FORGING

* Forging can be defined as the controlled plastic deformation of metal at elevated temperatures into a predetermined size or shape by using compressive forces.

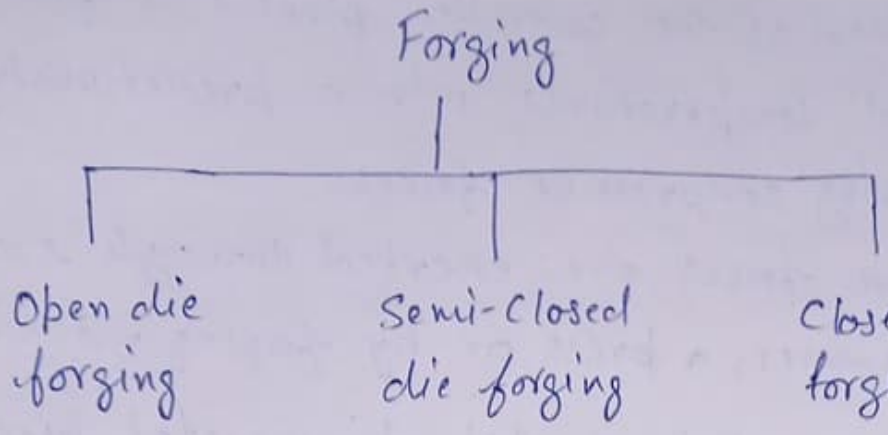
Compressive forces are exerted through some type of die by a hammer, a press or by forging machines.

* The process of giving a desired shape to a metal piece by heating and also hammering is known as forging.

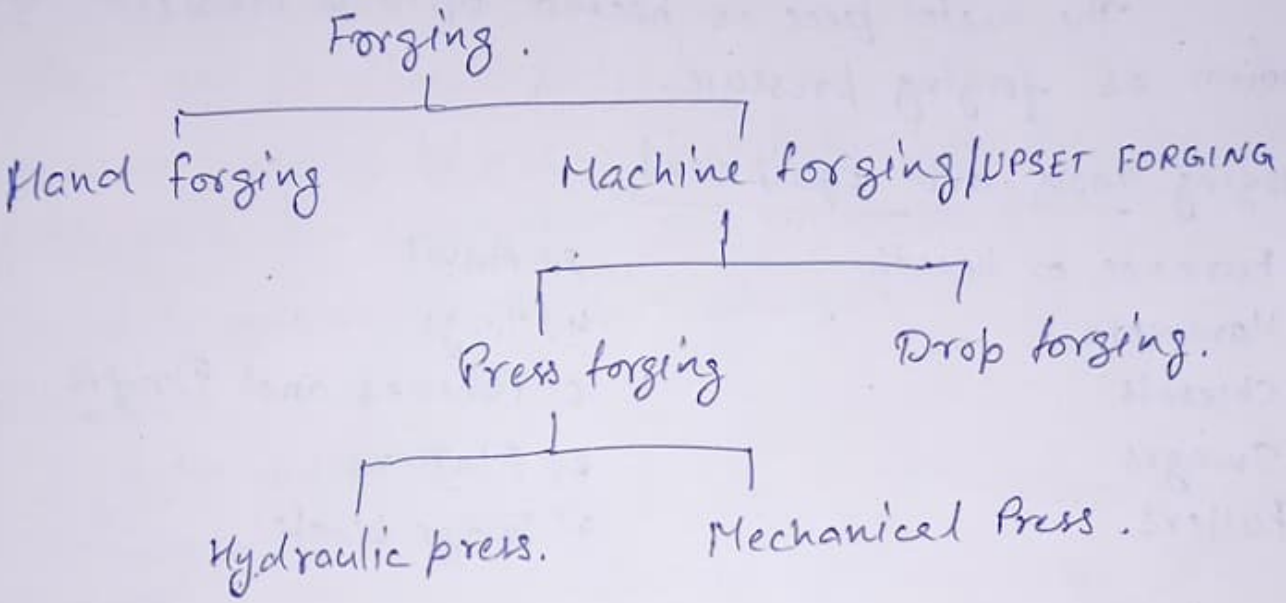
The metal piece is heated upto a desired temperature, known as forging pressure.

* Forging Tools and Equipment

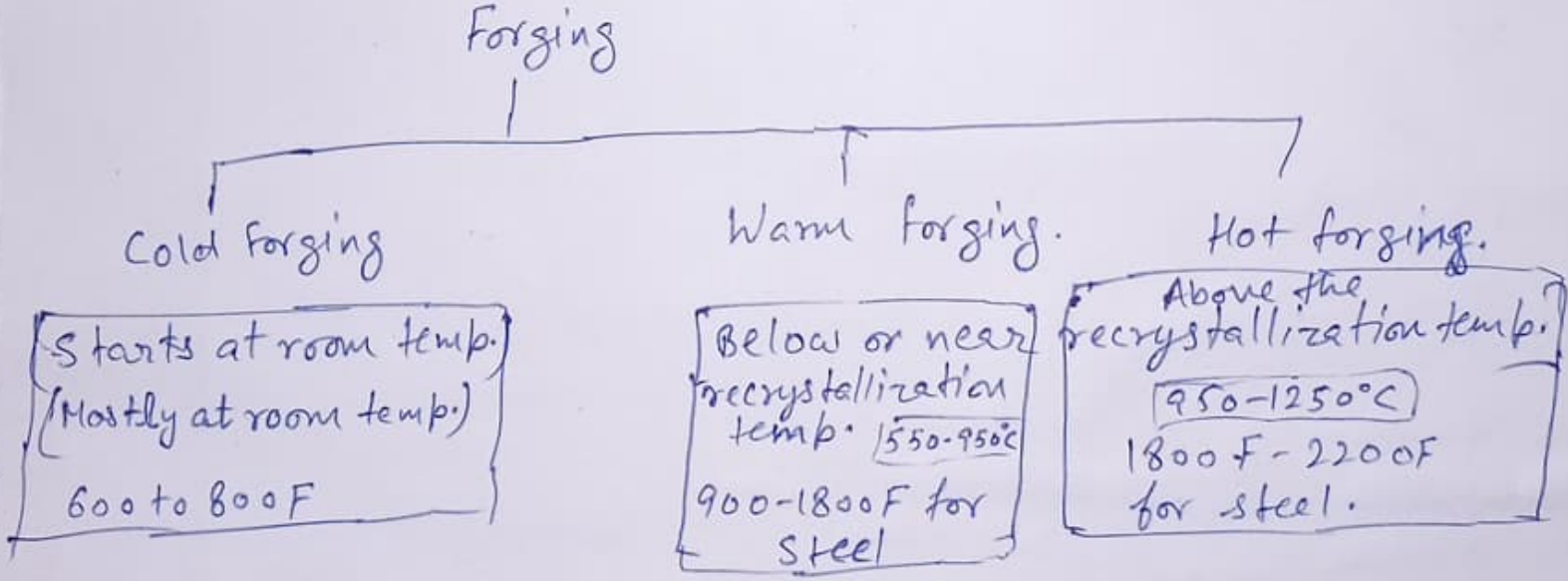
1.) Furnace or hearth.
2.) Anvil
3.) Hammers
4.) Tongs
5.) Chiesels
6.) Punches and Drifts.
7.) Swages
8.) Flatters
9.) Fullers
9.) Swage block.



On the basis of method of application of force.

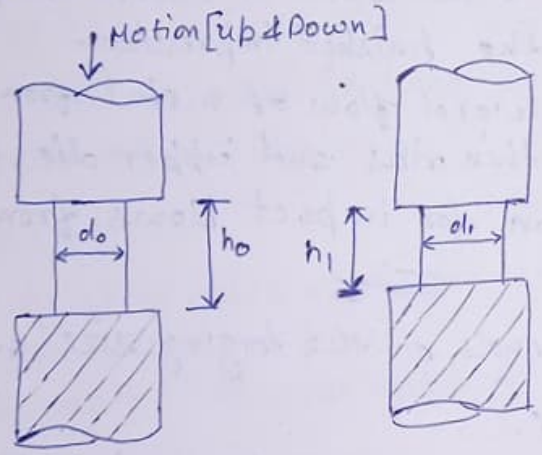


On the basis of temperatures.



OPEN-DIE FORGING

- Open die forging is the process of deforming a piece of metal between multiple dies that do not completely enclose the material.
- The metal is altered as the dies "hammer" the material through a series of movements until the desired shape is achieved.
- Products formed through open forging often need secondary machining and refining to achieve the tolerances required for the finished specifications.
- It is often used for simple parts.
- The repeated working of the material through the deformation process increases the strength of the grain structure.
- It improved fatigue resistance and strength.
- It also reduces voids.



Before forging After forging.

Assumption: Volume remain constant

i.e. Volume before forging = Volume After forging

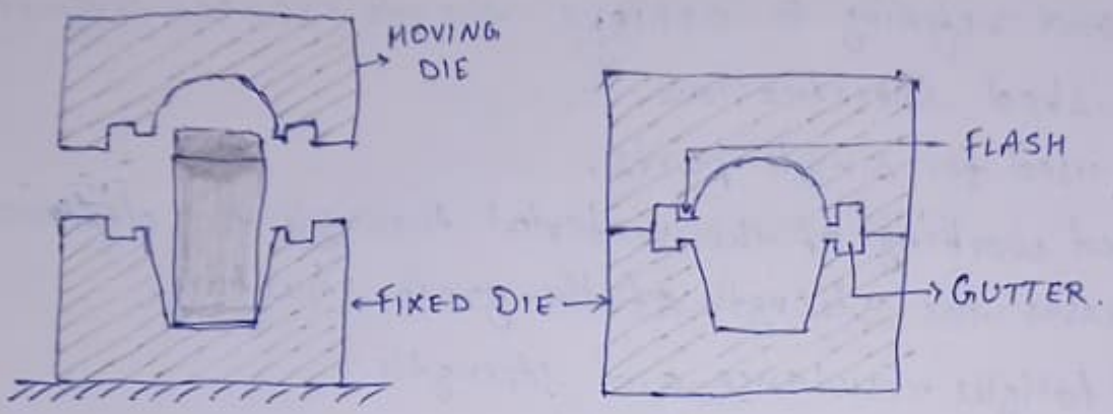
$$\frac{\pi}{4} d_o^2 h_o = \frac{\pi}{4} d_1^2 h_1$$

$$d_1 = d_o \sqrt{\frac{h_o}{h_1}}$$

$$h_1 = \left(\frac{d_o}{d_1}\right)^2 \cdot h_o$$

CLOSED DIE FORGING / IMPRESSION DIE FORGING

- It is a metal deformation process that uses pressure to compress a piece of metal to fill an enclosed die impression.
- It is also used to modify the shape of the material into the final desired shape and form.
- The type of material, tightness of tolerances and need for heat treatment can determine the number of passes the product requires through the dies.



FLASH: The excess metal added to the stock to ensure complete filling of the die cavity in the finished impression.

- It helps to restrict the outward flow of metal from the die and helps in filling thin ribs and upper die.
- A flash acts as a cushion for impact blows from the finishing impression.
- The amount of flash depends on the forging size and may vary from 10 to 50%.
- The forging load can be decreased by increasing the flash thickness.

GUTTER: In addition to the flash, provision should be made in the die for additional space so that any excess metal can flow and help in the complete closing of the die.

DRAFT:

* Draft provided on the sides for easy withdrawal of the forged piece.
* Draft should be provided at least 3° for aluminium and 5 to 7° for steel.
* Internal surfaces require more draft than external surfaces. During cooling, forging tends to shrink towards its centre and as a result, the external surfaces are likely to be separated, whereas the internal surfaces tend to cling to the die more strongly.

FOREGABILITY: The ability of a metal to undergo deformation by forging without cracking.
- Foregability increases with temperature.

FORGING OPERATIONS

1.) Upsetting:
- Increase the cross-sectional area of the workpiece at the expense of its length.

2.) Fullering
- In fullering, open die with convex surfaces are used to deform the work piece.
- The result is to cause material to flow out of one area and to both sides.

3.) Edging/Rolling:
- It performs the shape.
- It gathers the material as required in final forging.

4.) Bending
A process inwhich a force is applied to a piece of sheet metal, causing it to bend at an angle and form the desired shape.

(5) Punching and Drifting:
- To produce various types of holes in metal sheet.

(6) Forged Welding
- It is a process of joining two metal pieces to increase the length of job.

(7) Flating and Setting Down
- To remove hammer marks and to obtain a smoth surface on the job, a flatter or set hammer is used.
- Setting down is the operation bywhich the rounding of a corner is removed to make it square by hammer.

(8) Swaging:
- It is done to reduce and finish work for desired shape and size, usually either round or hexagonal.
- For small jobs top to bottom swage pair is employed. whereas for large work swage block can be used.
- finishing is given where the uneven surface of forging is smothened out with use of flatters or set hammer and round stems are finished to size with the use of swages.

COLD FORGING :

PROCESS FLOW

RAW MATERIAL → Receipt, Inspection & Billet cutting etc.

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Heat Treatment → Annealing
- to remove strain hardening.
- to set the desired mechanical properties.
- to normalize the microstructure.

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Surface treatment → Surface treatment
- to remove dust & oil cleaning by acid and degreasers.
- Pre coating - Phosphating.
- Soaps : Sodium / Calcium stearaters.

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Cold forging → Single or multi stage forging.
Secondary forming : Thread rolling / Machining.

Types of Cold forging processes.

- Cold forging
  - Extrusion
    - Forward.
    - Backward.
  - Coining
  - Rolling.
  - Punching.
  - Pearcing.
  - Blanking.
  - Heading.

Warm forging: Performed at temperatures above or below recrystallization temperature.

- 550°C to 950°C.

Recrystallization Temperature.

The minimum temperature atwhich destroyed grains of a crystal structure are replaced by the new strain free grains.

FORGING PROCESSES BASED ON TEMPERATURE

COLD FORGING	WARM FORGING	HOT FORGING
ADVANTAGES		
- Precision Process (Tight Tolerance) - Improved Part strength. - Better surface finish - Material Conservation	Combined Advantages of Cold & Hot forging. - Better formability - Lower forming Pressure - Higher deformation ratio No annealing required	- Can Forge Complex shapes. - Good formability. - Low forming Pressure. - Can forge parts of higher Weight & Volume.
DISADVANTAGES		
- High forming Pressure. Several Pre-forming Steps Needed. Annealing steps may be required during process. Low formability.	- High Tooling Costs. Tooling must withstand forming Pressures as well as High temperatures.	- formation of scale. Decreased Accuracy (Larger Tolerance)

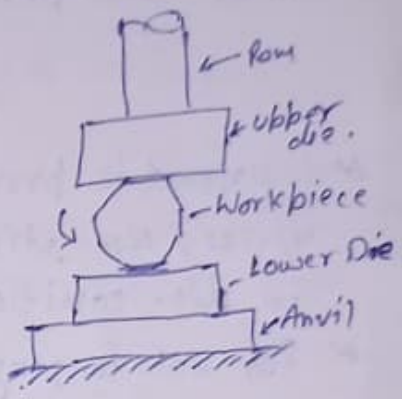
HOT FORGING WITH FLASH

HAND FORGING / SMITH FORGING:

- Oldest type of forging method.
- It is carried out by striking the heated part repeatedly until it takes on the desired shape & size.
- It is mainly used for small scale production.
- It is also called flat die and open die forging.

DROP FORGING:

- Drop forging die consists of two halves. Lower half is fixed to the anvil of the machine, while the upper half is fixed to the ram.
- In this process, the metal is heated and under the impact of ram/hammer, the heated metal which is very mellable will fills the die cavity. Excess metal is trimmed off.
- This process can be used for mass production.



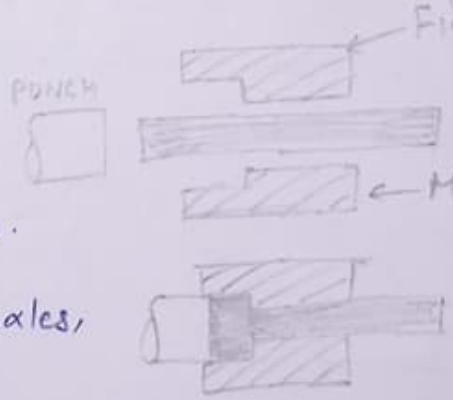
PRESS FORGING

Metal is squeezed gradually by a hydraulic or mechanical press and component is produced in a single closing of die, hence the dimensional accuracy is much better than drop forging.

UPSET FORGING / MACHINE FORGING

It consists of gripping heated bar stock b/w two dies and striking the end with another die.
This is called hot heading operation.

Application: Gear blanks, flanges on axles, valve system.



ROLL FORGING :

This method is used to produce the parts, which are having varying cross-section. The workpiece is fed against the set of rollers. The rollers are not completely circular. About half or more portion of these rolls is cut away to allow the stock to enter through them. The required size is obtained in more than one stages.

— Used to produce the leaves, leaf springs, cutlery & scissors, axles and performed blocks for forging.

LUBRICATION FOR FORGING

* Lubricant is provided to reduce friction, wear, deforming forces, Non-sticking, thermal barrier and flow of material in die-cavities.
* for hot forging – Graphite, MoS_2, Molten glass.
* for Cold forging – Mineral oil, Soaps.

In hot forging the lubricant is applied to the dies, but in cold forging, it is applied to the workpiece.

FORGING DEFECTS

(1) **Unfilled Sections**
Die cavity is not completely filled, due to improper design of die.

(2) **Cold Shut or Fold:**
A small crack at the corner and at right angles to the forged surface.
Cause – Improper design of the die.

(3) **Scale Pits:**
Irregular depressions on the surface due to improper cleaning of the stock.

(4) **Die Shift:**
Due to Misalignment of two die halves.
Making the two halves of the forging to be of improper shape.

(5) **Flakes:**
Internal ruptures caused by the improper cooling.

(6) **Improper grain flow:**
Due to improper design of the die, the flow of metal not flowing the final intended directions.

(7) **Forging Laps:**
- These are folds of metal squeezed together during forging.
- They have irregular contours and occurs at right angles to the direction of metal flow.

(8) **Hot tears and thermal Cracking.**
These are surface cracks occuring due to non-uniform cooling from the forging stage or during heat treatment.

#Barrelling. [Forging Defects]
Due to the friction b/w die & workpiece the body is not able to expand freely but at towards the centre the effect of friction is reduced.
∴ the workpiece expands at the centre.
This non-uniform deformation in the area of the workpiece is known as barrelling.