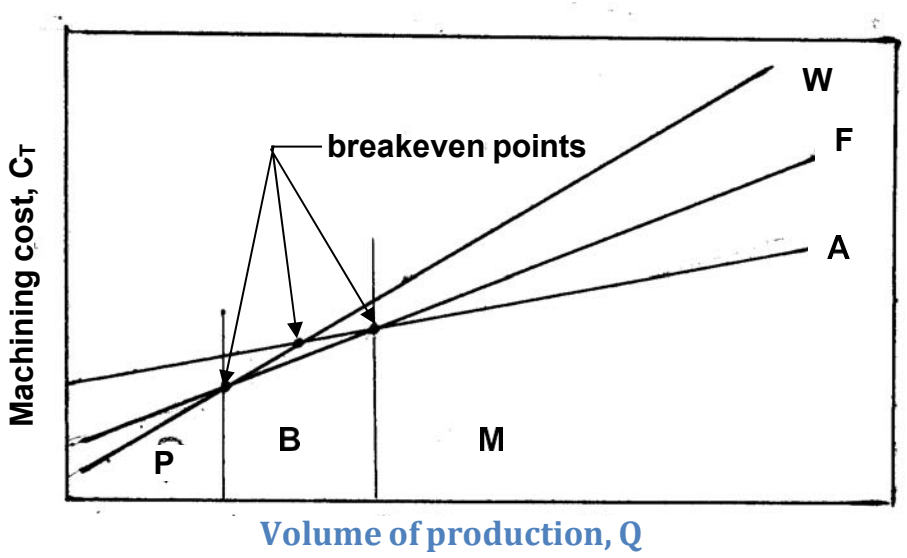
A through hole has to be drilled in a pre-machined mild steel disc.

conventional drilling machine without using any fixture or jig, the following elementary steps are to be sequentially followed

- cleaning and deburring the blank (disc)
- marking on the blank showing the location of the hole and its axison the blank
- punch the centre at the desired location and prick punch theperiphery of the hole to be made in the disc
- mount the blank in a drilling vice using parallel block, a small Veeblock etc. to provide support and clamp the blank firmly
- position the vice along with the marked blank to bring the hole axisin alignment with the drill axis by
    - Δ either adjusting the vise position w.r.t. the fixed drill axis
    - Δ or moving the drilling machine table and then locking thetable position
    - Δ or moving the radial arm and the drilling head, if it is aradial drilling machine
- after fixing the blank, vise and the table, alignment is checked again
- if error, like eccentricity, is found to occur then readjustment of location of the hole – axis is to be done before and even after starting drilling
- drilling is accomplished.

Therefore it appears that so many operations are needed to be carried out carefully and skilfully by the machinist or operator for such a simple job. Even after that there may be inaccuracies in machining. Such tedious and time consuming manual work are eliminated or drastically reduced in mass production by automatic or special purpose machine tools. But such machine tools are quite expensive and hence are economically justified for only hugeor mass production and not viable for small lot or batch production. For batch production proper design and use of simple but effective jigs and fixtures are appropriate and economically justified. This is schematically illustrated in Fig. 8.1.2.
The basic purposes of developing and using suitable jigs and fixtures for batch production in machine shops are :

- to eliminate marking, punching, positioning, alignments etc.
- easy, quick and consistently accurate locating, supporting andclamping the blank in alignment of the cutting tool
- guidance to the cutting tool like drill, reamer etc.
- increase in productivity and maintain product quality consistently
- to reduce operator's labour and skill – requirement
- to reduce measurement and its cost
- enhancing technological capacity of the machine tools
- reduction of overall machining cost and also increase in interchangeability.



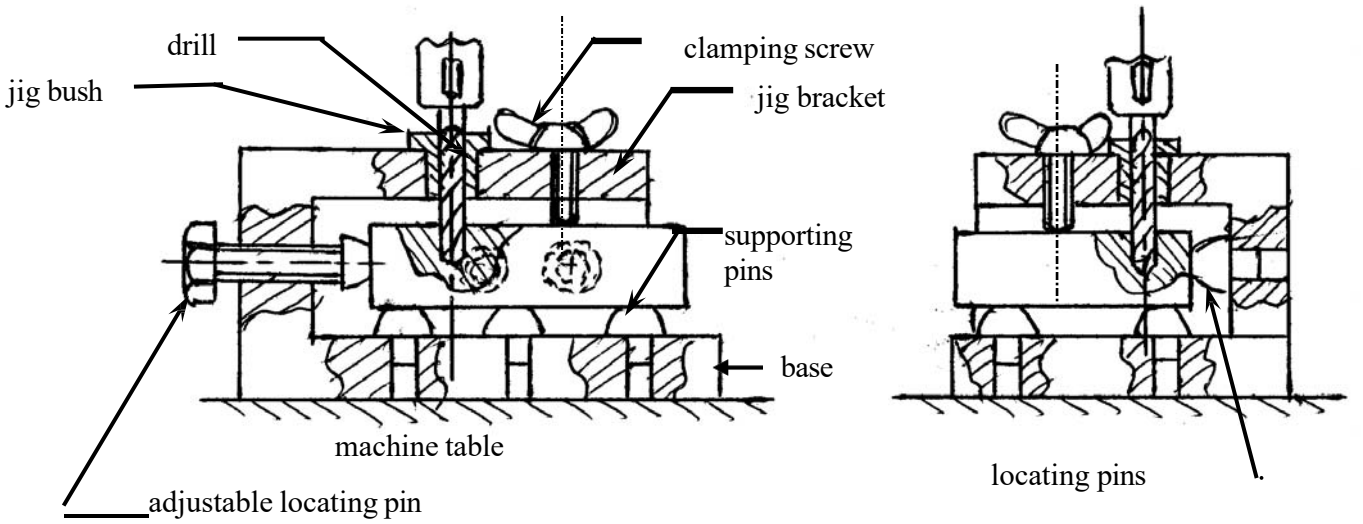
W – without using jig & fixtureF
– using jig and fixture
A – automatic (special purpose) machineP –
piece production
B – batch productionM –
mass production

Role of Jigs and Fixtures on machining cost

(ii) Design Considerations For Jigs And Fixtures

Jigs and fixtures are manually or partially power operated devices. To fulfil their basic purposes, jigs and fixtures are comprised of several elements (as indicated in Fig. 8.1.3) :

- base and body or frame with clamping features
- locating elements for proper positioning and orientation of the blank
- supporting surfaces and base
- clamping elements
- tool guiding frame and bushes (for jig)
- indexing plates or systems, if necessary
- auxiliary elements
- fastening parts



Major elements of jig and fixtures.

Therefore keeping in view increase in productivity, product quality, repeatability i.e. interchangeability and overall economy in batch productionby machining, the following factors are essentially considered during design, fabrication and assembly of jigs and fixtures :

- easy, quick and consistently accurate locating of the blank in the jigor fixture in reference to the cutting tool
- providing strong, rigid and stable support to the blank
- quick, strong and rigid clamping of the blank in the jig or fixture without interrupting any other operations
- tool guidance for slender cutting tools like drills and reamers
- easy and quick loading and unloading the job to and from the jig orfixture
- use of minimum number of parts for making the jig or fixture
- use of standard parts as much as possible
- reasonable amount of flexibility or adjustability, if feasible, to accommodate slight variation in the job - dimensions.
- prevention of jamming of chips, i.e. wide chips-space and easy chip disposal
- easy, quick and accurate indexing system if required.
- easy and safe handling and moving the jig or fixture on the machinetable, i.e., their shape, size, weight and sharp edges and corners
- easy and quick removal and replacement of small parts
- manufacturability i.e. ease of manufacture
- durability and maintainability
- service life and overall expenses

(iii) Principles And Methods Of Locating, Supporting And Clamping Blanks And Tool Guidance In Jigs And Fixtures

It is already emphasized that the main functions of the jigs and fixtures are :

(a) easily, quickly, firmly and consistently accurately

- locating
- supporting and
- clamping

the blank (in the jig or fixture) in respect to the cutting tool(s)

(b) providing guidance to the slender cutting tools using proper bushes There are and can be several methods of locating, supporting and clampingdepending upon the size, shape and material of the job, cutting tool and themachining work required. But some basic principles or rules are usuallyfollowed while designing for locating, supporting and clamping of blank infixtures.

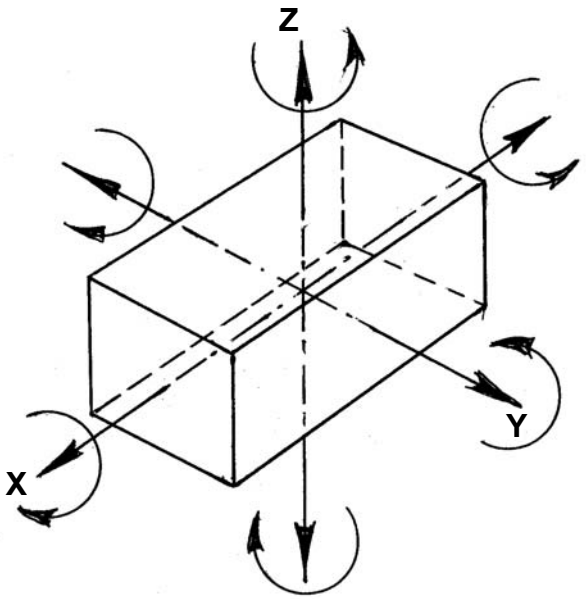
(a) Locating, Supporting and Clamping of jobs in jigs and fixtures

ϒ Locating – principles and methods

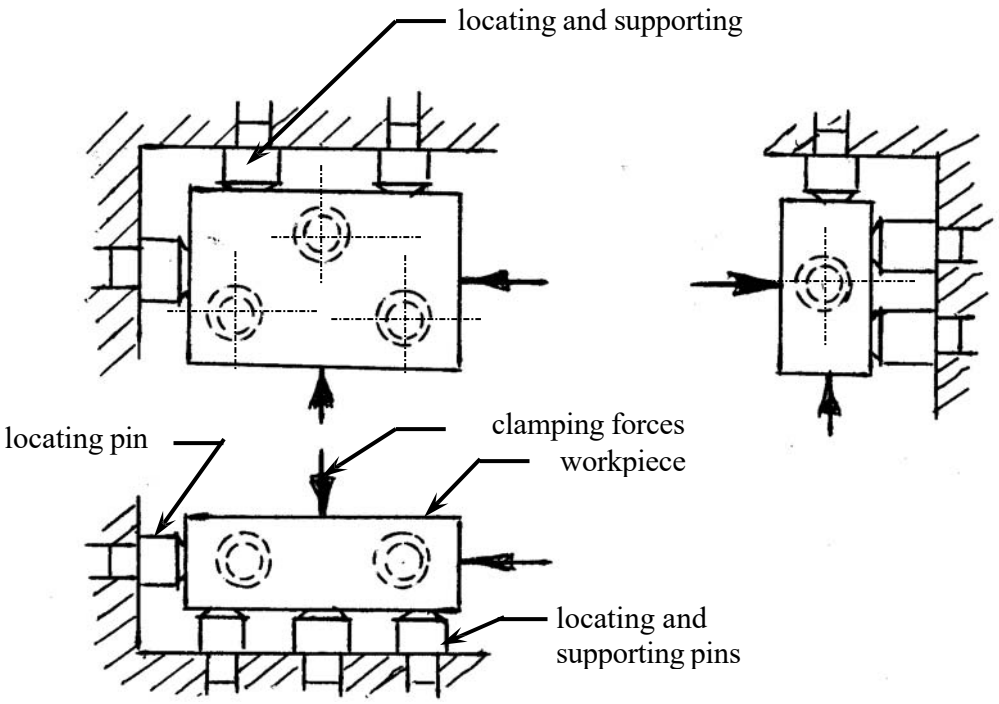
- **Principles or rules of locating in jigs and fixtures**

For accurate machining, the workpiece is to be placed and held in correct position and orientation in the fixture (or jig) which is again appropriately located and fixed with respect to the cutting tool and the machine tool. It hasto be assured that the blank, once fixed or clamped, does not move at all.

Any solid body may have maximum twelve degrees of freedom as indicated in Fig. 8.1.4. By properly locating, supporting and clamping the blank its all degrees of freedom are to be arrested as typically shown in Fig. 8.1.5.



Possible degrees of freedom of a solid body.



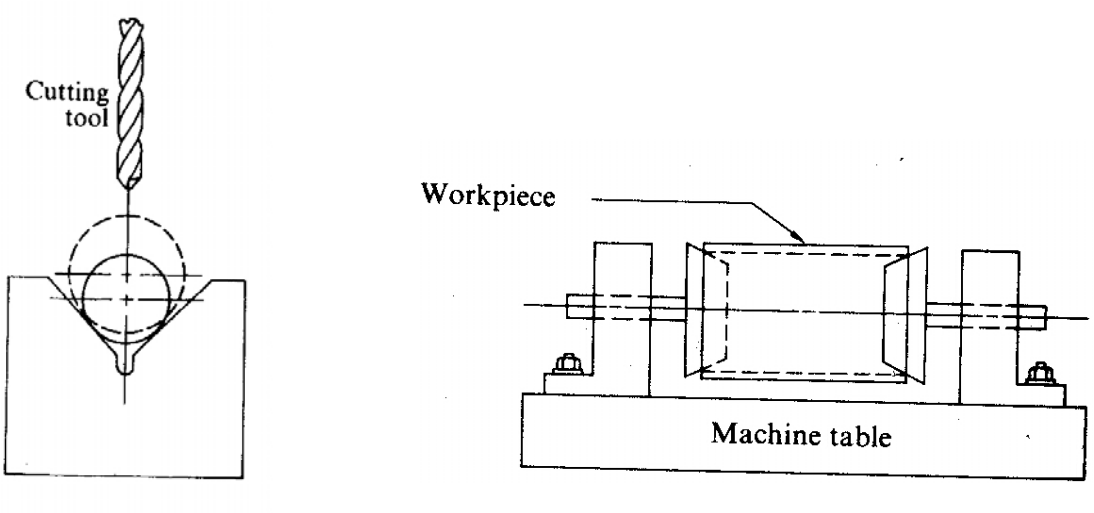
Arresting all degrees of freedom of a blank in a fixture.

The three adjacent locating surfaces of the blank (workpiece) are resting against 3, 2 and 1 pins respectively, which prevent 9 degrees of freedom. Therest three degrees of freedom are arrested by three external forces usually provided directly by clamping. Some of such forces may be attained by friction.

Some basic principles or rules need to be followed while planning for locating blanks in fixtures, such as;

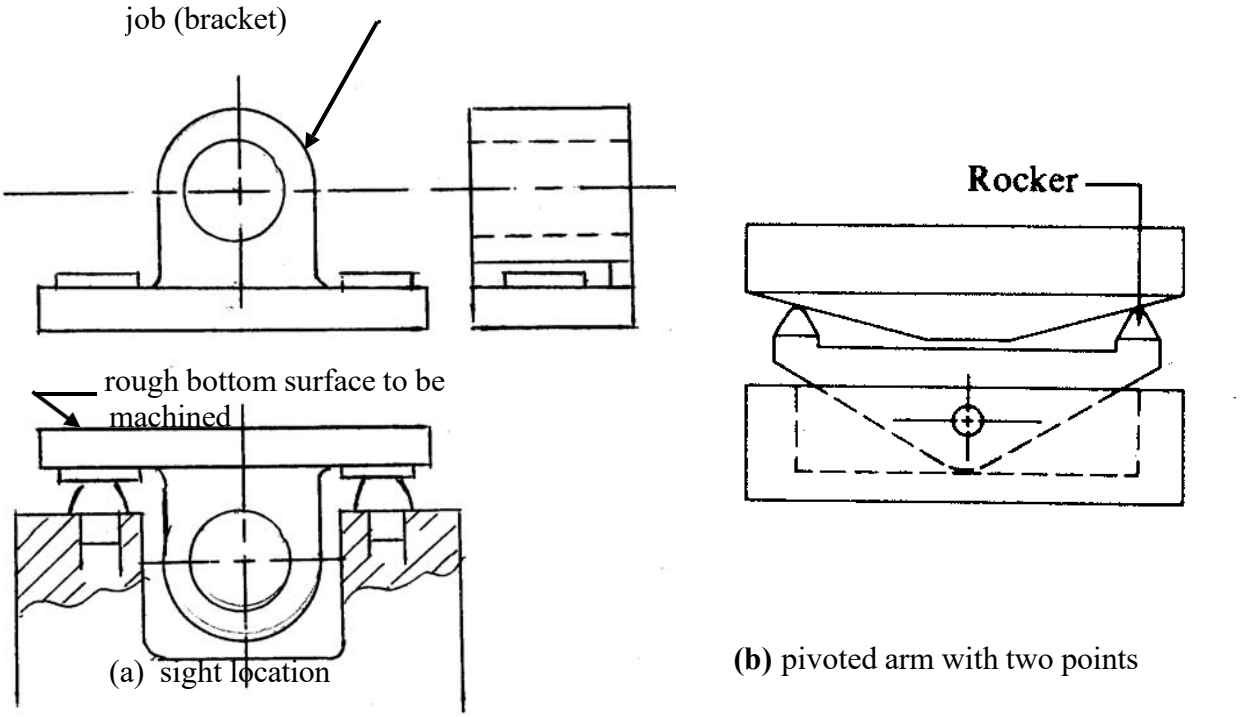
- One or more surfaces (preferably machined) and / or drilled / boredhole(s) are to be taken for reference
- The reference surfaces should be significant and important feature(s) based on which most of the dimensions are laid down
- Locating should be easy, quick and accurate
- In case of locating by pin, the pins and their mounting and contactpoints should be strong, rigid and hard
- A minimum of three point must be used to locate a horizontal flat surface
- The locating pins should be as far apart as feasible
- Vee block and cones should be used for self-locating solid and hollow cylindrical jobs as typically shown in **Fig**
- Sight location is applicable to first – operation location of blank with irregular surfaces produced by casting, forging etc. as indicated in **Fig.** when the bracket is first located on two edges to machine the bottom surface which will be used for subsequent locating.

o Adjustable locating pin(s) as indicated in Fig. 8.1.3 is to be used to accommodate limited part size variation



Locating by Vee block and cone.

o For locating large jobs by rough bottom surface one of the three pins may be replaced by a pivoted arm as indicated in Fig. 8.1.7. The pivoted arm provides wo contact points.



(a) sight location

(b) pivoted arm with two points

(a) Sight location and (b) location by pivoted points (equalizer)

- **General methods of locating**

Δ Locating blanks for machining in lathes

In lathes, where the job rotates, the blanks are located by

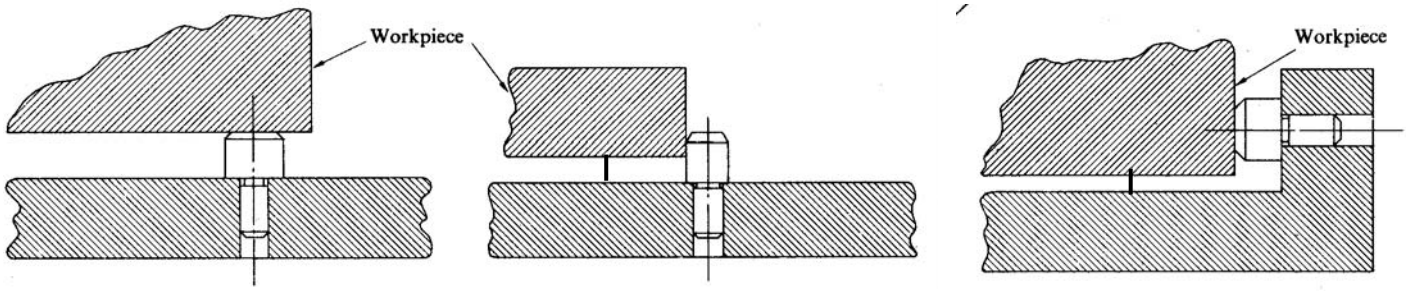
- fitting into self centering chuck
- fitting into 4 – independent jaw chuck and dead centre
- in self – centering collets
- in between live and dead centres
- by using mandrel fitted into the head stock – spindle
- fitting in a separate fixture which is properly clamped on a drivingplate which is coaxially fitted into the lathe spindle.

Δ Locating for machining in other than lathes

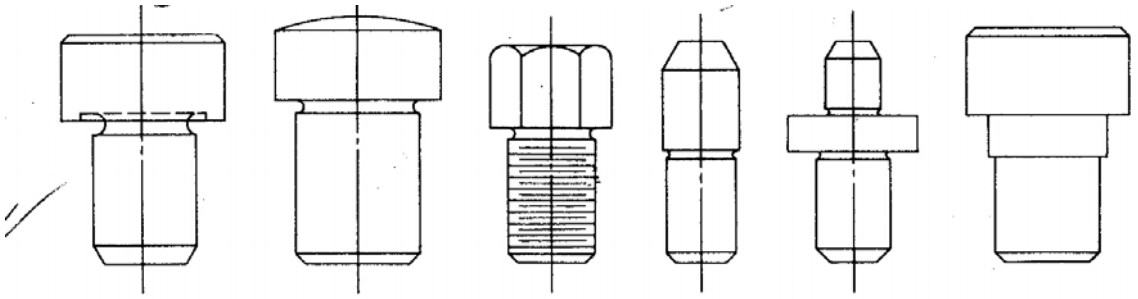
In machine tools like drilling machine, boring machine, milling machine, planing machine, broaching machine and surface grinding machine the job remains fixed on the bed or work table of those machine tools.
Fixtures are mostly used in the aforesaid machine tools and jig specially for drilling, reaming etc. for batch production.
For machining in those jigs and fixtures, the blank is located in several ways which include the followings :

- **Locating by flat surfaces**

Fig. 8.1.8 typically shows locating jobs by their flat surfaces usingvarious types of flat ended pins and buttons.



(a)



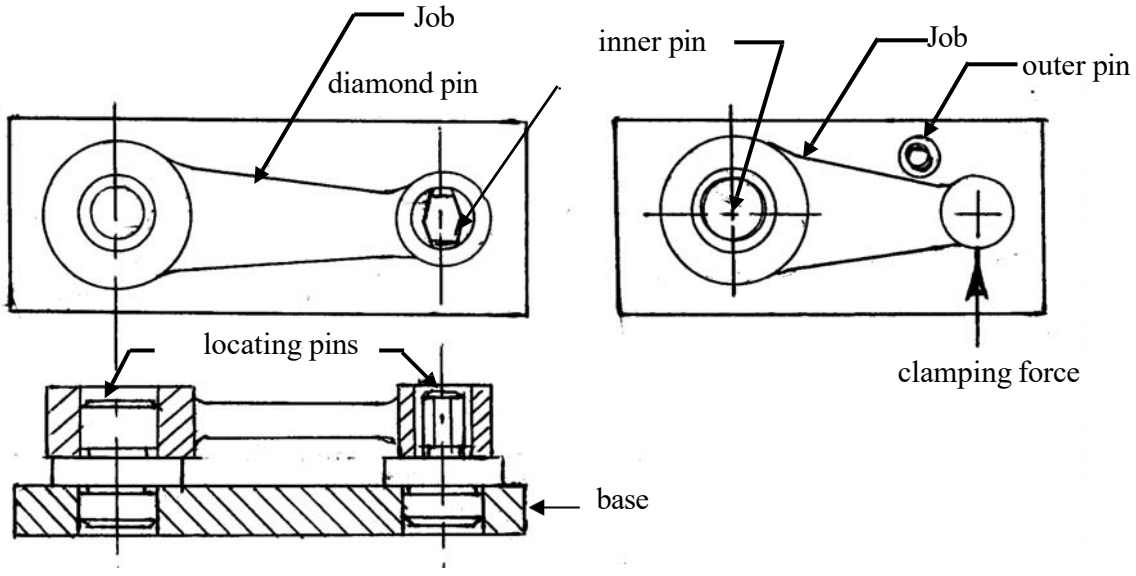
(b)

Locating by (a) flat surfaces and (b) types of pins used for that.

o Locating by holes

In several cases, workpieces are located by premachined (drilled, bored or pierced) holes, such as;

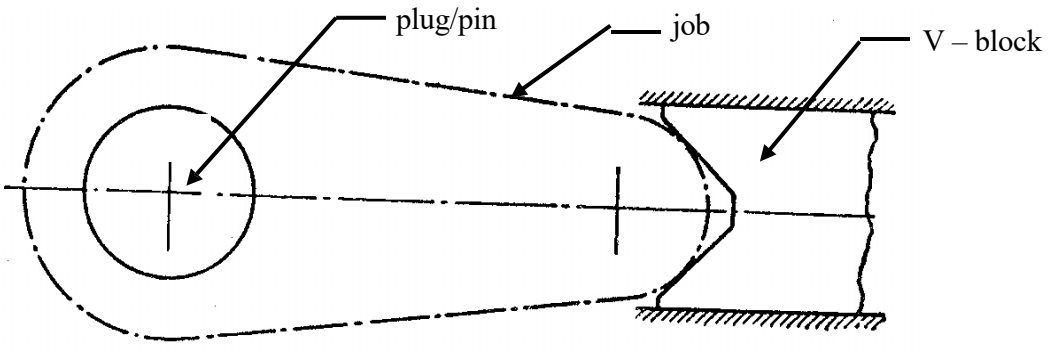
* Locating by two holes as shown in Fig. 8.1.9 (a) where one ofthe pins has to be diamond shaped to accommodate tolerance on the distance between the holes and their diameters
* Locating by one hole and an external pin which presents rotationof the blank around the inner pin as indicated in Fig. 8.1.9 (b)
* Locating by one hole and one Vee-block as shown in Fig. 8.1.10



(a) locating by two holes

(b) locating by one hole

Locating by holes.

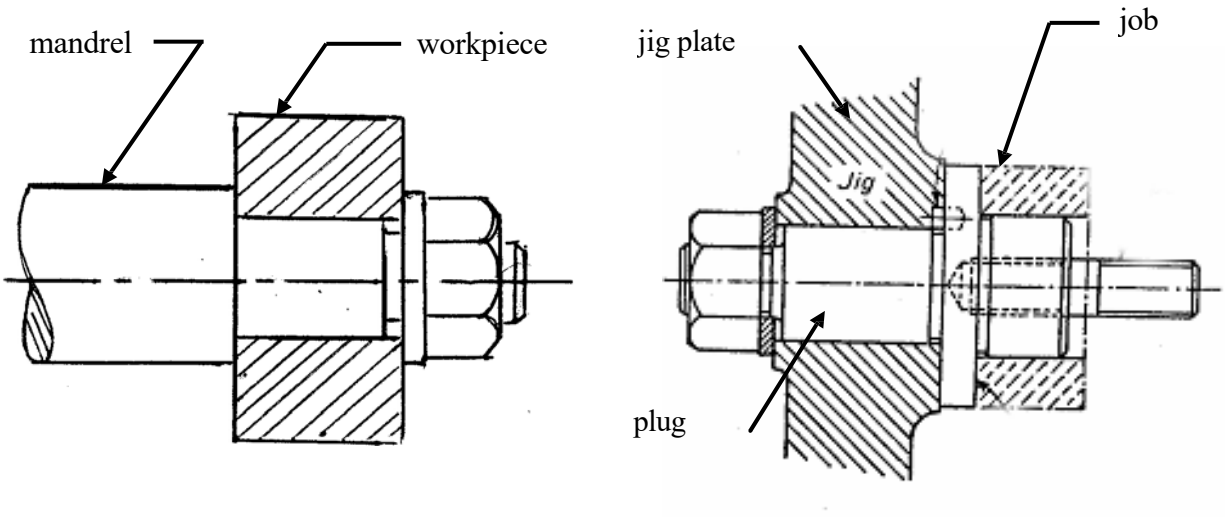


Locating by a pin and Vee block.

o Locating on mandrel or plug

Ring or disc type workpieces are conveniently located on mandrel orsingle plug as shown in Fig. 8.1.11.

However, there may be several other ways of locating depending upon themachining conditions and requirements.



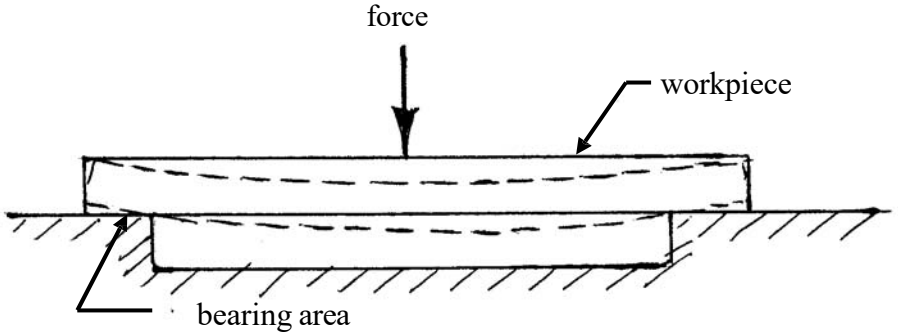
Locating by mandrel or plug.

ϒ Supporting – principles and methods

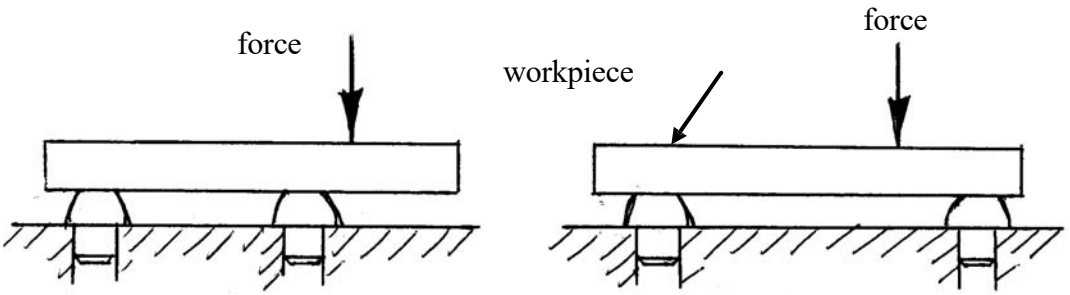
A workpiece has to be properly placed in the jig or fixture not only for desired positioning and orientation but also on strong and rigid support such that the blank does not elastically deflect or deform under the actions of the clamping forces, cutting forces and even its own weight.

- **Basic principles or rules to be followed while designing orplanning for supporting**
  - supporting should be provided at least at three points
  - supporting elements and system have to be enough strong and rigid to prevent deformation due to clamping and cutting forces
  - unsupported span should not be large to cause sagging as indicated in fig. 8.1.12
  - supporting should keep the blank in stable condition under theforces as indicated in fig. 8.1.13
  - for supporting large flat area proper recess is to be provided, as indicated in fig. 8.1.14, for better and stable support.
  - round or cylindrical workpieces should be supported (along with locating) on strong vee block of suitable size
  - heavy workpieces with pre-machined bottom surface should be supported on wide flat areas, otherwise on flat ended strong pins or plugs.
  - if more than three pins are required for supporting large workpieces then the additional supporting pins are to be spring loaded or adjustable

- o additional adjustable supporting pins need to be provided
  - * to compensate part size variation
  - * when the supporting surface is large and irregular
  - * when clamping and cutting forces are large
- o ring or disc type jobs, specially requiring indexing should be supported (and located) in mandrel

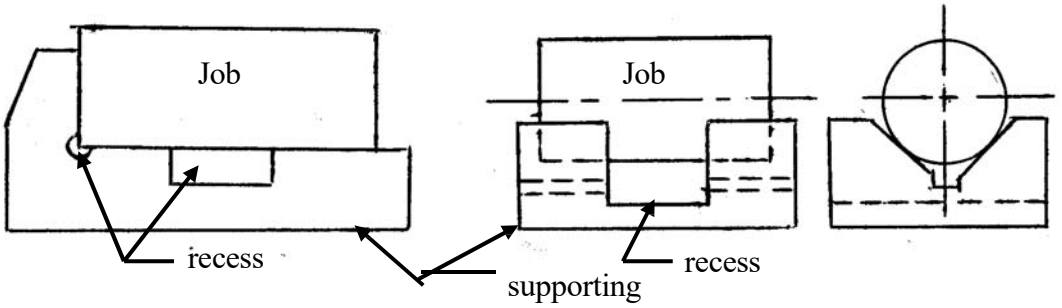


Deflection due to force(s) for wide gap in between supports.



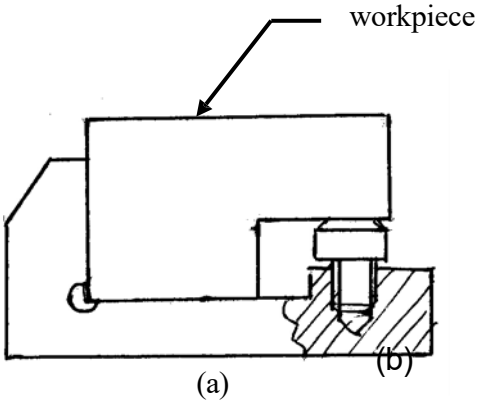
(a) not correct (unstable) (b) correct (stable)

Stability in supporting.

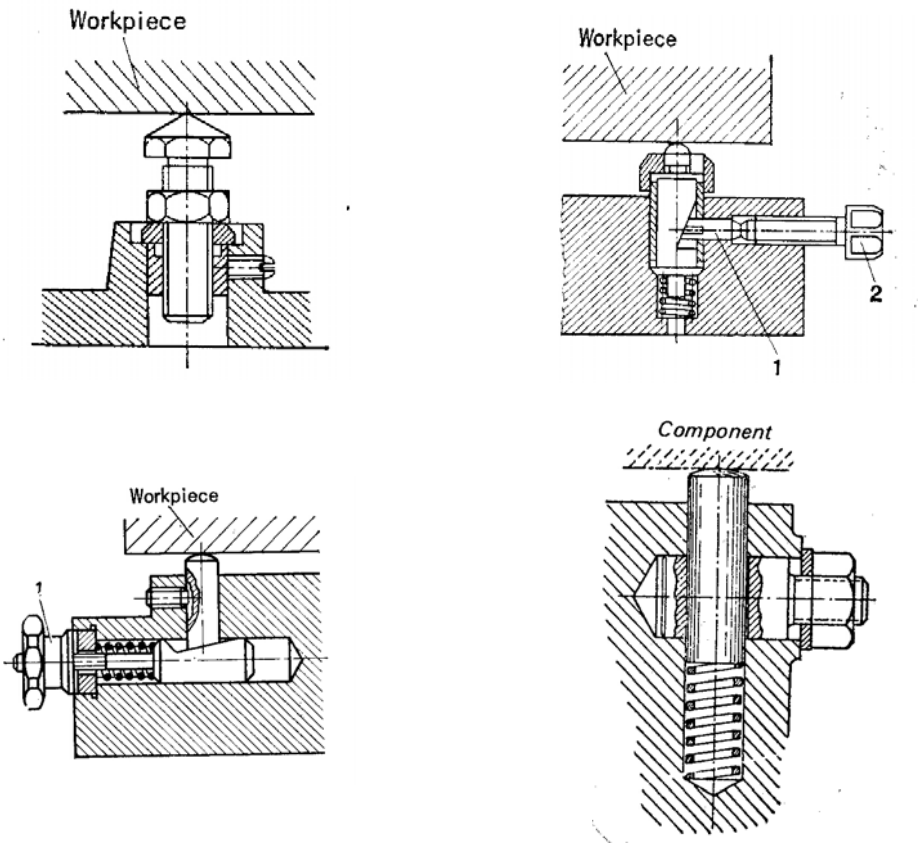


Recess in long span supporting.

- Common methods of supporting job in fixtures
  - o supporting on vices
  - o supporting on flat surfaces / blocks
  - o supporting by fixed pins
  - o additional supporting by adjustable pins and plugs or jackscrews as shown in fig.
  - o supporting (and locating) on vee blocks and mandrels



Supporting (a) by flat surface



Adjustable supporting pins.

ϒ Clamping of workpiece in fixtures

In jigs and fixtures the workpiece or blank has to be strongly and rigidly clamped against the supporting surfaces and also the locating features so that the blank does not get displaced at all under the cutting forces during machining.

- **While designing for clamping the following factors essentially needto be considered :**
  - clamping need to be strong and rigid enough to hold the blank firmly during machining
  - clamping should be easy, quick and consistently adequate
  - clamping should be such that it is not affected by vibration, chatter or heavy pressure
  - the way of clamping and unclamping should not hinder loading and unloading the blank in the jig or fixture
  - the clamp and clamping force must not damage or deform the workpiece
  - clamping operation should be very simple and quick acting whenthe jig or fixture is to be used more frequently and for large volume of work
  - clamps, which move by slide or slip or tend to do so during applying clamping forces, should be avoided
  - clamping system should comprise of less number of parts for ease of design, operation and maintenance
  - the wearing parts should be hard or hardened and also be easily replaceable
  - clamping force should act on heavy part(s) and against supporting and locating surfaces
  - clamping force should be away from the machining thrust forces
  - clamping method should be fool proof and safe
  - clamping must be reliable but also inexpensive

- **Various methods of clamping**

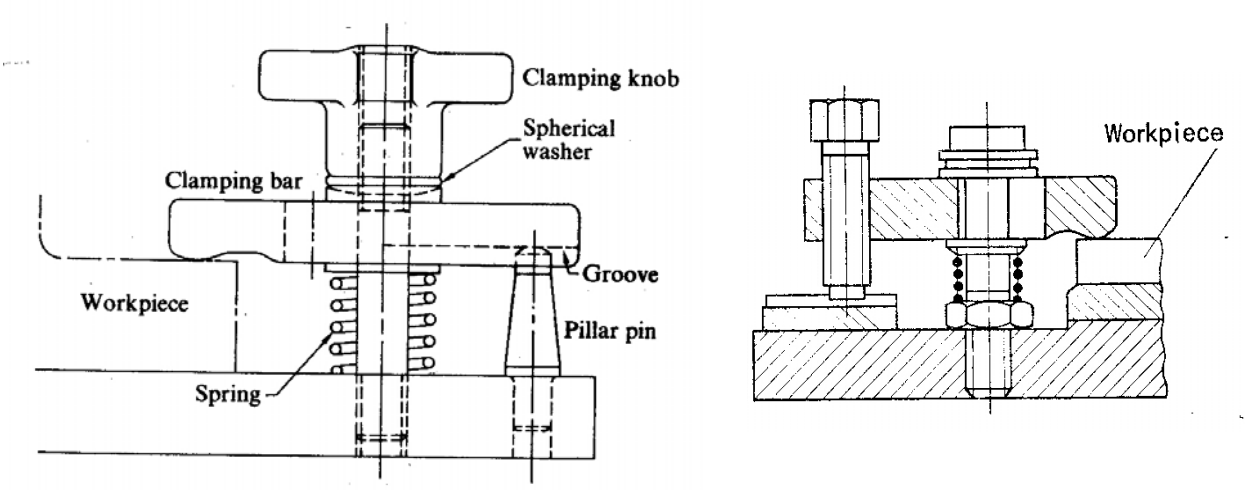
Clamping method and system are basically of two categories :

(a) general type without much consideration on speed of clampingoperations

(b) quick acting types

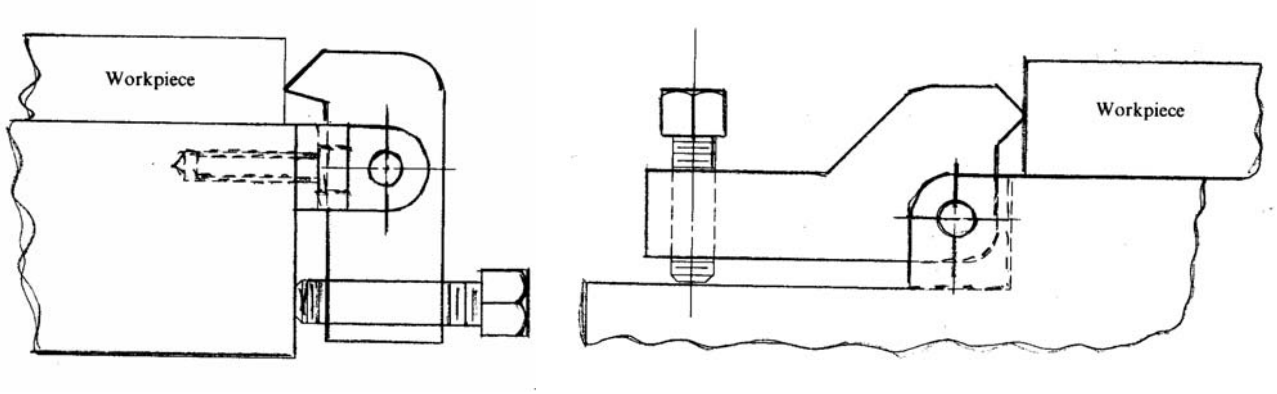
(a) General clamping methods of common use :

- Screw operated strap clamps as typically shown in Fig. 8.1.17. The clamping end of the strap is pressed against a spring which enables quick unclamping



Common strap type clamping.

- Clamping from side for unobstructed through machining (like milling, planing and broaching) of the top surface. Some commonly usedsuch clamping are shown in Fig. 8.1.18



- ## Clamping by swing plates

Such clamping, typically shown in Fig. 8.1.19, are simple and relatively quick in operation but is suitable for jobs of relatively smaller size, simpler shape and requiring lesser clamping forces.

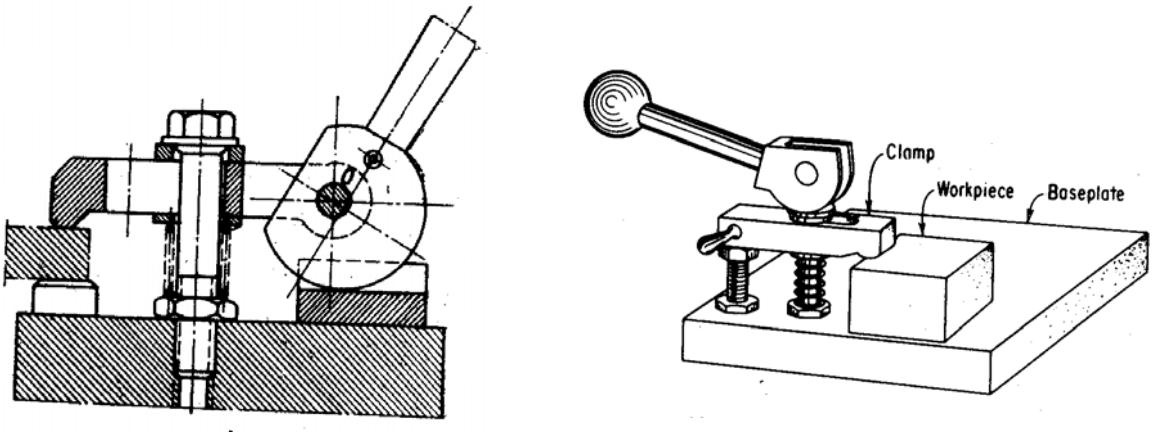
- Other conventional clamping methods include :
  - * Vices like drilling and milling vices
  - * Magnetic chucks
  - * Chucks and collets for lathe work

- ## Quick clamping methods and systems

  - ### Cam clamping

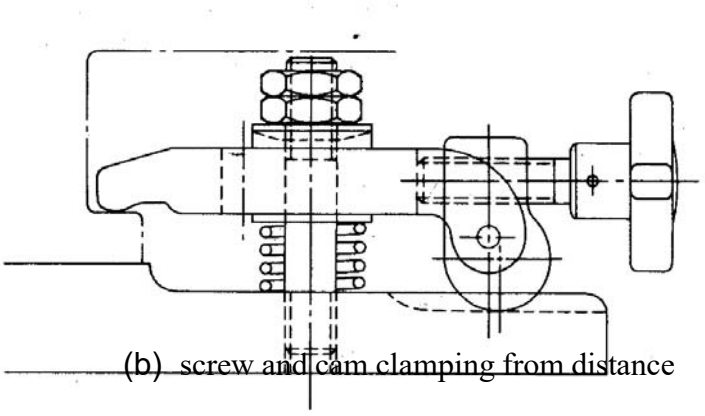
    Quick clamping by cam is very effective and very simple in operation. Some popular methods and systems of clamping by cam are shown in Fig. 8.1.21

    The cam and screw type clamping system is used for clamping through some interior parts where other simple system will not have access.



(a) clamping by cam

workpiece



(b) screw and cam clamping from distance

Quick clamping by cams.

- Quick multiple clamping by pivoted clamps in series and parallel. This method shown in Fig. 8.1.22 is capable to simultaneously clamp number ofrods even with slight diameter variation
- Quick clamping by hydraulic and pneumatic force for strong and light clamping respectively
- Light but quick clamping by bayonet type clamp as indicated in Fig.

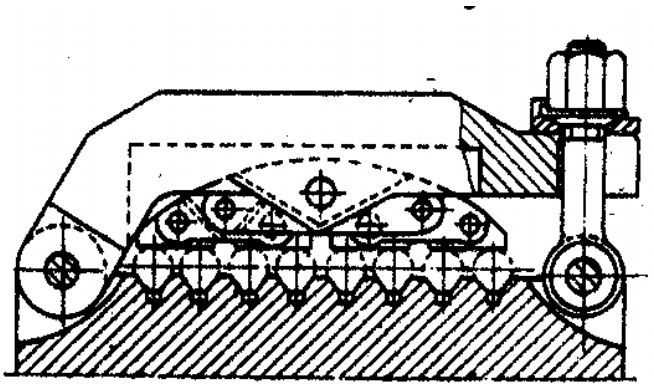


Fig. 8.1.22 *Quick multiple locating and clamping of cylindrical jobs.*

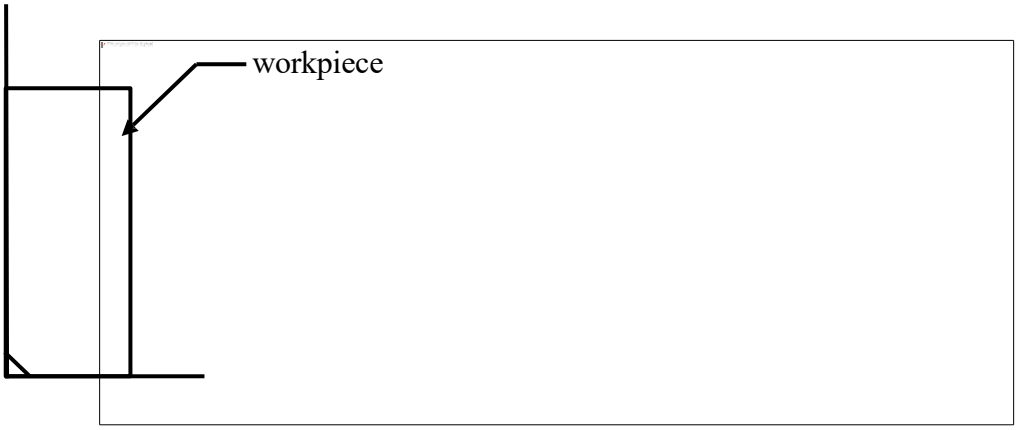


Fig. 8.1.23 *Quick acting screw (bayonet type) clamping.*

(b) Drill – jig bushing

Slender and cantelever type cutting tools, mainly drills, usually suffer from run – out due to possible errors in the drill, sockets and drilling machine spindle and finally in the overall alignment. Such run out causes over sizing, out of roundness and surface roughening of the drilled holes. Such run out aggravates further with the increase in drill speed (rpm) and the thrust force, specially if the drill is not geometrically symmetrical. This often leads to, in addition to poor product quality, breakage of the drill by bending and / or buckling. To reduce such problems, bushes are used in the jigs to guide the drill bits as indicated in Fig. 8.1.3.

∆ The factors to be considered while designing for jig – bushing, are :

- The bushes, used to guide and properly locate drills, reamers etc. are generally made of carbon or alloy steel and made wear resistive by hardening to R_C 60 and above. Often bushes are also made from grey cast iron for antifriction and protection ofthe tools.

- The hardened jig bushes are finished outside by grinding andinside by grinding and lapping if high precision is insisted.
- The bush's length should be sufficient (≥ twice drill diameter) and its diameter should be slightly larger than the drill diameter
- Design and construction should enable easy and quick properfitting and removal or replacement of the bushes
- Bushes should not come out from its seat along with the drill during its return.

∆ Types of jig bushes

Depending upon nature of fitting, quick mounting and replacement, jobrequirement etc. jig bushes are classified into several types.

- Bushes may be
  - — Press fitted type
  - — Slip type
  - — Screwed type

Press fitted thin sleeve type bushes are generally used for shorter runs and are not renewable. Renewable type slip bushes are used with liner. But screw bushes, though renewable may be used without or with liner.

- Bushes may be
  - — Without head
  - — With head
  - — With a flange being screwed on the bracketFig.

8.1.24 shows such various bushes

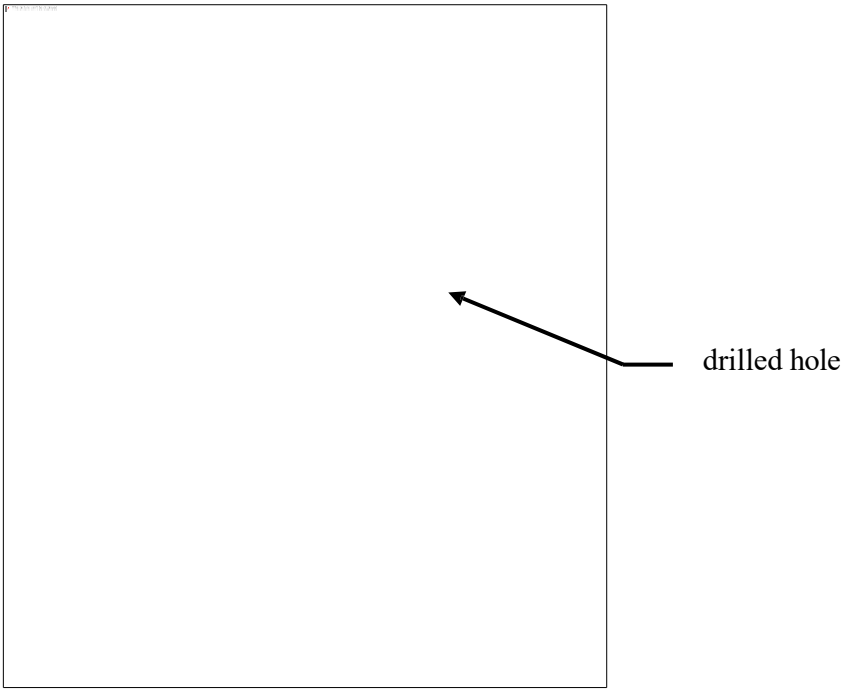


Fig. 8.1.24 *Bushes (a) without head, (b) with head and (c) flange.*

- Frequently replaceable bushes are provided with some lockingsystem as shown in Fig. 8.1.25

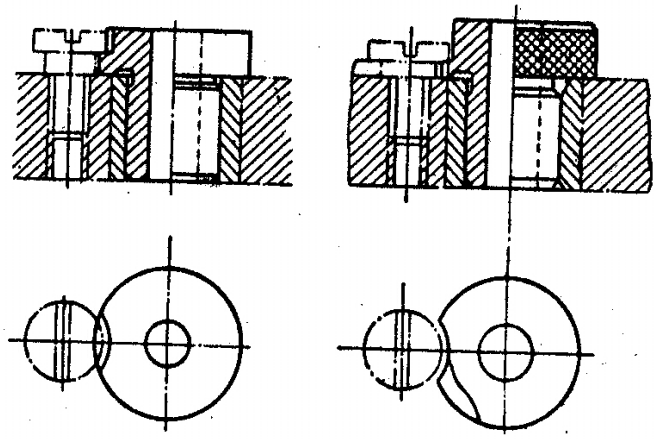
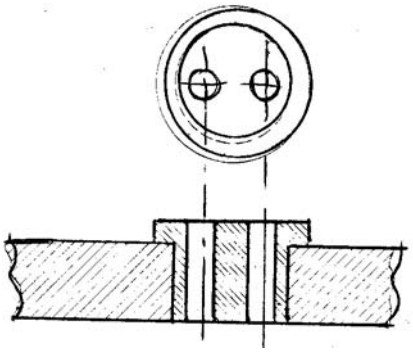
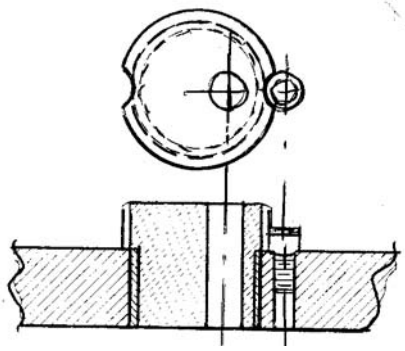


Fig. 8.1.25 *Locking of frequently replaceable bushes.*

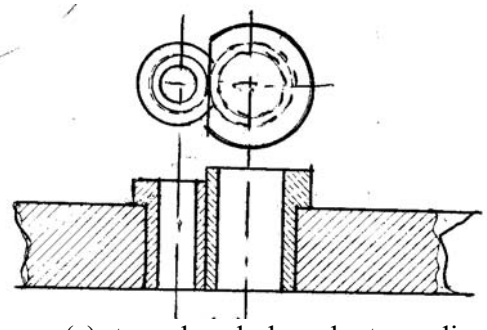
- Some special jig bushings are often designed and used as andwhen required as indicated in Fig. 8.1.26



(a) two close holes – in one bush



(b) two very close holes – using eccentric bush



(c) two close holes – by two adjacent modified bushes

Special jig – bushes for critical requirements.

Many other types are possible and made depending upon the working situation and critical requirements.