3.16.3 Comparison between Direct and Indirect Extrusion

Sl. No	Direct / Forward Extrusion	Indirect / Backward Extrusion
1.	During the process a solid ram is used.	A hollow ram is used for the process.
2.	Flow of metal is in the same direction as the movement of the ram.	Flow of metal is in the opposite direction as the movement of the ram.
3.	A dummy block is used during the operation.	Dummy block may or may not be used. Die plays a part of the dummy block.
4.	Die is mounted on the cylinder or container.	Die is mounted over the bore of the ram.
5.	Because of relative motion between the heated metal billet and the cylinder walls, friction problem arises.	As the billet in the container remains stationary, there is no friction.
6.	Large amount of force is required to move the billet in the cylinder.	As the billet is stationary, process does not require large amount of force.
7.	Handling of extruded metal is very easy.	Handling of extruded metal is difficult.

COLD WORKING PROCESSES

3.17 COLD ROLLING:

Cold rolling is use for producing bars of all shapes, rods, sheets and strips. Cold rolling is generally employed for providing a smooth and bright surface finish to the previously hot rolled steel. It is used to finish the hot rolled components, to close tolerances and improve their hardness and toughness. Before cold rolling, the hot rolled articles are cleaned through pickling and other operations. The same types of rolling mills, as in hot rolling, are used for cold rolling. The part being rolled is generally annealed and pickled before the final pass is made, so as to bring it to accurate size and obtain a perfectly clean surface.

3.17.1 Comparison between Hot Rolling and Cold Rolling

Sl. No	Hot rolling	Cold rolling
1.	Metal is fed into the rolls after being heated above recrystallisation temperature.	Metal is fed into the rolls when its temperature is below recrystallisation temperature.

2.	Hot rolled metal does not show work hardening effect.	Cold rolled metal shows work hardening effect.
3.	Coefficient of friction between the rolls and stock is higher.	Coefficient of friction between the rolls and stock is relatively lower.
4.	Heavy reduction is cross-sectional area is possible.	Heavy reduction is cross-sectional area is not possible.
5.	Close dimensional tolerances cannot be obtained.	Section dimensions can be finished to close tolerances.
6.	Very thin sections cannot be obtained.	Aluminum foils upto 0.02 mm can be made.
7.	Poor surface finish with scale on it.	Smooth and oxide free surface can be obtained.
8.	Roll radius is larger.	Roll radius is smaller.

3.18 Shape Rolling Operations

In shape rolling process various shapes like structural sectins (beams of I, T or C sections), sheets, rails, plates and bars are produced. Shape rolling process can be divided in two parts:

1. Ring rolling 2. Thread rolling

1. Ring Rolling

- Ring rolling is generally used for producing steel tyres of railway car wheels, rotating rights of jet engines, races, of ball bearings, etc.
- The initial material for ring rolling is a pierced billet for producing a thick walled ring.
- The ring is placed between driving roll and pressure as shown in figure 3.41.

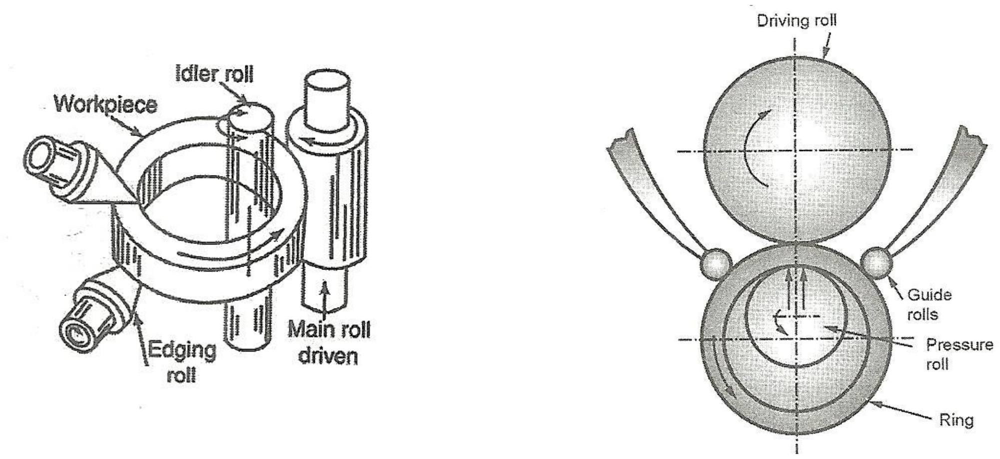


Figure 3.41 Ring Rolling

- The driving roll is fixe but it can rotate freely about its axis.
- The pressure roll applies pressure on the ring towards the driving roll.
- When the ring is gripped, it is caused to rotate and at the same time reduced in thickness continuously.

In order to ensure that a cirucular ring is rolled, a pair of guide rolls must be used.

Thread Rolling

- Thread rolling is the most economical and fastest method of making threads.
- It is actually a cold working process in which a plastic deformation takes place.
- No metal is removed and no chips are produced.
- Cold rolling strengthens the thread in tension, shear and fatigue.

Thread Rolling Machines

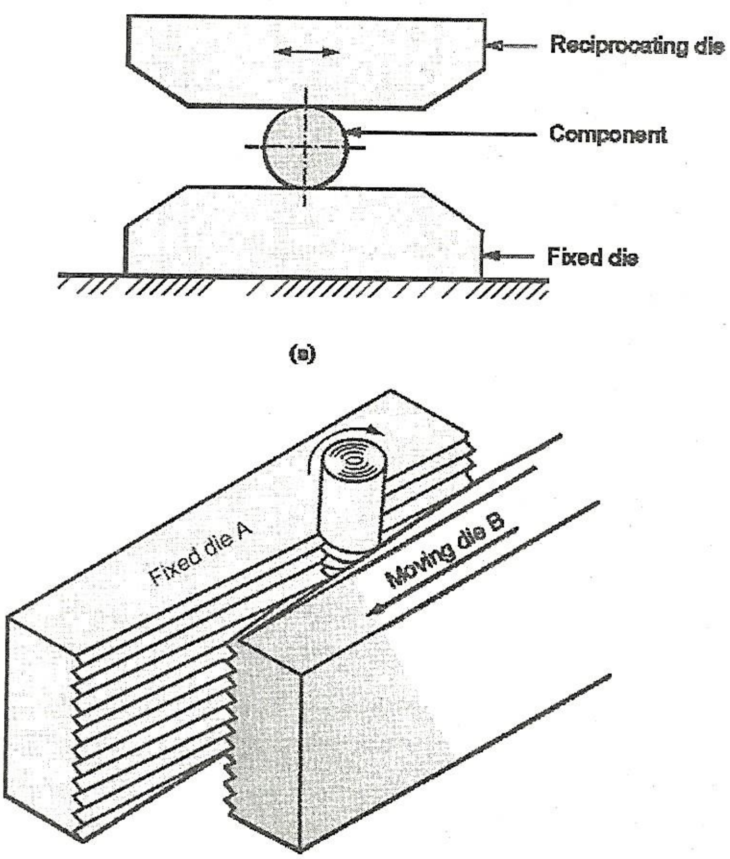
There are three types of thread rolling machines:

i. Reciprocating flat die machines.
ii. Cylindrical die machines.
iii. Rotary planetary machines having rotary die and one or more stationary concave-die segments.

The choice of machine depends upon the size and design of the workpiece, The work material and the number pieces to be produced.

i) Reciprocating flat die machines

- In this process two dies are used. One of them is stationary and another is reciprocating.
- The component to be threaded is rolled between these dies. The moving die reciprocates in reference to the fixed die as shown in figure 3.42 (a) and (b).
- The reciprocating die stroke depends on thread diameter to be produced, as in one stroke the blank makes one complete revolution.
- In one complete revolution thread is completely formed.
- It is very popular machine, as both right and left hand threads can be rolled.
- This is mainly used for production of threads on nuts and bolts.



(b) Reciprocating flat die machine
Fig. 3.42 : Thread rolling

Advantages of Thread Rolling

- It is the fastest method of producing a thread, with production rate more than 2000 pieces per minute.
- Being a chipless forming process, there is lot of material saving (about 16 to 27%).
- During thread rolling, the material is strained plastically and work hardened, therefore it becomes stronger against tension and fatigue.
- A rolled thread is superior to one that has been cut since the process work hardens the thread surface and promotes a grain direction which adds to the strength of the thread.
- Surface finish is better than thread milling and it is in the order of 0.08 to 0.2

Limitations of Thread Rolling

- Best suitable only for diameters upto 20 mm.
- Necessary to hold close blank tolerance.
- Uneconomical for low quantities.
- Cannot roll material having a hardness exceeding RC37.
- Only external threads can be rolled.

Thread Rolling Applications

- To produce external thread, thread rolling is the best method.
- Electric light bulb, wood screws, machine screws, sheet metal screws, hooks and eyes of bolts are produced by this method.
- Thread rolling g is also used for producing threads on stamped parts.

3.19 Defects in Rolled Parts

There are following types of defects which can be observed in rolled components:

1. Surface defects 2. Internal structural defects 3. Other defects

1. Surface defects:

Surface defects include defects like scale, rust, cracks, scratches, gouges, etc. It occurs due to the impurities and inclusions in the original cast material and different conditions related to material preparation and rolling operation.

2. Internal structural defects: These type of defects include following defects:

i) Wavy edges ii) Zipper cracks iii) Edge cracks
iv) Alligatoring v) Folds vi) Laminations

- The defects of wavy edges and zipper cracks occur due to bending of rolls.

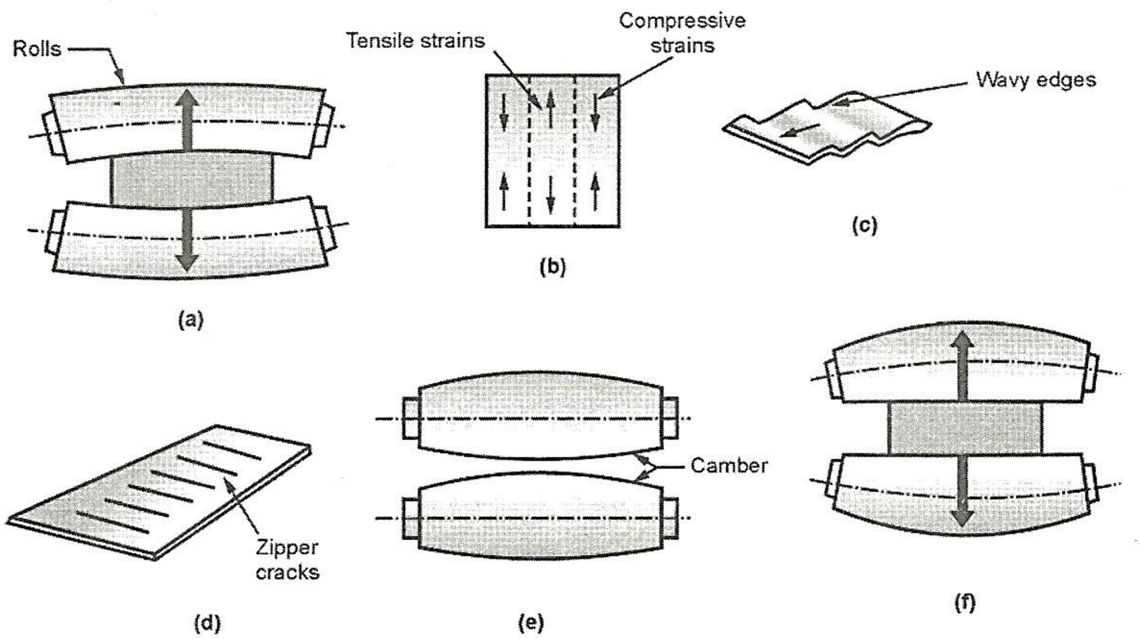


Fig. 3.43 : Rolling defects

- Rolls act as straight beams and due to rolling loads they deforms as shown in figure 3.43 (a). Due to this deformation, the edges of the workpiece get more compressed than the central region i.e. they form a shape of 'crown'.
- The reduction in thickness is converted into increase in length of the strip. Due to this, there are compressive strains on the edges and tensile strains at the centre as shown in figure3.43 (b).
- As the edges are restrained from expanding freely in the longitudinal direction, it results in wavy edges on the sheet as shown in figure 3.43 (c).
- Also, due to uneven ration of mean thickness to the length of the deformation zone, cracks may produce in the centre of the sheet. These cracks are called as **zipper cracks,** Refer figure 3.43 (d).
- To overcome these defects, generally the rolls are cambered i.e. their diameter is made slightly longer at the centre than at the edges as shown in figure 3.43 (e).
- Under loading action, the rolls will get flattened along the containing surface and provide a straight uniform gap to the strip as shown in figure 3.43 (f).

Folds: Folds are produced during plate rolling if the reduction per pass is very small.

Laminations: Due to incomplete welding of pipe and blow holes during rolling, internal defects like fissures are produced. Under severe conditions, these defects can result into small cracks or laminations which decrease the strength of material.

3. Other defects

i) Defects due to inhomogeneous deformation of elements across the width:

- When the workpiece passed through the rolls, the decrease in height results into increase in its length and there is lateral spread of the material.

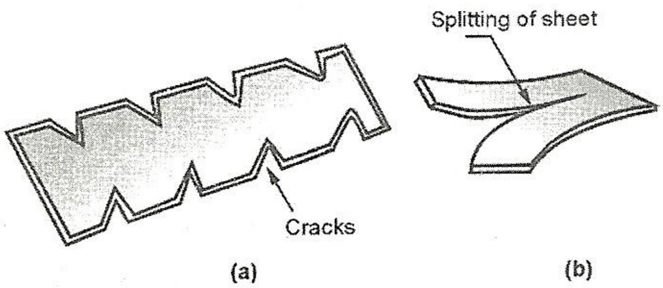


Fig. 3.44 : Other defects in rolling

- Due to continuity of material, the material near the edges will be under tension and near the centre will be under compression. This situation can lead to edge cracks as shown in figure 3.44 (a).

- Sometimes, these conditions may lead to split the sheet along the centre as shown in figure 3.44 (b).

ii) Defects due to inhomogeneous deformation in the thickness direction:

- While rolling, reduction in height is converted into increase in length of the sheet but all the elements do not undergo the same lateral deformation in the rolling direction. Due to this, barreled edge of the sheets is formed.
- With more sever conditions, the sheet-may rupture and follow the path of the respective rolls which results in **alligatoring** defect.

3.20 Cold Drawing

The most commonly used components which are cold drawn are tubes, bard, rods, wires and some typical shapes and items of novelties.

3.20.1 Wire Drawing

- Drawing is an operation in which the cross-section of a bar, rod or wire is reduced by pulling it through a die opening.

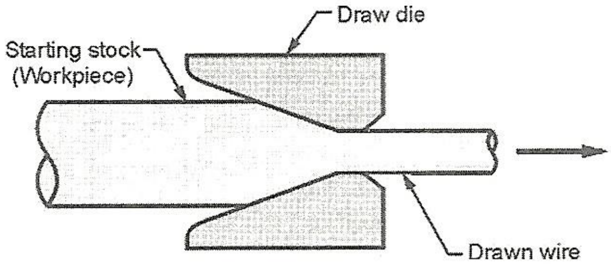
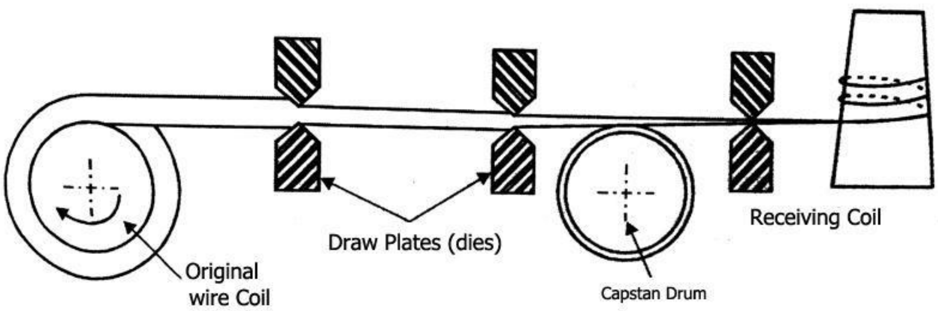


Fig. 3.45 : Wire drawing

- The general features of the drawing process are similar to extrusion. But the difference is that, in drawing the workpiece is pulled through the die whereas in extrusion workpiece is pushed through the die.
- During the process, tensile as well as compressive stress is produced in the material. The main difference between the bar drawing and wire drawing is the stock size (workpiece size). Bar drawing is used for large diameter (bar and rod) stock whereas wire drawing is used for small diameter stock.



- Wire size upto 0.03 mm can drawn by wire drawing process.
- The process consists of pulling the hot drawn bar or rod through a die of which the bore size is similar to the finished product size.
- Depending upon the material to be drawn and the amount of reduction required, total drawing can be accomplished in a single die or in a series of successive dies.
- One end of the rod to be drawn into wire is made pointed, entered through the die and gripped at the other end by using tongs.
- After pulling a certain length, this end is wound to a reel or draw pulley.
- When the pulley or reel is rotated, the rod is pulled through the die and its diameter reduces.
- The die is made of highly wear resistant material.
- Generally, tungsten carbide is used for die making.
- The die made of tungsten carbide is suitably supported in a die holder which is made of mild steel or brass.

3.20.2 Tube Piercing

Tube piercing is the tube drawing with mandrel. In tube drawing, cylinders and tubes which are made by extrusion process is finished by drawing process.

Tube drawing is classified into:

1. Tube sinking
2. Tube drawing with plug, and
3. Tube drawing with mandrel

In tube sinking process, only the outer diameter of the tube is reduced. For reducing the inner diameter of the tube, the other two processes. i.e., tube drawing with plug or Tube drawing with mandrels is used.

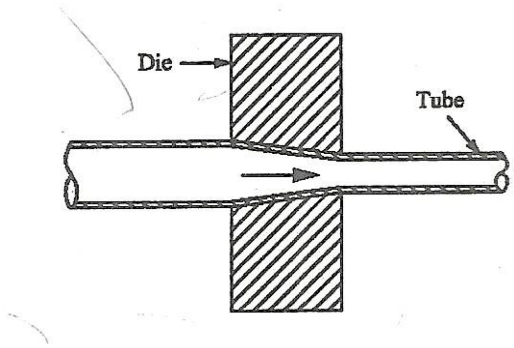


Figure 3.46 (a) Tube Sinking

In tube mandrel, the mandrel is place in the tube and the pull is given to the tube. It will reduce the inside diameter of the tube.

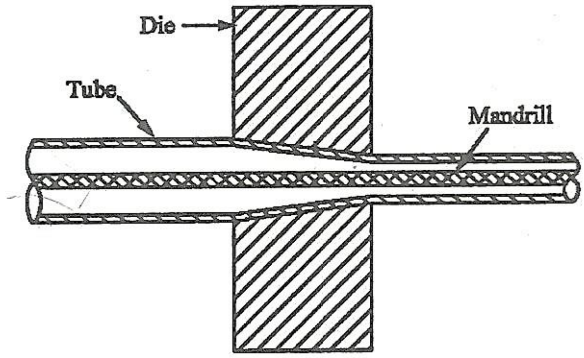


Figure 3.46 (b) Tube Mandrel

In plug drawing, both internal and external surfaces of the tube are controlled and the dimensional accuracy is good compared to other two methods. In this process, the plug is fixed or floating. The friction obtained in fixed plug is more than floating plug and drawing load is high is fixed plug and less in floating plug.

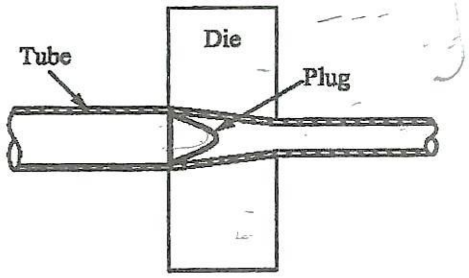


Figure 3.46 (c) Tube Plug

3.21 COLD FORGING AND SWAGING

3.21.1 Cold Forging

- Cold forging is a cold upsetting process adapted for large scale production of small cold upset parts from a wire stock. For example, small bolts, rivets, screws, pins, nails and small machine parts, small balls for ball bearing, etc.
- The machine used in the process is similar to hot forging.
- The dies are used for forming the required shapes.
- The rod is fed upto stops through straightening rolls, cut to size and pushed into the header die.
- The rod is gripped in the die and a punch operates on the projected part to apply pressure and form the head.
- During the process, a compressive force or impact causes the metal to flow in some determined shape of the die.

- Figure 3.47 shows the cold forming process in which the head will form in the punch, in the die, in punch and die or in between punch and die.

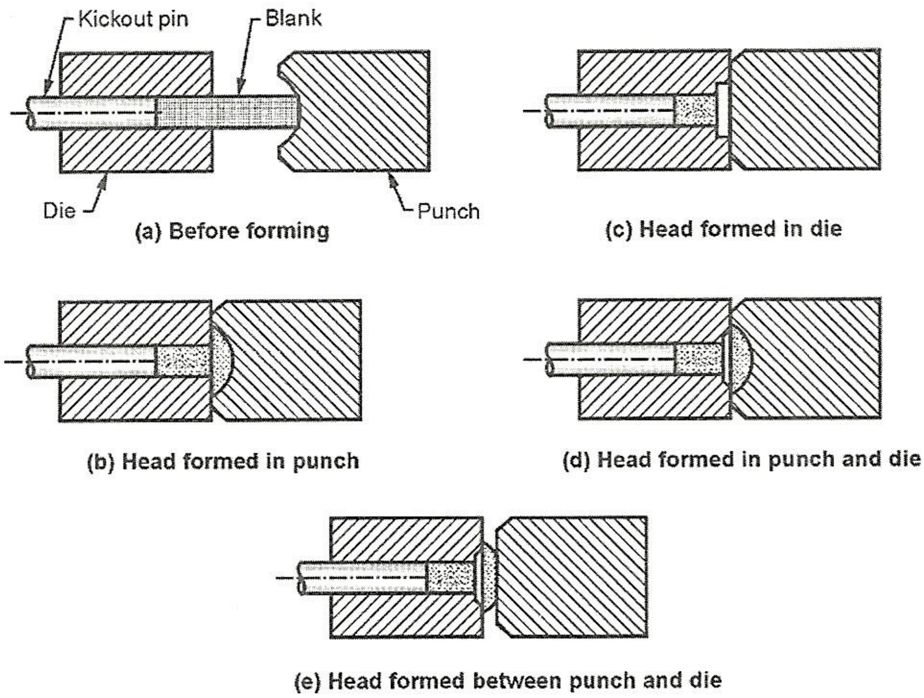


Fig. 3.47 : Cold forging process

3.21.2 Swaging

- Swaging term is applied to a number of metal forming operations.
- Swaging is also called as rotary forging.
- Swaging operations are generally performed on rotary swaging machines.
- Rotary swaging is a process of reducing the cross-sectional shape of bars, rods, tubes or wires by a large number of impacting blows with one or more pairs of opposed dies.
- The blows displace the metal and form the blank to the shape of the die.
- During the operation, as the die rotates around the workpiece, the final shaped is round.
- Swaging is an economical method for forming shapes usually confined to a portion of the total length of a given part, by pointing, tapering, reducing or sizing.
- The swaging process is also used for various joining and fastening operations.
- Figure 3.48 shows the principle of operation for a standard two-die rotary swager used for straight reduction of stock diameter or for producing taper and round stock.
- The die is engaged in a slot provided on the face of a spindle which rotates at a fairly high speed.
- Housing surrounds the spindle and a number of steel balls are provided between the spindle and the housing.

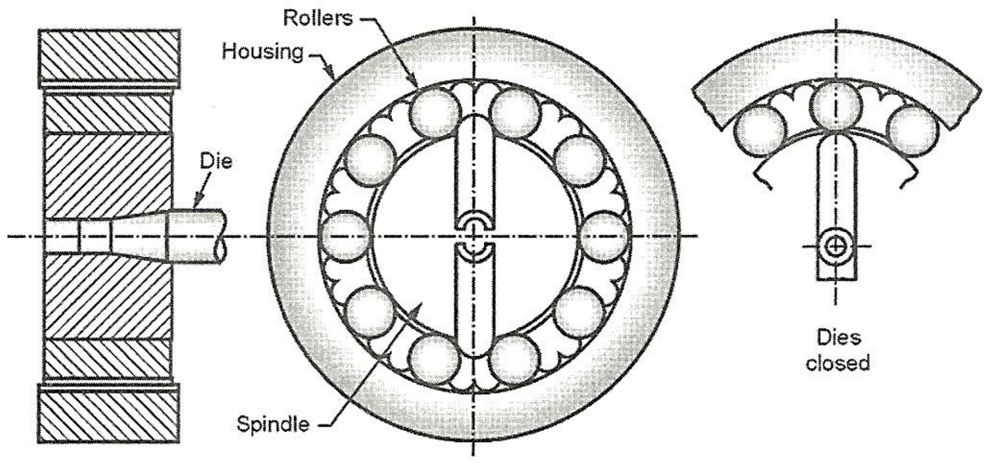


Fig. 3.48 : Operation of dies in a swaging machine

- As the spindle rotates the die passes between the pairs of opposite rolls, which close the dies.
- Hence, the dies are opened and closed alternatively as they pass between the gapes and rolls.
- Finally the metal is gradually squeezed to the desired shape and size.
- The metal gets hardened during the process because the swaging pressure is quite high and hence annealing has to be done.
- Commercial application of swaged parts includes various ratchets and sockets, various pins like guide pin, hinge pin, stop pin, shoulder pin, etc. Also, printed circuits, pen caps, shafts, spacers, umbrella components, mechanical pencils, metal chairs, table legs, etc.

Advantages of Swaging

- Tooling cost is high.
- Maintenance is easy.
- Initial investment is high.
- Semi-skilled operator is required, hence low labour cost.
- Production rate is high.
- Consistency of the product.

Limitation of Swaging

- Process is limited to parts of symmetrical cross-section only.