BLACKSMITHY

7.1 INTRODUCTION

Blacksmithy or hand forging is an ancient trade. It consists of heating a metal stock till it acquires sufficient plasticity, followed by hand forging, involving hammering, bending, pressing, etc., till the desired shape is attained.

Hand forging is the term used when the process is carried out by hand tools. The hand forging process is generally employed for relatively small components. However, it calls for a remarkably high degree of skill and judgment.

If power operated machines are used for the process, it is known as machine forging. Hooks, links, lifting tackles and agricultural implements are some of the items that are produced by machine forging.

The following are the advantages of forging:

1. Strength and toughness is high.
8. Strength to weight ratio is high.
3. Internal defects are eliminated.
4. Forged parts need less or no machining.

7.8 TOOLS AND EQUIPMENT

7.8.1 Forge or Hearth

A smith's forge or hearth is used to heat the metal to be shaped. Hearths are used for heating small jobs to be forged by hand. Gas, oil or coal firing may be used for the purpose. The required air for the fire, is supplied under pressure, by a blower through the tuyere in the hearth. The blowers may either be hand operated or power driven. In the latter case, the amount of air supply is controlled by valves near the forge. Figure 7.1 illustrates

Metal	Forging temperature, °C
Mild steel Wrought iron Medium carbon steel High carbon and alloy steel	**750-1300 700-1300 750-1850 800-1150**

Heating of a metal to proper temperature is essential as excessive temperature may result in burning of the metal that destroy cohesion between atoms. Insufficient temperature will not induce sufficient plasticity to the metal, to shape it properly by hammering. Insufficient temperature also results in cold working defects like strain hardening and cracking.

7.8.8 Anvil

It provides the necessary support during forging by resisting the heavy blows rendered to the job. It is also useful for operations such as bending, swaging, etc. Its body is generally made of cast steel, wrought iron or mild steel, with a hardened top layer of about 80 to 85 mm thick. Figure 7.8 shows an anvil with various parts marked on it.

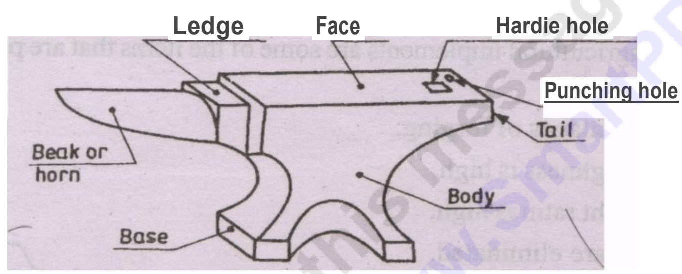


Fig. 7.8 **Anvil**

The beak or horn is used for bending metal to round shape of different radii. The portion between the beak and face is called ledge, which is used as a base for cutting operations, using hot chisels.

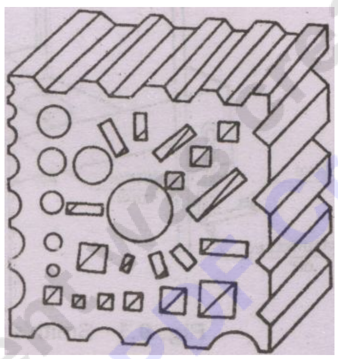
The square hardie hole is used to hold square shank tools like swages and fullers. A round hole is also provided near the hardie hole, which is used for bending round rods and as a die for hot punching operation.

Anvils are made in sizes weighing from 85 kg to 850 kg. An anvil weighing about

75 kg is suitable for general purpose.

7.8.3 Swage Block

It is also a supporting tool used in a forge shop. It has a number of slots of different shapes and sizes along its four side faces and through holes of different shapes and sizes, running from its top to bottom faces (Fig. 7.3). This is used as a support while forming (swaging) different shapes, bending and in punching'holes. It is generally made of cast iron or cast steel.



Swage block

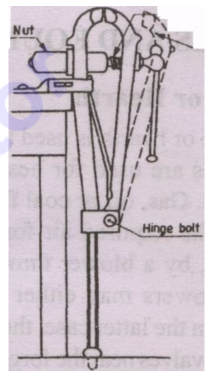


Fig. 7.4 **Leg vice**

7.8.4 Leg Vice

It is a heavy duty vice, fixed to the work bench at one end of a leg or set in a concrete base. It is mainly used for light forging and bending work (Fig. 7.4).

9.2.5 Hammers

Hammers of different types and weights are used in smithy. The ball-peen hammer used for forging, weighs 0.5 kg to 1 kg. The sledge hammer (Fig. 7.5) which is used for heavy work, has flat ends on either side and weighs 3 kg to 8 kg. The length of the handle of a hammer increases with its weight.

7.8.6 Tongs

The metal to be forged must be held securely, while it is being shaped. A pair of tongs of suitable size and shape must be used for the purpose. Figure 7.6 shows the most commonly used shapes in a smithy shop. They are made of mild steel and the sizes vary from 40 cm to 60 cm in length and 0.6 cm to 5.5 cm opening.

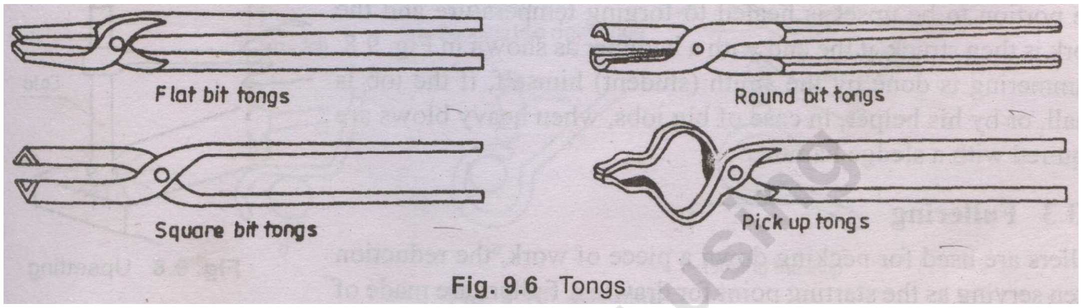


Fig. 9.6 Tongs

A flat bit tongs can hold the job along the entire length of its jaws. It is used for holding work of rectangular section. Round bit tongs is used for holding a round rod. Square bit tongs is used for holding a square rod. Pick-up tongs is used for pick-up the heated rods from the hearth.

7.3 FORGING OPERATIONS

The following are the basic operations that may be performed by hand forging:

7.3.1 Drawing-down

Drawing is the process of stretching the stock while reducing its cross-section locally. Forging the tapered end of a cold chisel is an example of drawing operation. The steps in drawing down to a point are shown in Fig. 7.7.

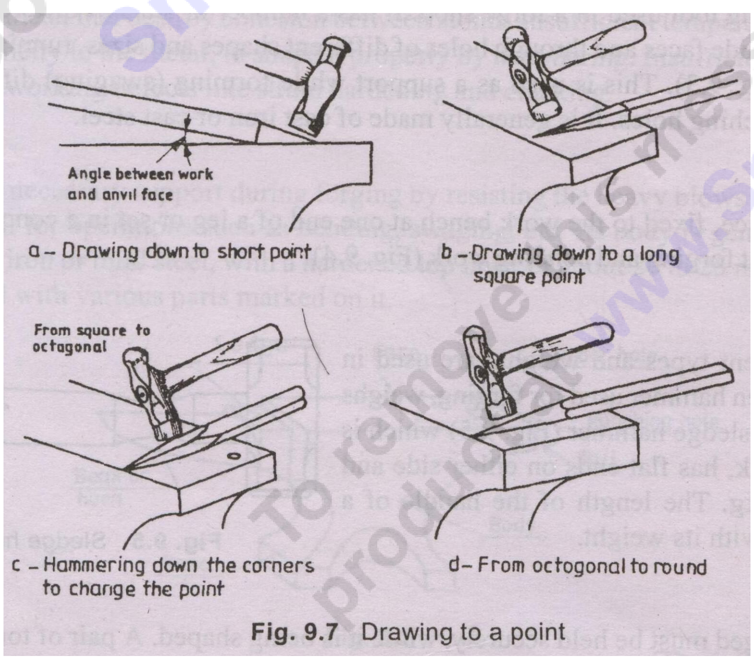


Fig. 9.7 Drawing to a point

7.3.8 Upsetting

It is a process of increasing the area of cross-section of a metal piece locally, with a corresponding reduction in length. In this, only the portion to be upset is heated to forging temperature and the work is then struck at the end with a hammer as shown in Fig. 7.8. Hammering is done by the smith (student) himself, if the job is small, or by his helper, in case of big jobs, when heavy blows are required with a sledge hammer.

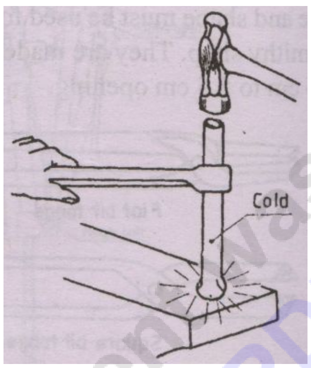


Fig. 7.8 **Upsetting**

7.3.3 Fullering

Fullers are used for necking down a piece of work, the reduction often serving as the starting point for drawing. Fullers are made of high carbon steel in two parts, called the top and bottom fullers. The bottom tool fits in the hardie hole of the anvil. Riller size denotes the width of the fuller edge. Fullering operation is shown in Fig.7.7a.

7.3.4 Flattening

Flatters are the tools that are made with a perfectly flat face of about 7.5 cm square. These are used for finishing flat surfaces. A flatter of small size is known as set-hammer and is used for finishing near corners and in confined spaces. Flattening operation is shown in Fig. 7.7 b.,

7.3.5 Swaging

Swages, like fullers are also made of high carbon steel and are made in two parts called the top and bottom swages. These are used to reduce and finish to round, square or hexagonal forms. For this, the swages are made with half grooves of dimensions to suit the work.

7.3.6 Bending

Bending of bars, flats, etc., is done to produce different types of bent shapes such as angles, ovals, circles, etc. Sharp bends as well as round bends may be made on the anvil, by choosing the appropriate place on it for the purpose. The stages in bending a loop is shown in Fig. 7. 10.

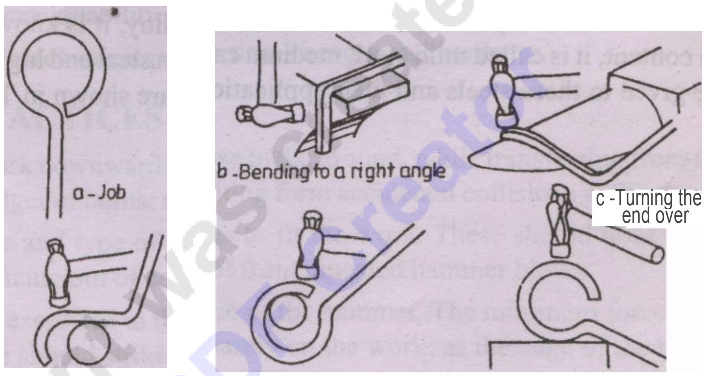


Fig. 7.10 **Bending**

7.3.7 Twisting

It is also one form of bending. Sometimes, it is done to increase the rigidity of the work piece. Small pieces may be twisted by heating and clamping a pair of tongs on each end of the section to be twisted and applying a turning moment. Larger pieces may be clamped in a leg vice and twisted with a pair of tongs or a monkey wrench. However, for uniform twist, it must be noted that the complete twisting operation must be performed in one heating. Figure 7.11 shows the twisting operation.

7.3.8 Cutting (Hot and Cold Chisels)

Chisels are used to cut metals, either in hot or cold state. The cold chisel is similar to fitter's chisel, except that it is longer and has a handle. A hot chisel is used for cutting hot metals and its cutting edge is long and slender when compared to cold chisel. These chisels are made of tool steel, hardened and tempered. Figure 7.18 shows the two chisels in operation.

7.3.7 Iron - Carbon Alloy

If the carbon content is less than 8 percent in the iron-carbon alloy, it is known as steel. Again, based on the carbon content, it is called mild steel, medium carbon steel and high carbon steel. The heat treatment to be given to these steels and their applications are shown in Table

7.8.

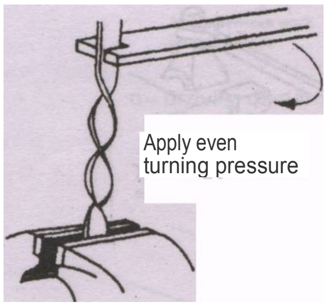


Fig. 7.11 Twisting

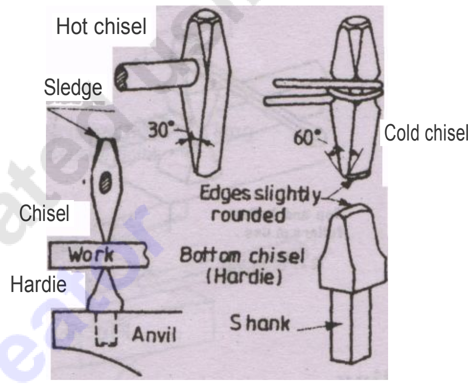


Fig. 7.18 Hot and cold chisels

Table 7.8 Plain carbon tool steels

Mild Steel	Carbon	Hardening temp. °C	Tempering temp. °C	Applications
	0.1	800-840	850-300	Chains, rivets, soft wire, sheet,
	0.85	•n	,,	tube, rod, strip
	0.5	800-840	850-300	Girders
	0.6	800-840	850-300	Saws, hammers, smith's and general purpose tools
Medium carbon steel	0.75	760-800	850-300	Cold chisels, smith's tools, shear blades, table cutlery
	0.7	760-800	850-300	Taps, dies, punches, hot shearing blades
	1.0	760-800	850-300	Drills, reamers, cutters, blanking and slotting tools, large turning tools
High carbon	1.8	780-760	850-300	Small cutters, lathe and engraving tools, files, drills
	1.35	780-760	850-300	Extra hard, planing, turning and slotting_tools, dies and mandrels
	1.5	780-760	850-300	Razor blades

NOTE: The forging produced either by hand forging or machine forging should be heat treated. The following are the purposes of heat treatment:

i. To remove internal stresses set-up during forging and cooling,

ii. To normalise the internal structure of the metal,

iii. To improve machinability.

iv. To improve mechanical properties, strength and hardness.

7.4 SAFE PRACTICES

1. Hold the hot work downwards close to the ground, while transferring from the hearth to anvil, to minimize danger of burns; resulting form accidental collisions with others.
8. Use correct size and type of tongs to fit the work. These should hold the work securely to prevent its bouncing out of control from repeated hammer blows.

   Care should be exercised in the use of the hammer. .The minimum force only should be used and the flat face should strike squarely on the work; as the edge of the hammer will produce heavy bruising v on hot metal.

4. Wear face shield when hammering hot metal.
5. Wear gloves when handling hot metal.
6. Wear steel - toed shoes.
7. Ensure that hammers are fitted with tight and wedged handles.

Models for practice

1. Make a square rod of side 10 mm, from the given round rod of diameter 15 mm.
8. Make a ring of square cross-section of side 10 mm, from a given round rod of 15 mm diameter.
3. Forge the models, the shapes of which are given in Fig. 7.13 to Fig. 7.83 from the given round

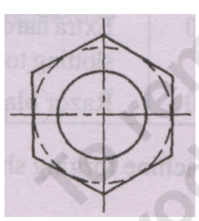


Fig. 7.14 Hexagonal headed bolt

Fig. 7.15 Square headed bolt

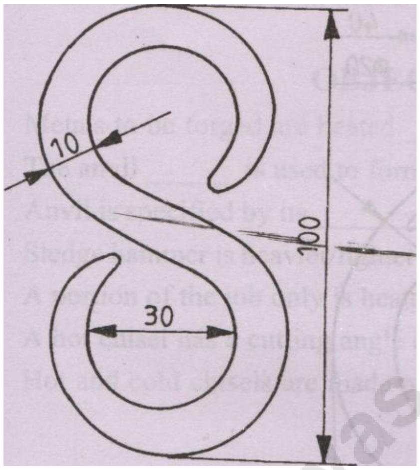


Fig. 7.17 **S-hook**

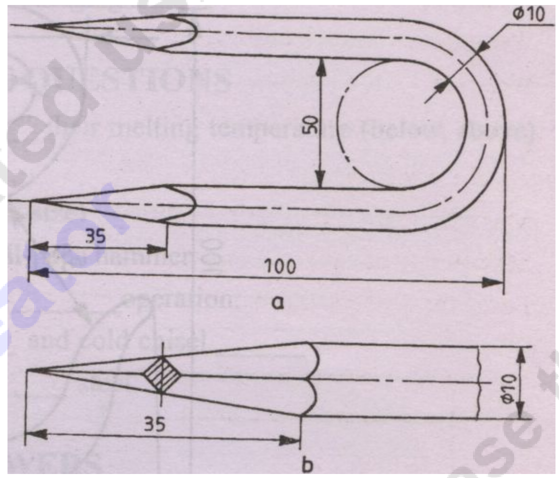


Fig. 7.18 **Staple**

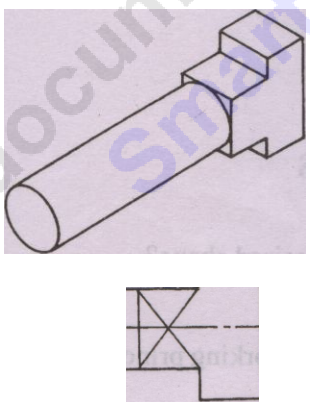


Fig. **7.17** **T-headed bolt**

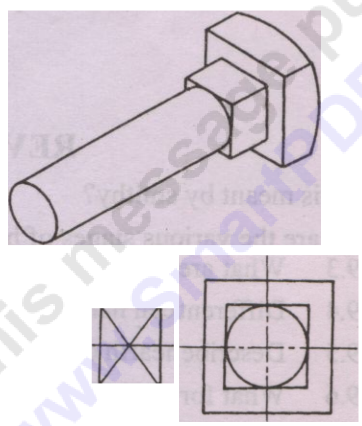


Fig. 7.80 **Square headed bolt with square neck**

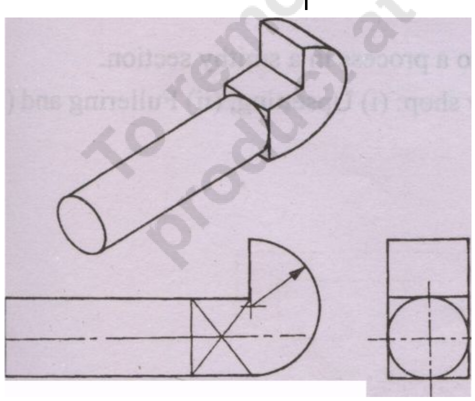


Fig. 7.81 **Hook bolt**

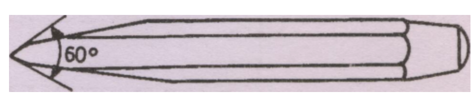


Fig. 7.88 **Flat chisel**