

INTRODUCTION TO METAL FORMING

Objective

To study and observe through demonstration the metal forming processes (Rolling, Forging and Sheet metal forming)

Background

ROLLING

Rolling is the process of plastic deformation of metals by squeezing action as it passes between a pair of rotating rolls, either plane or grooved. The process may be carried out hot or cold. The most common rolling mill is the 2-high rolling mill, which consists of two rolls usually mounted horizontally in bearings at their ends and vertically above each other (Fig. 2.1). The rolls may be driven through couplings at their ends by spindles, which are coupled, to pinions (or gears), which transmit the power from the electric motor.

To control the relative positioning of rolls, a roll positioning system is employed on the mill stand. In small mills, such as the one in the laboratory, the roll positioning system called the 'mill screw' is hand driven, while in commercial mills they are motor driven.

The 2-high mills could be either reversing or non-reversing type. In the reversing type, which is the most common one, the direction of motion of the rolls can be reversed, and therefore the work can be fed into the mill from both sides by reversing the direction of rotation of rolls.

For rolling to take place the roll separation or roll gap must be less than the in going size of the stock. After rolling, the height of the stock is reduced and length is increased. The difference in height of ingoing and outgoing is called 'draught'. Fig. 2.1 shows a flat piece of metal of thickness h_1 , through a pair of rolls of radius R . The AC is called the 'arc of contact'. The angle θ subtended at the roll center by the arc of contact is called the 'angle of contact' and can be evaluated from

$$\cos \theta = [1 - (h_0 - h_1) / 2R]$$

If there is no elastic deflection of rolls during rolling, the final thickness of metal h_1 is same as the roll gap. If elastic deflection of rolls occur, the final thickness of metal after rolling h_1 , is greater than the roll gap fixed before rolling. Depending upon the condition under which the metal is introduced into the roll gap, two situations can occur:

- The metal is gripped by the rolls and pulled along into the roll gap.
- The metal slips over the roll surface.

The process of rolling depends upon the frictional forces acting between the surfaces of the roll and the metal. The condition of biting or gripping of metals into rolls is $\mu \geq \tan \theta$, where μ is the coefficient of friction between the roll and metal surfaces. The maximum value of θ

$(\theta_{\max} = \tan^{-1}\lambda)$ is often called the angle of bite. The average coefficient of friction can now be estimated as $\mu = \tan \theta_{\max}$.

Rolling of a metal plate on a two high rolling mill will be demonstrated. The demonstration of the situations when (a) metal slips on the roll surface, and (b) metal is gripped by the rolls, would also be shown to you.

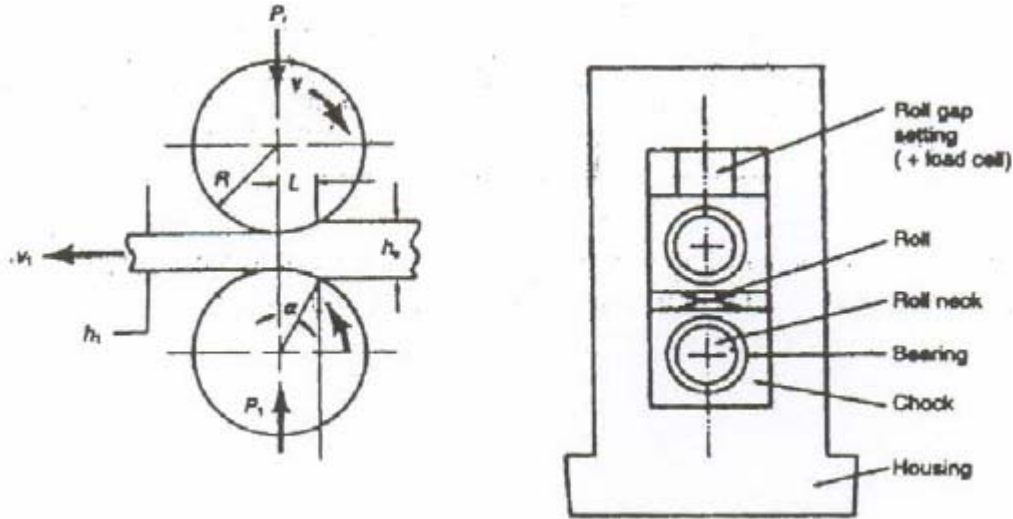


Fig.2.1: Rolling is steady state process that (a) reduces the thickness of the work piece (b) in rolling mills of considerable stiffness

Observations

(1) Report the various parameters in a tabular form for the various passes during the rolling of the given metal piece as shown in rolling demonstration.

Metal used:

Roll diameter:

Roll speed:

Pass No.	Initial Dim.			Passive Roll Gap	Final Dim.			Draught	% Inc.			Spring back	Bite Angle	Coefficient of Friction
	L	W	T		L	W	T		L	W	T			

1.

(L: Length, W: Width, T: Thickness, Inc: Increase, Red: Reduction, Dim: Dimension)

FORGING

Forging primarily consists of a work piece material and dies, which is of a predetermined shape by applying compressive load. Forging may be done in open or closed dies. Open die forgings are nominally struck between two flat surfaces, while closed die forgings are formed in die cavities. All forging processes require skill, but more skill is required in the open than closed dies forging.

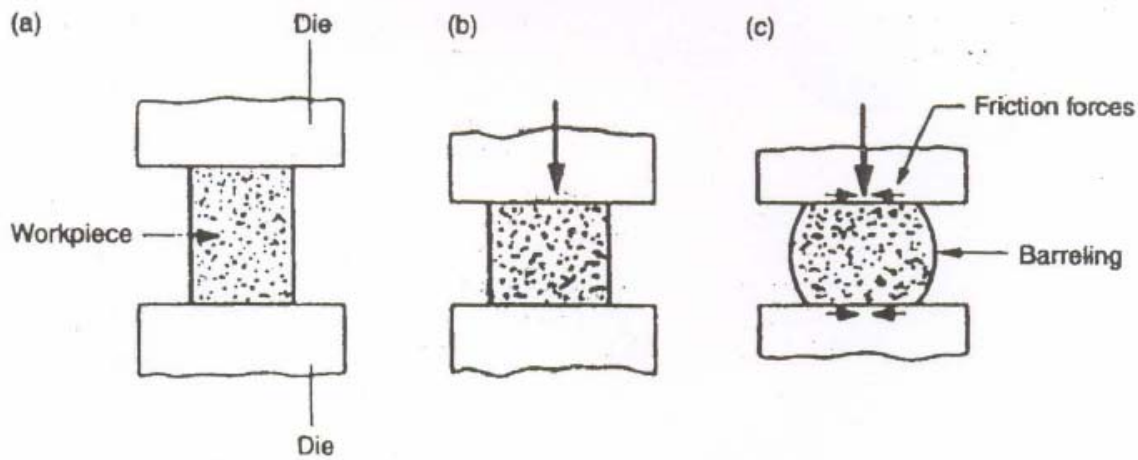


Fig: 2.2: a) Solid cylindrical billet upset between two flat dies (b) Uniform deformation of the billet without friction (c) Deformation with friction

Observations

- 1) Report the percent reduction in height, and percent increase in diameter, and your observation on the shape of the blocks after forging as shown in the forging demonstration.
- 2) Draw schematically the shape of the blocks after forging.

Lubrication Condition	Initial Length	Dimension Diameter	Pressure/Load	Final Length	Dimension Diameter	Remarks

LABORATORY EXERCISE II

FORGING

Objective

To manufacture a small object using hot forging technique
 Report the observations during the cold forging of given metal pieces.

Equipment & materials

Forge hearth, tongs, anvil, sledge, flatter hammer, steel rod.

Procedure

- Take a steel rod of about 25 mm dia and about 75 mm long.
- Take piece weight before the heating.
- Place it in the hearth and heat it up to 1150°C (yellow hot).
- Remove it from the hearth and hammer it to square shape
- Grind the head and sharpen the edge
- Weigh the final object.

Report The Following

- (i) Sketches depicting each major step in processing.
- (ii) Give the weight loss during the hot forging in your object.
- (iii) Problems associated with heating of steel prior to forging.
- (iv) Applications of the open die cold forging.
- (v) Precautions to be taken.

SHEET METAL FORMING

Many products are manufactured from sheet metal involving combination of processes such as shearing, bending, deep drawing, spinning etc. In all these operations, some plastic deformation of the metal is involved. They are essentially cold working operations.

LABORATORY EXERCISE III

SHEET METAL FORMING

Objective

- (i) To prepare a sheet metal product (square container).
- (ii) Report the various parameters for the various passes during the rolling of the given metal piece.

Equipment & material

Mallet, hand shear, bench shear, grooving and riveting tool, metal sheet, soldering equipment

Demonstration

Self secured sheet metal joints

(a) Internal grooved joint

- Mark out portions of given sheets near edges to be joined with a marker (Fig. 3.1a)
- Fold the sheets at edges in the portion marked, first at right angles to the plane of the sheet (Fig. 3.1b) and then at 180° to the plane (Fig. 3.1c)
- Insert one folded sheet into the other (Fig. 3.1d)
- Groove the seam using grooving die (Fig. 3.1e)

(b) Double grooved joint

- Fold sheets after making them as per the instructions given (Fig. 3.2a)
- Cut a piece of sheet (called strap) of required width
- Strap width = (4 × size of marked edges) + (4 × thickness of sheet)
- Close the edges of the strap slightly as shown in Fig. 3.2(b)
- Slip the strap on the bent edges of the sheets after bringing them together (Fig. 3.2c)

(c) Knocked-up joint

- Fold one sheet and close edges slightly (Fig. 3.3a)
- Bend one sheet to form a right angles band (Fig. 3.3b)

- Slip the second sheet in the folded one (Fig. 3.3c)
- Close the right angled sheet using a mallet (Fig. 3.3d)

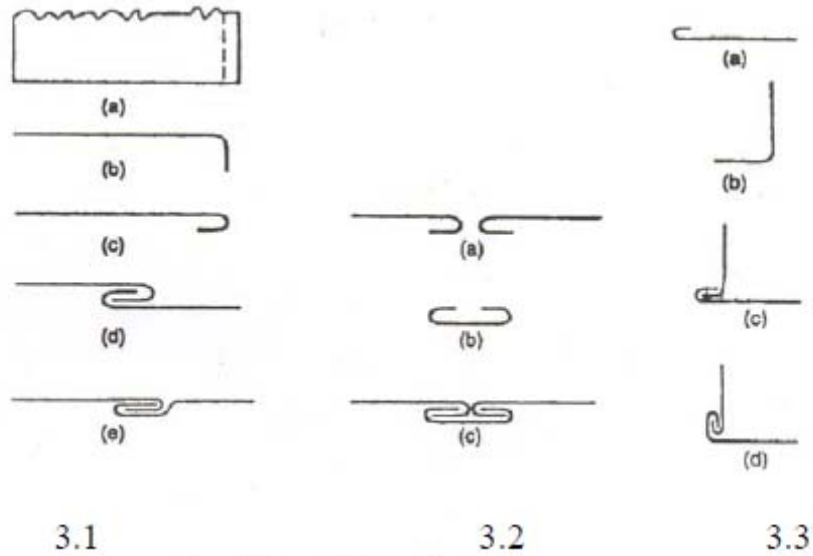


Fig: Sheet Metal Joints

Procedure for Square Container:

- Cut a sheet of 120 mm x 120 mm, and mark a center of 60 mm x 60 mm to indicate bend lines.
- Mark bending lines of 4 mm and 6 mm on outer edge of square sheet as shown in figure
- Join the diagonals and mark 15° from corners of Inner Square (60 x 60 mm) ...i.e. 7.5° on the either side of the diagonals
- Mark the intersection of 15° line with 10mm outside bending line, mark a 60° to the bending line (for all four corners, or eight times).
- From 60° intersecting line at 4mm from outer edge, now mark 172.5° to bending line (for all four corners, or eight times).

Now remove the corner portions

- i.e. 60° till 6 mm (from inner corner edge towards outside edge), and then
 - 172.5° for last 4 mm till outer edge.
- Fold the sides of container (try avoiding waviness)
 - Seam the edges at all corners and make sure it is leak proof

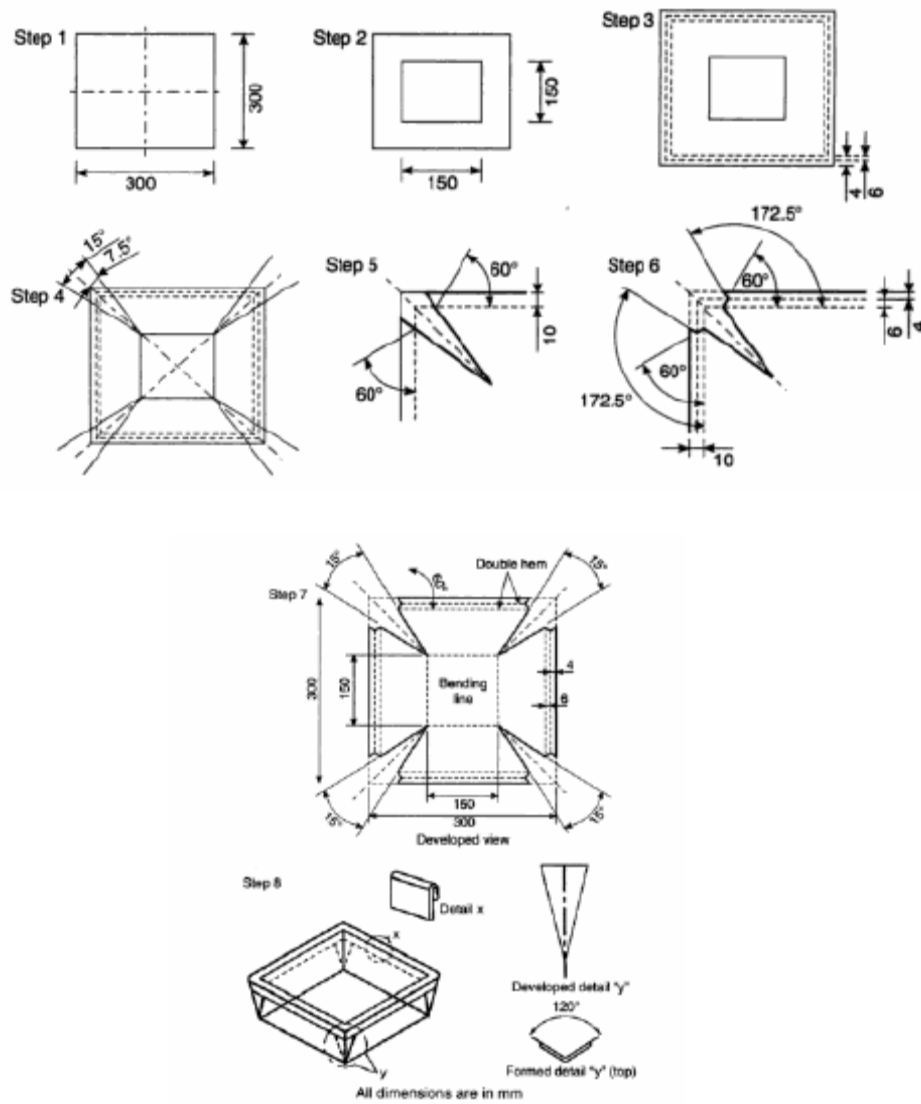


Fig. 2: Sheet metal forming of square container

Report the following

1. Precautions to be taken during sheet metal working
2. Name the processes used in soldering with description.
3. Composition of Solder alloy.
4. Draw the sketches showing the principle of the development of the job as shown in the sheet metal forming demonstration.
5. What are the machines used in the shearing and bending operation.