UNIT-5

Hot working – cold working – strain hardening – recovery recrystalization and grain growth – comparision of properties of cold working and hot working parts – rolling fundamentals – theory of rolling – types of rolling mills and products – forces is rolling – types of rolling mills and products – forces in rolling and power requirements and products – forces in rolling and power requirements.

HOT WORKING & COLD WORKING:-

Mechanical working of metals can be carried out in the form of either hot working or cold working. Working above the recrystalization temperature is called hot working (lower initial temperature). But below the burning point is called hot working. Working below the recrystalization temperature is called cold working.

The difference between hot working and cold working is that residual stresses are produced in cold working but not in hot working.

HOT WORKING ADVANTAGES:-

1. To bring the metal to the required shape and size.
2. To improve the properties of the metal compound to those in cost conditions.
3. Extensive deformation is possible because of increased plasticity.
4. Inter mediate annealing is not required because of no strain hardening.
5. Power requirements for the process are less.
6. Mechanical properties are improved as a result of grain refinement.
7. The porosity is largely eliminated and the impurities are uniformly distributed throughout the volume.

DISADVANTAGES:-

1. Tooling cost is high.
2. Surface finish is usually poor, because of the scale formation on the surface of the metal.
3. Close dimensional tolenance cannot be maintained.

HOT WORKING PROCESSES:-

1. Hot rolling: to produce plate, sheet, strip and simple sections.
2. Extrusion: to manufacture complex solid and hallow sections
3. Forging: to produce simple shapes.
4. Hot piercing: to produce seamless tubes.
5. Hot ruling: to produce smooth finish tubes.

6. Hot spinning: to produce shallow containers.
7. Hot drawing: to produce up shaped articles.

COLD WORKING ADVANTAEGES:-

1. Smoother finish is possible.
2. Close dimensional tolerances can be maintained.
3. No surface oxidation or scaling results.
4. Strength and hardness are increased.

DISADVANTAGES:-

1. Requires high power.
2. Suitable only for ductile materials.
3. Requires intermediate an neoling for large deformations.

COLD WORKING PROCESSES:-

1. ROLLING
2. Drawing
3. Bending
4. Squeezing
5. Shearing
6. Extruding
7. Shot running
8. Hobbing

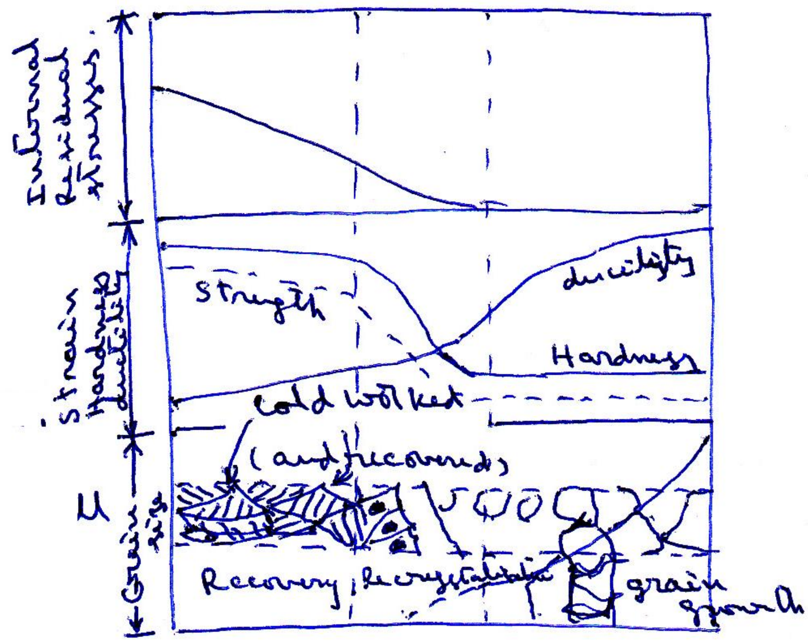
If the temperature raised sufficiently, the metal attempts to approach equilibrium through three processes

1. Recovery
2. Recrystalization
3. Grain growth

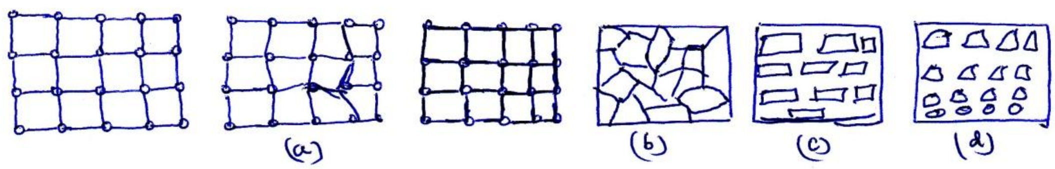
RECOVERY: -

If the strain hardened metal is heated to comparatively low temperature. The following changes occurs

1. The elastic deformation of lattice is reduced due to the increase in amplitude of thermal oscillation of the atoms.
2. This heating will slightly decrease the strength of the strain hardened metal but the elastic limit and ductility increase but not to the value of the initial material (before strain hardening).
3. No change in the microstructure
   This partial restoration of the original properties produced by reducing the distortion of the crystal lattice without noticeable changes in the microstructure is called recovery.



Recrystalisation:-



The formation of new enquired grains in the heating instead of the oriented fibers structure of the deformed metal called recrystalization. Due to effect of heating new minute grains are formed (a)

The grains rapidly enlarge until further growth is restricted as shown (b) and (c). the original system of grain go out of the picture and the new crystallized structure is shown at (b). Recrystalization in fact, does not produce new structure but produce new grains or crystals of the same picture. The temp at which recrystalization takes place is called recrystalization temperature .

GRAIN GROWTH:-

Just after a metal has recrystalised the grains are small and some what regular in shape. The grain will grow if the temperature is high enough or if the temperature is allowed to exceed the minimum required for recrystalization. This growth is the result of a tendency to return to more stable and larger state and appears to depend primarily on the shape of the grain.

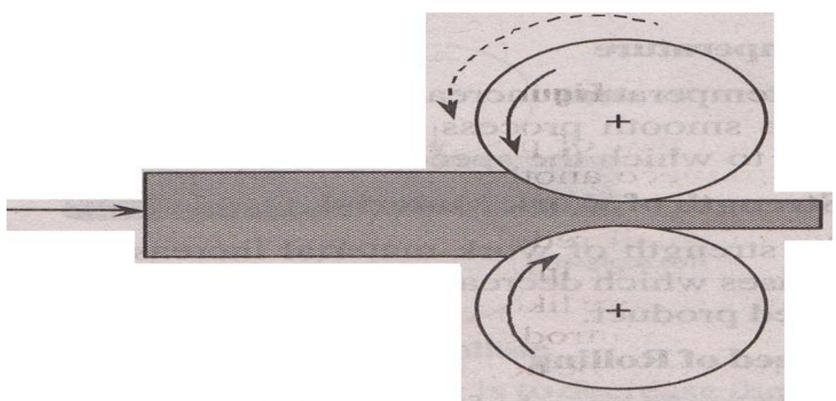
HOT ROLLING:-

This process is most rapid method of converts large sections into designed shapes. By this the coarse structure cast in got is converted into a fine grain structure and improvement is achieved in its various physical properties such as strength, toughness, ductility and shock resistance. Useful articles like bars, plates, rails, angles, shuts, I-beams and other structural sections are produced by hot rolling.

In this process a hot in got is passed through at least two rolls rotating in opposite directions at the same speed. The space between the rolled section, and the same is less than the thickness of the in got being fed. The rolls thus, squeeze the passing in got to reduce its cross section and increase its length.

TYPES OF ROLLING MILLS:-

1. TWO HIGH ROLLING:-

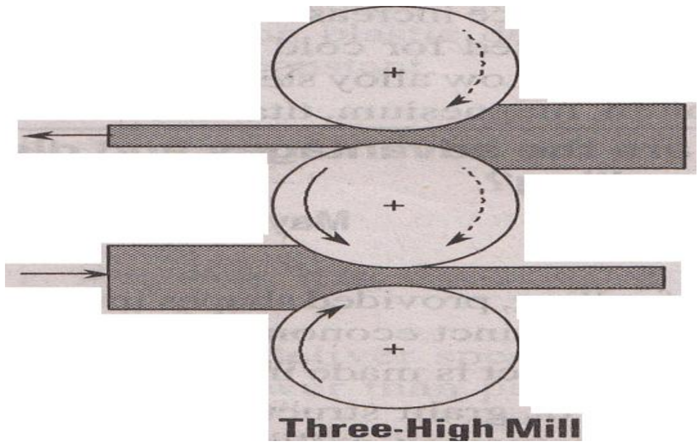


Two-High Pullover Mill

It consists of two heavy horizontal rolls, placed exactly one over the other. The position of the lower roll is fixed. The space between the rolls can be adjusted by raising or lowering the upper roll. Both the rolls rotate in opposite direction to one another. Their direction is fixed and cannot be reversed. Thus the work can be rolled in one direction only.

In another type of two high mill mechanism the direction of rotation of rolls can be reversed. This facilitate rolling of the work piece continuously through back and fro it passes between the rolls. This is called two high reversing mill. This is used normally for the initial rolling of an ingot.

2. Three high rolling:-

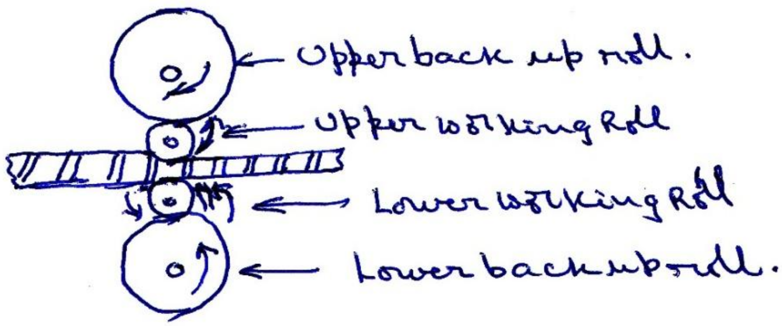


It consists of there horizontal rolls positioned directly one over the other. The direction of rotation of upper and lower rolls are same, but the inter mediate roll rotates in a direction opposite to both of these all the three rolls are continuously revolve in the same fixed direction and never reversed. The work piece is one direction between the upper and middle rolls and in the reverse direction between the middle and lower rolls. Many pieces may be passed through the rolls simultaneously. Higher rate of production than the two high mill.

This may be used for blooming, billet rolling or finish rolling.

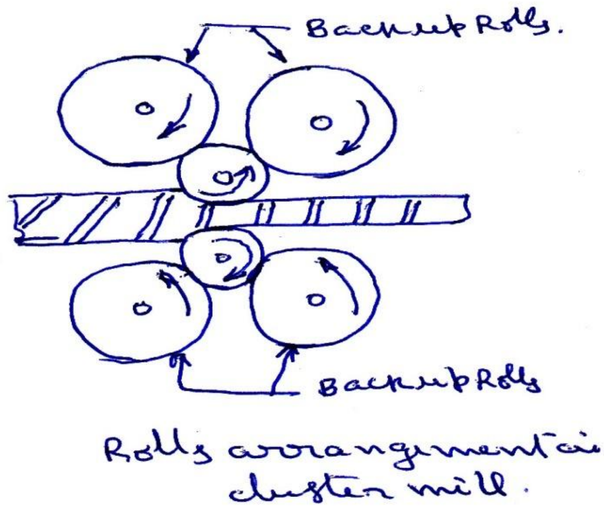
FOUR HIGH ROLLING MILL:-

This consists of four horizontal rolls, two are smaller and two are larger diameters arranged directly one over the other. The larger dia rolls are called back up rolls and their main the larger dia. Rolls are called back up rolls and their main function is to prevent the deflection of the smaller rolls, which otherwise result in thickening of rolled plates or sheets at the centre. The smaller rollers are known as working rolls and they are the rolls which concentrate the total rolling pressure over the metal. These are used for subsequent rolling of slabs.



The common product of these rolls are plates is sheets

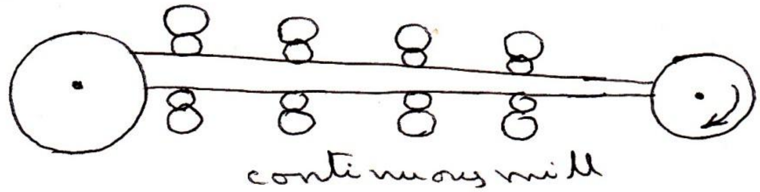
CLUSTER MILL:-



This consists of two working rolls of smaller dia. And four more back rolls of smaller dia and four more back up rolls of larger dia.

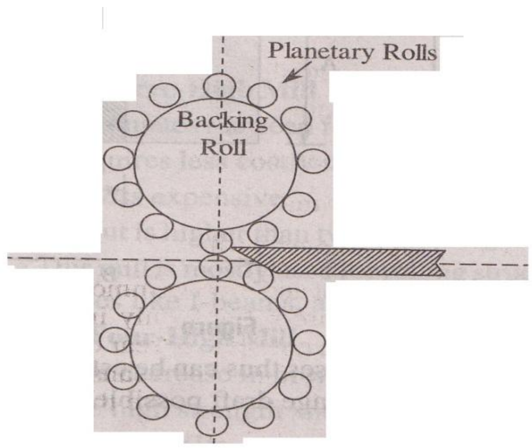
The number of back up rolls may go as high as 20 or more depending on the support needs for the working rolls during the operation this type of mill is generally used for cold rolling.

CONTINUOUS MILL:-



In a continuous rolling mill the same amount of material must pass through each stand in a given period of time. If the cross section is reduced the speed must be increased proportionality. Thus the rolls of each successive stand must turn faster than those of the proceeding one by an amount equal to the change in cross sectional area. If this synchronization is not maintained for incoming material may accumulate between stand or the demand for incoming material may place the material under excessive tension and cause a tearing rupture.

PLANETARY MILL:-



Planetary Mill

This mill consists of a pair of backing rolls surrounding by a large number of small planetary rolls. The cheap feature of the planetary mill is that it reduces a slab directly to strip in one all most constant reduction to the slab as it sweeps out a circular path between the backing roll the slab.

At each pair of planetary rolls cases have to contact with piece another pair of rolls makes a contact and repeats that reduction. The over all reduction is the sum motion of small reduction by each pair or rolls in turn following each other in rapid succession. The action in the planetary mill is more like forging. It is necessary to use feed rolls to introduce the slab in to the mill and pair of plavishing rolls may be needed on the exit side to improve the surface finish.

The power is expended principally in four ways.

1. Energy required to deform the material.
2. Energy required to over come frictional force in the bearings.
3. Energy lost in the pinions and power transmission system.
4. Electrical losses in the various motors and generators.

The entire rolling load is distributed over the arc of contact in the typical mill pressure distribution. The total rolling load can be assumed to be concentrated at a point along the arc of contact at a distance (L) from the centre of the rolls the rolling force is given by

$$P_r = L W Q_p \sigma_{fm} \text{ when } \frac{h}{L} < 1$$

$$= L W Q_i \sigma_{fm} \text{ when } \frac{h}{L} > 1$$

where σ_{fm} = Mean flow stress.

W = width of strip

L = Length of contact between Roll and work piece.

Torque calculation during Rolling:

The torque required to rotate two rolls assuming that the rolling force acts in the middle of arc of contact.

$$\text{Total torque, } T = \frac{2 P_r \cdot L}{2} = P_r \cdot L$$

$$\text{The power required, } P = \frac{2 \pi N \cdot P_r L}{60{,}000} \text{ K·W}$$

(1x)

1. On a certain mill the rolling load for 25% reduction is 7 kN/mm of width. What is the rolling load when front and back tensions of 120 and 150 MPa are applied σ_0 = 13 kN/mm^2 and $\alpha = 2\beta$

Data given: $\mu = 25\% = 0.25$; $H = 7$ kN/mm ; $t_i = 120$ MPa

$t_o = 150$ MPa ; $\sigma_0 = 13$ kN/mm^2 ; $\alpha = 2\beta$

$$t_1 = \frac{t_i + t_o}{2} = \frac{120 + 150}{2} = \frac{270}{2} = 135 \text{ MPa}$$

$$F_i = \left(1 - \frac{t_i}{t_o}\right) \sigma_0 \cdot e^{\mu H}$$

$$= \left(1 - \frac{120}{150}\right) \times 13\, e^{0.25 \times 7}$$

$$= (1 - 0.8) \times 13 \times 5.75 = 0.2 \times 13 \times 5.75 = 14.96 \text{ kN.}$$

Rolling load = 14.96 kN say 15 kN

2. A 5 mm thick aluminium alloy strip is rolled to a thickness of 4 mm, using steel rollers of radius 100 mm. The tensile yield stress of aluminium is 0.28 kN/mm^2. Determine
(a) Minimum coeff. of friction between the work piece and rolls for an unaided bite to be possible.
(b) Angle subtended by the contact zone at the roll center.
(c) The location of neutral point with the coefficient of friction equal to the minimum coefficient of friction.

Assuming a rolling speed of 30 m/minute determine the seperating force and the power required for this rolling operation. The width of the strip is 200 mm. Neglect strain hardening.

Data given: $t_1 = 5$ mm ; $t_2 = 4$ mm ; $r = 100$ mm ; $\sigma = 0.28$ kN/mm^2

$V = 30$ mt/min ; $W = 200$ mm.

$$V = \pi D N$$

$$N = \frac{V}{\pi D} = \frac{30}{\pi \times 0.2} = 47.74 \text{ rpm.}$$

(X)

(a) Minimum coeff. of friction $= \sqrt{\frac{t_1 - t_2}{r}} = \sqrt{\frac{5-4}{100}} = 0.1$

(b) Angle subtended by the contact zone at the Roller center.

$t_1 - t_2 = 2r(1 - \cos\alpha)$

$5 - 4 = 2(100)(1 - \cos\alpha)$

$1 = 200 - 200\cos\alpha$

$\cos\alpha = \frac{199}{200} = 0.995.$

$\alpha = \cos^{-1}(0.995)$

$\therefore \alpha = 5.73^\circ.$

(c) The location of neutral point with the coefficient of friction equal to the minimum coff. of friction

coeff. of friction $= \tan\theta = \sqrt{\frac{t_1 - t_2}{r}}$ or $\tan\theta = 0.1$

$\therefore \theta = 5.71^\circ$

seperating force, $F = 2\sigma LW \left[0.8 + \frac{L}{4t_2}\right]$

where $L = \sqrt{r(t_1 - t_2)}$
$= \sqrt{100(5-4)}$
$= 10\text{ mm}$

$F = 2 \times 0.28 \times 10^3 \times 10 \times 200 \left(0.8 + \frac{10}{4 \times 4}\right) = 1.59\text{ MN}$

Power required for Rolling operation:

$$P = \frac{2FL\pi N}{60{,}000}$$

$$= \frac{2 \times 1.596 \times 10^6 \times 0.01 \times \pi \times 47.74}{60{,}000}$$

$= 79.789\text{ W}$

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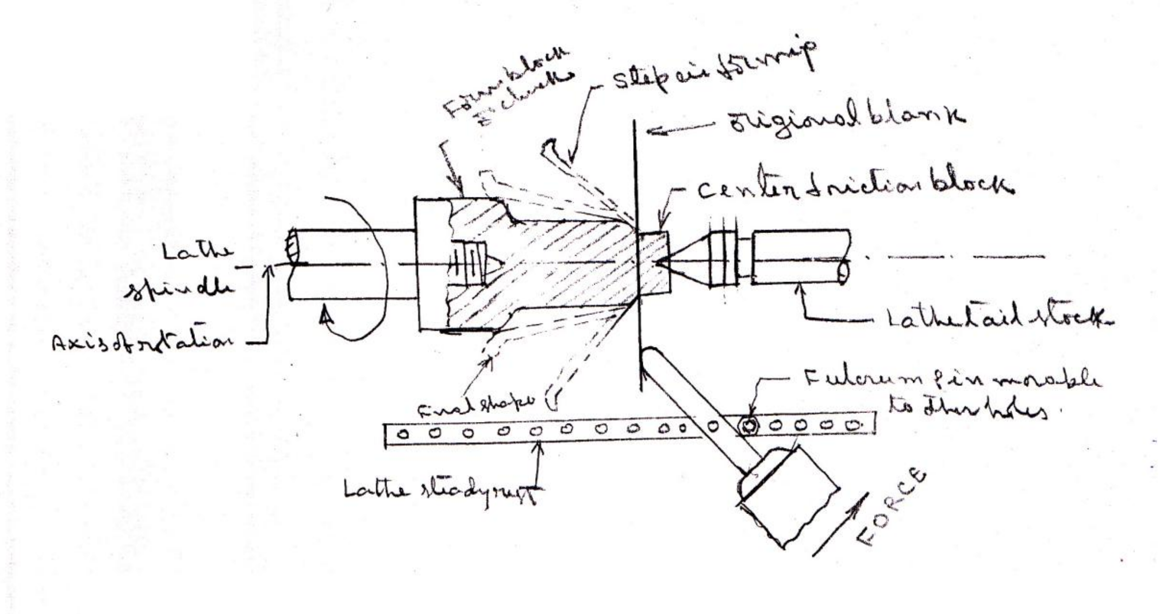
HOT SPINNING:-

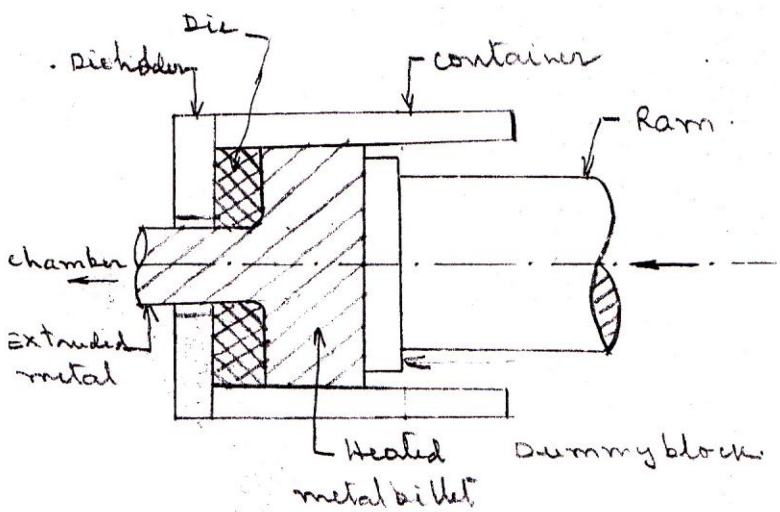


Heating the metal blank to forging temperature and then forming into the desired shape on a spinning lathe which is similar to engine lathe . The metal is shaped over a formed revolution metal holding device called chuck, by means of spinning tools. The heated circular blank of sheet metal is lightly held against the chuck made of plaster or metal and is revolved on the spindle of the lathe.

Blunt pressure tool is used for shaping the desired section during the operation a considerable friction heat is generated which keep the already hot blank in the plastic state.

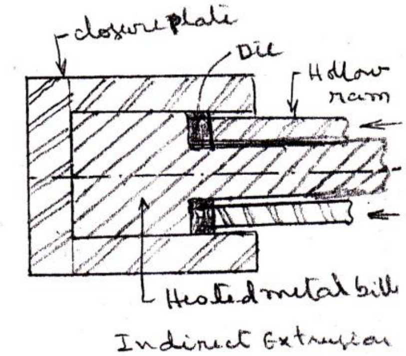
Hot spinning is carried out on thick sheet metal work to compare circular and desired contours.

HOT EXTRUSION:-

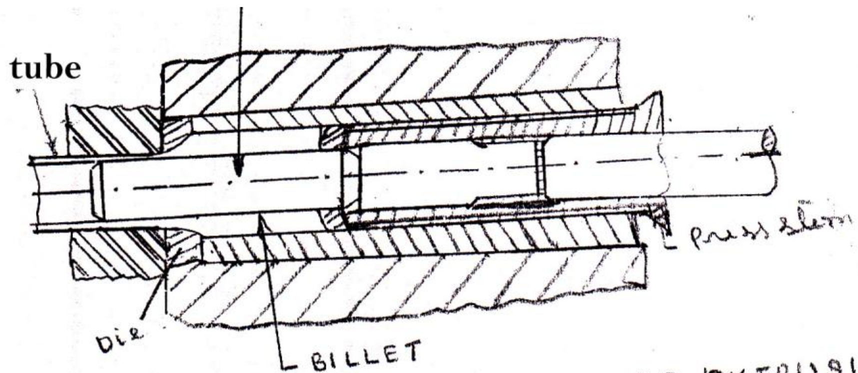


Direct forward extrusion: the heated round billet is placed into the die chamber and the dummy block and rammer placed into position. The metal is extruded through the die opening by applying the pressure on the ram. The pressure is applying the pressure on the ram. The pressure is applied until only a small amount of metal remains direct extrusion.

LIMITATION:-



1. The ram becomes weak, as it is made holler .
2. The difficulty is experiment

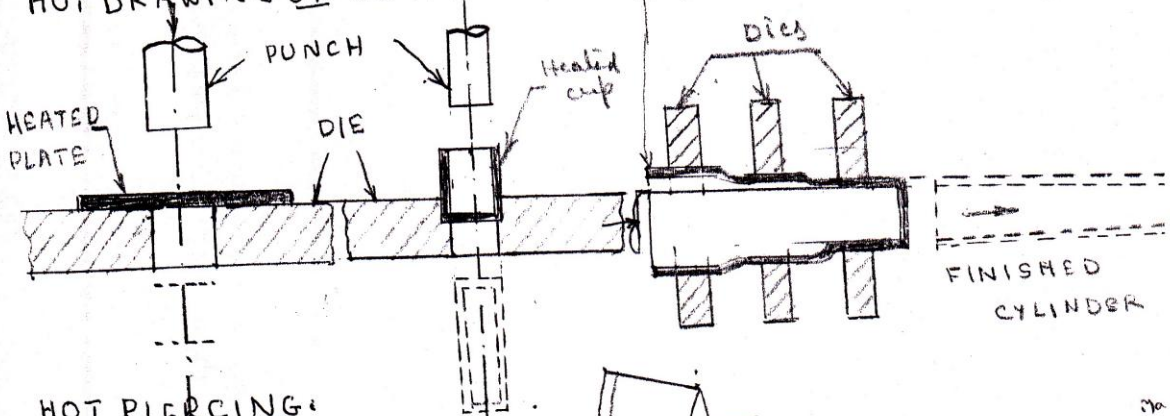


PRINCIPLE OF TUBE EXTRUSION

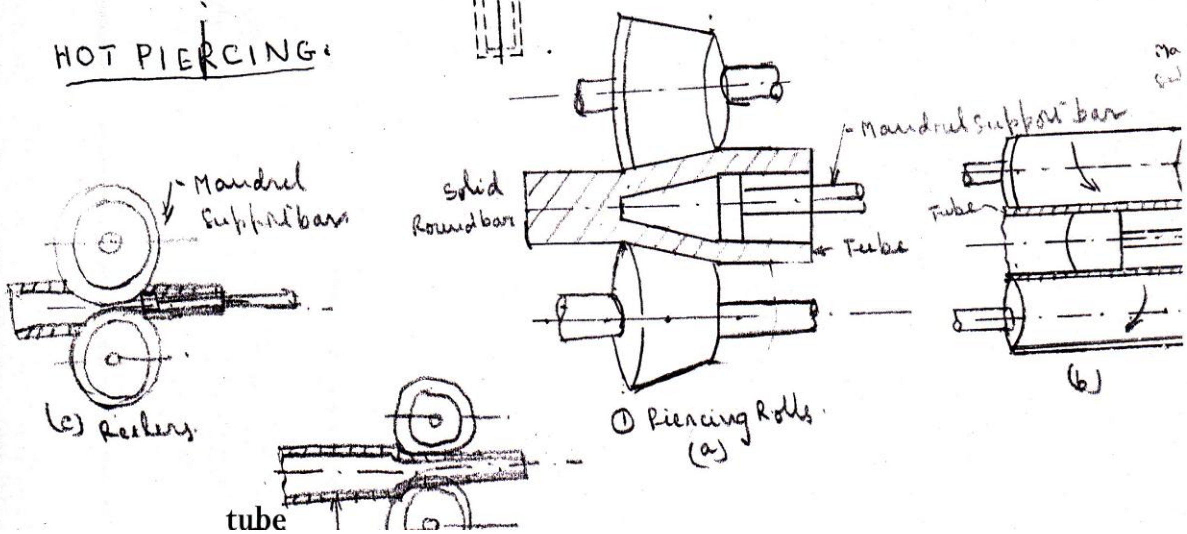
Tube extrusion is a form of direct extrusion using mandrill to form required size of tube. The heated billet is placed inside, the die contains the mandrill is pushed through the ingot. The press stem then advances and extrudes the metal through the die and around the mandrel.

Impact extrusion will be discussed in cold working process.

HOT DRAWING OR CUPPING:

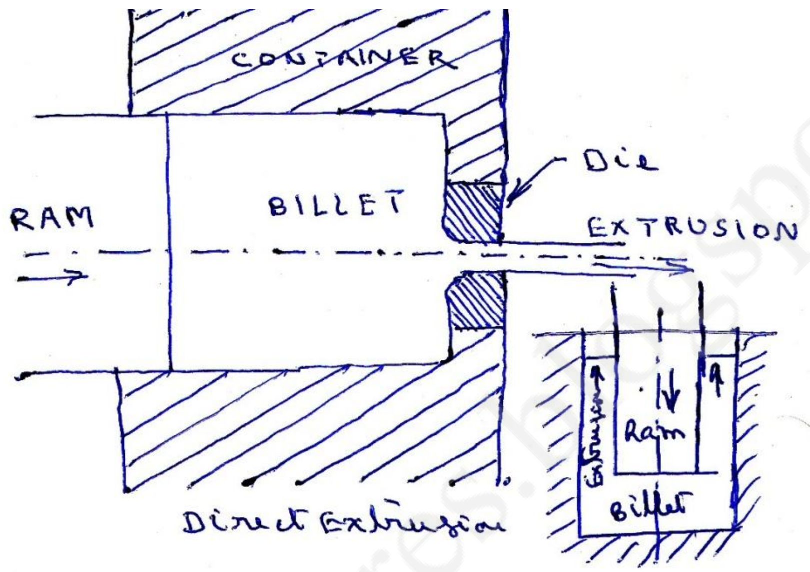


HOT PIERCING:



Methods of extrusion:-

1.Direct extrusion:-



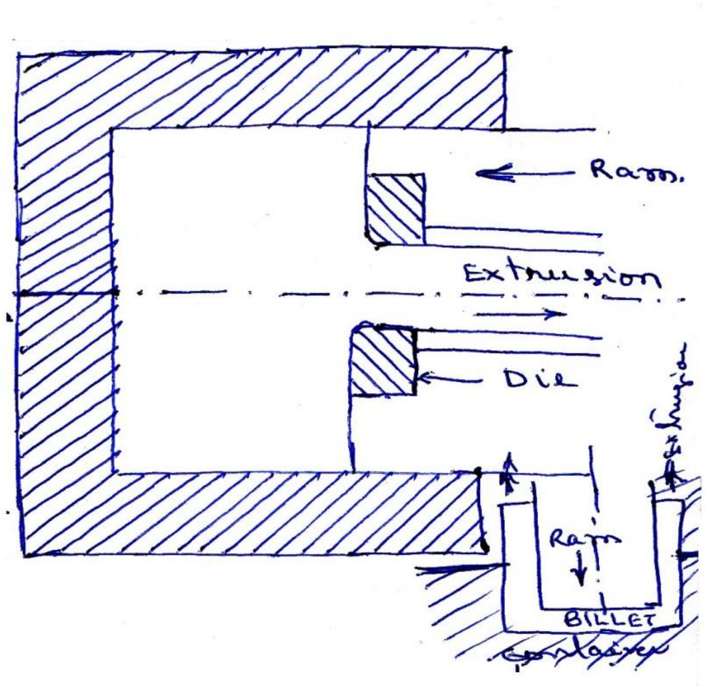
The flow of metal through the die is in the same direction as the movement of ram, ram is solid.

1) A hot billet is placed with in the container that has a die at one end.
2) A ram forces that hot billet than the extruded product

The oxides are that exist on the exterior walls of the billet Do not mixed in to the final extrusion as the billet is pushed through the die. a dummy block which is little smaller through the billet chamber diameter and there fore does not touch the billet employed for the purpose. As the punch moves forward, the exterior of the billet remains stationary where as the interior metal is forced through the die for making extruded product.

2.INDIRECT EXTRUSION:-

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



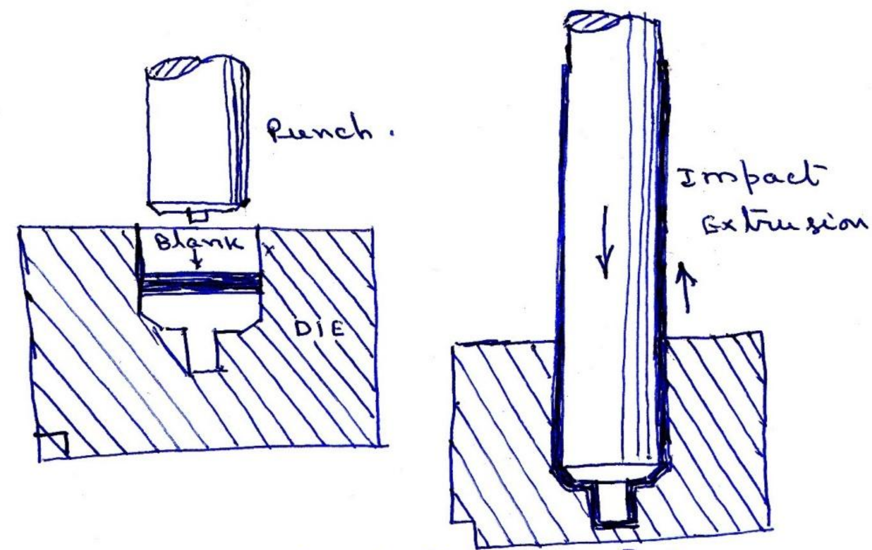
1. In indirect extrusion the billet remains stationary while the die is pushed in to the billet by the hallow ram. through which the extrusion takes place.
2. In direct extrusion does not require as much force as direct extrusion because no force is required to move the hot billet inside the chamber walls.
3. The length of the billet is in direct extrusion is limited only by the column length of the ram because there is no relative motion between the billet surface and container walls.
4. Practical limitations restrict the usefulness of indirect extrusion .since the ram must be hallow and extrusion product must be passed back through the ram. In indirect extrusion the die plays the part of dummy block. Direct extrusion is more common.

Cold extrusion:-

It is same as hot extrusion except that the metals are extruded without application of heat. These metals are posses high degree of ductility.

Cold extrusion is done any o the several methods 'among the impact and hooker process are widely employed.

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



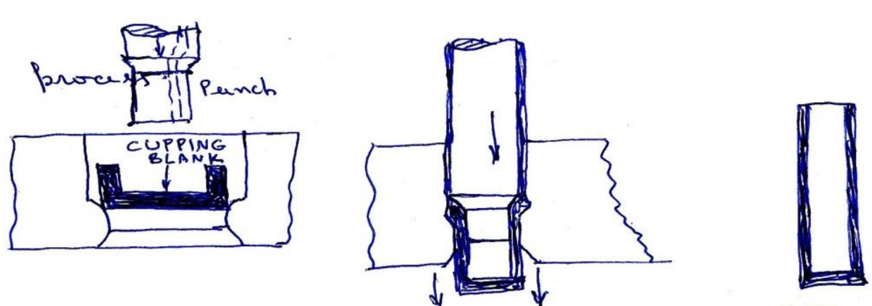
Impact extrusion of Tubes

In the hooker process and unheated cupped balance of metal is placed in the die and as the punch descends, it forces down the metal between the punch and the die, their by producing tabular shaped component .

Hooker process used to produce small brass cartridges cases, copper tubes for radiators and heat exchangers.

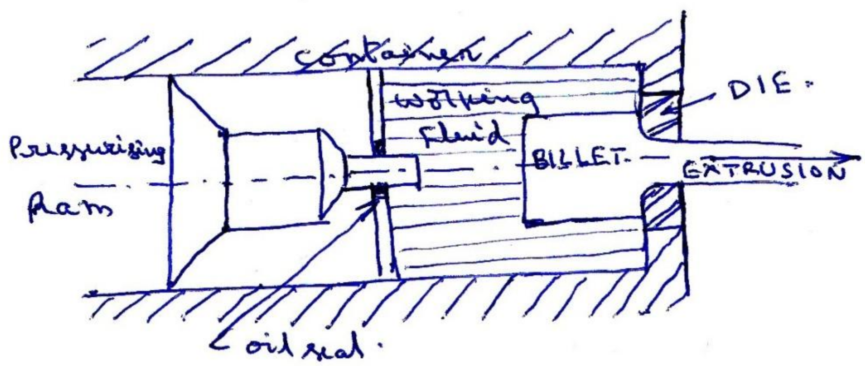
Tin, copper and copper alloys can be easily extruded by this process . the billet is surrounded by a working fluid which is pressurized by ram to provide extrusion force.

In hydro static extrusion fluid remains between the billet and the chamber rolls there by eliminating contact between the two. There by friction is eliminated.



Hooker Process of Impact Extrusion

The absence of container friction permits extrusion of very long billets or even wire and large reductions can be taken . more over, ram does not act directly on the billet rather act on the hydraulic fluid, which can turn forces the hot metals(billet)through the die there by producing the extrusion.



Many materials of limited ductility which cannot be extruded by conventional methods can be extended by hydrostatic process.

<u>Advantages :-</u>

1.very little scrap is there in the process.

2.a little trimming or final machining is require because of the surface finish and dimensional accuracy obtain in the finished part.
3.tools can be changed rapidly.

4.complex parts can be produced quickly.

5.fewer operations require than in conventional shaping methods.

6. mechanical properties are prepared by extruding without need of heat treatment.

Disadvantages :-

1. Tools are expensive and methods practical only mass production.
2. Metal balance should be free from internal or external defects which makes the stock more expensive.

Applications:-

1. Low carbon steel many alloy steels , strain less steels, led, tin, zinc, Al, cu, and it's can be cold extrusion.
2. Gear blanks bearing races or caps copper fittings thin rolled collapsible tubes, cartridge coses , radiator tubes etc can be produced by cold extrusion.

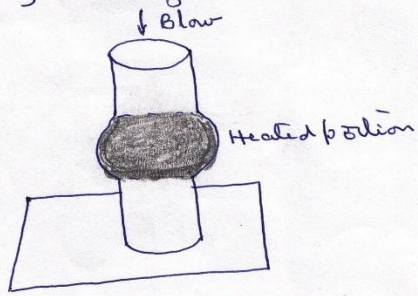
Characteristics :-

1. Any cross sectional shaped can be extruded from the non ferrous metals.
2. Number draft is required so extrusion can offer saving in both metals and weights.
3. Cross sectional shapes are not possible by rolling.
4. More times is wasted in other process to change the shape since the dies may be removed and mounted quickly in the extrusion process.
5. Dimensional accuracy is better then compared rolled ones.
6. The range of extruded items is very wide. Rods from 3 to 25 mm in dia. Pipes of 20 to 400 mm diameter and wall thickness of 1 mm and above. Components contains complicated shapes which cannot be obtain by other methods, but can obtain this process.
7. Very large reduction possible compared to rolling.
8. Automation of extrusion is simpler as etc ms are produced in single passing.

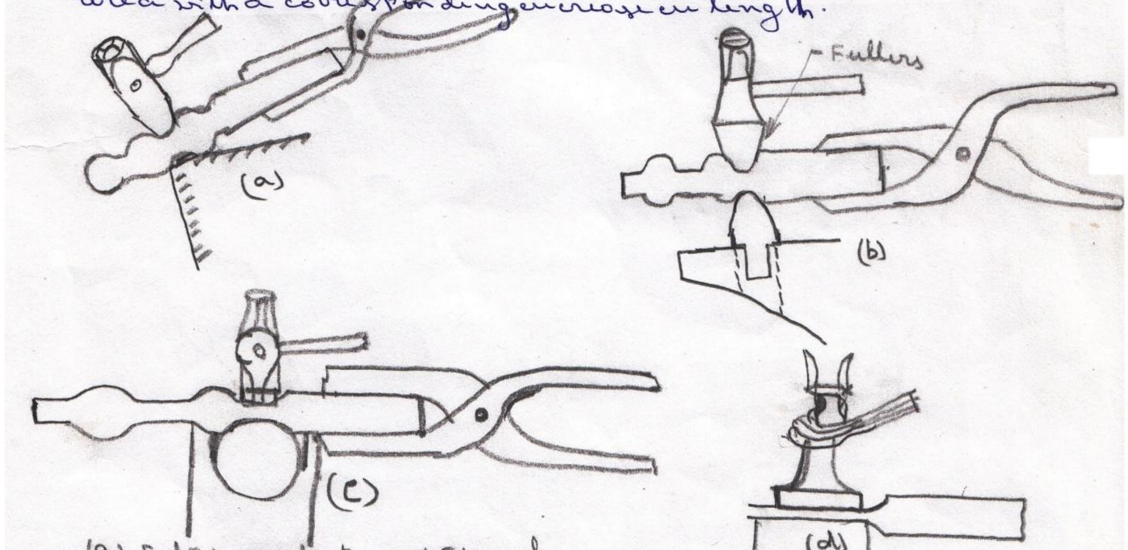
Smithy operations

1. Up setting 2. Drawing down 3. Setting down 4. Fullering, 5. Swaging 6. Punching 7. Drifting 8. Bending 9. cutting 10. Welding

1. Up setting: It is the process of increasing the cross sectional area by reducing the length



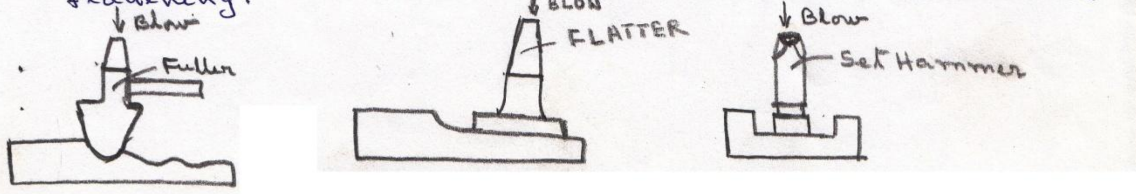
2. Drawing down: It is the process of decreasing the cross sectional area with a corresponding increase in length.



(a) Edge and straight peen hammer.
(b) Set of fullers.
(c) Horn and Hand hammer.
(d) Finishing by flatters

3. Setting down: It is the process of decreasing the thickness rather than a general reduction of area

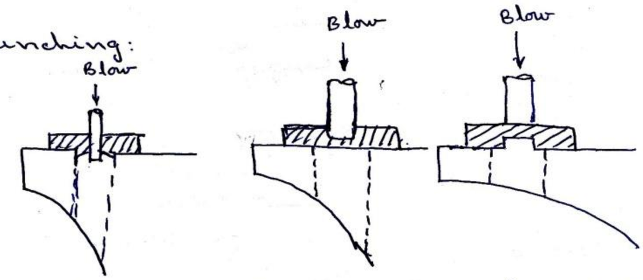
Finishing and smoothing the surface with flatters is called flattening.

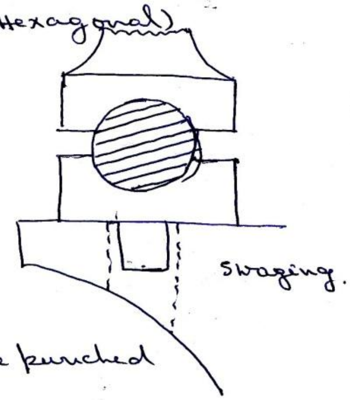


4. Fullering: It is the process of increasing the length by necking the bar between two fullers

5. Swaging: Swaging is an operation by which a smooth and accurate shape of desired size is obtained (Round or Hexagonal)

6. Punching:

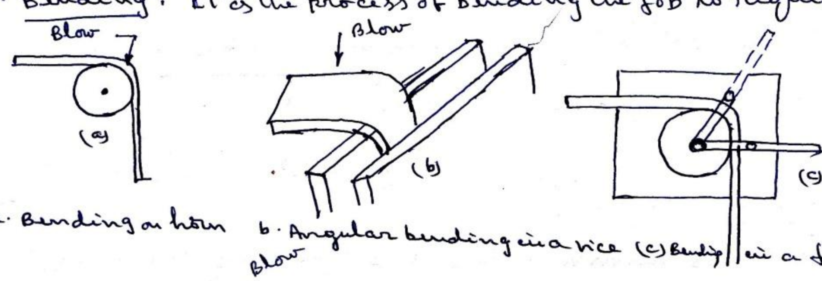




Swaging.

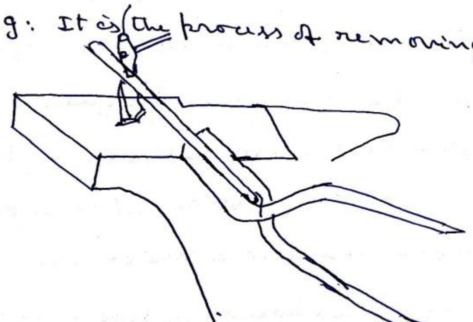
7. Drifting: It is the process of enlarging the punched hole.

8. Bending: It is the process of bending the job to required shape.



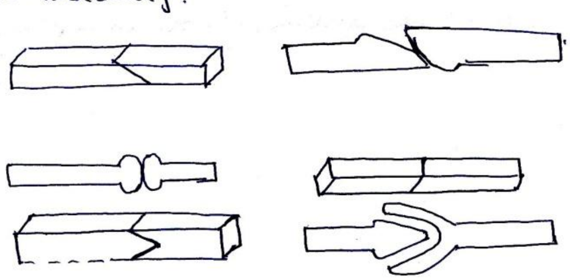
a. Bending on horn b. Angular bending in a vice (c) Bending in a fixture for mass production

9. cutting: It is the process of removing excess metal from the stock.



cutting with Hot chisel.

10. Welding:



scarf or lap joint and its preparation

Butt joint and its preparation

V-Joint and its preparation

FORGING HAMMERS OR POWER HAMMERS:-

Power hammers are used for medium and large jobs forging. They consists of anvil block which supports jobs during forging. The heavy falling part of the hammer is called the ram. The anvil block and ram has one die each. They are called upper die and lower die to bring the metal to the required shape.

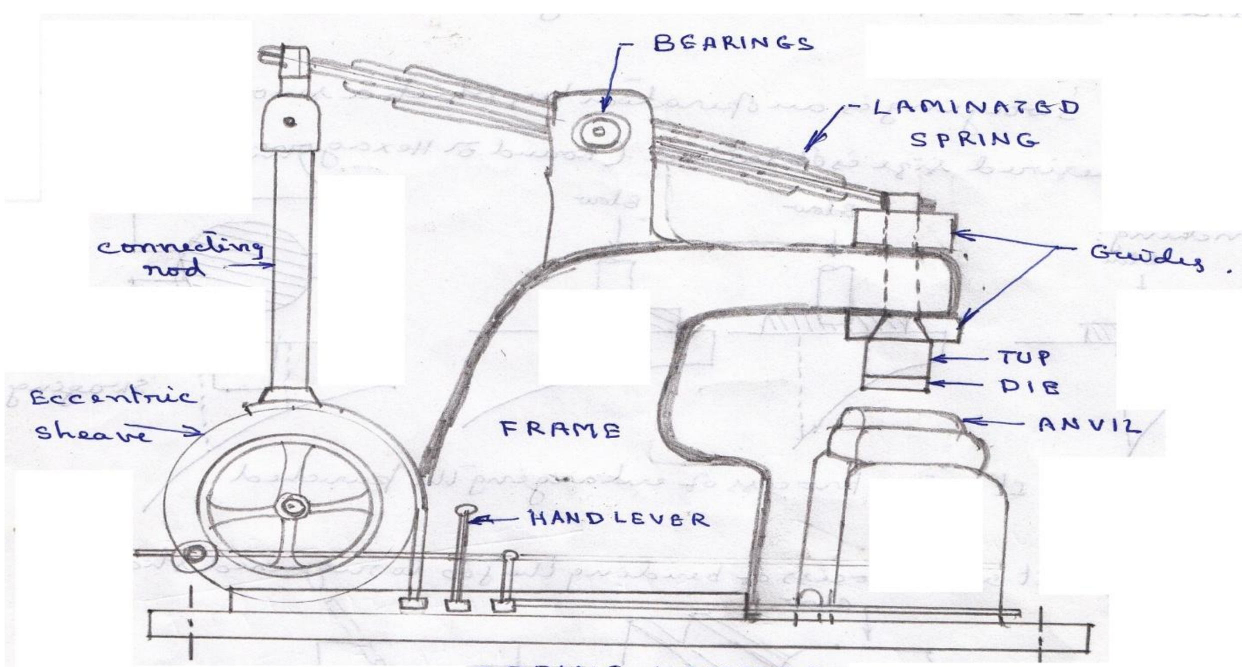
The capacity of the power hammer is given by the total weight of the ram and die. To increase the intensity of blow the ram and die has to fall from greater height.

Classification of (power hammers):-

1. Mechanical hammers
   a. Spring hammer
   b. Pneumatic hammers
2. Drop hammers
   a. Steam or aid drop hammers
   b. Board or gravity drop hammers

In mechanical hammers the work is forged in drop hammers, the dies are not flat.

SPRING HAMMERS:-



SPRING HAMMER

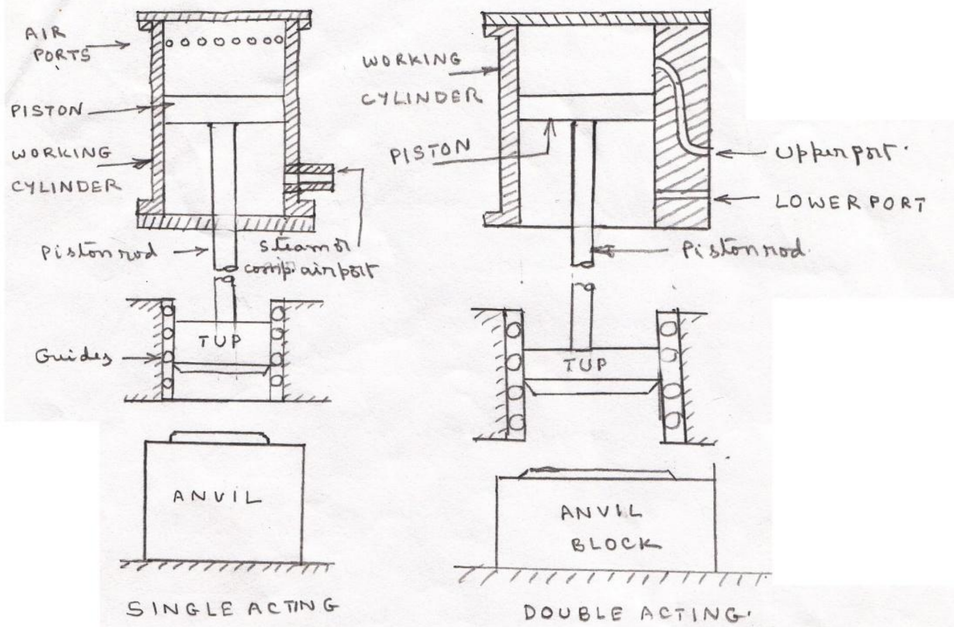
The spring hammer has rigid frame. To this a laminated spring is attached to the connecting rod which is attached to the eccentric sheave. When the treadle is pressed down eccentric sheave rotates. This causes the spring to oscillate about the pivot. As the spring oscillates the ram moves up and down in the guide to strike the work placed on anvil. The stroke of the connecting rod is adjusted by hand lever to control the intensity of blows on the jobs of various sizes.

This hammer is available in various sizes. The force of ram varies from 0.3 to 2.5 KN with 40 to 300 blows/ minute.

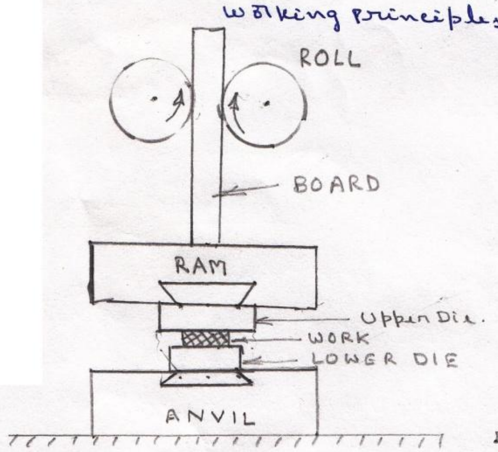
PNEUMATIC HAMMER:-

This hammer has two cylinders. Compressor cylinder and ram cylinder. Piston of the compressor cylinder compresses the air and delivers it to the ram cylinder where it actually the piston which is in with ram delivering the blows to the work. The reciprocating of compression piston is obtained from a crank drive which is powered from a motor through a reducing gear. The air distribution device between the two cylinders consists of rotary valve with parts through which air passes into the consists of rotary valve with parts through which air passes into the ram cylinder below and above the piston. This drives the ram up and down respectively.

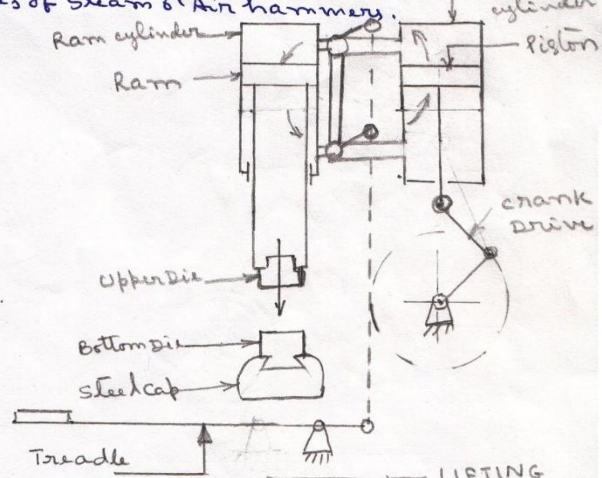
Steam or Air Hammers:



Working principles of Steam or Air hammers.



BOARD OR GRAVITY HAMMER

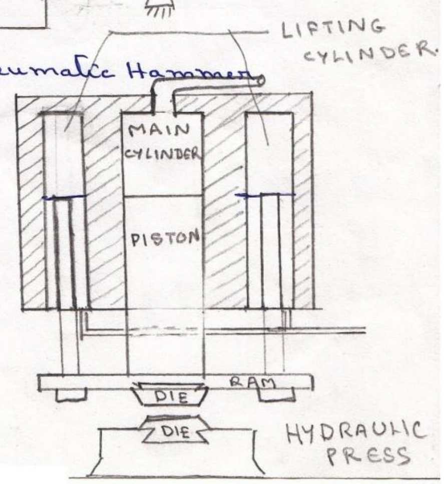


Pneumatic Hammer

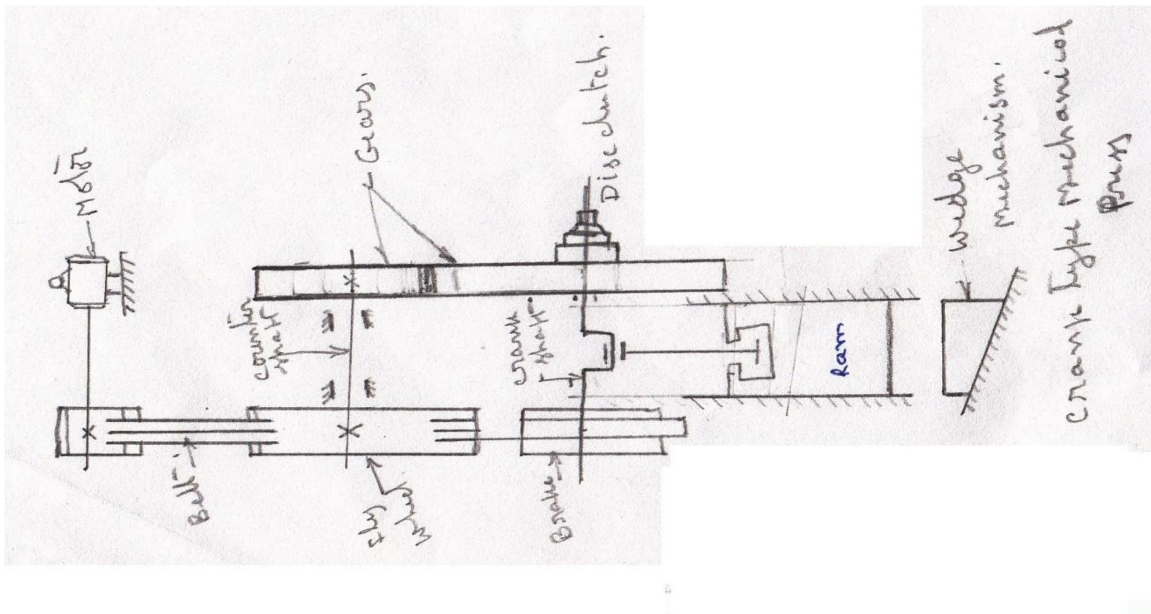
Forging press;

Mechanical Press

Hydraulic Press: The ram is moved by the pressure of the fluid. oil is mostly used in modern press. The pressure of oil is increased by pump and is transmitted to the cylinder in order to lift the ram or force it down. The usual capacity of hydraulic press is about 150 MN.



HYDRAULIC PRESS



Impression dies are used. Parts are made by plastically deforming a metal blank into die cavities by a slow squeezing action. Pressure is developed gradually resulted in a maximum penetration and in improved grain flow throughout the entire forging. Complicated forgings are removed manually or mechanically from the cavities.

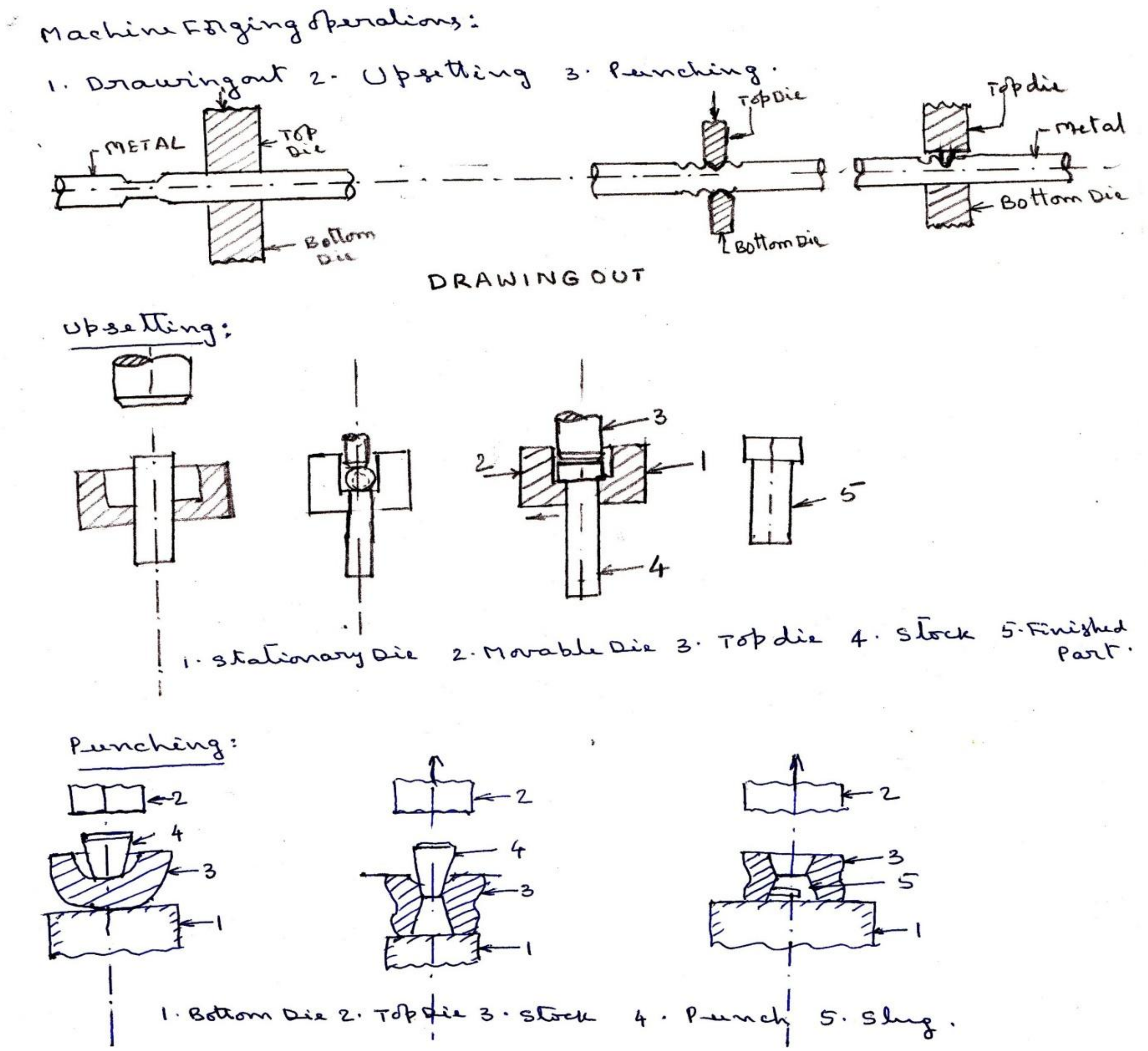
Pressures for press forging are mechanical presses or hydraulic press

An electric motor drives the fly wheel mounted on the counter shaft by means of belt drive. Torque from the counter shaft through gearing .From the crank shaft reciprocating motion is given to the ram by means of connecting rod. The bottom dies is located in positive by means of wedge mechanism which is brought to a gradual stop by means of a break. Clutch mechanism is used to start and stop.

DIES:-

dies are made of high grade carbon or alloy steel and must resist heat, abrasion and pressure. They must with the stand severe strains, long wear life and minimize checking. The majority blocks are heat treated before impression are machined to avoid working and cracking.

In general impression dies last 15000 to 30000 patterns before they need reworking. The dies are made in sections, called inserts fitted in to the die block. Locking surfaces or pins can be provided so that the dies match each other.



TOOLS USED IN MACHINE FORGING:-

1. DIES 2.SWAGES 3.PUNCHES 4.TONGS 5.FULLERS OR SPREADERS 6.HOT SETS 7.CUTTERS 8.CHARGING BAR

Used for charging round and square from 500 to 2000 kg in weight, in to heating furnaces and for delivering them from furnaces to the bottom die of the hammer.

Reasons for defects in forgings:-

1. Due to defective original metal
2. Improper heating of component for forging
3. Faculty die design.
4. Improper placement of metal in the die
5. Forging operations not carried out properly.
6. Faculty forging design.

DEFECTS FOUND IN FORGING:-

1. Cold shuts :- found in corners and right angles to the surface. Looks like cracks due to the metal folding against it self during forging the possible causes are:
   a. Misplacing the metal in the die
   b. Poor design of forging
   c. In correct die design
2. Mismatched forgings:- due to mis alignment of upper die and lower die end
3. Unfilled sections :- die cavity is not filled completely with metal.
   Causes:-
   a. Use of insufficient quantity of metal
   b. Misplacing the metal in the die
   c. Not heating the metal sufficiently
   d. Incorrect die design
   e. Poor forging design
4. Ruptured fiber flow lines:- due to rapid flowing of the metal
5. Slur pits:- depressions caused by scale due to the scales formed was not removed from the die
6. Burnt and overheated metal:- this is caused by heating the metal to high temp or for a too long to me

Safety precautions:-

1. Work price should not keep against the air blast. It should be kept in heat gone.
2. Cold metal should not be directly inserted in the forge as it may produce cracks.
3. Job should be given minimum possible member of heats because molecular structure may be damaged due to more heating's.
4. Wear face shield when hammering hot metal
5. Wear gloves
6. Hammers should be fitted with wedged handles
7. Use proper hand tools
8. Super risers room.
9. Stores for finished products.