1. INTRODUCTION

Articles such as pipe funnels, container guards and boxes etc. which fulfill our day-to-day needs are generally made from metallic sheets or plates.

Sheet metal trade is a useful trade in Engineering works to convert the job of sheet or plate into required shape of article by using various operations, like hand tools and simple machines. It has its own significance to prepare all the relative items economically and without too many complications as compared to the other trade methods.

However, it should be understood very clearly that for successfully working in this trade one must have a good knowledge of menstruation, geometry, and properties of different metals. Laying out of patterns and cutting of sheet to exact sizes and shapes entirely depends upon the study and sketch practice. If the layout of pattern is drawn properly it means saving of time and money.

After studying this, you should be able to -

- explain scope of sheet metal work in engineering field,
- describe various tools, machines and operations which are widely used in sheet metal shop,
- sketch the various types of sheet metal joint,
- describe the process of soldering,
- know the types of flux and their applications,
- make a list of metals used in sheet metal work, and
- sketch the layout of pattern.

2. Safety Precautions in Sheet Metal Shop

1. Keep your mind on your job.

2. The sheet metal shop is no place to play! Careless or thoughtless acts such as playing, running, tripping, or pushing may cause accidents resulting in serious injury.

3. Report any injury immediately. Failure to do so can have serious consequences for you in unnecessary infections and resulting time lost.

4. Never carry tools in your pockets. Should you fall, sharp ends might be driven into your body or even more commonly you will gouge another worker.

5. Wear snug fitting clothing. Loose garments are easily caught in machinery. Never wear wrist watches, rings, long sleeves or neckties when working around machinery.

6. Don't use dull tools. Using dull tools means that you will either damage them permanently or wound yourself.

7. Report damaged tools and machinery. The possibility of someone being injured or the tool or machine being damaged beyond repair increases when such damage goes unreported.

8. Avoid hand cuts by using a brush rather than your hand to remove chips from machine areas.

9. Chisels, punches, and similar tools often burr over the top after continual pounding. These are called "mushroomed" heads. These mushroom heads will splinter off when hit and cause cuts and steel slivers in the arms and face. Grind off all mushroomed heads whenever they start to form.

10. Never use a hard hammer on machined, tempered, or hardened surfaces. Use a soft-faced hammer such as brass, lead, or rawhide. Using a hard hammer will damage the finished work. In the case of hardened work either the hammer or the work will splinter, possibly cutting you.

3. METAL USED IN SHEET METAL WORKS

The sheet of black iron, tin, galvanized iron (G.I), stainless steel, copper, zinc and aluminum etc. are widely used in tin-smithy work. The sheets are specified by gauge numbers. The larger the gauge number, the lesser the thickness.

Black Iron Sheet

It is the cheapest type of metallic sheet. It has a bluish black appearance and is often referred to as uncoated sheet. The use of this sheet is limited to articles that are to be painted after fabrication work such as tanks, stoves and pipes.

Galvanized Iron (GI) Sheet

The zinc coating resists rust and improves the appearance of the metal and permits it to be soldered easily. Welding work on this sheet is not as easy as zinc gives toxic fumes and residues. As it is coated with zinc, galvanized iron sheet withstands contact with water and exposure to weather. It is mainly used to make the articles such as furnaces, cabinets, buckets, pans and gutters etc.

Tin Sheet

Basically this is an iron sheet coated with the tin to protect it against rust. This is specially used for soldering work as it is the easiest metal to join by soldering process. It has very bright silvery appearance and is used mainly in making of roofs, canes, pans, dairy equipment and food containers etc.

Stainless Steel Sheet

Stainless steel sheet used in tin smithy shop can be worked as galvanized iron sheet, but is tougher than galvanized iron sheet. Stainless steel is an alloy of steel with chromium and nickel. It has good corrosive resistance and can be welded easily. It is costly metal. This type of sheet is used in food processing items, chemical plants, canneries, dairies items and kitchen wares etc.

Copper Sheet

This type of sheet has better appearance than other metals. Cost of copper sheet is higher in comparison to Galvanized iron sheet. Being resistant to corrosion, it is used for making the articles such as hoods, roof flashing, expansion joints and gutters etc.

Aluminum Sheet

Aluminum cannot be used in pure form, but is used with a small amount of silicon, manganese, copper and iron. It is highly resistant to corrosion and abrasion, whitish in color and light in weight. It is now widely used in the manufacturing of a number of articles such as trays, refrigerators, house hold appliances, lighting fixtures, parts of aero planes, electrical and transport industries and in the fitting and fixture used in windows, doors and building requirements etc.

4. HAND TOOLS AND MACHINES

There are a large number of hand tools and machines which are commonly used by a tin smithy or sheet metal worker such as mallets, hammers, shears or snips and stakes or forming supports, shearing machine, bending machine and folding machine etc.

According to their use all the concerning tools may be classified as follows -

4.1 Description of Tools

Marking and Measuring Tools

Steel Rule

It is particularly useful in measuring and laying out small size of work. It is shown in Figure 4.1(a).

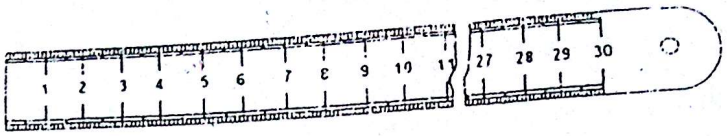

Figure 4.1(a): Steel Rule

Folding Rule

It is very useful in measuring and laying out of larger size of work.

Steel Circumference Rule

This type of rule is used to find out directly the circumference of a cylindrical shape.

Thickness Gauge

It is also known as slip gauge and is used to measure the clearance between two assembled parts (Figure 4.1(b).

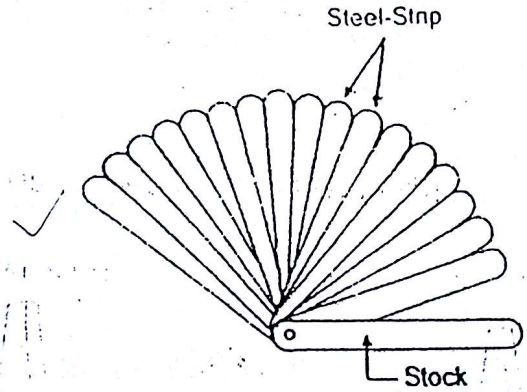

Figure 4.1(b): Slip Gauge

Straight Edge

The main function of this edge is to scribe long straight lines. It is simply a flat graduated bar of steel with one longitudinal edge is beveled.

Steel Square

This is L-shaped hardened steel piece. It has two parts

(a) Tongue

(b) Body

The narrow arm of the square is known as tongue while the wider part is called as body. It is used for checking the 90° between two adjacent

surfaces and for making the line in perpendicular direction to any base line.

Sheet Metal Gauge

This is used to measure the thickness of sheets as shown in Figure 4.1(c).

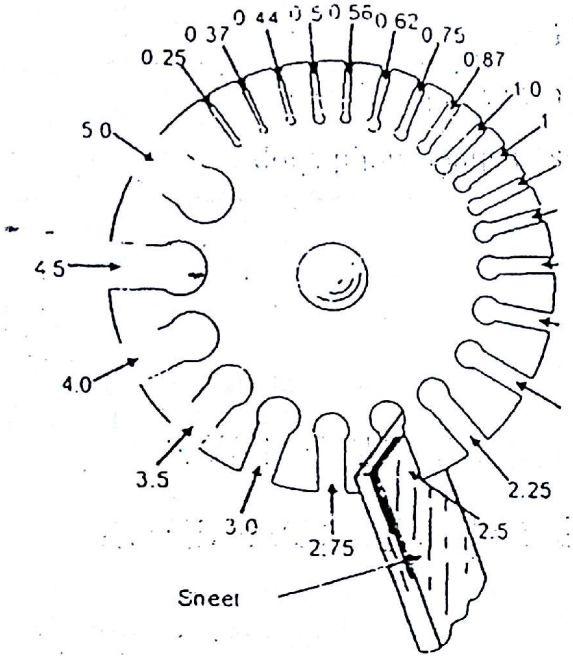

Figure 4.1(c): Sheet Metal Gauge

Scriber

This is simply a long wire of steel with its one end sharply pointed and hardened to scratch the lines on metallic sheet in laying out patterns.

Dividers

It is made by hardened steel and generally used for drawing or scratching the circles or arcs on the metallic sheet.

Trammel

It consists of a steel bar with two movable steel heads which have bottom part sharply pointed and hardened. Main function of this trammel is to draw large sizes of circles or arcs that are beyond the limit of dividers.

Punches

These are also made by hardened steel Punches are used for marking out work and to locate the centre in a permanent manner. Punches may be divided in two types

(a) Prick Punch or Dot punch

(b) Centre Punch

Prick punch is used to make small marks and to make this prick punch marks larger, we have to use centre punch. Centre of the hole that is to be drilled is marked by centre punch.

Cutting Tools

Chisels

These are generally used for chipping and cutting operations and are made of high carbon steel. For sheet metal work, the flat and round nose chisels are widely used.

Snip or Shears

These are made of high carbon steel and used for cutting thin and soft metallic sheets. There are so many types of snip but straight and curved or bent types of snip are commonly used in practice (Figure 4.1(d)).

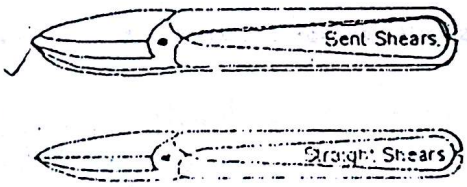

Figure 4.1(d)

The straight snip or shear is used for cutting along a straight line while the curved or bent type of snip is used for cutting the sheet along a curvature. Both these snips are very light and can be easily handled by only one hand. A heavier class of snip is known as bench-strip or bench-shear which is fitted on bench.

Striking Tools

Hammer

To suit the different types of work on tin sheet, various sizes and shapes of hammers are used. They are made to have square or round heads to suit for striking or hammering the corners and round surfaces respectively. For avoiding the damage of sheet, soft faced hammers are frequently used.

Mallet: This is also used for striking purpose and made of hard rubber, lead, copper or mostly of hard wood

Holding Supporting and Forming Tools

Stakes: Stakes are used for seaming, bending or forming operations. They actually work as supporting tools as well as forming tools. As per nature of work some useful forms of stake are shown in Figure 4.1(e).

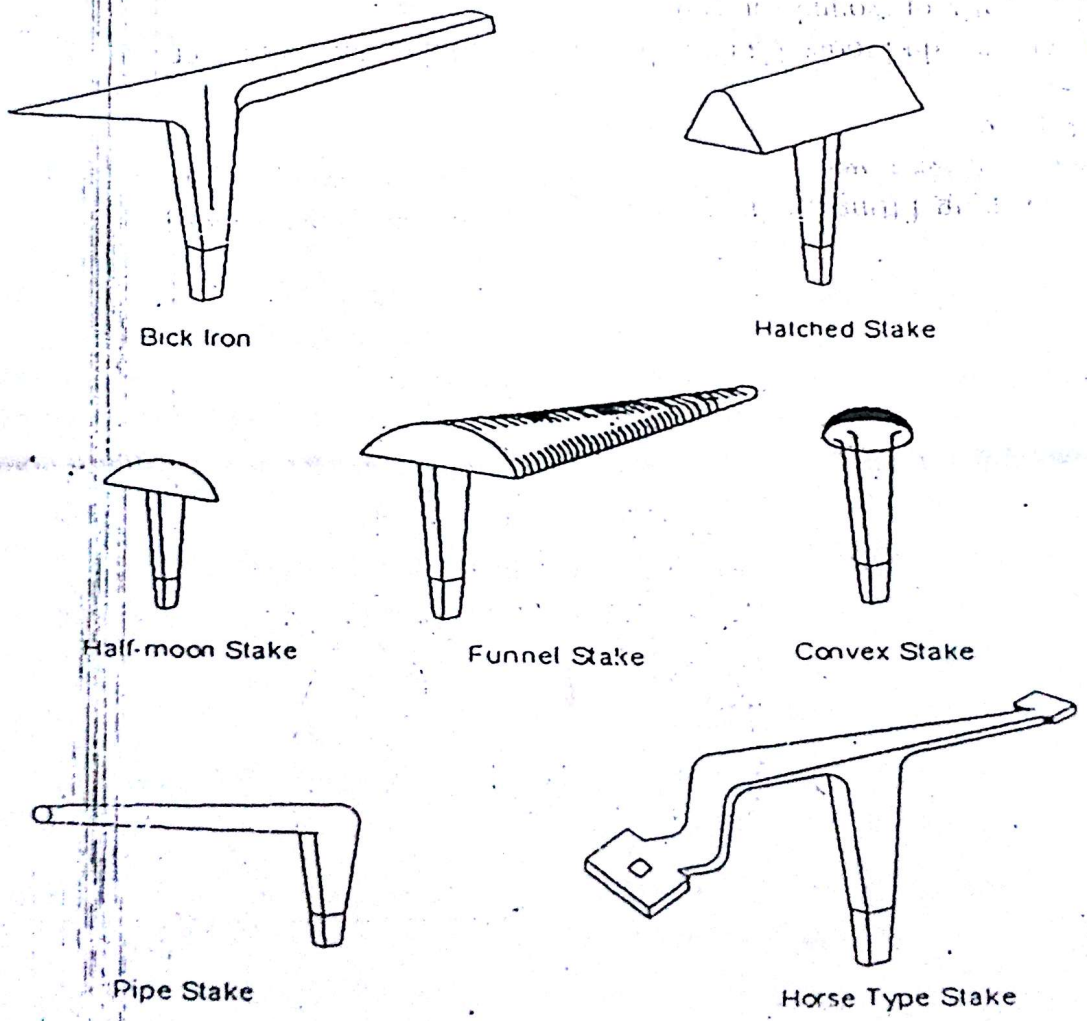

Figure 4.1(e): Different Forms of Stake

In forming operation for long tapered cylindrical items, a bick iron is used while the hatched stake is preferred for forming, seaming and bending the edges. For conical work, a funnel stake is very useful. Half moon stake is very useful for working the edges of discs. For spherical work, a convex stake is preferred. Pipe stake is used for forming tubes. Horse type of stake is used for bending and general work for holding and supporting the other stakes.

Pliers

These are used for holding and forming the various shapes and patterns. In general, flat nose and round nose pliers are widely used.

Rivet Set

This is a hardened steel tool with a hollow part at one end. It is used to shape the end of a rivet into a round and smooth head.

Miscellaneous Tools

Tools which are generally used in this shop on time to time such as soldering iron, spanner set and screw driver etc. are classified as miscellaneous tools.

4.2 Description of Machines

Sheet Metal Working Machines

For mass production when a large number of jobs are made by using heavier sheet. It is obvious that hand operation like bending, shearing and punching etc. will be too un widely and at the same time uneconomical too. To compete with this problem both hand and power operated machines have been developed. These are designed in such a way that a wide variety of operations may be performed easily.

Machines, which are commonly used in sheet metal work to perform different types of operation, are listed as follows:

(a) Shearing Machine
(b) Forming Machine
(c) Bar Folder
(d) Burring Machine
(e) Setting Down Machine
(f) Turning Machine

Shearing Machine

It is used to cut or shear the sheet in many ways. The selection of particular method depends upon the size and shape of the parts required and the numbers needed.

As shown in Figure 4.2(a), it is a simply hand operated machine. It consists of a base which can be fixed easily in any position as desired, two blades of high carbon steel arranged in the machine, lower one is known as fixed while the upper one as movable. The fixed blade is rigidly fixed with the frame. The movable blade is operated by means of the hand lever.

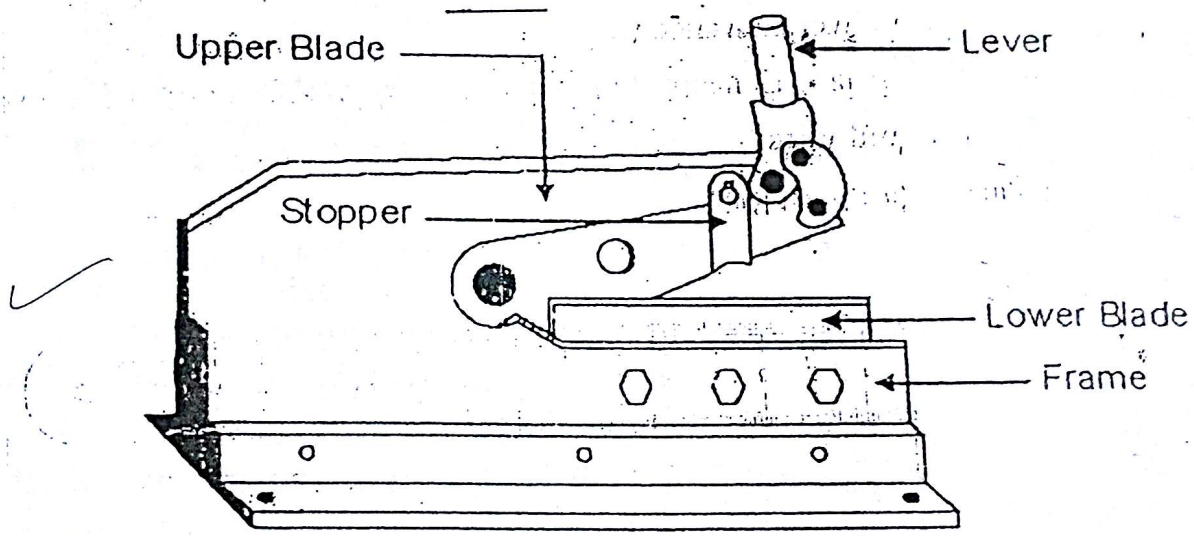

Figure 4.2(a): Shearing Machine (Hand Operated)

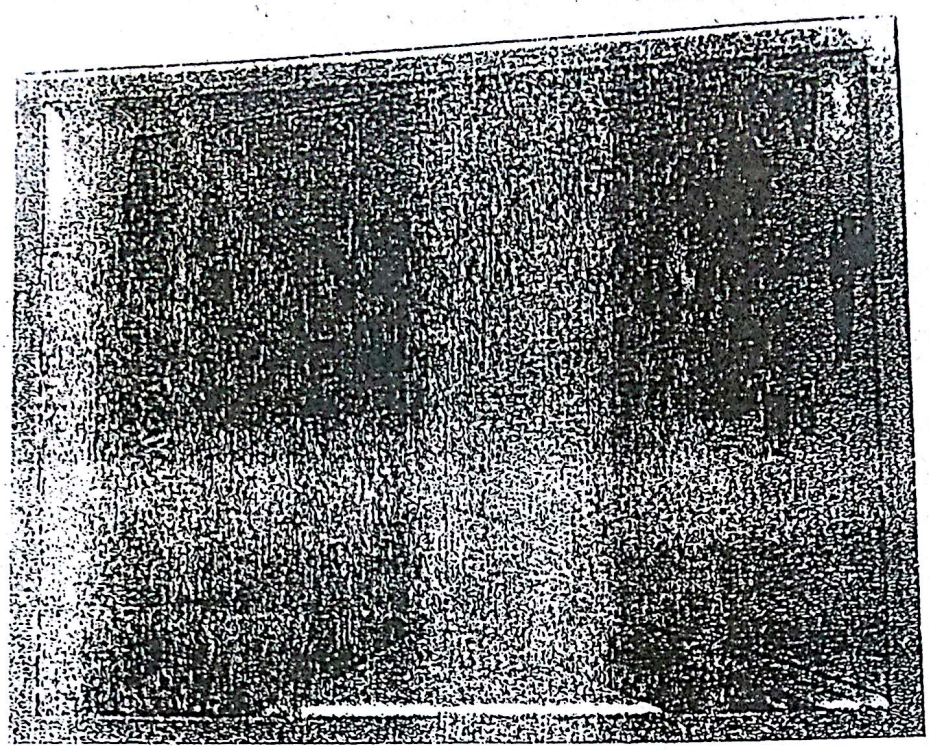

Fig 4.2(a): shearing machine (Power Operated)

The job of sheet is placed between the blades so that the layout marking come properly under the cutting edges of both the blades. After fixing this position the lever is pulled down by the operator Due to the pulling action of the upper blade, which is in movable condition, moves downward position and thus the job of sheet is cut.

Forming Machine

Pipes, cans and stoves etc. are formed out of flat sheet blank on this forming machine. It consists of three rollers. Out of three, two rollers at the bottom have fixed position while the third one (Top Roller) may be adjusted in vertical direction to adjust the required pressure and give the fixed curvature to the sheet as shown in Figure 4.2(b).

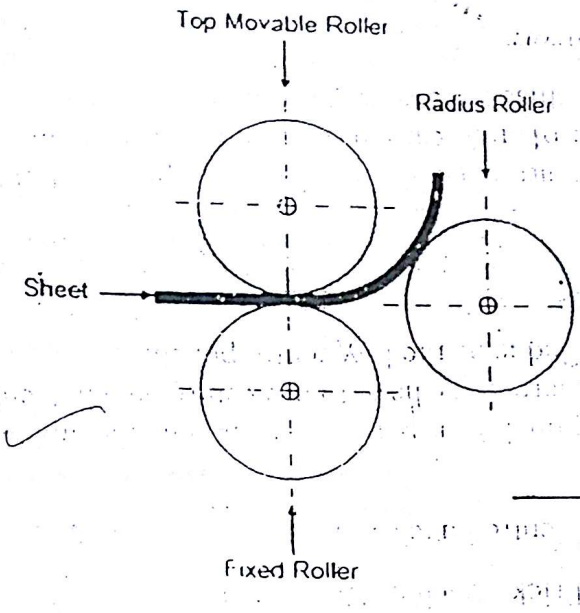

Figure 4.2(b): Forming Machine

Bar Folder

It is used for folding and bending the side edges of the metallic sheet blank to form the joint at the seam. Normally, it is used for shaping metal sheet into cylindrical shape.

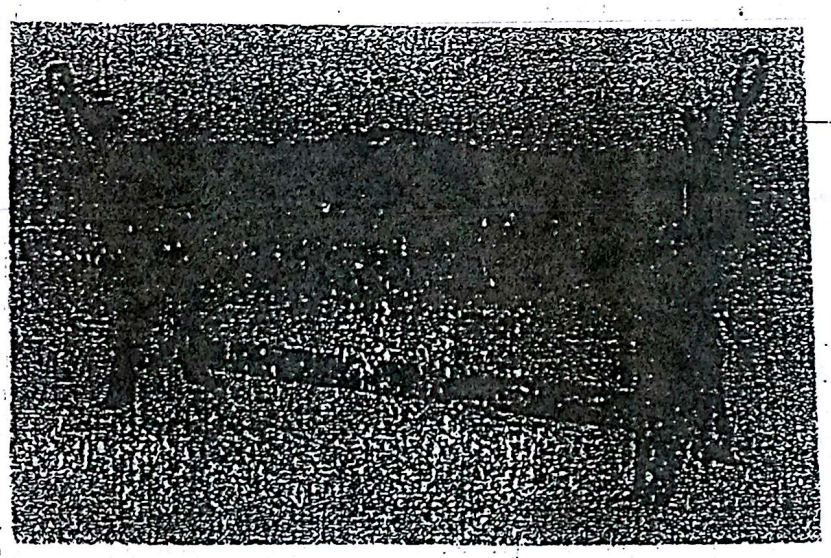

Figure 4.2(c): Metal bending machine

Burring Machine

The burring machine is used to make a burr on the bottom edges of a can or cylinder. To make this burr by using burring machine, is the first step in making double seam with a double seaming machine.

Setting down Machine

As the burrs have been made by a burring machine, the seams are closed or set down on a machine called as setting down machine.

Turning Machine

Turning machine is similar to the burring machine but it is used for producing rounded edges for bodies of cylinders and in double seaming.

5. SHEET METAL OPERATIONS

In short the practical art of sheet metal works lies in making jobs of different sizes and shapes by adopting different operations. The various operations which are commonly used in sheet metal works can be listed as follows :

(a) Shearing

(b) Bending and forming

(c) Drawing

(d) Squeezing

General Description of Operations

As per above mentioned list of operations description of each operation is given here in brief just to clear the basic points of each operation.

Shearing

Word of shearing is a general name for most sheet metal cutting operation in a specific sense. It designates a cut in a straight line across a sheet, bar or strip. It shows clean edges on the metallic job that is to be sheared or cut.

Some of the basic shearing operations are described below

Cutting-off To divide a piece from a strip with a cut along a single line.

Blanking

To cut a whole piece from given metallic sheet just sufficient scrap is left all around the opening to ensure that the punch has to cut the metal along its entire edge.

- *Parting*

It signifies that scrap is removed between the two pieces to part them.

Punching

It is the operation of producing circular holes on a metallic sheet by using punch and die. The punched out metal is removed as a scrap or waste.

Piercing

It is the process of producing holes of any desired shape.

Notching

To remove the metal in desired shape from the side or edge of a metallic strip or sheet is known as notching.

Bending and Forming

Sometimes it is thought that bending and forming are synonymous terms. However, bending occurs when forces are used to localize areas, such as in bending case, a piece of metal into a right angle while for forming, it occurs when complete parts or items are shaped.

It is observed in all bends of metal, the metal is stressed beyond the elastic limit in compression on the inside and in tension on the outside of bend. Only one line, known as neutral line, retains its original length. Generally, roll bending and angle types of bending are used in practice.

Drawing Operations

It is defined as a process for making of cup or thin walled hollow shaped parts from flat blank of metallic sheet. In this operation, the blank is heated up to a required temperature just to provide necessary elasticity for working then the heated blank is placed in fixed position over the die. Die will remain stationary by exerting a calculated pressure from punch against the blank. The punch will push the metal through the die to form a cup.

Squeezing

Squeezing means to press closely. The squeezing operations such as sizing coining, hobbing and riveting etc mostly used on sheet metal (Figure 8.1). It is normally a quick and widely used way of forming for ductile metals.

Sizing

To finish the job of forged steel, aluminium and other ductile non-ferrous metals in thickness is called as sizing operations.

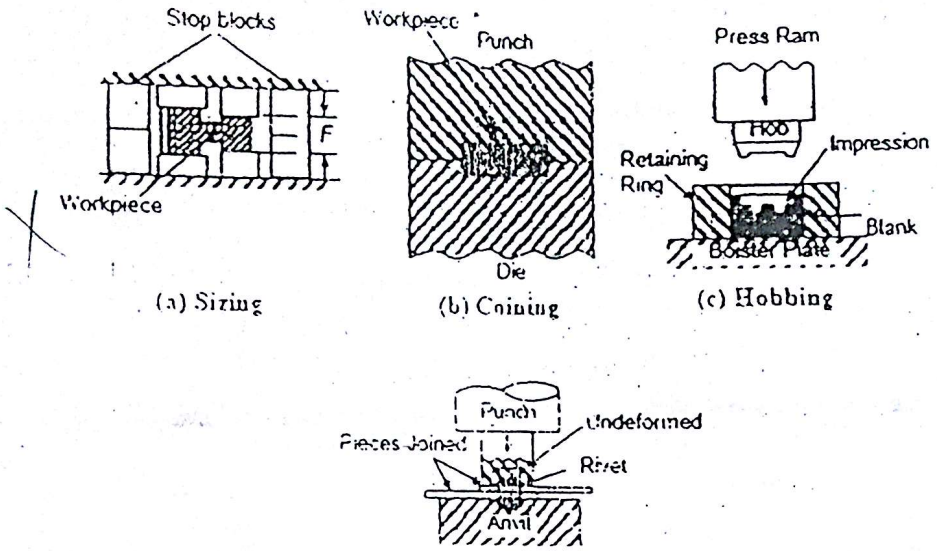

Figure 5: Squeezing Operation

Coining

With comparison to sizing, coining, more truly involves the impression and raising of images from punch and die into the metal. It is the process of forming designs on both side of a blank at the same time as is done in making money coins.

Riveting

Riveting is a process of joining two metallic pieces by compressing an auxiliary joining component, i.e. rivet. Riveting process may be of two types (a) Cold Riveting and (b) Hot Riveting

Hobbing

Hobbing is a method of making different types of moulds for the plastic and die casting industries. A tool steel punch known as Hub is machined to the shape of the cavity is then pressed into a blank of soft steel to form the mould. This machined hub should be hardened

6. LAYOUT OF PATTERNS

For the fabrication of different shapes of jobs in sheet metal work, the projective geometry forms the basis of successful layout of patterns.

It is very useful to determine the correct amount of sheet metal or plate that is necessary to fabricate any product. The pattern is nothing but simply a flat outline of the job. Almost all the patterns are obtained from the development of surfaces of some common types of geometrical solids such as prism, pyramid cone and cylinder. The pattern or outline of the given job to be fabricated may be drawn on a paper and then transferred to the metal or may be laid out directly on the metal pattern is known as template from which the actual job is to be marked off.

6.1 Basic Concept of Development of a Surface

Imagine that a solid is enclosed in a wrapper of thin material such as paper. If this covering is opened out and laid on a flat plane, the flattened out paper is the development of the solid. In short we can say when surfaces of a solid are laid out on a plane, the figure obtained is called its development. Figure 9.1 shows a square prism covered with paper in process of being opened out. Its development, as shown in Figure 6.2, consists of four equal rectangles for the faces and two similar squares for its ends. The development of solid, thus, represents the actual shape of all its surfaces which, when folded at the edges, would form the solid. In short, we can say that the thorough idea of the methods for the development of surfaces is most important in sheet metal works.

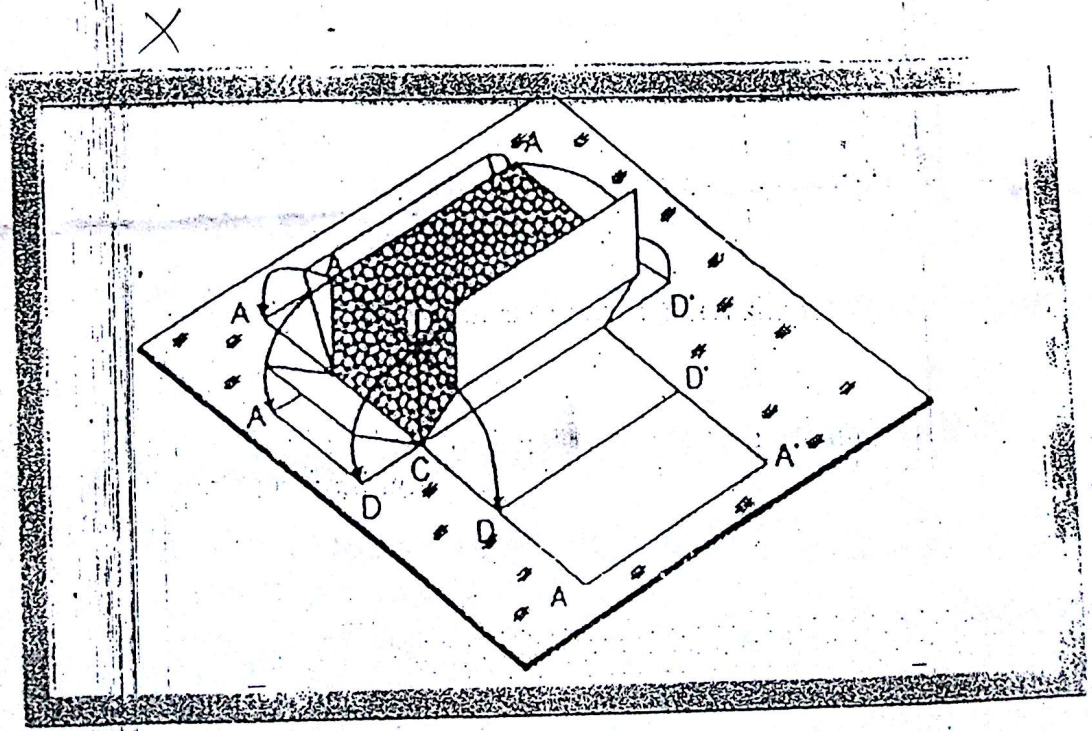

Figure 6.1

6.2 Methods of Development

Both stretch outs and patterns are originated by the following methods of development :-

(a) Parallel line method

(b) Radial line method, and

(c) Triangulation method.

Parallel Line Method

It is employed in case of prisms and cylinders in which stretch out lines principle is used (Figure 9.2). Lines A-A and $A_1 - A_1$ are called the stretch out lines.

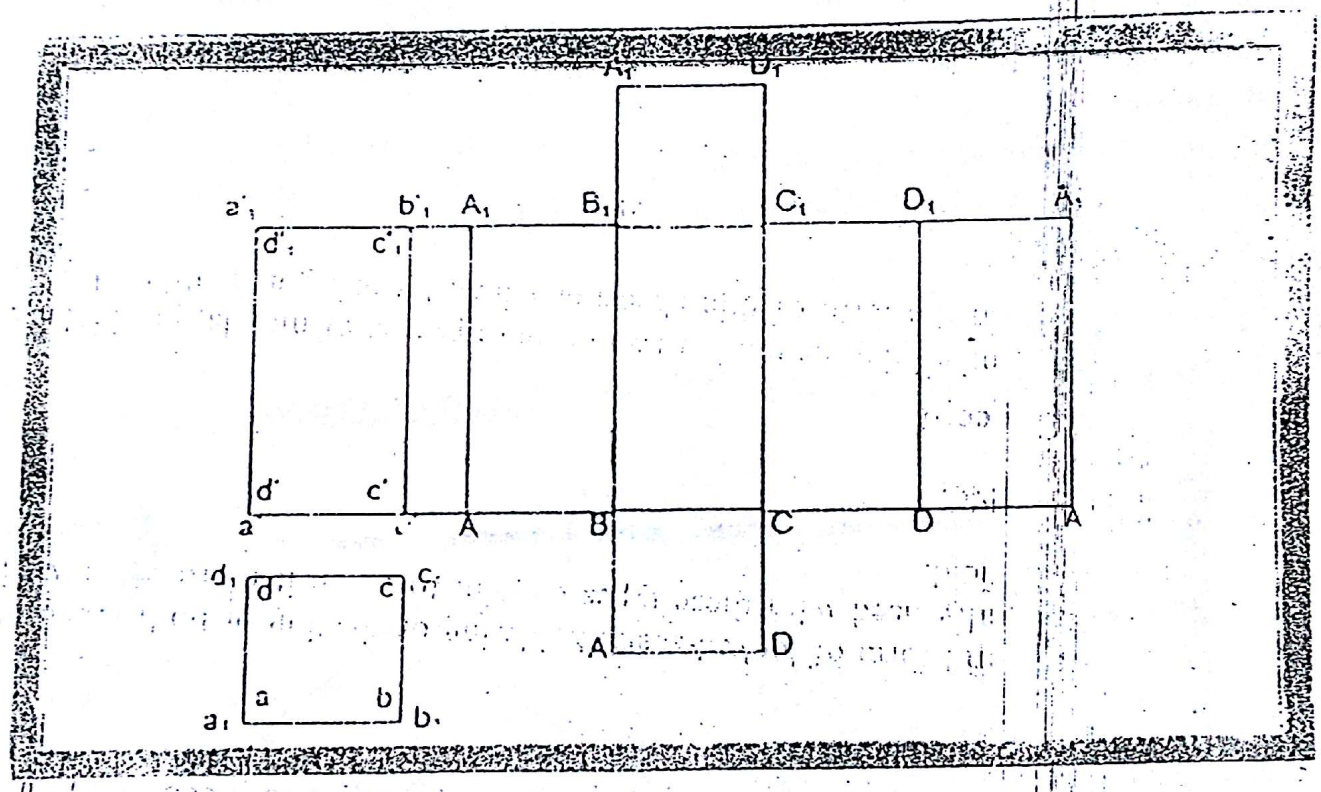

Figure 6.2 (a): Parallel Line Method

Radial Line Method

It is widely used for the development of surfaces of pyramids and cones surfaces where the true length of slant edge or the generator is used as a radius

Triangulation Method

It is used for developing the surfaces of transition pieces. The transition piece is a connecting piece, which connects openings of different shapes and sizes. These pieces are used in ventilating and heating and similar pipes.

Example 1:-

Develop the lateral surface of the truncated cylinder shown in Figure 6.2(c).

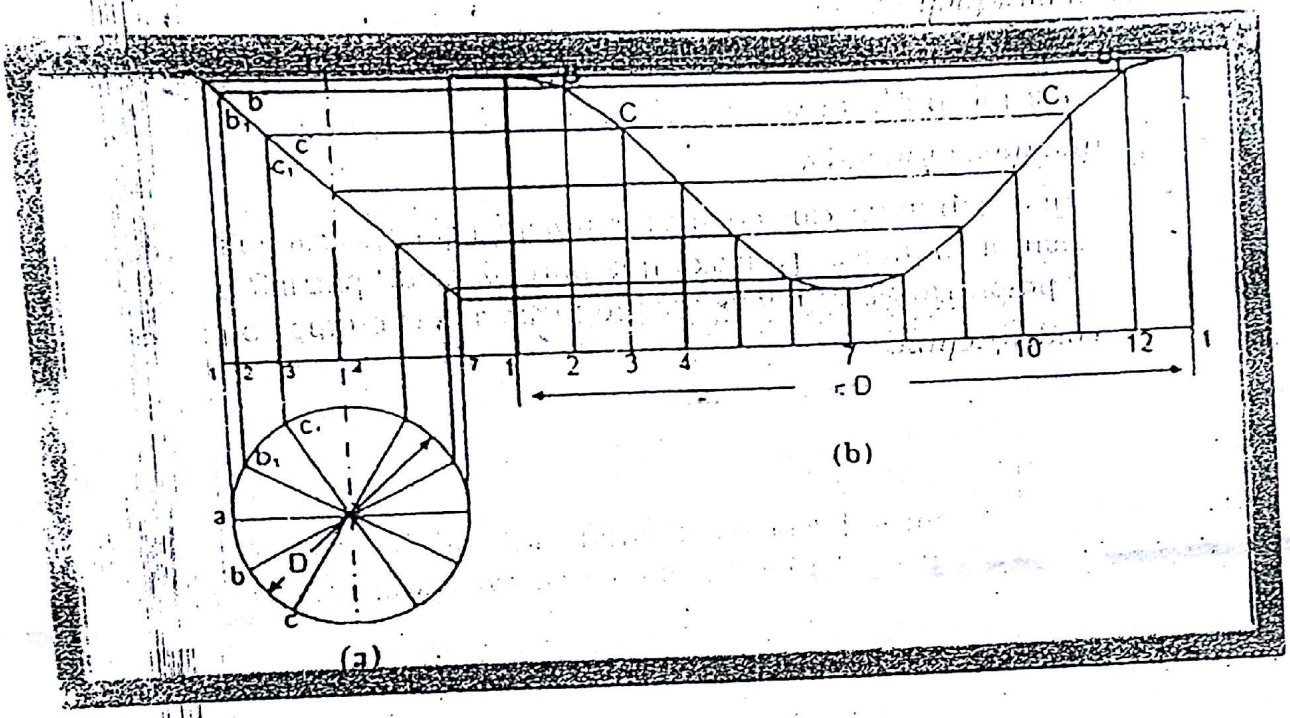

Figure: 6.2(c)

Solution

First of all draw the plan (top view) and elevation (front view) of the given truncated cylinder. Then divide the circle in twelve equal parts. Project the division points of the Top View to Front View and draw the generators.

Mark points a', b' and b'_1, c' and etc. in which the generators are cut.

Draw the development of the lateral surface of the whole cylinder along with the generators as shown in Figure 9.3. The length of the line $1'-1'$ is equal to $\pi \times D$. This length can also be marked approximately by stepping

off with a bow divider, twelve divisions, each equal to the chord length *ab*. Draw horizontal lines through points *a'*, *b'* and b_1' etc. to cut the corresponding generators in point *A*, *B* and B_1 etc.

Draw a smooth curve through the points. Thus, the figure obtained 1-*A*-*A*-1 is the required development of the given truncated cylinder.

7. TYPES OF SHEET METAL JOINTS

As per demand or requirements there are so many types of joints which are widely used in sheet metal or Tin Smithy work as shown in Figure 7.1.

Lap Joint

It is the simplest and common type of joint that can be prepared by means of soldering or riveting processes.

Seam Joint

A seam is a joint made by fastening two edges to each other.

Hem Joint

Hem is an edge or border made by folding. It stiffens the sheet and does away with the sharp edge. Generally, two types of Hem joint – single hem and double hem – are there. Single Hem joints are made by folding the edges of the sheet over once to make it smooth and stiff while double hem are made by folding the edges over twice to make it smooth and stiff.

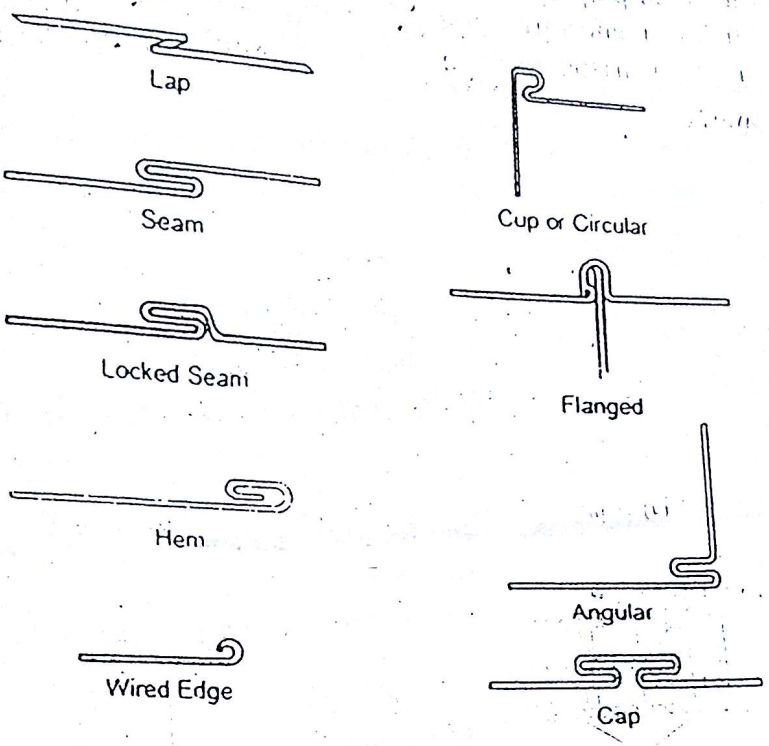

Figure 7.1: Sheet Metal Joints

Wired Edge

The wired edge is smooth and very strong as it is prepared by folding the edges along a piece of wire.

Flange Joint

It is commonly used in making pipe connection.

Angular and Cup Joint

Angular and cup joints are mainly used for joining two pieces at an angle of 90°.

Cap Joint

It is a useful form of locked-seam. Soldering or riveting or both processes are generally used with these types of joint to make it more effective in practical field.

8. SOLDERING

8.1 Basic Concept

It is a method of joining or uniting two or more pieces of metals, particularly when they are in the form of thin sheets or wires, by using a fusible alloy or

metal which has fairly low melting point as compared to the metals to be joined. The metal or alloy used for this purpose is known as "Solder".

Classification of Soldering

Soldering method may be classified in two groups:

(a) Soft Soldering, and

(b) Hard Soldering

Soft Soldering

Soft soldering is preferred in sheet metal work for joining parts that are not exposed to the action of high temperature and are not subjected to excessive loads and forces. Soft soldering is used extensively for joining small parts and wires. The solder which is primarily an alloy of lead and tin has a melting range of 150° to 350°C is commercially known as soft solder. A suitable flux is also used. Its function is to prevent oxidation of surface during the heating process.

Hard Soldering

It employs solder which has high temperature range of about 600° to 900°C and are stronger than those used in soft soldering, e.g. silver soldering is a hard soldering method and silver alloyed with tin is used as a solder which is known as hard solder. The fluxes are mostly in paste form and are applied to the joint with a brush before heating.

8.2 Soldering Operation or Technique

Before starting the operation, the metal pieces which are to be soldered should be properly cleaned for small light parts. The heat may be supplied by a soldering iron which must be large enough to carry enough heat to heat up the parts to just above the melting point of solder.

The soldering irons used in the operation are made in different shapes and sizes. A forge type of soldering iron is shown in Figure 3.1. It consists of a copper bit tapered to form an edge at its end. This bit is fastened to an iron rod already fitted with wooden handle. For light soldering work, electric type of soldering iron is preferred. After cleaning the joining parts and placing them in right position, a flux is employed. The purpose or function of using the flux is to prevent the oxidation on the metal surface when the same is heated. Zinc chloride is a common flux used specially for this purpose.

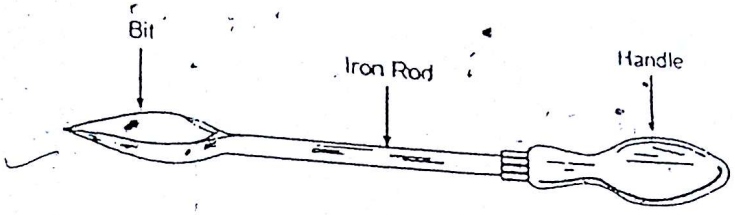

Figure 8.1

After the soldering iron has been heated to the required temperature surface is cleaned by means of grinding or filing and then dipped in a mixture of flux and solder. Another practice is to first dip it in a mass of flux followed by the application of solder. This enables the solder to melt and spread over the hot surface of the bit to form a coating over it. Practically this operation is known as "Tinning".

After this the bit is again dipped in the flux to remove the oxides from its surface, if any, and then repeat in the solder to pick up required quantity of solder. After this step now it is ready for application to the surfaces which are to be soldered. It is an important fact to keep in mind that the solders which have low percentage of tin have a higher melting point.

The different composition of solder for different purposes are as follows :

	Lead + Tin
Soft Solder	37% + 63%
Medium Solder	50% + 50%
Plumber's Solder	70% + 30%
Electronics Solder	58% + 42%

8.3. FLUXES

Fluxing agents are non-metallic materials which remove the oxides from the soldering surface and prevent oxidation. Generally, fluxes are available in powder, paste or liquid forms.

Function of Flux

Every metal has an oxide layer, which prevents the filler metal from wetting the surface to be joined. Even when this layer is dissolved, the oxides layer is again formed on the surface as soon as the metal is heated. Fluxing agents or fluxes remove the oxide layer and also prevent its formation anymore.

Types of Flux and their use

Generally, two types of flux exist which are :

(a) corrosive type, and

(b) Non-corrosive type

Zinc chloride, Hydro-chloric acid (HCL), Phosphoric acid and Sal Ammoniac are known as corrosive type while oleic acid and tallow as non-corrosive type.

Corrosive types of flux are used for soldering work on iron, steel, copper and its alloys surfaces while non-corrosive types of flux are used specially for soldering work on tin sheet and lead surface.

Some Important Fluxing Agents and their Applications

Hydro Chloric Acid (HCL)

Diluted solution of this acid with water is used for soldering work on zinc or zinc coated surfaces. It is useful for both "soft" and "hard" type of solders.

Zinc Chloride

It is used in liquid form (1 part of zinc chloride + 3 to 4 parts of water) for soldering work on ferrous or non-ferrous metal.

Sal Ammoniac

It is used for soldering work in powder crystal or liquid form as per requirement specially used with soft solder.

Borax

It is used in the form of powder or liquid for brazing work on copper brass and silver metals surfaces.

Resin

It is non-corrosive type of flux, and is used in the form of powder, rod or liquid for soldering purpose of electric joints.

Soldering Paste

It is a combination of zinc chloride and starch. It is commonly used for soldering purpose.

Selection of Fluxing Agents

Selection of appropriate flux depends upon

(a) Working temperature of the filler metal

(b) Material to be joined.

(c) Corrosive properties of the filler metal