# SMITHY TOOLS & OPERATIONS

**Forged**, forging to form by heating and hammering; beat into shape, to form or make.

**Forging** is the process of shaping metal into its finished shape by pressing or hitting it against an anvil or die.

## 8.1 INTRODUCTION

*Smithing* is understood to handle relatively small jobs only such as can be heated in an *open fire* or *hearth*. The shop in which the work is carried out is known as the smithy or smith's shop, and the various operations are performed by means of hand hammers or small power hammers.

*Forging* refers to the production of those parts which must be heated in a *closed furnace*. The portion of a work in which forging is done is termed the forge and the work is mainly performed by means of heavy hammers, forging machines, and presses. Forging processes are among the most important manufacturing techniques since forged are used in the small tools, rail-road equipments, automobile and truck, aeroplane industries, as well as in smaller industries.

## Forgeability

- The forgeability of a metal can be defined as its capability to undergo deformation by forging without cracking
- Metal which can be formed easily without cracking, with low force has good forgeability.

Although in general the forgeability of metals increases with increasing temperature, for certain metals there is a maximum temperature above which some undesirable phenomena occur, such as fast grain growth or melting of a phase.

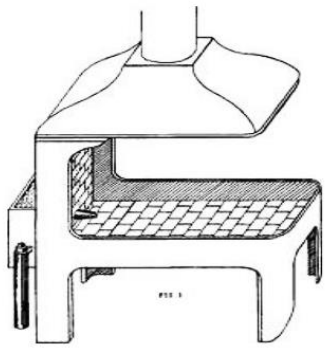
Fine grain metals have better forgeability. Two popular tests for determining the forgeability of materials are the ‘upset test’ (where cylindrical specimens are upset in steps until they start cracking radially or circumferentially) and the hot ‘twist test’ where a round bar is heated in a tubular furnace then twisted. The number of twist turns to failure is a relative measure of forgeability. Testing can be carried out in a range of temperatures.

# Heating devices

## Hearths & Furnaces

***Black Smith Forge Hearth***

- Hearth
- Tuyere (nozzle)
- Hood
- Water Tank
- Blower
- Chimney



**Furnace or hearth:**
A black smith uses a furnace for heating the metal pieces. Furnace consists of four legs, a cast iron or steel body, iron bottom, a chimney and a blower. The main parts of forging furnace are as:

***a. HEARTH:***
The iron bottom where fire is lightened is known as hearth. It is provided with fire brick lining.

***b. TUYERE:***
A pipe containing from the bottom or rear of the hearth is known as tuyere. It is used to supply the air at high pressure.

***c. HOOD:***
The upper part of furnace is called hood. It is made up of mild steel sheet with the fire brick inside it.

***d. CHIMNEY:***
Chimney is fitted on the upper end of the hood. It is used for the purpose of easy escaping of exhaust gases and smoke.

***e. WATER TANK:***
A small iron tank is attached with the hearth of the furnace. It is used for dipping purposes.

## 8.3 HEATING DEVICES

The stocks are heated to the correct forging temperature in a smith's hearth or in a furnace located *near* the forging operations. Gas, oil or electric-resistance furnaces or induction heating classified as *open* or *closed hearths* can be used. Gas and oil are economical, easily controlled, and mostly used as fuels. The formation of scale, due to the heating process, specially on steel creates problems in forging. A non-oxiding atmosphere should, therefore, be maintained for surface protection. New styles of gas-fired furnaces have been developed to reduce scaling to minimum. Electric heating is the most modern answer to scaling, and it also heats the stock more uniformly. In some cases, coal and anthracite, charcoal containing no sulphur and practically no ash are the chief solid fuels used in forging furnaces. However, fuels must have a calorific value of at least 1,400 to 1,500 large calories (5,600 to 6,000J). Petroleum sometimes serves as an excellent fuel.

Forge furnaces are built so as to ensure a temperature upto 1350°C in their working chambers. They should be sufficiently large to allow proper combustion of the fuel, and to obtain uniform heating of the workpiece. Each heating furnace consists of the following parts : firebox, working chamber, chimney, flues, recuperator or regenerator, and various auxiliary arrangements. Several types of furnaces are used for heating the workpiece and some of them are briefly described below.

### BOX OR BATCH TYPE FURNACES

These are widely employed in forging shops for heating small and medium size stock because they are the least expensive. There is a great variety of design of box-type furnaces, each differing in their location of their charging doors, firing devices and methods employed for discharging their products. These furnaces are usually constructed of a rectangular steel frame, may be 2400 mm wide by 1200 mm deep, lined with insulating and refractory bricks. One or more burners for gas or oil are provided on the sides. The workpieces are placed side by side inside a low 'slot' through which the furnace operator reaches with tong. This is, therefore sometimes called *slot-type furnace*. However, usually two people tend all types of furnaces, one feeding in the cold stock and other bringing heated stock to the forge operator.

## ROTARY–HEARTH FURNACE

These are doughnut shaped and are set to rotate slowly so that the stock is heated to the correct temperature during one rotation. These are also heated by gas or oil.

## CONTINUOUS OR CONVEYOR FURNACES

These are used of several types if only one end of the work must be heated, though they also will heat complete stock. Especially for larger stock, a pusher furnace may be used. This has an air or oil-operated cylinder to



push stock end-to-end through a narrow furnace. The pieces are charged at one end, are conveyed through the furnace, and are moved at the other end at the correct temperature for forging.

## INDUCTION FURNACES

In induction furnaces the stocks are passed through induction coils in the furnaces. These furnaces are becoming very popular because induction greatly decreases scale, can often be operated by one person, requires less maintenance than oil–or gas–fired furnaces, and is faster. Delivery to the forging machine operator can be effected by slides or automatic handling equipment.

## RESISTANCE FURNACE

Resistance furnaces are faster than induction furnaces, and are often automated. In resistance heating the stock is connected into the circuit of a step-down transformer. Fixtures must be made for holding each different length, shape, and diameter of stock. However, the fixtures are often quite simple, and some can be adjusted to handle a 'family' of parts.

## OPEN FIRE AND STOCK FIRE

In a forge, the fire itself plays an important part on the efficient heating of the stock. The fire must be deep and kept well banked. A fire which is thin and spread all over the hearth is useless for forging. Further it must be kept clean, i.e., free from excess dust or clinkers. The placing of the work in the fire is also important. Work which is laid on top of the fire will get hot underneath and remain colder on the top because it is exposed to the atmosphere, and uneven heating will result. In the same way, work which is placed low in the fire but at the same time against the tuyere will become hot on one side, but will have a blast of cold air blowing against it, from the tuyere, on the other side. The correct position is in the hearth of the fire.

Two methods of firing a smith's forge in common use are : (1) open fire, and (2) stock fire.

**Open fire.** Open fire, sometime called loose fire, is convenient for all general work. This is made up in the hollow space in front of tuyere nozzle with coke left from the last fire, covered with green coal (Fig. 8.1). As the fire burns away coke from the top and sides is drawn into the centre, and its place is taken by more green coal taken from the supply maintained on the front place of the forge or taken from the outside. The work must be covered with a layer of coal, and to obtain a flame at a single spot, the coal should be slightly damped with water and pressed down with a flat shovel.



In the spot where the flame is desired, the coal should be loosened with a pocker. To ensure uniform heating of work on all sides it must be turned round from time to time.

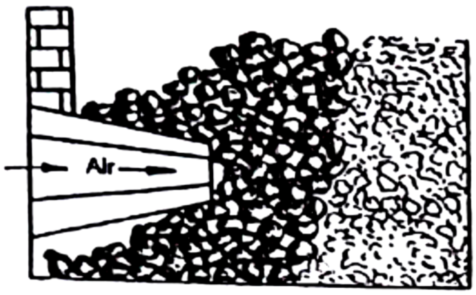



**Figure 8.1** Open fire

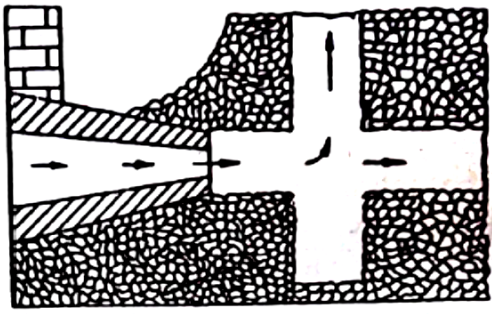


**Figure 8.2** Stock fire

**Stock fire.** A stock fire (Fig.8.2) is intended to last for several hours, and is especially useful in dealing with large pieces, when a heat may have to be kept up for some time. Another advantage with the stock fire is that the work may be turned in all directions to ensure uniform heating of the job. Stock fire is made up round a block of the size desired, which is placed near the tuyere nozzle and upon coal damped with water that is closely built into the form of a mound or "stock". Fine coal or pulverized coal is suitable for use in stock fire. The block is then withdrawn from the bed of the hearth with a turning force to prevent the stock from being broken, and a tunnel is thus formed with an opening at the top. The fire is lighted in the hollow space. From the bottom of the tunnel a small amount of coal is removed and a cavity is formed in the place into which clinker may fall. Here the work is heated, being carefully covered with freshly-coked fuel from time to time as the fire burns away.

**Blower:**

It is used to supply air at high pressure to the hearth. Centrifugal blowers use high speed impellers or blades to impart velocity to air or other gases. They can be single or multi-stage units. Like fans, centrifugal blowers offer a number of blade orientations, including backward curved, forward curved, and radial. Blowers can be multi- or variable speed units. They are usually driven by electric motors, often through a belt and pulley arrangement, but some centrifugal blowers are directly coupled to drive motors.

**OPEN FIRE Vs STOCK FIRE**

**1.** Open fire is used for general work whereas stock fire is used for heating for a long period of several hours to heat relatively big jobs.

**2.** In making open fire fresh coal is placed on the previously burnt coal. As the fire burns, the coal from sides, coal from top is drawn to the centre of hearth and its place is occupied by more fresh coal.

Whereas in stock fire the coal is stocked around a wooden block. After packing the coal, the wooden block is withdrawn by turning it. Thus, a tunnel is formed with an opening at the top.

**3.** In open fire the job is covered by coal from all sides and coal is slightly damped with water in the spot where the flame is desired, the coal should be loosened with a pocker.

Whereas in stock fire, the job is placed into the tunnel after the fire is ignited from the bottom of the tunnel. A small amount of coal is removed from the cavity, the ash may fall into this cavity.

## 8.4 FORGING TEMPERATURE

For forging, a metal must be heated to a temperature at which it will possess high plastic properties both at the beginning and at the end of the forging process. For instance, the temperature to begin the forging for soft, low carbon steels is 1,250 to 1,300°C, the temperature to finish forging is 800 to 850°C. The respective temperatures for hard, high-carbon and alloy steels are 1,100 to 1,150°C and 825 to 875°C. Wrought iron is best forged at a temperature little below 1,300°C. Nonferrous alloys like brass and bronze are heated to about 600 to 950°C, and aluminium and magnesium alloys to about 350 to 500°C.

If the forging operation is finished at a lower temperature, this leads to cold hardening and cracks. With excessive heating the forgings suffer oxidization and much metal is wasted. The blanks should be heated uniformly all over and at a definite rate.

The temperature of heating steel for hand forging can be estimated by the *heat colour* which is the colour of the light emitted by the heated steel. The heat colour disappears when the steel cools down. For more accurate determinations, *optical pyrometers* are used. Surface colours for iron and steels at various temperatures are given in Table 8.1.

**TABLE 8.1** SURFACE COLOURS FOR IRON AND STEEL

| *Color* | *Temperature (approximate) in °C* |
|---|---|
| Faint red | 500 |
| Blood red | 650 |
| Cherry red | 750 |
| Bright red | 850 |
| Salmon | 900 |
| Orange | 950 |
| Yellow | 1050 |
| White | 1200 |

## 8.2 FORGING MATERIALS

In all plastic deformation processes such as in forgings, the workpiece calls for materials that should possess a property described as ductility that is, the ability to sustain substantial plastic deformation without fracture even in the presence of tensile stresses. If failure occurs, it occurs by the mechanism of ductile fracture and is induced by tensile stresses. A material of a given ductility may fare very differently in various processes, depending on the conditions imposed on it. Therefore, it is proper to think of a more complex property called *work-ability* in plastic deformation processes, and *forgeability* in forging processes. All one can say is that wrought alloys must possess a minimum ductility that the desired shape should possess.

**TABLE 8.1 RELATIVE FORGEABILITY OF VARIOUS ALLOYS**

| *Good* | *Somewhat difficult* | *Difficult* | *Very difficult* |
|---|---|---|---|
| Aluminium alloys | Martensitic stainless | Titanium alloys | Nickel-base alloys |
| Magnesium alloys | Maraging steel | Iron-base super alloys | Tungsten alloys |
| Copper alloys | Austenitic stainless | Cobolt base super alloys | Beryllium |
| Carbon and alloy steels | Nickel alloys<br>Semiaustenitic stainless | Columbium alloys<br>Tantalum | Molybdenum alloys |

## 8.5 HAND TOOLS AND APPLIANCES

The tools and appliances used and their applications in numerous forging operations are described below.

**The anvil**. The anvil (Fig.8.3) forms a support for blacksmith's work when hammering. The body of the anvil is made of mild steel with a tool steel face welded on the body; but the beak or horn used for bending curves is not steel faced. The round hole in the anvil called *pritchel hole* is used for bending rods of small diameter, and as a die for hot punching operations. The square or *hardie hole* is used for holding square shanks of various fittings.

Anvils vary up to about 100 to 150 kg and should stand with the top face about 0.75 m from the floor. This height may be attained by resting the anvil on a cast iron or wooden base.

**The swage block.** This forgeshop tool (Fig. 8.4) is used for mainly squaring, sizing, heading, bending and forming operations. It is 0.25 m or more wide and may be used either flat or edgewise in its stand.

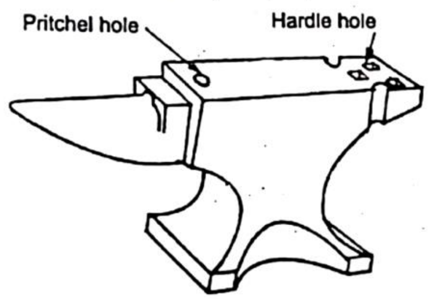



**Figure 8.3** **The anvil**

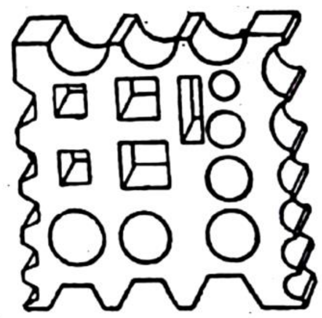


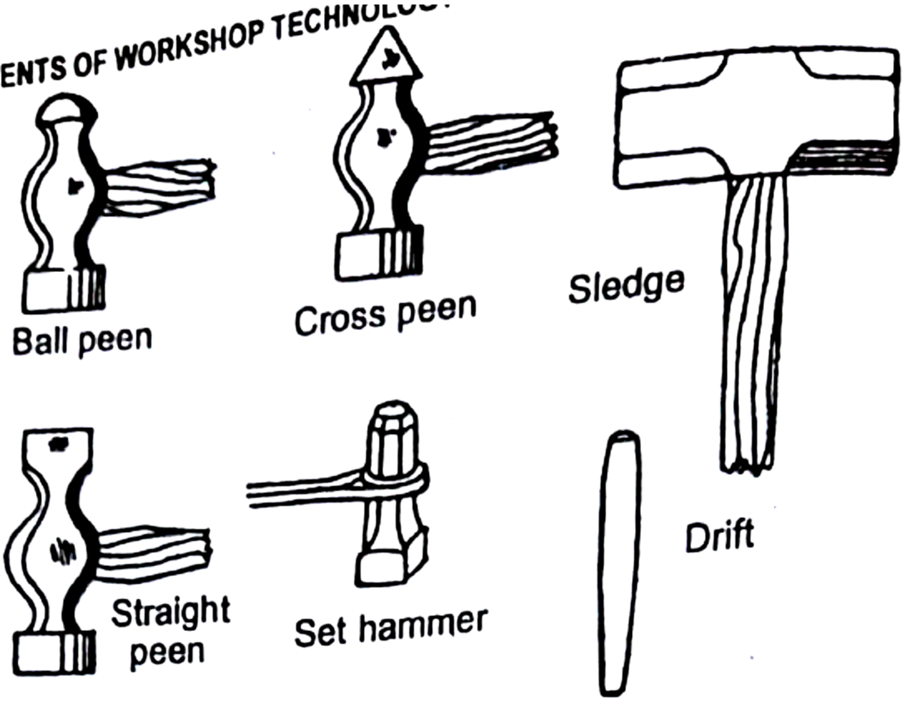
**Figure 8.4** **The swage block**

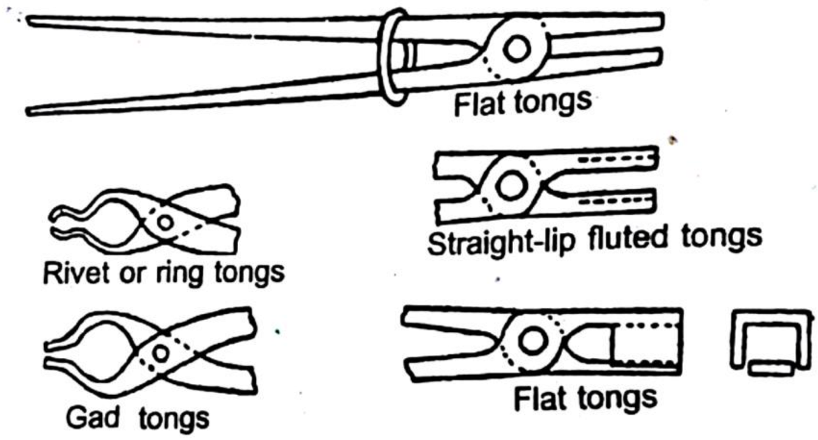
**Hand hammers**. Two kinds of hammers are used in hand forging: (1) the hand hammer used by the smith himself, and (2) the sledge hammer used by the striker (Fig. 8.5)

Hand hammers may be classified as : (a) ball peen hammer, (b) straight peen hammer, and (c) cross peen hammer. Hammer heads are made of cast steel, the ends hardened and tempered. The striking face is slightly convex. The weight of a hand hammer varies from about 0.5 to 2 kg while the weight of a sledge hammer varies from 4 to 10 kg. Hand hammers have been fully described in Article 14.3.

**Tongs**. The work to be forged is generally held with tongs. The tongs generally used for holding work are (Fig. 8.5) :





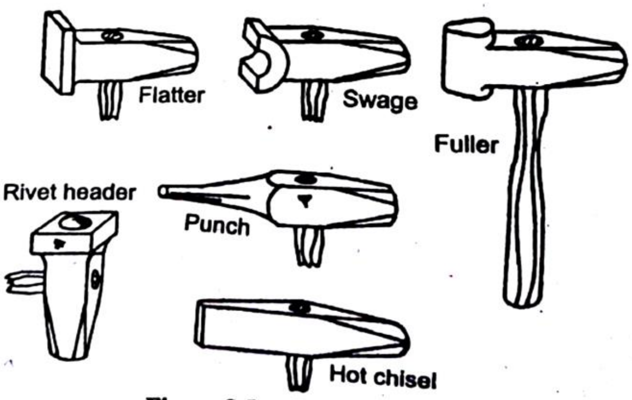



**Figure 8.5 Forging tools**

1. The *gad tong* used for general pick-up work, either straight or tapered.
2. The *straight-lip fluted tong* used for square, circular and hexagonal bar stock.
3. The *ring tong* used for bolts, rivets and other work of circular section.
4. The *flat tong* used for holding work of rectangular section.

**Chisels.** Chisels are used for cutting metals and for nicking prior to breaking. They may be hot or cold depending on whether the metal to be cut is hot or cold. The main difference between the two is in the edge. The edge of a cold chisel is hardened and tempered with an angle of about 60°, whilst the edge of a hot chisel is 30° and the hardening is not necessary. The edge is made slightly rounded for better cutting action (Fig.8.5).

**Swages.** Swages are used for work which has to be reduced and finished to round, square or hexagonal form. These are made with half grooves of dimensions to suit the work being reduced. Swages consist of two parts --the top part having a handle and the bottom part having a square shank which fits in the hardie hole in the anvil face (Fig. 8.5)

**Fullers.** Fullers are used for necking down a piece of work. They are made in top and bottom tools as in the case of swages. Fullers are made in various shapes and sizes according to needs, the size denoting the width of the fuller edge (Fig. 8.5)

**Flatters.** Flatters are used to give smoothness and accuracy to articles which have already been shaped by fullers and swages (Fig.8.5).

**The set-hammer.** It is really a form of flatter. A set hammer is used for finishing corners in shouldered work where the flatter would be inconvenient. It is also used for drawing out. (Fig. 8.5).

**The punch and the drift.** A punch is used for making holes in metal part when it is at forging heat, and holes are opened out by driving through a larger tapered punch called a drift (Fig.8.5).

## 8.6 SMITH FORGING OPERATIONS

A number of operations are used to change the shape of the raw material to the finished torm. The typical forging operations are :

1. Upsetting.
2. Drawing down.
3. Setting down.
4. Bending.
5. Welding.
6. Cutting.



7. Punching.
8. Fullering

All these operations are carried out with the metal in a heated condition, which must be maintained by taking a 'fresh' heat when the work shows signs of getting cold.

### UPSETTING

Upsetting or heading is the process of increasing the thickness of a bar at the expense of its length and is brought about by end pressure. The pressure may be obtained by driving the end of the bar against the anvil, by supporting on the anvil and hitting with the hammer, by placing in swage block hole and hitting with the hammer or by clamping in a vice and then hammering.

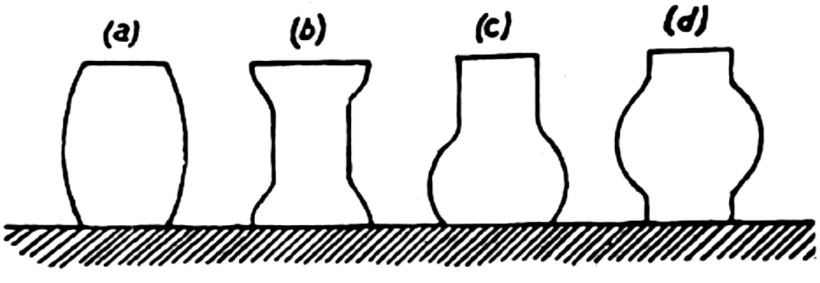



**Figure 8.6 Upset forging operations**

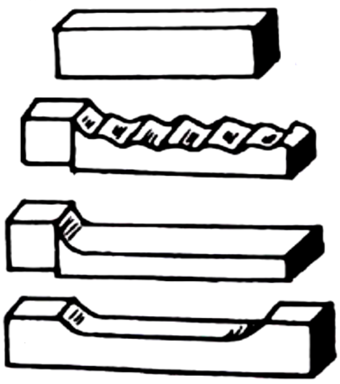


Fig. 8.6 (a) shows the effect of heavy hammer blows on a uniformly heated bar ; (b) shows the effect of comparatively light hammer blows. Local upsets may be obtained as shown at (c) and at (d) by heating only the end or the middle of the bar.

## DRAWING DOWN OR SWAGING

It is the process of increasing the length of a bar at the expense of its width or thickness or both. In Fig. 8.7, *A*, *B*, and *C* illustrate this operation. *A* represents the original stock, *B* shows the stock after hammering with a straight peen

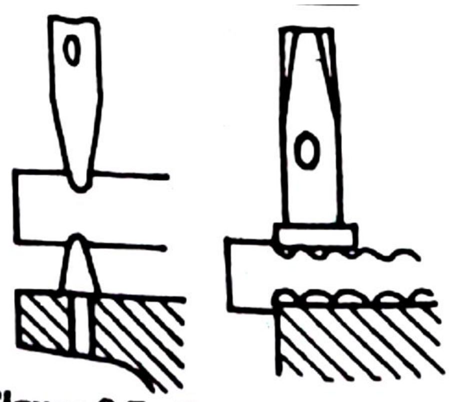


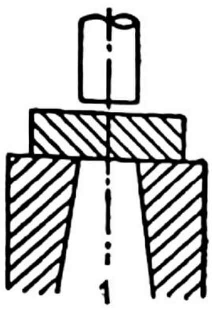
**Figure 8.7 Swaging operation**



hammer or with a top fuller and sledge, and *C* shows the finished forging after the flatter has been used.

## SETTING DOWN

It is a localized drawing-down or swaging operation as illustrated at *D* in Fig. 8.7. In other words, it may be said as the process of local thinning down effected by the set-hammer or set. Usually, the work is fullered at the place where the setting down commences. In Fig. 8.7, *E* shows the process of setting down both edges of a bar using the top and bottom fuller and *F* illustrates how the flatter may be used close to a shoulder.




## PUNCHING

It is the process of producing holes, generally cylindrical, by using a hot punch over the pritchel hole of the anvil, over a cylindrical die, or over a hole of the correct size in the swage block. Fig. 8.8 shows the stages in punching a hole.

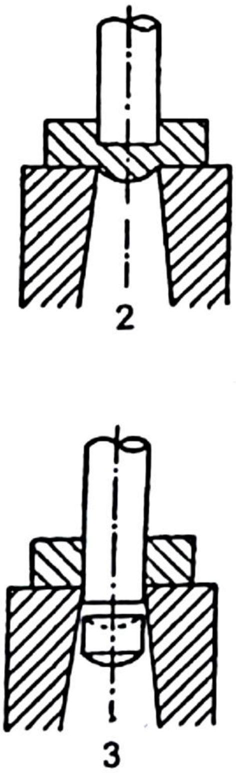



**Figure 8.8 Punching operations**

BENDING

Bending is an important operation in forging and is one very frequently used. This may be classified as angular or curvilinear. Bending may be done over the edge of the anvil face, over the anvil horn, in special forms such as the swage block edges, or for bar stock, by inserting the end in the pritchel hole and bending the bar with a wrench or tong.

When metal is bent, the layers of metal on the inside are shortened and those on the outside are stretched. This causes a bulging of

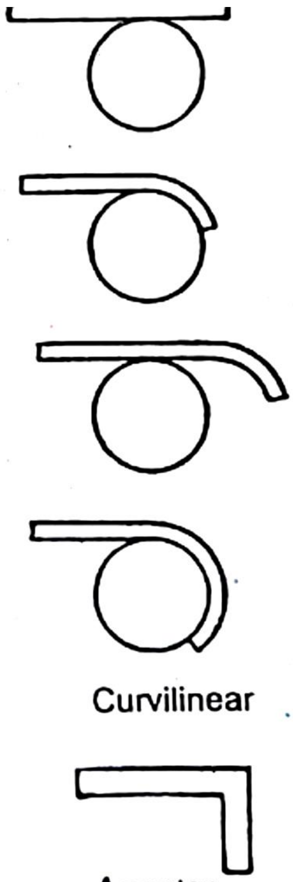



**Figure 8.9 Bending operations**



the sides at the inside, and a radius on the outside of the bend. If a perfect square bend is required, additional metal must be worked to the place where the bend occurs. When this is bent the additional metal will go to make up the corner. Gradual bends may be made by using the beak of the anvil as a former, or the metal may be bent round a bar of the correct radius held in a vice. Fig. 8.9 shows the stages in bending a bar over the horn of an anvil using a hammer.

## WELDING OR SHUTTING

It is perhaps the principal operation performed by the smith. The metal which remains pasty over a wide range of temperature is most easily welded, and in this respect wrought iron and mild steel have some advantage over other metals. The first essential to the production of a sound weld is that the surfaces in contact must be perfectly clean, both mechanically and chemically so that cohesion will take place when the metal is in a plastic state. A protection to the metal is a coating of flux which covers the surfaces of the metal and, by excluding the air prevents oxidation. Fluxes which are commonly used in forge welding consist of clean quartz sand, calcined borax, or a mixture of four parts of borax with one part of sal-ammoniac.

A forge weld is made by hammering together the ends of two bars which have been formed to the correct shape and heated to a welding temperature in a forge fire. The method of preparing the pieces of metal for welding is known as *scarfing*. This involves the shaping of the ends of the pieces to be welded so that they will unite at the centre when they are brought together.

Four forms of welded joint commonly employed are : (1) the lap or scarf weld, in which the ends are prepared so that they may be welded one upon the other, with the joint in an inclined direction ; (2) the butt weld, in which the ends of the pieces to be joined are butted together, the weld being between the ends at right angles to the length of the piece ; (3) the 'T' or jump weld, in which one piece is placed at the centre of another at right angle to each other in the form of an inverted 'T' ; and (4) the split,

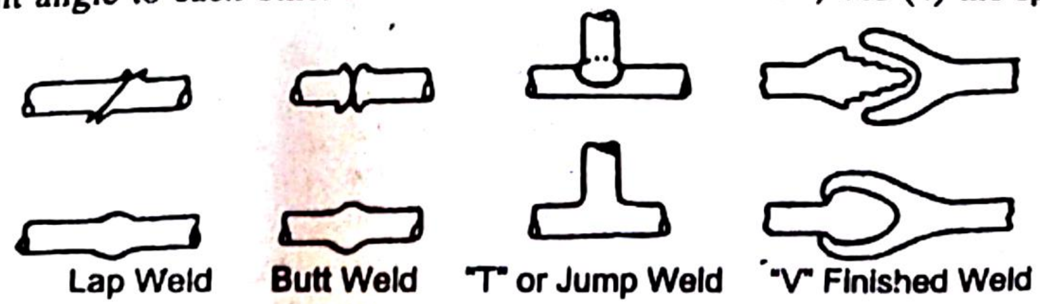



**Figure 8.10 Forge welded joints**



fork, or 'V' weld or splice, in which the ends are first brought to the shape of fork and tongue respectively. They are illustrated in Fig. 8.10.

In the lap weld, the ends of the pieces to be joined must be upset, and shaped slightly convex, so that when put together the junction takes place first at the centre, extending to the edges, and forcing out the slag in front. Lap weld is easier to make by hand hammering, but butt welding is neither preferable nor easy to make by hand operation. V-weld is regarded as the most secured form of weld and is particularly suitable for thick pieces where the formation of 'V' can be done easily and most conveniently.

CUTTING

Cutting-off is a form of chiseling whereby a long piece of stock is cut into several specified lengths, or a forging is separated (cut-off) from its stock. For hot chiseling, steel must be heated in a blacksmith's hearth or furnace to a light cherry red heat, i.e., from 850 to 950°C. When cutting with chisels, the hammer blows are directed on to the chisel head, which must be slightly rounded.

A notch is first made about one-half the thickness or diameter of the stock. After the spot where the stock is to be cut off has been notched, the work must be turned through an angle of 180° and the chisel is placed exactly opposite the notch. The required length of metal can then be cut-off by giving the chisel a few blows with a sledge hammer. Before striking the last blow, the stock must be placed on an anvil so that its cut-off end is parallel with the edge of the anvil. If the steel is very hard, four notches will be required instead of two and the stock will have to be turned through 90° after each blow, instead of 180°.

FULLERING

Fullering or spreading the metal along the length of the job is done by working separate sections. In this case, the axis of the job is positioned perpendicular to the width of the flat die.

## 8.8 FORGING PROCESSES

The processes of reducing a metal billet between ***flat-dies*** or in a ***closed-impression*** die to obtain a part of predetermined size and shape are called *smith forging* or *impression-die forging* respectively. Depending on the equipments utilized they are further sub-divided as hand forging, hammer



forging, press forging, drop hammer forging, mechanical press forging, upset or machine forging.

In general, the methods of forging may, therefore, be classified as follows :

1. Smith die forging.
   - (a) Hand forging.
   - (b) Power forging.
     - (i) hammer forging.
     - (ii) press forging.

For production purpose it is important not only that the material can be deformed with feasible pressures and forces, but also that the deformation should be uniform and free from defects.

SMITH DIE FORGING

Smith forging, also called *flat-die* and *open-die forging*, includes the broad field of forging work produced between flatfaced dies and possibly supplemented by stock tooling. The final shape of the forging depends largely on the skill of the smith for size and shape.

Smith forging, done by hand on an anvil, is employed only to shape a small number of light forgings, chiefly in repair shops. Heavy forgings weighing upto 25,000 kg, as well as medium forgings in small batches, are produced exclusively in hammers and presses.

Smith forging or open-die forging processes produce work pieces of lesser accuracy than impression or closed-die forging ; however, tooling is usually simple, relatively inexpensive and allows the production of a large variety of shapes.

## 8.9 HAND FORGING

The forging is done by hammering the piece of metal, when it is heated to the proper temperature, on an *anvil*. While hammering, the heated metal is generally held with suitable tongs. *Formers* are held on the forging by the smith while the other end is struck with a sledge by a helper. The surfaces of formers have different shapes, and they are used to impart these shapes to the forgings. One type of former, called a *fuller*, having a well-rounded chisel shaped edge is used to draw out the work. Fullers are also made as anvil fittings so that the metal can be drawn out, using both top and bottom fullers. Anvil fittings of various shapes can be placed in the square hole of the anvil. For cutting the metal, hot *chisels* are used. *Punches* and a *block* having proper-sized openings are used for punching out holes. *Welding* can be done by shaping the surfaces to be welded, removing any scale or impurities from between the surfaces with a flux, and hammering the surfaces together.

Hand forging is employed only to shape a small number of light forgings chiefly in repair shops. Hand forging has, recent years, been superseded by power forging.

## 8.10 POWER FORGING

Large machine parts cannot be forged by hand, since the comparatively light blow of a hand-or sledge-hammer is unable to produce a great degree of deformation in the metal being forged. Moreover, hand forging is a lengthy process and requires repeated heating of the metal. This has led to the use of power hammers and presses in forging. Machines which work on forgings by blow are called *hammers*, while those working by pressure are called *presses*.

### POWER HAMMERS

All power hammers employ the same general principle of operation, a falling weight striking the blow, with the entire energy being absorbed by the work. Where further blows are necessary, the striking weight is raised for the succeeding blow. Some hammers employ only a gravity fall, the energy delivered on the work being the product of the weight of the hammer head and the distance of the fall. Other hammers increase the striking velocity of the hammer head by mechanical means.

The part of the hammer which serves as a rigid support during forging is called the *anvil block*. The anvil block of a forging hammer is built on a foundation separate from the frame so that the shock of the hammer blows will be cushioned by the foundation and will not be transmitted to the frames. The heavy falling part of the hammer is called the ram. The anvil block and the *ram* each has one die called upper-die and lower-die respectively for squeezing the metal to be forged. In smith forging, the working surfaces of both the upper and lower dies are flat and horizontal.

POWER PRESSES

Forging presses for smithing work are usually of the hydraulic type. The principle of a typical forging press is illustrated in Fig. 8.18. The water passes first from a large capacity tank to a pump and then is delivered on the press with the aid of an accumulator and distributor at 200 to 300 kgf per $cm^2$ (19,600 to 28,600 $kN/m^2$). The accumulated water pressure flows into a main cylinder and presses on the top of the large piston. Since the cross-sectional area of the piston in the main material is large, the press ram is forced down upon the material to be forged which lies on the anvil with a high total into its initial position of the action of the working fluid on the piston rods in the pull back cylinder.

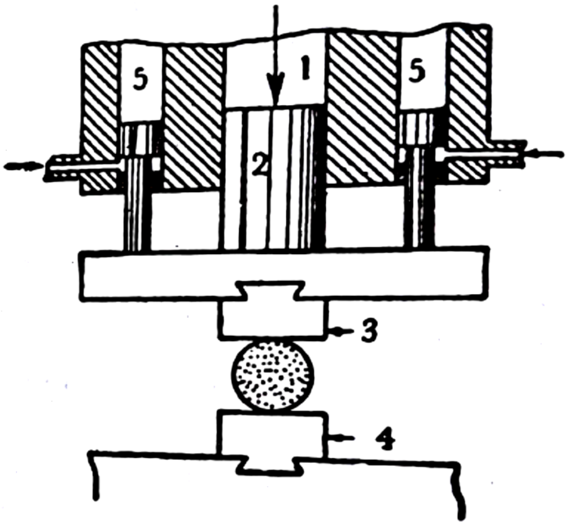



**Figure 8.18 Principle of a forging press**

1. Main cylinder, 2. Piston, 3. Upper die, 4. Lower die, 5. Pull back cylinder