UNIT 6 SMITHYING AND FORGING WORKSHOP

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6.1 INTRODUCTION

Smithying is to handle relatively small jobs only such as can be heated in an open fire or hearth. 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, presses, etc.

<table>
<thead>
<tr>
<th>Good</th>
<th>Some What Difficult</th>
<th>Difficult</th>
<th>Very Difficult</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium Alloys</td>
<td>Martensitic Stainless</td>
<td>Titanium Alloys</td>
<td>Nickle-base Alloys</td>
</tr>
<tr>
<td>Magnesium Alloys</td>
<td>Maraging Steel</td>
<td>Iron-base super Alloys</td>
<td>Tungsten Alloys</td>
</tr>
<tr>
<td>Copper Alloys</td>
<td>Austenitic Stainless</td>
<td>Cobolt base super Alloys</td>
<td>Beryllium</td>
</tr>
<tr>
<td>Carbon and Alloys Steels</td>
<td>Nickle Alloys Semiaustenitic stainless</td>
<td>Columbium Alloys Tantalum</td>
<td>Molybdenum Alloys</td>
</tr>
</tbody>
</table>

Objectives
After studying this unit, you should be able to
- describe smithying and forging,
- know the properties of forging materials,
- describe different types of furnaces, and
- recognise various types of forging tools and operations.

6.2 FORGING MATERIALS AND FORGE-ABILITY

Workpiece in forging shop calls for materials that should possess a property described as ductility, i.e. the ability to sustain substantial plastic deformation without fracture even in the presence of tensile stresses. The basic lattice structure of metals and their alloys same to be a good index to their relative forge-ability or workability. Forge-ability increases
with temperature up to a point at which a second phase appears [e.g. from ferrite to austenite in steel] or if grain growth becomes excessive. Metals which have low ductility have reduced forge-ability at higher strain rates, whereas highly ductile metals are not so strongly affected by increasing strain rates.

## 6.3 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, e.g. temperature to begin the forging for soft, low carbon steels is 1250 to 1300°C and finishing temperature is 800 to 850°C.

If forging operation is finished at lower temperature, this leads to cold hardening and cracks with excessive heating the forgings suffer oxidation and much metal is wasted.

When steel is heated well above the upper critical temperature, the grains begins to grow in size and they will continue to grow as the temperature is increased. During forging, the grains are broken up and become finer. If forging temperature is high (above 910°C) the grains will grow during process of cooling in the air, the cold forging will then have a coarse grained structure and low mechanical properties. If forging is finished at low temperature (below 910°C), the grains will not grow when the steel is cooled awing to the low temperature. The cold forging will then possess a fine grained structure and high mechanical properties. If steel is hammered when it is below the lower critical temperature (above 723°C) it will be cold worked and may be given small hair cracks.

### Table 6.2:Forging Temperature

<table>
<thead>
<tr>
<th></th>
<th>Forging Must</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start at</td>
</tr>
<tr>
<td>Mild Steel</td>
<td>1300°C</td>
</tr>
<tr>
<td>Medium Carbon Steel</td>
<td>1250°C</td>
</tr>
<tr>
<td>High Carbon Steel</td>
<td>1150°C</td>
</tr>
<tr>
<td>Wrought Iron</td>
<td>1250°C</td>
</tr>
<tr>
<td>Aluminium and Magnesium Alloys</td>
<td>500°C</td>
</tr>
<tr>
<td>Copper, Brass and Bronze</td>
<td>950°C</td>
</tr>
</tbody>
</table>

### Colour Cooling for Different Temperatures

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.

Hot working is the plastic deformation of metals above their recrystallization temperature, of a metal determines whether or not hot or cold working is being accomplished. For steel recrystallization starts around 680°C to 1030°C, although most hot work on steel is at temperature considerably above this range.

### Heating Devices

For forging the work-piece is to be heated. There are following heating furnaces to heat the work-piece to optimum temperature before carrying out work on it:

#### Rotary-Hearth Furnace

These are doughnut shaped and are set the rotate slowly so that the stock is heated to the correct temperature during one rotation. These are also heated by gas or oil.
Table 6.3: Surface Colour for Iron and Steel

<table>
<thead>
<tr>
<th>Colour</th>
<th>Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fairt Red</td>
<td>500</td>
</tr>
<tr>
<td>Blood Red</td>
<td>650</td>
</tr>
<tr>
<td>Cherry Red</td>
<td>750</td>
</tr>
<tr>
<td>Bright Red</td>
<td>850</td>
</tr>
<tr>
<td>Salmon</td>
<td>900</td>
</tr>
<tr>
<td>Orange</td>
<td>950</td>
</tr>
<tr>
<td>Yellow</td>
<td>1050</td>
</tr>
<tr>
<td>White</td>
<td>1200</td>
</tr>
</tbody>
</table>

Table 6.4

<table>
<thead>
<tr>
<th>Metal</th>
<th>Recrystallisation Temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>150</td>
</tr>
<tr>
<td>Copper</td>
<td>200</td>
</tr>
<tr>
<td>Gold</td>
<td>200</td>
</tr>
<tr>
<td>Iron</td>
<td>450</td>
</tr>
<tr>
<td>Lead</td>
<td>Below Room Temp.</td>
</tr>
<tr>
<td>Magnesium</td>
<td>150</td>
</tr>
<tr>
<td>Nickel</td>
<td>590</td>
</tr>
<tr>
<td>Silver</td>
<td>200</td>
</tr>
<tr>
<td>Tin</td>
<td>200</td>
</tr>
<tr>
<td>Zinc</td>
<td>At Room Temp.</td>
</tr>
</tbody>
</table>

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 furnace, each differing in their location of their charging doors, firing devices and methods employed for discharging their products. These furnace are usually constructed of a rectangular steel frame, may be 2400 mm widely 1200 mm deep, lined with insulating and refractory bricks. One or more burners for gas or oil are provided on the sides. The work-pieces 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 feeling in the cold stock and other bringing heated stock to the forge operator.

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 on air or oil-operated cylinder to push stock end to end.

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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.

**Muffle-type Furnace**

In order to prevent hot gases coming in contact with the stock to be heated, the product is kept inside the muffle. The gases circulate around the muffle which is made of cast iron or any thin refractory material, and raises the temperature of work piece through radiate heat. So, no scaling is produced.

![Smiths Furnace Diagram]

**Black Smiths Forge**

It is used for heating the work piece for hand forging operations. This hearth is made of cast-iron having fire bricks lining and filled with coke. A nozzle pointing into centre of the hearth (called tuyere) is used to direct air-stream with the help of an air blower into the burning coke. Since, the hottest part of the fire is near to tuyere opening. So, the tuyere is provided with a water jacket to prevent overheating. The hood provided at the top of the hearth collects the smoke, fumes and direct them into the air through chimney. The work-piece is heated by putting it just below the upper burning coal layer to avoid oxidation. Impurities are collected as clinker and removed from the bottom of the fire when the hearth is cool.
The most common forging operations done in forging shops are:

**Upsetting**

This is carried out to increase the thickness or diameter of work-piece after reducing its length by hammering process. The work is held by tong at one end while the other end of work is supported on the anvil-face. Upsetting may be required on any of the end portions, central portion or complete length. This is accomplished by heating the work in furnace. The portion of the work to be upset must remain hot and the rest may be cooled down by dipping it into the cold water.

**Drawing Down**

This operation reduces the thickness of the work or diameter by increasing the length of the stock. This operation is carried out by hammering the hot work piece while keeping it on the anvil (use straight been hammer) and holding it by a suitable tong. Sometimes the fullers are also used to reduce the thickness. It may be localized drawing down also the rectangular part of the fuller is mounted in the anvil square hole and kept the hot work-piece hold by tong on the fuller top. Counter part of the same set is kept on it and hammer the head of fuller usually it is followed by flatter to make the surface of work flat. So this process is termed a fullering and flattening.

**Bending**

It is also a very common operation and frequently used in work shop. Bending operation is carried out by keeping the work-piece on the edge of the anvil face, anvil horn or any other fixture/support. A thin box can be bent by inserting one end of the bar in the hole and bend it with the help of wrench or tong. While bending the bar, the metallic fibers on the inside portion of the bend-rod are shortened and those on outer periphery of the bar are extended. Slight thinning also takes place at the contact. So the avoid thinning, little upsetting can be done on that portion bending portion before doing the bending operation. It is a little bit slow process.
Punching and Drifting

Punching operation is used to produce or to enlarge the hole in the metallic workpiece by hammering a tool called punch. The hole may also be blind. Drafting operation is to cut and slit in the work and the tool used is called ‘draft’ which is having a very small cutting angle with sharp edge. Sometimes a circular drift is also used to enlarge the hole to the required dimensions. Both the operations can be carried out at room as well as at high temperature.

Figure 6.4: Bending Operation on Anvil

Figure 6.5: Punching and Drifting Operations

Surging

This operation brings an already-deformed work-piece into the desired shape and size usually round or hexagonal.

Fullering and Flattening

Fullering operation uses fullering tool to reduce thickness of the heated workpiece. The fuller head is held in the hardie-hole of anvil and the work is reduced in thickness by moving the work between the top and bottom fullers, thus having the work in corrugated shape. Those corrugations are latter flattened by using flatter tool and a hammer set hammer can also be used for his purpose. Fullering is always followed by flattening operation. However, flat rod can again be made round by the use of fullers of less diameter, if necessary.

Figure 6.6: Swaging Operation
Forge-Welding

It is one of the most important operations performed by blacksmiths. Wrought iron and low carbon steels including mild steel can be satisfactorily forge welded. The process of forge-welding is explained in the following steps:

(a) The ends of the two work pieces to be welded are little bit upset and cleft shape or tapered shape is given. In case, the work pieces are > 30 mm, cleft shape is given and in other cases tapered shape is enough. This operation may need heating again and again.

(b) Both the ends are heated to about 1000°C in case of mild steel which is essential for sound welding.

(c) The ends of both pieces after heating must be mechanically cleaned so as to remove oxidized film, so that proper cohesion may take-place while both the pieces are in pasty state (red white hot). At this stage a protection to the metal is provided to prevent the air oxidation of the red hot surfaces. Flux may also sometimes be used (usual fluxes-clean quartz sand; calcined borax; a mixture of four part of borax and one part sal-ammoniac). Before, putting both ends (red hot) together, the ends must be cleaned by striking the work pieces on the anvil (removing oxidized scale) or flux can also be sprinkled.

(d) After putting both the red hot clean ends together, hammer the joint slowly to avoid excessive metal spread. Thus it enables the crystals of both needs anchor the each other and during this period the temperature may also drop.

(e) Now firm hammering can be applied at the junction, thus both the ends are forge welded, which has a much strength as the parent metal has four forms of welded joints are employed:

(i) Lap or scarf weld
(ii) Butt weld
(iii) Tor jump weld
(iv) Split, fork, splice or V-weld

![Figure 6.7](image)

Figure 6.7: (a) Butt Weld, (b) Scarf Weld, and (c) 'V' weld or Splice Weld

Cutting

It is sometimes termed as hot cutting or chiseling by the use of hot chisels (cutting edge 300) and the work piece is red hot (light cherry red hot) by heating it into the furnace the approximate temperature of 8000 to 9000. The cutting process is accomplished by hammering the chisel into the notch of cherry red hot work piece.

6.5 MACHINERY USED FOR COMMON TYPES OF FORGING OPERATIONS

Upsetting

*Method of Operation*

Compression in the longitudinal axis of work such that its length decreases and thickness increases.
Commonly Used Machinery
(a) Single action and counter blow hammers.
(b) Upsetting machines.
(c) Hydraulic, air and mechanical presses.
(d) High velocity forging machines

Drawing Out
Method of Operation
Stretch-out of the work by a series of upsets along the length or work-piece such that its length increases and thickness decreases.

Commonly Used Machinery
(a) Single action hammers.
(b) Hydraulic and air presses.

Die-Forging
Method of Operation
Compression of billet or pre-forge in closed impression dies, which may or may not contain flash gutter.

Commonly Used Machinery
(a) Single action and counter blow hammers.
(b) Hydraulic and mechanical presses.
(c) High speed forging machines

Swaging
Method of Operation
Compression to lengthen a work piece and decrease the diameter of work piece.

Commonly Used Machinery
(a) Swaging machines.
(b) Hammers and presses.
(c) Air, hydraulic presses.

Ring Rolling
Method of Operation
Radial compression on a ring shape work piece to increase diameter.

Commonly Used Machinery
(a) Ring Rolling mills.
(b) Hammers and presses with supported mandrel.

Core Forging
Method of Operation
Displacing metal with a punch to fill a die-cavity. This process is very common in die-forging when the cavity is not filled.

Commonly Used Machinery
Multiple ram presses.
Extrusion Forging

**Method of Operation**
Forcing a metal into a die-opening by restriction flow in other directions.

**Commonly Used Machinery**
(a) Hydraulic and mechanical presses.
(b) Multiple Ram presses.
(c) High speed forging machines

Back Forging (Back Extrusion Forging)

**Method of Operation**
Forging with a punch and forcing metal to flow opposite to the punch direction.

**Commonly Used Machinery**
(a) Single action and counter blow hammers.
(b) Hydraulic and Mechanical presses.
(c) Multiple Ram presses.
(d) High speed forging machines.

### 6.6 FORGING TOOLS

**Anvil**

It is made of solid wrought iron or cast-steel mounted on a cast iron stand. Hot work-pieces are placed in the anvil face to forge with hand hammers. The top-part of anvil (working face and cutting face) is made of tough steel to withstand the blow of hammers. The square and round holes are used to bend the work piece by inserting one end in these holes. The horn portion of the anvil is used for bending the work almost all the smiths operations can be carried out on the anvil.

![Figure 6.8: Details of Anvil](image)

**Swage**

Block: It is made of forged steel/cast steel having on its faces assorted types of recesses and holes in the body. Recesses are used as dies to give shape to hot work as per the shapes of recesses. Assorted holes are used to make holes of various shapes in the work piece. Sometimes the block recesses can be used to shape the work according to recesses.
Tong

It is made of carbon-steel having 0.3-0.4 % carbon and used as holding devices which is capable to hold a wide variety of jobs.

Hammer

It is made of carbon-steel having its working face and head hardened and tempered. Usually hammers are specified by weight, commonly used to impart energy to work piece to deform in the desired shape and size. The energy is imparted through its slightly spherically formed face which helps to concentrate the flow force on the desired spot on the work. Common types of hammers are:

Ball Peen Hammer

Suitable to practically all hand operations.

Cross Peen Hammer

Suitable to bend, Stretch and strike the work.

Straight Peen Hammer

Suitable to stretch and strike.

Sledge Hammer

Usually heavier (3 kg-10 kg) than hand hammer and operated by helpers exclusively by striking.
Hot Chisels (Hot set)

It is used to cut the hot metallic work doing forging operations. Usually made of high carbon steels having cutting edge hardened and tempered and its head is kept soft. The cutting edge-angle for hot chisels is about 300-350 and for cold chisel, the cutting angle varies from 600 to 650. During cutting processes, the chisel must be kept cool to avoid softening of the cutting edge. Sometimes lubricant (kerosene) also used during operation.

![Figure 6.12: (a) Hot Chisel, and (b) Cold Chisel](image)

Swages

These are always in pair (top part and bottom part are separate) and these usually used to reduce or improve the finish of the work piece to desired size. Made of carbon steel (0.4-0.5%C) having soft heads and hardened and tempered working forces.

![Figure 6.13: Swages](image)

Fullers and Flatters

Fullers are in pair of two halves (top and bottom halves). The bottom part having a square shank is fitted into square hole of anvil and the top part carries a handle use to produce grooves, spreading the metal, reducing the thickness; made of carbon steels (0.3-0.4%C). Working face is hardened and tempered.

Punches and Drifts

Punches are made of carbon-steels having working area hardened and tempered. These are available in different sizes so as to make holes of different sizes in hot work. Drifts are there to produce very fine slit or to enlarge the holes/ slits in hot work.

![Figure 6.14: Punches](image)
6.7 FORGING MACHINES

Usually, there are power-hammers used to deform the metallic work-piece under the action of repeated blows or gradually increasing pressure. Equipments imparting blows are called forging hammers and those applying gradually increasing pressure are called forging presses.

Forging Hammers

Various forging hammers of different specifications are available in the market; some of them are mentioned below:

Spring Hammers

It is a simple design of hammer available in different specifications. It is usually used to upset and drawing out the metals. Force of blow is roughly controlled by springs and this imparts the required force blow to the workpiece. These are driven by motors and their stroke is adjusted by the eccentricity provided at the driving end. Owing the very poor alignment they usually have, the impression dies cannot be used on these hammers.

Drop Hammer

This type of hammer usually works on the principle of the energy released by free drop of ram. In this hammer, the ram is raised with the help of some power device to a desired height and then the ram is allowed to drop or fall freely (sometimes within some guide) under its own weight (gravity). The blow imparts energy force depending on the height of free fall and the weight of ram.

\[ \text{Imparted kinetic energy to the work piece} = \frac{mv^2}{2} \]

where \( m = \) Mass of the free falling ram, and \( v = \) Velocity of ram during free fall.

The drop hammers are used for die-forging of light and medium weights and are available in different forms such as belt-drop hammers, rope-drop hammers. In both the cases, the drop weight (ram) is suspended either by belt or rope and the energy is imparted due to free fall of ram. For raising the ram weight, the weight is directly lifted with the help of motor, stream air. The lifting of the weight can also be accomplished by friction rolls rotation in the opposite direction. In a friction drop hammer, the blow is delivered by a weight raised by some frictional device and then allowed to drop freely. The TUP or falling weight travels in vertical guides. The pair of pulleys is driven from a rotating shaft by a friction clutch which is engaged to raise the tup and then disengage to allow it to fall. The top die is fixed to the tup (ram) by dovetail and wedge assembly, while the bottom of die to a bolster fixed to the anvil. The constant hammering causes considerable wear on all the bearing surfaces and these have to be truly aligned by machining at intervals. The bolster and ram can be removed and either machined or replaced easily.

In a Board-Hammer, the ram is raised by along board gripped between two rollers, which can be separated when desired in order to release the tup. In each case, the power of the blow can be varied by altering the height of fall.

The mass of the anvil block must be sufficiently greater than that of the falling weight to absorb its energy (20 : 1). Belt or board drop hammers with falling weight ranging from 5 kN to 20 kN are employed to a lesser extent and to impart successive blows is little difficult.
Drop forging may be accomplished in either single or multiple impression dies. The single impression die is suitable for forging simple shapes (gear-blank, pulley-blank, etc) and the shape and size of the impression must correspond to those of the finished forging. The irregular shape (connecting rod, etc) are made in multiple impression dies which carry engraved impressions matching the preliminary impressions and then ultimately the finished impression.

Air or Steam Hammers

These hammers need compressed air or steam to operate them. In this case, blow depends not only on gravity, but also on steam and pneumatic pressure and therefore, variable power can easily be available. Thus all the energy is directed at the die set. So these can be used with large capacities on less massive foundations. In case of steam hammers, the working principle is very similar to steam engine. It has the falling weight varying from 5 kN to 300 kN.

In a single acting hammer, the air or steam is used to raise the ram to the desired height but it falls due to its own weight (gravity) and deliver the energy to the work piece lying in between the die set. Whereas in the double acting hammers, the ram is raised as well as fall under the influence of steam or pneumatic pressure. The work piece may be hit in a series of blow in succession in the same impression die.
A single blow of hammer deforms the metal only at the surface layers of the forging, thus deformation does not effectively penetrate into the inner volume of the metal. The squeeze pressure of the press applied to the stock gradually increases and penetrates deep into the metal involving its whole volume. Thus, the features of press forging reduces the number of stages required for a forging and thereby economical production is made possible.

The presses available can be put into the following categories:

**Mechanical Forging Presses**

Basically, mechanical presses make use of a powerful electric motor driving a large, heavy flywheel which in turn drives the ram through a crank/eccentric arrangement. A clutch disengaging the flywheel and a brake to stop the shaft (frank eccentric mechanism) at the end of forging stroke are the important elements to control the functioning of the presses. Crank and eccentric presses are generally employed for press forging due to high strength and rigidity of frames. Capacities from 80 MN and speed from 35 to 90 strokes per minute are available. These presses are rated on the basis of maximum pressure built up at the bottom of work stroke. Being strong and rigid, it is possible to work in closer tolerances on a mechanical press. However, greater skill is required in designing the tooling. It is assumed that the work should be accomplished in one stroke and in one impression. Owing to the high cost of the press, automation is very costly, so these presses are suitably used to produce small parts in large quantities in closed die forging.

**Hydraulic Presses**

These are employed in the production of heavy forgings weighing from 1 to 3.5 kN or more. These presses are suitable for closed die forging work in mass production with the feeding of stock in the form of pre-forged stock. The pre-forging stock is prepared on hammers. Since the presses are having limited stroke (100-200 mm), so the pre-forging are prepared on hammers. These are capable of imparting deep penetration deforming to work piece. The operation of hydraulic press is based on a cylinder with a piston capable to move inside the cylinder. The piston is attached to press platen moving between a rigid guide frames. The pressure is mounted by operating pump to flow more an more hydraulic oil under pressure (mineral oil at 300 kg/cm²) in the cylinder which ultimately transmitting the pressure of the order of 300 to 1500 tones to ram through piston. Maximum pressure/energy is available at the instant the upper die touches the work piece an the energy is gradually absorbed as metal flows. Squeezing of the work piece is obtained under heavy pressure with a small stroke. Similar presses can also be used for sheet metal working, provided the stroke suits the operation and product to be produced.

![Schematic View of Eccentric Press](Image)
**Screw Press**

It carries a screw (square thread) fitted to a heavy fly wheel and the other end of the screw is fitted to ram which can move up and down in a strong rigid guiding structure. The fly wheel rotation can move the ram up and down through square threaded screw. It is generally used for form bending, straightening, upsetting, etc. and is also capable for the large production of small parts. Such presses are usually re-offered to as Friction screw presses and are very useful for small part production in closed die forging.

![Diagram of a Friction Screw Press](image)

**Figure 6.18**: Schematic Diagram of a Friction Screw Press

**Application of the Forging**

Forging is used in most of the manufacture of metallic goods (especially hard, strong and heavy) which especially require proper stress distribution as per the application of product manufactured, e.g. Crain hooks, chisels, etc.

**Comparison between Forging and Casting**

Forging refines the structure of metal by smashing up large grain formations and closing up any cavities that may be present. In addition to the refinement of grain size other effects also result from suitable forging. Pieces formed by forging exhibit directional properties indicated by the flow lines. The original crystals typical of the cast structure are destroyed, hard films of brittle constituents or impurities are broken up or rolled into fibers and uniformity is established. In additions to those effects certain mechanical properties, particularly elongation percentage, reduction of area percentage and resistance to shock and vibration are improved and in favorable cases cracks and blow holes are welded up whereas casting leads to a weak crystalline structure having no grains.

![Spanners Produced through Different Methods](image)

**Figure 6.19**: Spanners Produced through Different Methods
Computer, Electronics and Forging

Numerical Control (NC) is the operation of machine tools and other processing machines by a series of coded instructions in the form of numerical data stored on paper or magnetic tapes, tabulating cards, computer storage disks or direct complete information.

NC machine tools incorporate many advances such as programmed optimization of cutting speeds and feeds, work positioning, tool selection and chip dispersal, e.g. modifications to the turret lathe have resulted in a turret slanted on the back side rather then placed on the front horizontal ways. A greater number of tools can be mounted on the turret as a result of the structural adaptation.

Computer Numerical Control (CNC) system use a dedicated stored program minicomputer to perform NC functions in accordance with control programs stored in computer memory.

Direct Numerical control (DNC) systems can control more than one machine tool at a time. They can store extremely long programs which do not first into the memory of CNCs.

NC offers following advantages:

(a) The amount of non-productive time is reduced.
(b) There are fewer rejects because of reliability and qualities are consistent.
(c) Inspection costs are usually reduced.
(d) Forged parts are more accurate and strong to proper hammering (computer controlled) at specific positions.
(e) Resistance furnaces show the application of electronics in forging
(f) Plasma Arc cutting method is used to cut the work-piece.
(g) Radio frequency heating devices are used when forging is to be controlled by (A/C or DNC) systems.

Figure 6.20: Flowchart of Numerical Control Steps
6.8 EXPERIMENT NO. 1

Smithy and Forging Workshop

Aim

To prepare a cylindrical piece of Mild Steel into a rectangular one.

Apparatus

Anvil, hammer, Tangs, Gloves

Procedure

(a) To convert a cylindrical piece into a rectangular piece it is important that we heat it up to temperature of approx. 1200°C (in workshop we are heating up to 1088°C) for this we place the piece in a furnace and just switch it on.

(b) We take out the piece when temperature is close to 1088°C. We place it on the anvil.

(c) Now the first step is to remove slag present on it.

(d) Then we hammer the heated piece on one side, so as to produce a flat surface.

(e) We turn the piece through 180°C then, and just repeat the same procedure to produce another flat surface.

(f) Now just carrying out the same procedure for the remaining two inflated sides, gives us a rectangular piece.

(g) Once, the hammering has been completed the piece is then quenched under tap water.

![Diagram of Size and Shape of Raw Material and Finished Product]

**Figure 6.21**

Precautions

(a) Hammering should be done with great care so that any part of the metal may not break into pieces and cause injury.

(b) Use goggles to protect the eyes from gases, sparking, etc.

(c) Always use proper tools, take all care while using them. If necessary, take the help of foreman.

(d) Spray of water should be frequently done to avoid dust in shop.

(e) Use of apron is essential to protect the body and clothes.
Extreme care must be taken, while inserting and with drawing the piece from the furnace.

Gloves should be worn while working with the piece.

Result
A cylindrical piece has been converted into a rectangular piece.

6.9 EXPERIMENT NO. 2

Aim
To give an octagonal shape to a rectangular piece of mild steel.

Apparatus
Anvil, Gloves, Hammer, Tongs

Procedure
(a) To change the shape of the piece, it will have to be heated in furnace at an approximate temperature of 1200°C.
(b) Take out the piece and with the help of the tong, place it on the anvil.
(c) Remove the slag present on the piece by scrapping it along the edges of the rectangle in such a way that the sides formed are of equal width and so subtend an angle of 135° with each side. The rectangle can’t be converted into octagon in one round; therefore it will have to be heated again and again.
(d) The initial process that is to be performed after removing the piece from the furnace is the same but, it will have to be turned through an angle of 180°.
(e) Once the hammering is completed, the piece is quenched under the tap water

Figure 6.22
Precautions

(a) Extreme care should be taken for placing and withdrawing the piece from the furnace.

(b) The piece should be held firmly by the tongs, as the piece has to be removed along its edges.

(c) Gloves should be worn while hammering.

Result

We got an octagonal shape piece after quenching.

6.10 EXPERIMENT NO. 3

Aim

To convert an octagonal shaped piece of mild steel into chisel.

Apparatus

Gloves, Tongs, anvil, hammer

Procedure

(a) Place the piece in the furnace so that, piece can be heated up to a temperature of 1200°C, with the help of tongs place the heated piece on the anvil and remove the slags present on it by scraping it along the edges of the anvil. Hold the piece with tong and hammering is directed inwardly. Now hammer the piece in such a way that its head is no longer than one inch.

(b) After this is done, the front end need to be sharpened.

(c) This gives us a fine shape edge. Make all the edges fine, by hammering.

(d) The back of piece must be flattened by placing the piece at right angles to the anvil.
Precautions

(a) Hammering should not be done in cold state.

(b) It should be seen that the width of the piece does not exceed the prescribed length.

(c) Extreme care and caution must be taken while working with the piece.

Result

The piece of metal has been converted into a chisel.

FURTHER READING

Hajra Choudhury, *Workshop Technology*.
S. Dalela, *Manufacturing Science and Technology*.