FORGING

14.1 INTRODUCTION

Forging is an oldest shaping process used for the producing small articles for which accuracy in size is not so important. The parts are shaped by heating them in an open fire or hearth by the blacksmith and shaping them through applying compressive forces using hammers. Thus forging is defined as the plastic deformation of metals at elevated temperatures into a predetermined size or shape using compressive forces exerted through some means of hand hammers, small power hammers, die, press or upsetting machine. It consists essentially of changing or altering the shape and section of metal by hammering at a temperature of about 980°C, at which the metal is entirely plastic and can be easily deformed or shaped under pressure. The shop in which the various forging operations are carried out is known as the smithy or smith's shop. A metal such as steel can be shaped in a cold state but the application of heat lowers the yield point and makes permanent deformation easier. Forging operation can be accomplished by hand or by a machine hammer. Forging processes may be classified into hot forging and cold forgings and each of them possesses their specific characteristics, merits, demerits and applications.

Hand forging process is also known as black-smithy work which is commonly employed for production of small articles using hammers on heated jobs. It is a manual controlled process even though some machinery such as power hammers can also be sometimes used. Black-smithy is, therefore, a process by which metal may be heated and shaped to its requirements by the use of blacksmith tools either by hand or power hammer. In smithy small parts are shaped by heating them in an open fire or hearth. Shaping is done under hand control using hand tools. This work is done in a smithy shop. In smith forging or hand forging open face dies are used and the hammering on the heated metal is done by hand to get the desired shape by judgment.

Forging by machine involves the use of forging dies and is generally employed for mass-production of accurate articles. In drop forging, closed impression dies are used and there is drastic flow of metal in the dies due to repeated blow or impact which compels the plastic metal to conform to the shape of the dies. The final shape of the product from raw material is achieved in a number of steps. There are some advantages, disadvantages and applications of forging operations which are given as under.

Advantages of forging

Some common advantages of forging are given as under.

1. Forged parts possess high ductility and offers great resistance to impact and fatigue loads.
2. Forging refines the structure of the metal.
3. It results in considerable saving in time, labor and material as compared to the production of similar item by cutting from a solid stock and then shaping it.
4. Forging distorts the previously created unidirectional fiber as created by rolling and increases the strength by setting the direction of grains.
5. Because of intense working, flaws are rarely found, so have good reliability.
6. The reasonable degree of accuracy may be obtained in forging operation.
7. The forged parts can be easily welded.

Disadvantages of forging

Few dis-advantages of forging are given as under.

1. Rapid oxidation in forging of metal surface at high temperature results in scaling which wears the dies.
2. The close tolerances in forging operations are difficult to maintain.
3. Forging is limited to simple shapes and has limitation for parts having undercuts etc.
4. Some materials are not readily worked by forging.
5. The initial cost of forging dies and the cost of their maintenance is high.
6. The metals gets cracked or distorted if worked below a specified temperature limit.
7. The maintenance cost of forging dies is also very high.

Applications of forging

Almost all metals and alloys can be forged. The low and medium carbon steels are readily hot forged without difficulty, but the high-carbon and alloy steels are more difficult to forge and require greater care. Forging is generally carried out on carbon alloy steels, wrought iron, copper-base alloys, alumunium alloys, and magnesium alloys. Stainless steels, nickel-based super-alloys, and titanium are forged especially for aerospace uses.

Producing of crank shaft of alloy steel is a good example which is produced by forging. Forging processes are among the most important manufacturing techniques utilized widely in manufacturing of small tools, rail-road equipments, automobiles and trucks and components of aeroplane industries. These processes are also extensively used in the manufacturing of the parts of tractors, shipbuilding, cycle industries, railroad components, agricultural machinery etc.

14.10 FORGING METHODS

Fig. 14.15 Beak iron

The forging methods are commonly used for changing the shape of the raw material in to the finished form in the forging shop are generally classified into two categories namely hand forging and power forging. These are being discussed as under

14.10.1 Hand forging

Hand forging is performed in the black smithy shop. The job is heated at the forging temperature in hearth and it is then brought on anvil using tong. It is then forged using hand hammers and other hand forging tools for imparting specific shape.

14.10.1.1 Forging Operations

The hand forging operations (Fig. 14.16) are

1. Upsetting
2. Bending
3. Drawing down
4. Cutting
5. Setting down
6. Punching
7. Flattening
8. Fullering
9. Forge Welding
10. Swaging

(ii) Upsetting

Upsetting is also known as jumping operation which is carried out to increase the thickness (or diameter) of a bar and to reduce its length. Generally, the increase in thickness is only local, for example, when forming a bolt head. This operation is an operation just

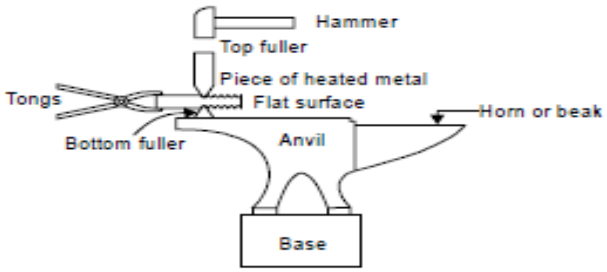

Fig. 14.16 Hand forging

Some important hand forging operations are described as under.

(i) Drawing out

Drawing out is used to reduce the thickness of a bar and to increase its length. It may be carried out by working the metal over the horn the anvil as shown in Fig. 14.17, then by hammering it on the anvil face. The rounded horn of the anvil acts as a blunt edge, which forces the metal to flow lengthwise when struck by the hammer. For drawing down very heavy work, fuller may be used for drawing down a bar over the horn (round portion) of anvil.

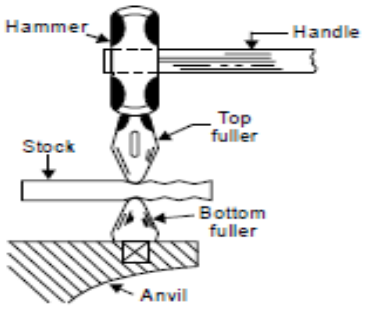

Fig. 14.17 Drawing out

(ii) Fullering

Fullering operation generally used in forging shop is shown in Fig. 14.18. It involves heating the stock in the black smith hearth. Then heated stock is placed on the fuller fixed on anvil. A fuller is put over the sock and hammering is done to reduce the cross section of job at required point.

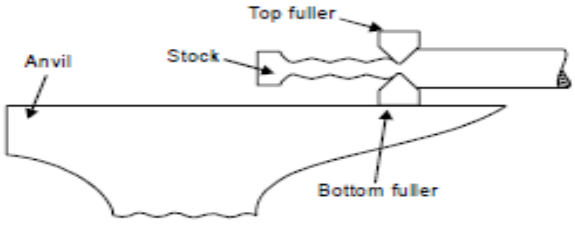

Fig. 14.18 Fullering

opposite to drawing and involves increasing the cross-sectional area usually by hammering or pressing in a direction parallel to the ingot axis. The length of the ingot decreases and following the path of least resistance it spreads out. The required shape is given the ingot by spreading it between two dies. Only that portion of the bar which is to be upset is heated locally. Or, the whole bar is heated and except for the portion to be upset, the rest is quenched in water so that upset will form only on the hot portion of the bar. In one method of upsetting, the bar is held in the tong and supported vertically on the anvil. The top edge of the bar is then hammered to form the upset on the bottom hot end of the bar. For upsetting, the blow of the hammer must be in line with the bar to prevent bending of the bar.

(iv) Bending

Bending is a very commonly used forging operation in forging shop to give a turn to a metal rod or plate. It is accompanied by spreading of the metal in the inside of the bend and narrowing at outside. The simplest method of bending a piece of metal in hand forging is to support it on the anvil and to strike its free end with a hammer When bent, the metal of the workpiece thins out round bend causing weakness. This can be overcome by upsetting the bar prior to bending.

(v) Cutting

Cutting is a main forging operation to cut out a metal rod or plate into two pieces with the help of a chisel and hammer when the metal is in red hot condition. A hot or cold cut (chisel) is used for cutting heated metal bars in a smithy shop. The hot set does not require hardening and tempering. Its cutting edge is keener than that of a cold set. Hot sets are manufactured from a tough variety of steel in order that they may cut through relatively soft red-hot metal with ease. While cutting, it is best to cut half through the workpiece to turn it over and cut through from the other end.

(vi) Punching

Punching is a main forging operation used for producing hole in metal plate by using a tool known as punch. The metal plate is placed over the hollow cylindrical die and punch is placed above it at required location where hole is being made. For punching a hole, the metal job must be at near welding heat and the punch is driven part way through the job with hammer blows. The work is then turned over and the hole is completed from the other side. The above said practice is adopted for thicker jobs.

(vii) Forge Welding

It is a process of joining two metal pieces to increase the length by pressing or hammering them when they are at forging temperature. It is performed in forging shop and hence sometimes it is called as forge welding.

14.11 DEFECTS IN FORGED PARTS

Defects commonly found in forged parts that have been subjected to plastic deformation are as follows.

(*i*) Defects resulting from the melting practice such as dirt, slag and blow holes.

(*ii*) Ingot defects such as pikes, cracks scabs, poor surface and segregation.

(*iii*) Defect due to faulty forging design.

(*iv*) Defects of mismatched forging because of improper placement of the metal in the die.

(*v*) Defects due to faulty design drop forging die.

(*vi*) Defects resulting from improper forging such as seams cracks laps. etc.

(*vii*) Defects resulting from improper heating and cooling of the forging part such as burnt metal and decarburized steel.

Some well identified common forging defects along with their reason are given as under.

1. Mismatched forging

Reasons

Due to non alignment of proper die halves.

2. Brunt and overheated metal

Reasons

This is caused by improper heating the metal at high temperature or for a long time.

3. Fibred flow lines discontinued

Reasons

This will occur because of very rapid plastic flow of metal.

4. Scale pits

Reason

These are formed by squeezing of scale into the metal surface during forging.

5. Oversize components

Reasons

Due to worn out dies, incorrect dies, misalignment of die halves.

14.12 REMOVAL OF DEFECTS IN FORGING

Defects in forging can be removed as follows:

(*i*) Surface cracks and decarburized areas are removed from forging parts by grinding on special machines. Care should also be taken to see that the job is not under heated, decarburized, overheated and burnt.

(*ii*) Shallow cracks and cavities can be removed by chipping out of the cold forging with pneumatic chisel or with hot sets.

(*iii*) The parting line of a forging should lie in one plane to avoid mismatching.

(*iv*) Destroyed forgings are straightened in presses, if possible.

(*v*) Die design should be properly made taking into consideration all relevant and important aspects that may impart forging defects and ultimate spoilage

(*vi*) The mechanical properties of the metal can be improved by forging to correct fibre line. The internal stresses developed due to heating and cooling of the job can be removed by annealing or normalizing.