

MANUFACTURING PROCESS OF A FORGED COMPONENT

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ABSTRACT:

The basic concept discussed here is about forging process by using different equipments like pneumatic hammer, forging machines, furnaces, saddles, dies etc. The use of forging is to reduce material wastage and manufacturing time, avoids complex machining operations and used for mass production.

Forging includes various operations like up-setting, punching, roll forging and flattening. The process includes heat treatment and proof machining also. Pneumatic forging hammers, hand tools like saddles, mandrels, punches, calipers and tongs will play prominent role in this process.

INTRODUCTION:

Forging is the process by which metal is heated and is shaped by plastic deformation by suitably applying compressive force. Usually the compressive force is in the form of hammer blows using a power hammer or a press.

Forging refines the grain structure and improves the physical properties of the metal. With proper design, the grain flow can be oriented in the direction of principal stresses encountered in actual use. Grain flow is the direction of the pattern that the crystals take during plastic deformation. Physical properties (such as strength, ductility and toughness) are much better in a forging than in the base metal, which has, crystals randomly oriented.

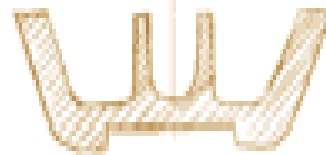
FORGING PROGRESSION



Sheared Billet



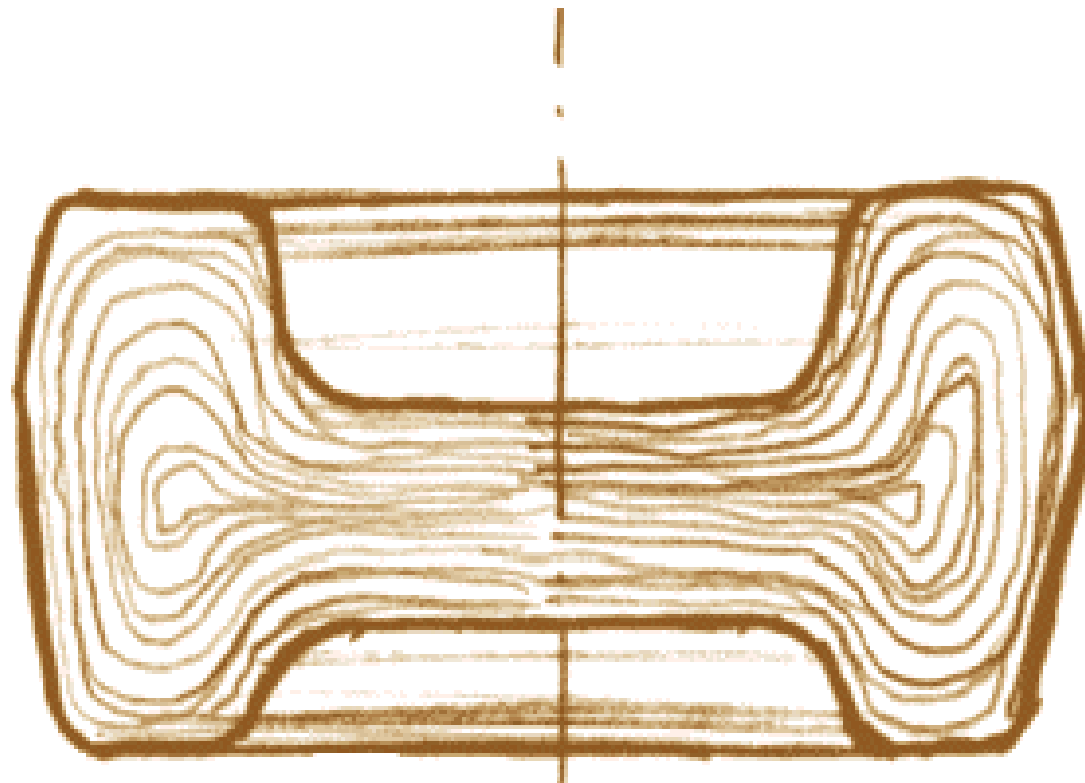
Upset Pancake



Finished Part

A Forged metal can result in the following :

- Increase length, decrease cross-section, called drawing out the metal.
- Decrease length, increase cross-section, called upsetting the metal.
- Change length, change cross-section, by squeezing in closed impression dies. This results in favorable grain flow for strong parts



FORGING GRAIN FLOW

COMMON FORGING PROCESSES:

The metal can be forged hot (above recrystallization temperatures) or cold.

- **Open Die Forgings / Hand Forgings:** Open die forgings or hand forgings are made with repeated blows in an open die, where the operator manipulates the work piece in the die. The finished product is a rough approximation of the die. This is what a traditional blacksmith does, and is an old manufacturing process.
- **Impression Die Forgings / Precision Forgings:** Impression die forgings and precision forgings are further refinements of the blocker forgings. The finished part more closely resembles the die impression.

Design Consideration:

- Parting surface should be along a single plane if possible, else following the contour of the part. The parting surface should be through the center of the part, not near the upper or lower edges. If the parting line cannot be on a single plane, then it is good practice to use symmetry of the design to minimize the side thrust forces. Any point on the parting surface should be less than 75° from the principal parting plane.
- As in most forming processes, use of undercuts should be avoided, as these will make the removal of the part difficult, if not impossible.

Recommended draft angles are described in the following table.

Material	Draft Angle (°)
Aluminum	0 - 2
Copper Alloys (Brass)	0 - 3
Steel	5 - 7
Stainless Steel	5 - 8

Generous fillets and radius should be provided to aid in material flow during the forging process. Sharp corners are stress-risers in the forgings.

Height of Protrusion mm (in)	Min. Corner Radius mm (in)	Min. Fillet Radius mm (in)
12.5 (0.5)	1.5 (0.06)	5 (0.2)
25 (1.0)	3 (0.12)	6.25 (0.25)
50 (2.0)	5 (0.2)	10 (0.4)
100 (4.0)	6.25 (0.25)	10 (0.4)
400 (16)	22 (0.875)	50 (2.0)

FORGING TEMPERATURES:

- **Forging temperature** is a temperature at which a metal becomes soft like clay or its shape can be changed by applying a relatively small force without creating cracks in metal.
- Note: Temperatures for alloys (combination of metals) will lie between the temperatures specified for the metals utilized.

CHART FOR FORGING TEMPERATURE:

Material	Celsius	Fahrenheit
Carbon steel	1230	2246
Stainless steel (Magnetic)	1095	2003
Stainless steel (Nonmagnetic)	1150	2102
Nickel	1095	2003
Titanium	955	1751
Copper	900	1652
Brass	815	1499
Commercial bronze	900 to 419.53	1652 to 787.154
Aluminum	540	1004

HAND FORGING:

Iron or steel heated and hammered to shape without the use of "closed dies". Drop forging uses "closed dies". Other than moving the piece from one cavity to the next there is no human input to the shape of the finished piece, the dies do it.

Hand forging involves hammering the heated metal on an anvil - the movement of the material and the finished form are determined by the smith as the material is moved under the hammer. Each piece is slightly different. If you find "Hand Forged" and a barcode on plastic packaging is suspicious.



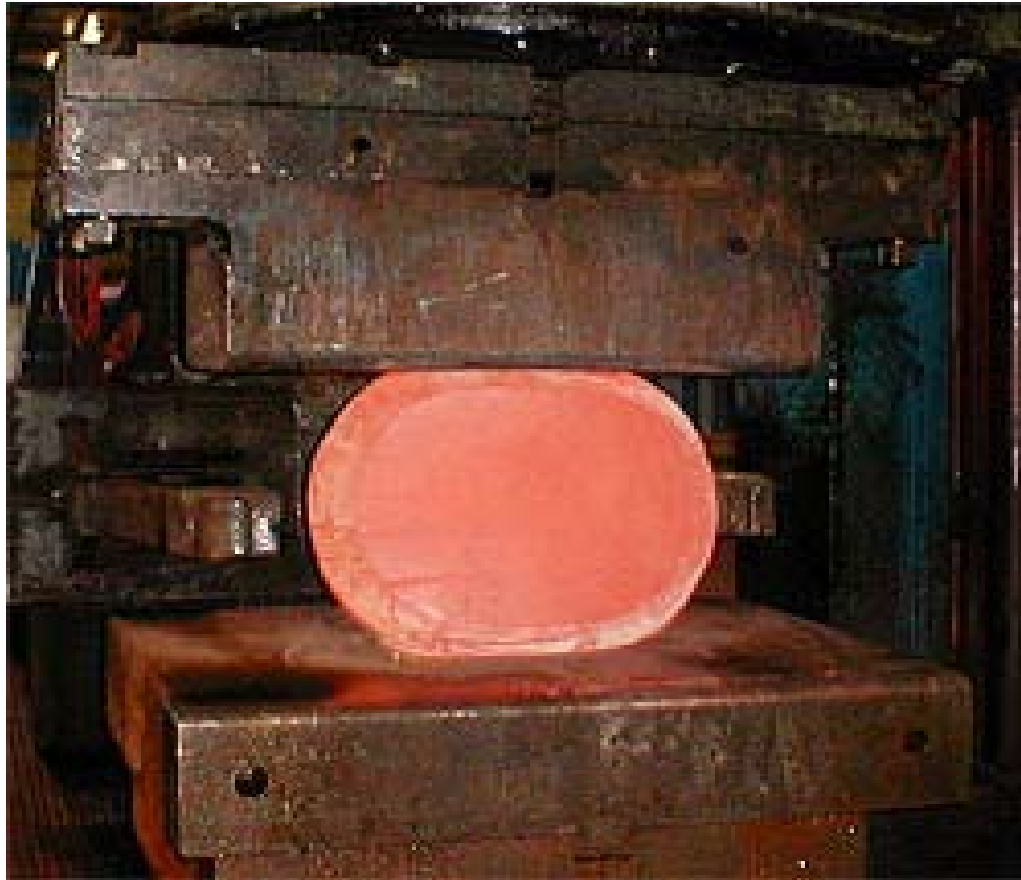
Tools used in hand forging : Anvil, Swage block, Tongs, Hammers, Chisel, Fullers, Flatters, Punches, Drifts.

PRESS FORGING:

Press forging works slowly by applying continuous pressure or force, which differs from the near-instantaneous impact of drop-hammer forging. The amount of time the dies are in contact with the work piece is measured in seconds (as compared to the milliseconds of drop-hammer forges). The press forging operation can be done either cold or hot.

The main advantage of press forging, as compared to drop-hammer forging, is its ability to deform the complete work piece. Drop-hammer forging usually only deforms the surfaces of the work piece in contact with the hammer and anvil; the interior of the work piece will stay relatively undeformed. Another advantage to the process includes the knowledge of the new parts strain rate. We specifically know what kind of strain can be put on the part, because the compression rate of the press forging operation is controlled.

Press forging can be used to perform all types of forging, including open-die and impression-die forging. Impression-die press forging usually requires less draft than drop forging and has better dimensional accuracy. Also, press forgings can often be done in one closing of the dies, allowing for easy automation.



Tools used in press forging: Swages, Hot cutters, Tongs, Pinch-bars, Spreaders, Charging bars.



FORGING OPERATIONS:

Some of the forging operations are as follows:

- Up setting
- Roll forging
- Piercing
- Flattening
- Drawing
- Shaping

UPSET FORGING:

Upset forging increases the diameter of the work piece by compressing its length. Based on number of pieces produced this is the most widely used forging process. A few examples of common parts produced using the upset forging process are engine valves, couplings, bolts, screws, and other fasteners.



ROLL FORGING:

Roll forging is a process where round or flat bar stock is reduced in thickness and increased in length. Roll forging is performed using two cylindrical or semi-cylindrical rolls, each containing one or more shaped grooves.

A heated bar is inserted into the rolls and when it hits a stop the rolls rotate and the bar is progressively shaped as it is rolled out of the machine. The work piece is then transferred to the next set of grooves or turned around and reinserted into the same grooves.

This continues until the desired shape and size is achieved. The advantage of this process is there is no flash and it imparts a favorable grain structure into the work piece.



MATERIALS USED IN FORGING:

Mostly in forging, Ferrous & Non-Ferrous metals are used in manufacturing purpose.

Ferrous metals: These contain iron as a main constituent. These are stronger. Some of them are low and medium carbon steels, alloy steels, stainless steels, titanium, die-steels.

S.NO	FERROUS METAL	FORGING TEMP, IN °C
1.	Low carbon steel	1250
2.	Medium carbon steel	850-1100
3.	Stainless steel	1200

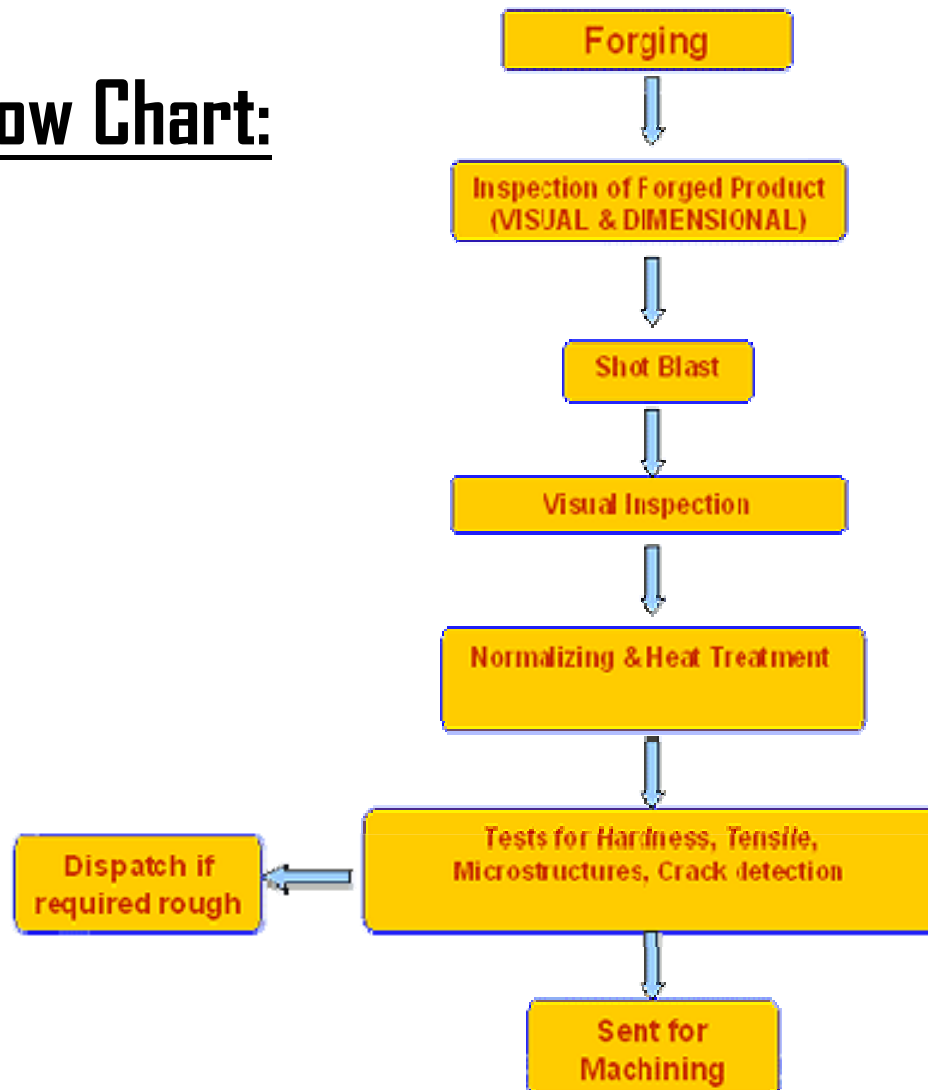
Non-Ferrous metals:

Non-ferrous metals do not contain iron as the main constituent. Generally they are weaker than ferrous metals but have other important properties such as corrosion resistance, high electrical and thermal conductivity, good formability and special electrical & magnetic properties the chief non-ferrous metals used in the industrial purpose are copper, aluminum, zinc, lead, tin, magnesium and their alloys.

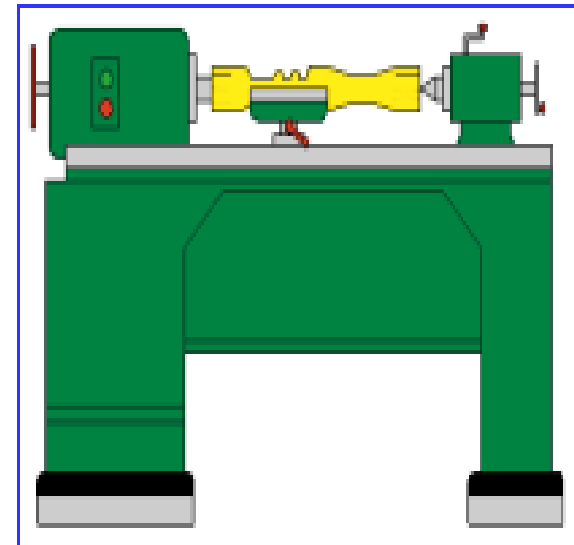
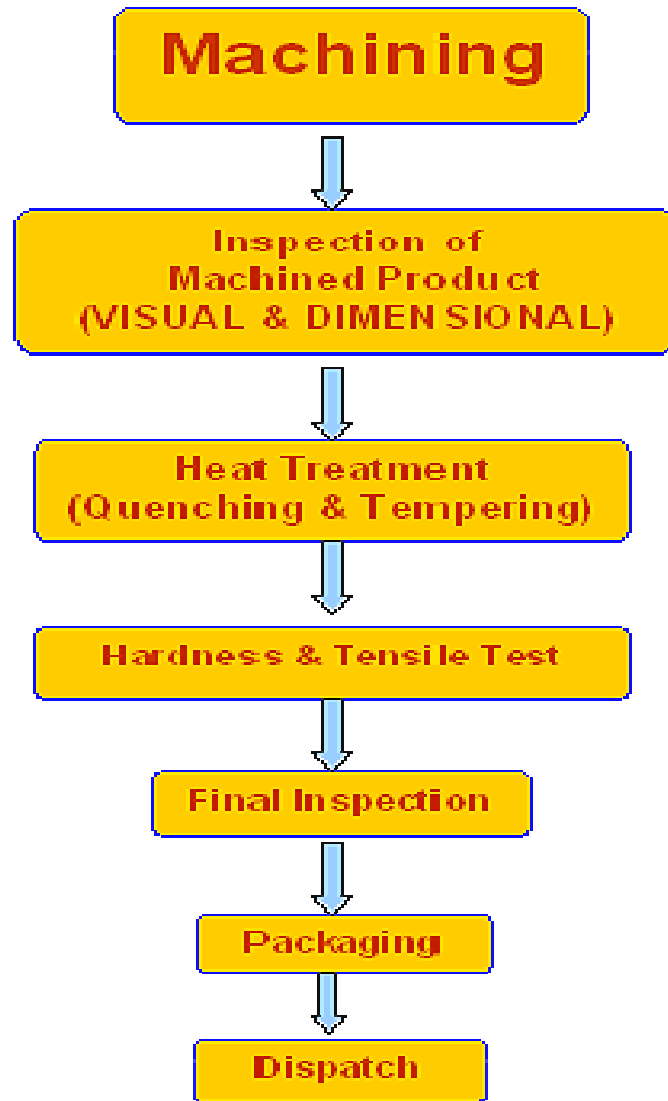
S.NO	NON-FERROUS METALS	FORGING TEMP IN °C
1.	Brass	650-800
2.	Bronze	825-900
3.	Aluminum alloys	350-450

MANUFACTURING PROCESS:

Forging Process Flow Chart:



Machining Process Flow Chart:



ADVANTAGES & DISADVANTAGES:

Advantages:

- More uniform structure with directional characteristics.
- Minimum cavities and blow holes.
- High mechanical strength and toughness.
- Smooth surface, closer dimensions permitting less machining.
- Economy in mass production.

Disadvantages:

- Size is limited
- Not suitable for complicated shapes.
- Tools and equipment cost in high.
- Process is not economical for small quantities.

CONCLUSION:

The process of forging is so simple that unskilled labour can do the job easily without inconvenience. Accuracy cannot be obtained in forging. The forged components made by using pneumatic hammer machine have high rigidity and strength.