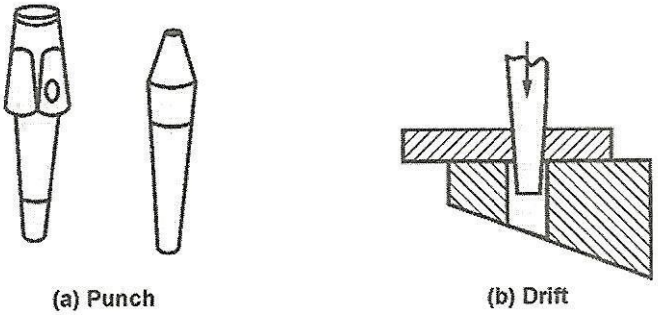



Fig. 3.27 : Punch and drift

**j) Set hammer**

It is used to finish off surfaces to a good smooth surface in restricted areas like corners. It is made of hardened tool steel. Its construction is similar to flatter but smaller in size and its bottom is also small.

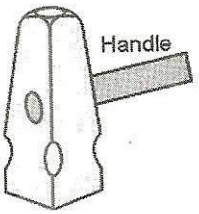



Fig. 3.28 : Set hammer

## 3.11 Drop Forging

- Drop forging differs from smith's forging as in drop forging closed impressions rather than open face of flat dies are used.
- This process utilises closed impression die to obtain the required shape of the component.
- The dies are matched and separately attached to the movable ram and the fixed anvil.
- The forging is produced by impact or pressure, which compels hot and pliable metal to confirm to the shape of the dies.
- During the operation, there is a drastic flow of metal in the dies caused by repeated blows of hammers on the metal.
- To ensure proper flow of the metal during the intermittent blows, the operation is divided into a number of steps.
- Each step changes the metal form gradually, controlling the flow of the metal until the final shape is obtained.
- The number of blows required varies according to the size and shape of the part, forgoing quality and required tolerances.
- The equipment used for applying the blows is called as drop hammer.

- Three types of drop hammers are used in making drop forgings:
    - Board or gravity hammer
    - Air – lift hammer
    - Power drop hammer or steam hammer
- Figure 3.29 shows the principle of a board or gravity hammer.

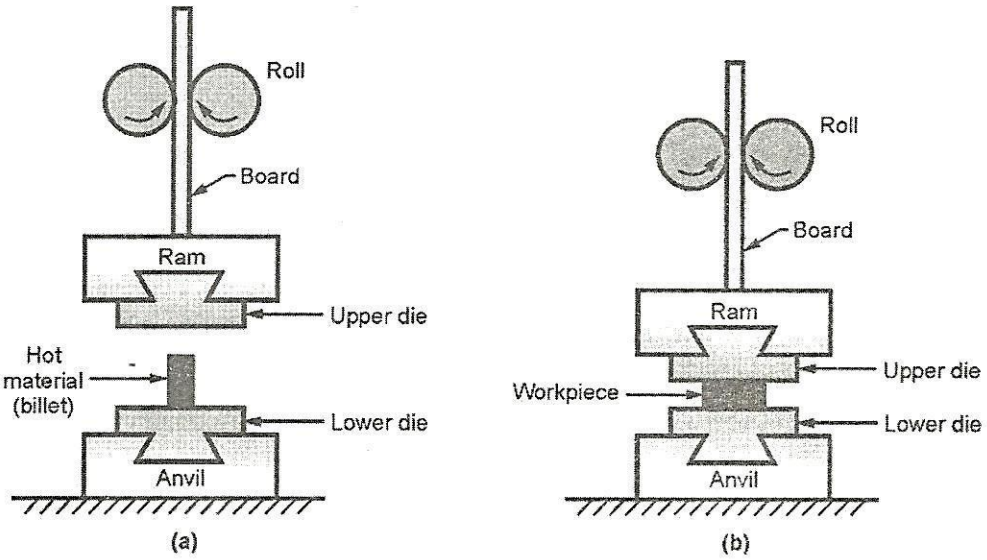



**Fig. 3.29 : Principle of a board or gravity hammer**

- The drop forging die consists of two halves i.e. lower half and upper half.
- The lower half of the die is fixed to the anvil of the machine while upper half is fixed to the ram.
- The heated stock or the workpiece is kept in the lower die while the ram delivers four to five blows on the metal in quick succession, so that the metal spreads and fills the die cavity.
- The force of the blow can be varied by changing the distance of the fall.
- The anvil which must absorb the blow is generally 20 times heavier than the hammer.
- A board hammer which works rapidly, gives overs 300 blows per minute.
- Board hammer can do a wide variety of work and they are less expensive as compared to the others.
- Components manufactured by drop forging are car axles, crankshafts, connecting rods, leaf springs, crane hooks, jet engine turbine dies and blades.

**Disadvantages of Drop Forging**

- The boards are liable to frequent breakage.
- The intensity of blow cannot be controlled during the stroke.
- Dimensional accuracy is less.

- The life of the hammers and dies is less.
- More noise and vibrations are produced during the operation.

### 3.11.1 Press Forging

- It is done in presses rather than by using hammers.
- The action is relatively slow squeezing instead of delivering heavy blows and penetrates deeply because it gives the metal time to flow.
- Press forgings are shaped at each impression with a single smooth stroke and they stick to the die impression more rigidly.

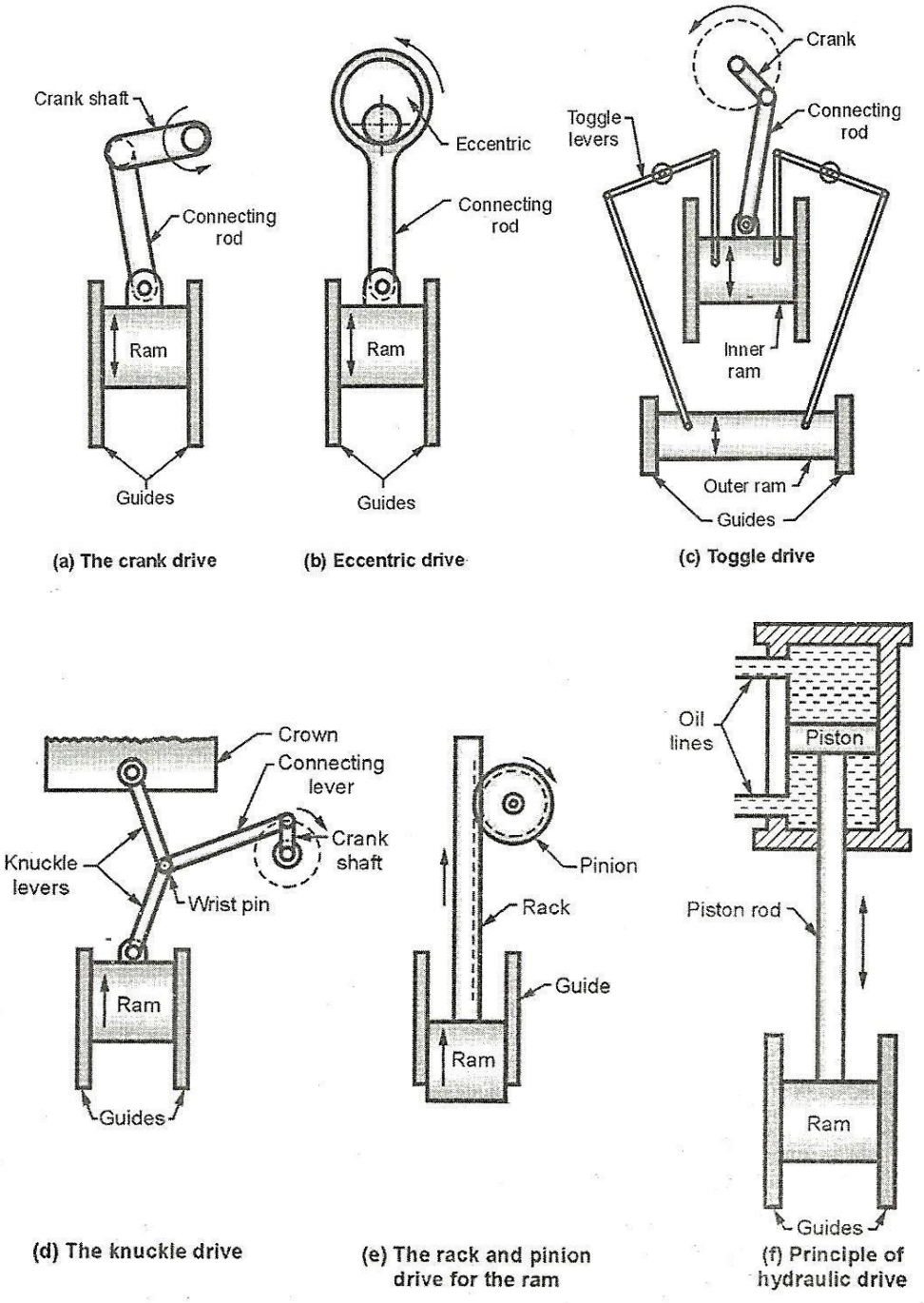



**Fig. 3.30 : Ram driving mechanisms**

- Press forgings are generally more accurate dimensionally than drop forgings.
- Press for forgings are generally more accurate dimensionally than drop forgings.
- Press for forgings may be of two types i.e. hydraulic and mechanical press.
- The dies used carry relatively less draft and hence more complicated shapes can be forged.
- The life of the presses and dies is longer than that of the hammer and dies used on them.
- The process does not require highly skilled operator because the speed, pressure and travel of the die are automatically controlled.
- There are less vibrations and noise as compared to hammering.
- Presses of 500 to 600 tonnes capacities are generally used.
- Press forging is used for the manufacturing of large levers, flanges, toothed wheels, crankshafts, propellers, hollow bodies, railway wheel disks, tank bottoms, panels and other bodies of air-craft and rocket bodies.
- Figure 3.30 shows different types of ram driving mechanisms.

Following table 3.1 gives the comparison between hydraulic and mechanical press:

**Table 3.1: Comparison between hydraulic and mechanical press**

| Sl. No | Hydraulic press | Mechanical press |
|---|---|---|
| 1. | Hydraulic presses are used for heavy work. | Mechanical presses are used for light work. |
| 2. | Operating speed of hydraulic presses is slow. | Mechanical Presses operate faster than hydraulic presses. |
| 3. | Hydraulic presses are designed to provide greater squeezing force. | Less squeezing force is applied by the Mechanical presses. |
| 4. | Pressure can be changed at any point in the stroke by adjusting the pressure control valve. | Pressure cannot be changed during the process. |
| 5. | Life of dies is short. | Life of dies is more. |
| 6. | Initial cost of machine is high. | Initial cost of machine is low. |

### 3.11.2 Comparison between press Forging and Hammer forging

| Sr. No | Press forging | Hammer / Drop forging |
|---|---|---|
| 1. | Press forging is slow as compared to hammer forging, but the reduction in the size of heavy parts is comparatively rapid. | Hammer forging is fast process, but a large number of blows are applied in rapid succession for reduction in the size of heavy parts. |
| 2. | In press forging there is no restriction of the size of the components. | In hammer forging there is a restriction of the component size. |
| 3. | The life of the presses and dies is more. | The life of the hammers and dies is less. |
| 4. | Less vibrations and noise during the operation. | More vibrations and noise during the operation. |
| 5. | The process does not require highly skilled operator. | Skilled operator is required for the process. |
| 6. | More complicated shapes with better dimensional accuracy can be produced. | Less dimensional accuracy. |
| 7. | The distance of the fall cannot be changed. | The force of the blow can be varied by changing the distance of the fall. |

### 3.11.3 Machine or Upset Forging

- Machine forging is also called as hot heading.
- It consists of applying pressure longitudinally on a hot bar, which is gripped firmly between grooved dies, to upset a required portion of its length.
- All forgeable metals can be upset through this process.
- They may have any shape of cross-section, but round shape is most commonly used.
- The equipment used for this type of forging is known as forging machine or upsetter.
- The machine provides forging pressure in a horizontal direction.
- The dies are so designed that, the complete operation is performed in several stages and the final shape is attained gradually.
- The operation is performed by using die and punch which is called as heading tool, as shown in figure 3.31.
- The die is either made hollow to receive the round bar through it or in two parts to open out and receive the bar.

- Between the heading tool and the die, a mechanical stop is place which determines the correct projecting length of the bar.
- After the bar has been gripped firmly, with its correct length projecting outside, the stop is replaced and the heading tool is advanced into the die.

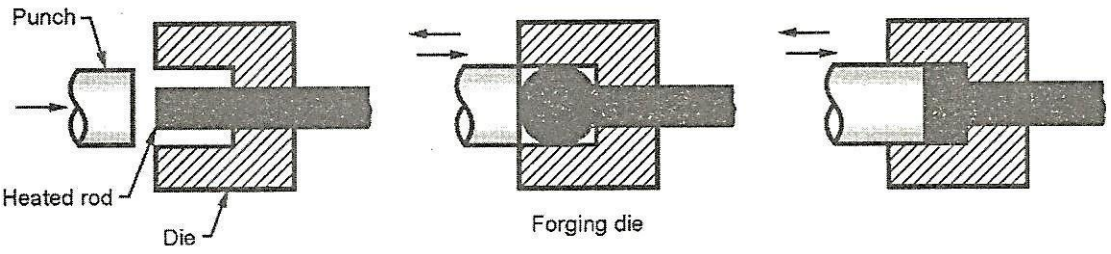



**Fig. 3.31 : Upset forging**

- Many such strokes are required to complete the upsetting.
- Forging of the ring and rod types with all kinds of heads and shoulders such as bolts, nuts, washers, collars, pinion gear blanks, etc. can be easily produced by this process.

**Advantages of Machine forging**

- The quality of machine forging is better than the other forging methods.
- The dies carry no draft, hence flash is not produced on the parts.
- Better dimensional accuracy can be obtained.
- With the help of this forging process piercing can also be done with considerable accuracy.
- Forging machines have higher productivity and their maintenance is less expensive than the other methods.
- The process can be automated.

**Disadvantages of Machine Forging**

- Due to material handling difficulties, heavier components cannot be forged easily.
- The components having diameter more than 250 mm cannot be forged by this process.
- Intricate and unsymmetrical components are difficult to be forged.
- Tooling cost is high.

### 3.11.4 Roll Forging

- Roll forging process consists of placing raw stock between two roll dies which are of semi-cylindrical form and are grooved to impart a desired shape to the workpiece being forged.
- The roll dies are carried on roll shafts and rotate continuously towards the operator.

- Figure 3.32 (a) shows the rolls in an open condition, with the heated workpiece in the tong and resting on the guide.
- In figure 3.32 (b) the rolls are brought together, with the stock gripped in the grooves of the rolls.

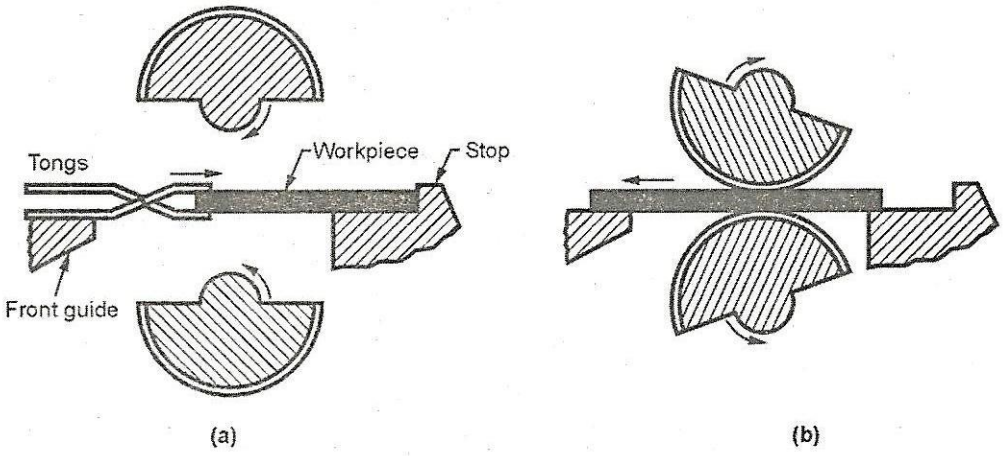



**Fig. 3.32 : Principle of operation of a roll forging machine**

- The rolling action forces the stock towards the operator.
- When the dies are again in an open condition the stock is placed in appropriate grooves of the rolls and the operations are repeated until the required shape is not obtained.
- This process is also used to make large reductions in the cross-section and distribution of the metal of a billet, hence saving considerable work in the forging hammer or press.
- By using roll forging, parts such as knife blades, automobile drive shafts, axles, leaf springs and gear-shift levers are made.

## 3.12 Forging Operations

A number of operations are used to change the shape of the raw material to the finished form. A typical smith forging operations are as follows:

1. Upsetting
2. Drawing out or drawing down
3. Cutting
4. Bending
5. Punching and Drifting
6. Setting down
7. Welding

### 1. Upsetting

- Upsetting is also called as jumping or heading.
- It is a process through which the cross-section of metal piece is increased with a corresponding increase in its length.
- When a metal is sufficiently heated, it acquires the plastic stage, so that it becomes soft.

- If some pressure (blows) is applied to it, then the metal tends to swell or increase in its dimensions at right angles to the direction of application of force with corresponding reduction in its dimensions.
- This is what actually takes place during upsetting or jumping a metal part.

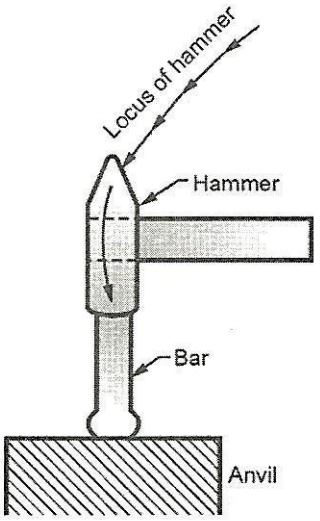



**Fig. 3.33 : Upsetting a bar**

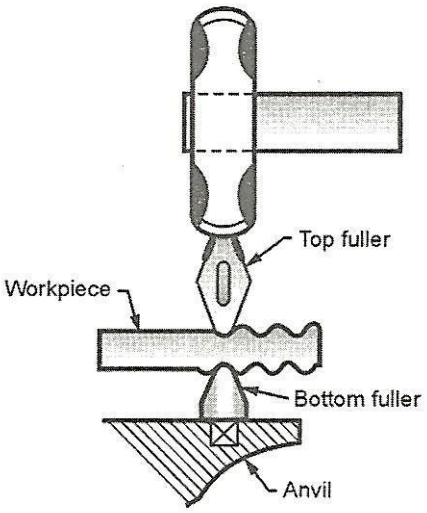



**Fig. 3.34 : Drawing out**

**2. Drawing out or drawing down**

- Drawing out is exactly a reverse process to that of upsetting.
- It is employed when a reduction in thickness, width of a bar is desired with a corresponding increase in its length.
- The desired effect is obtained by the use of either the peen of a cross peen hammer, a set of fullers or a pair of swages.
- Figure3.34 shows the drawing out operation by using top and bottom fullers.

**3. Cutting**

- Cutting – off is a form of a chiseling whereby a long piece of stock is cut into several specified lengths, or a forging is cut-off from its stock.
- A notch is first made about one-half the thickness or diameter of the stock. After that, the workpiece must be turned an angle of 180° and the chisel is placed exactly opposite the notch.
- The required length of metal can then be cut-off by giving the chisel a few blows with a sledge hammer.

**4. Bending**

- Bending is an important operation in smith forging and it is very frequently used.
- It may be classified as angular or curvilinear.

- Any required angle or curvature can be made through this operation.
- Bending operation is carried out on the edge of the anvil or on the perfectly square edge of a rectangular block.
- For making a right angle bend, particular portion of the stock is heated and jumped on the outer surface.
- When metal is bent, the layers of metal on the inside are compressed and those on the outside are stretched.
- Figure 3.35 shows a round bar being bent to form a helical spring.

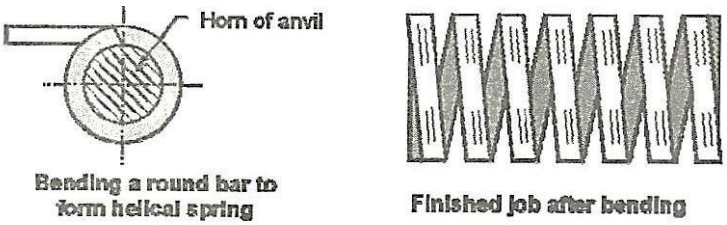



Fig. 3.35 : Bending a round bar to form a helical spring

**5. Punching and Drifting**

- The term punching refers to the operation in which a punch is forced though a workpiece to produce a hole.
- The workpiece is first heated and then placed on the anvil face.
- The punch is then forced into it upto about half its thickness.
- The workpiece is then turned upside down and placed over a tool called as bolster.
- The punch is again forced into the workpiece and made to pass through by hammering. Refer figure.
- Punching without using a die, is generally followed by drifting.
- In drifting, a tool known as drift, is made to pass through the punched hold to produce a finished hole of the require size.

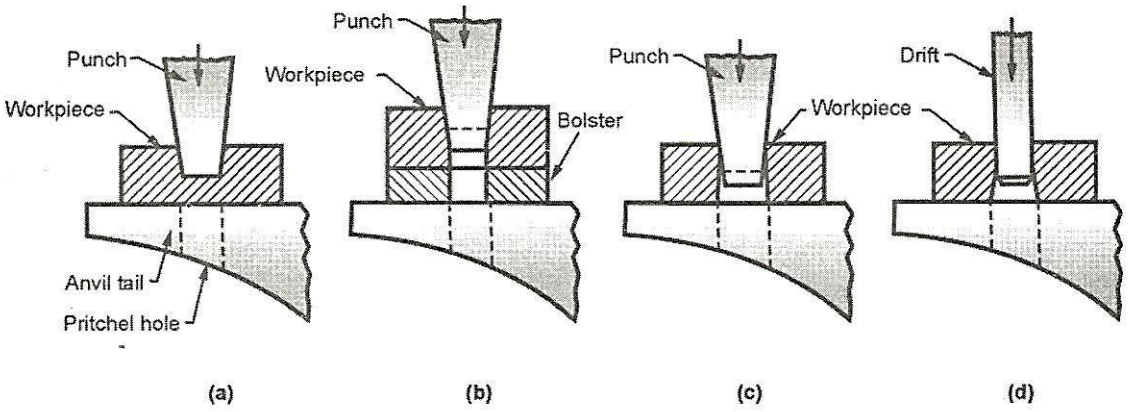



**Fig. 3.36 : Punching and drifting operations**

**6. Setting down**

- Setting down is the operation through which the rounding of a corner is removed, to make it square by using a set hammer.
- By putting the face of the hammer over the round portion, formed by bending or fullering of the corner and hammering it at the top a local reduction in thickness takes place resulting in sharp corner.
- Hence, finishing operation is performed through which the unevenness of a flat surface is removed by using a flatter or a set hammer.

**7. Welding**

- Welding or shutting is the principle operation performed by the smith.
- The metal which remains pasty over a wide range of temperature is most easily welded.
- For production of sound weld, the surfaces in contact must be perfectly clean, both mechanically and chemically, so that cohesion will take place when the metal is in a plastic state.
- A protection to the metal is a coating of flux which covers the surfaces of the metal and prevents oxidation.
- A forge weld is made by hammering together the ends of two bards which have been formed to the corrected shape and heated to a welding temperature in a forge fire.
- The method of preparing the metal pieces for welding is called scarfing.

**Following are the forms of welded joint which are commonly used:**

a) **Lap scarf weld:** In this, the ends are prepared so that they may be welded one upon the other with the joint in an inclined position.

b) **Butt weld:** In this, the ends of the pieces to be joined are butted together, the weld being between the ends at right angles to the length of the piece.

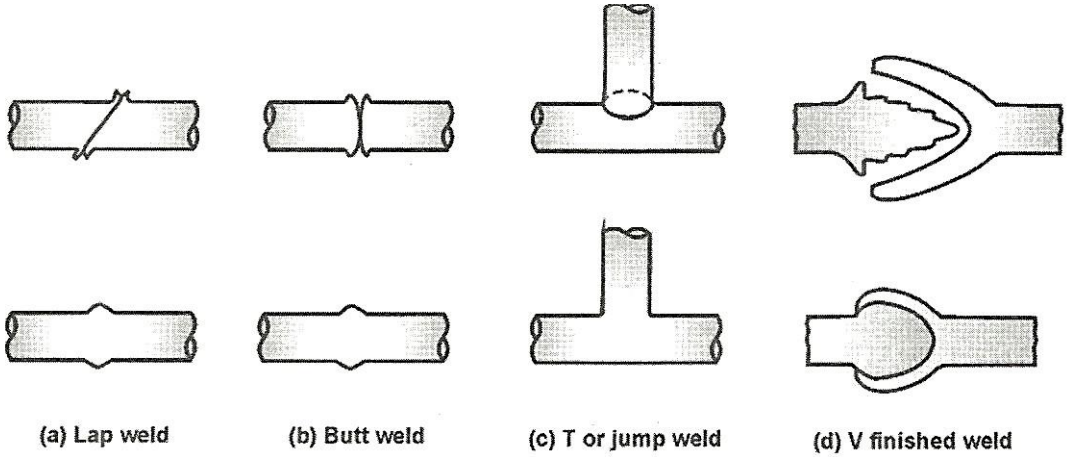



**Fig. 3.36 : Forge welded joints**

c) **T or Jump weld:** In this, one piece is place at the center of another at right angle to each other in the form of an inverted T.

d) **V-weld or Splice:** In this, the ends are first brought to the shape of fork and tongue respectively.

### 3.13 DEFECTS IN FORGING

The defects commonly observed in forged components are as follows:

**1. Defective metal structure:**

The main cause of this defect is defective original metal.

**2. Presence of cold shuts or cracks at corners or surfaces**

This defect is due to improper forging and faulty die design.

**3. Incomplete components:**

This is due to less metal used, inadequate heating of metal, improper forging design, faulty die design, metal not placed properly in the die and inadequate flow of metal.

**4. Mismatched forging:**

When the die halves are not properly aligned, forging will be mismatched.

**5. Burnt and overheated metal:**

This defect is because of improper heating.

**6. Fibre flowlines discontinued:**

The main cause of this defect is very rapid plastic flow of metal.

**7. Scale pits:**

Scale pits are formed by squeezing of scale into the metal surface while forging.

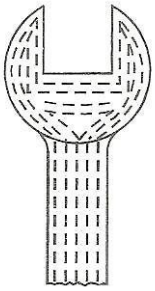
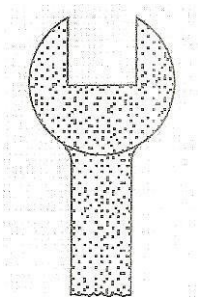
**8. Oversized components**

Worn out dies, incorrect dies, misalignment of die halves are the main causes of oversized components.

**Forging defects can be removed as follows**

- Shallow cracks and cavities can be removed by chipping out of the cold forging with pneumatic chisel.
- Surface cracks are removed from forgings by grinding on special machines. Care should be taken
- By taking into considerations, all relevant and important aspects die design should be made properly.
- To avoid mismatching of the dies, the parting line of a forgoing should lie in one plane.
- The mechanical properties of the metal can be improved by forging to correct fibre line and developed internal stresses are removed by annealing or normalising.

### 3.14 Comparison between Forging and Casting Processes

| Sr. No | Forging | Casting |
|---|---|---|
| 1. | In forging process, grain flow is continuous and uninterrupted Refer figure.  | In casting process, there is no grain flow. Refer figure.  |
| 2. | Due to improved grain size and true grain flow, forging give greater strength and toughness. | Due to no grain flow and weak crystalline structure, casting is weak in withstanding working stresses. |
| 3. | Requires minimum machine finish. | Requires more machine finish. |
| 4. | Forged components have better mechanical properties like strength, toughness, resistance to shock and vibrations. | Cast components are brittle i.e. weak in tension. Also they have poor resistance to shock and vibrations. |
| 5. | Welding of forged parts is easy. | Welding of cast parts is difficult. |
| 6. | During the operation, cracks and blow holes are welded up. | Defects like cracks and blow holes make the casting weak and unsuitable for use. |
| 7. | Accuracy is more. | Accuracy is less. |
| 8. | Complicated shapes cannot be produced. | Complicated shapes can be produced. |
| 9. | Generally used for large parts. | Generally used for small parts. |
| 10. | Because of cost of dies, process is costly. | As there are not dies, hence casting is less expensive. |

### 3.15 Roll Piercing of Seamless Tubing

- Roll piercing is a method of producing seamless tubes.
- Seamless tubing is a popular and economical raw stock for machining because it saves drilling and boring of parts.