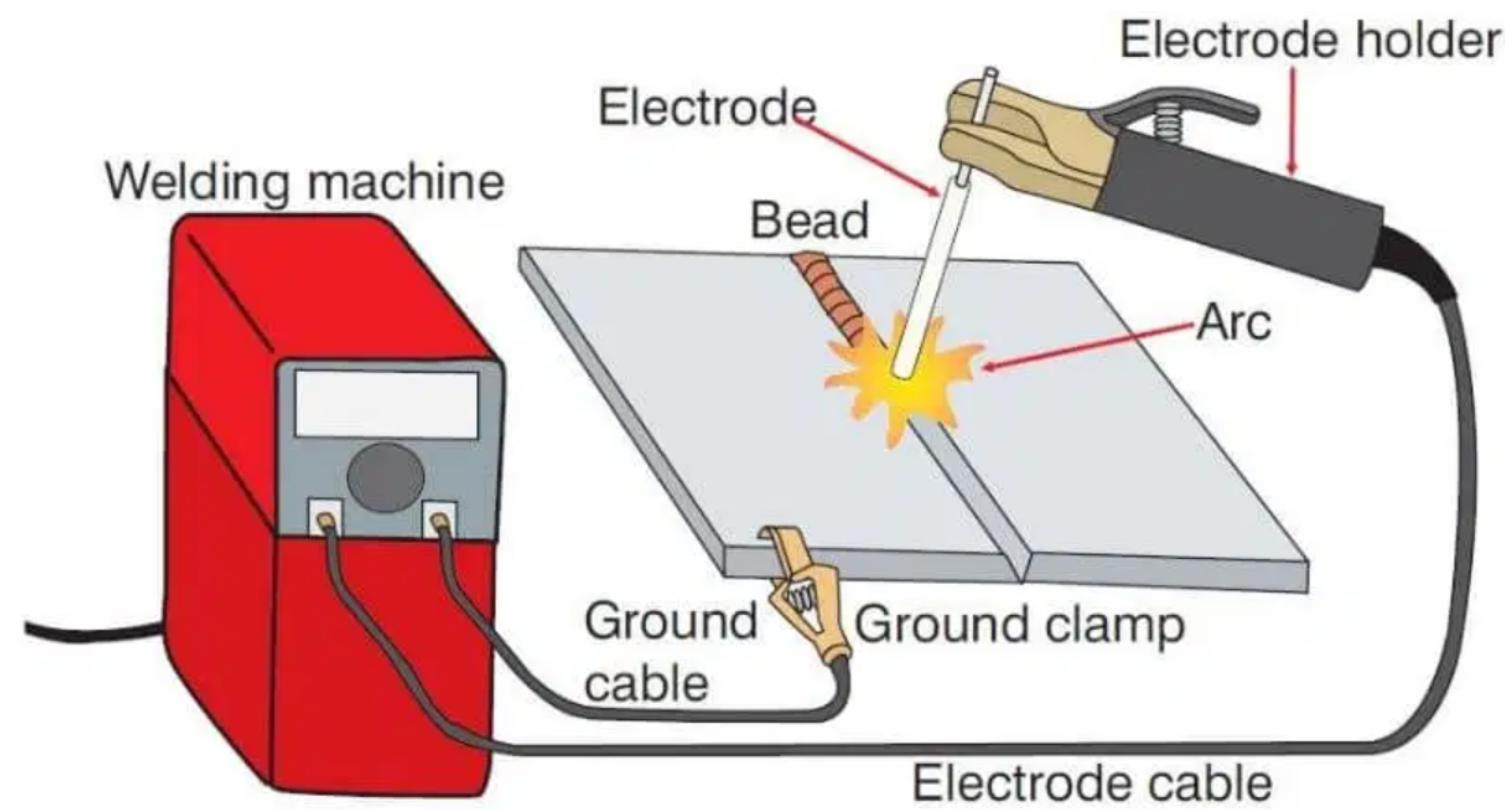


# Welding

# Arc Welding

- Arc welding is a type of welding process using an electric arc to create heat to melt and join metals.
- A power supply creates an electric arc between a consumable or non-consumable electrode and the base material using either direct (DC) or alternating (AC) currents.
- In arc welding, metal rod is used as one electrode, while the workpiece being welded is used as another electrode.
- During welding operation, consumable metal electrode is melted by the heat of the arc and is fused with the base metal (workpiece), thus forming a solid uniform weld after the metal has been cooled.
- The arc can be guided either manually or mechanically along the joint line, while the electrode carries the current and at the same time melts into the weld pool to add filler metal to the joint.



# Arc Welding

- Arc welding is the most extensively employed method for joining metal parts. The source of heat is an electric arc.
- The arc column is generated between an anode, which is the positive pole of DC power supply, and the cathode, the negative pole.
- When these two conductors of an electric circuit are brought together and separated with a small distance (2 to 4 mm) such that the current continues to flow through a patch of ionized particles (gaseous medium), called plasma, an electric arc is formed.
- Approximately 1 kWh of electricity will create 1000 J, the temperature at the center of the arc being 6000-7000 °C.
- The temperature of an electric arc depends upon the type of electrodes between which it is struck.
- The heat of the arc raises the temperature of the parent metal which forms a pool of molten metal along the joint.
- The electrode metal is also melted and is transferred into the base metal in the form of globules of molten metal.
- The deposited metal serves to fill and bond the joint or to fuse and build up the parent metal surface.

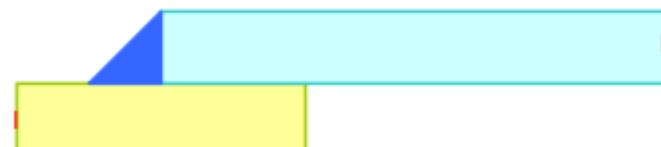
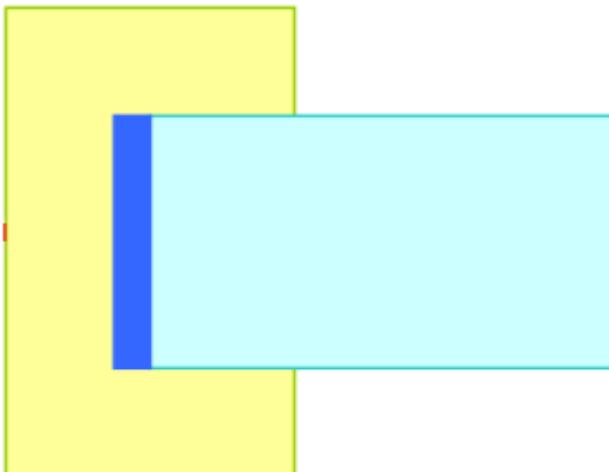
# Arc welding electrodes

- Two types of electrodes are used in arc welding:
  1. Consumable electrode
  2. Non-consumable electrode
- Consumable electrodes melts along with the workpiece and fills in the joint.
- When non-consumable electrodes are used, an additional filler material is used.
- The advantage of using non-consumable electrode is the metal deposited by a filler rod can be controlled, which is not possible with consumable electrode.
- Because the metals react chemically to oxygen and nitrogen in the air when heated to high temperatures by the arc, a protective shielding gas or slag is used to minimize the contact of the molten metal with the air.
- A consumable electrode has metal core surrounded by flux coating. Flux coating is made up of ferrous alloys.
- During welding, flux coating produces a gas which shields around the arc.
- Flux forms slag by mixing with impurities of the molten metal and thus refines the metal.
- The slag, being lighter, floats over the surface of the molten metal and on solidification forms a thin layer over the weldment, which helps in gradual and uniform cooling of the weld and prevents its oxidation.

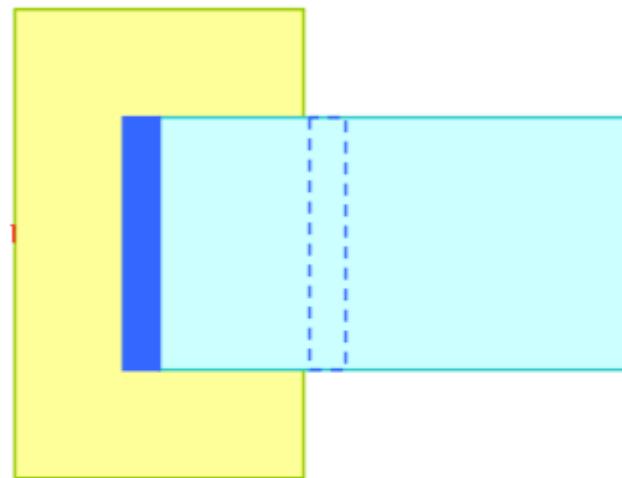
# Types of welded joints

- **Lap or fillet joint:**

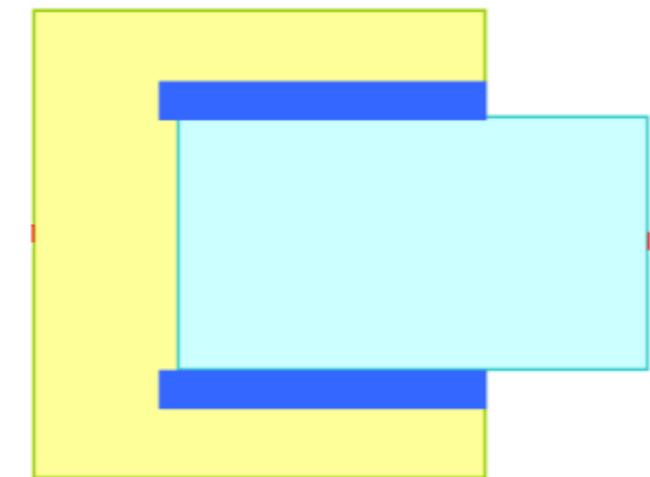
- ✓ This type of joint is obtained by overlapping the plates and welding their edges.
- ✓ The fillet joints may be single transverse fillet, double transverse fillet or parallel fillet joints.
- ✓ The single transverse lap joint has the disadvantage that the edge of the plate which is not welded can buckle or warp out of shape.



Single transverse



Double transverse



Parallel

# Types of welded joints

- **Butt joints:**

- ✓ Butt joints are formed by placing the plates edge to edge and welding them.
- ✓ Grooves are sometimes cut (for thick plates) on the edges before welding.
- ✓ According to the shape of the grooves, butt joints can be classified.



Square butt joint



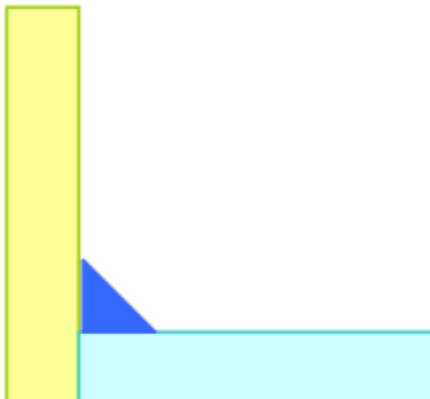
Single – V butt joint



Double – V butt joint

# Types of welded joints

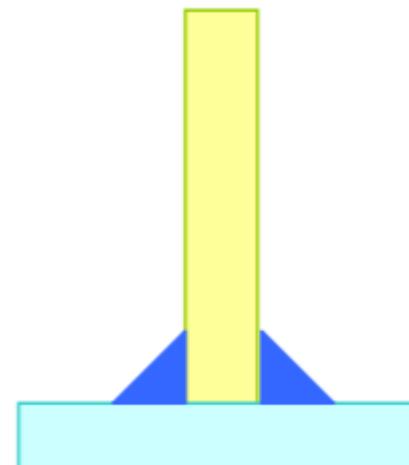
- **Corner joint:**
  - ✓ The corner joint is obtained by joining the edges of two plates whose surfaces are at an angle of approximately  $90^{\circ}$  to each other.
- **Edge or seal joint:**
  - ✓ The edge joint is obtained by joining two parallel plates.
- **T-joint:**
  - ✓ The T-joint is obtained by joining two plates whose surfaces are approximately at right angles to each other.
  - ✓ These joints are suitable up to 3 mm thickness.



Corner joint



Edge joint



T-joint

# Equipment and tools used in Arc Welding

## 1. Transformer

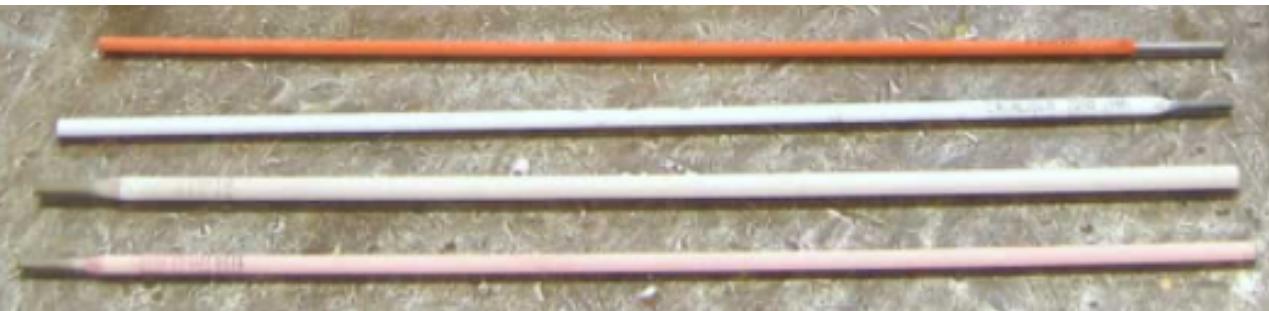


Cable connector

- Transformer (or welding machine) takes power directly from a power supply line and transforms it to the required voltage for welding.
- Transformer generates a low voltage (10 to 50 V), and high amperage (50 A to 300 A) electric current.
- Transformers are available in single phase and three phase.

# Equipment and tools used in Arc Welding

## 2. Electrode



- When the arc is produced at the tip of the electrode during welding process, the electrode itself melts and fills the gap between two workpieces.
- Electrodes commonly used are of two types: flux coated electrodes and bare electrode.
- Bare electrodes are cheaper, but welds produced through these are of relatively poor quality, and an inert gas environment should be provided during welding.
- Coated electrodes carry a core of metallic wire covered with a flux coating.
- Metallic core wire is made of approximately the same composition as the metal to be welded.
- The common ingredients of a flux which help in slag formation and metal refining are asbestos, mica, silica, fluorspar, steatite, etc.

# Equipment and tools used in Arc Welding

## 3. Electrode holder



- The electrode holder is connected to the end of the welding cable and holds the electrode.
- It should be light, strong and easy to handle.
- It should not become hot while in operation.
- The jaws of the holder are insulated, offering protection from electric shock.

# Equipment and tools used in Arc Welding

## 4. Ground (earthing) clamp

- It is connected to the end of the ground cable and is clamped to the workpiece or welding table to complete the electric circuit.
- It should be strong and durable, and give a low resistance connection.



# Equipment and tools used in Arc Welding

## 5. Face or head shields

- A face shield is used to protect the eyes and face from the rays of the arc and from spatter or flying particles of hot metal.
- It is available either in hand or helmet type.
- The hand type is convenient to use wherever the work can be done with one hand.
- The helmet type, though not comfortable to wear, leaves both hands free for the welding work.



# Equipment and tools used in Arc Welding

## 6. Chipping hammer

- Chipping hammer is used for removing or chipping off the slag that forms on welded surface.
- A chipping hammer has two striking ends, one end of the head is sharpened like a cold chisel and the other end is flat.



## 7. Wire brush

- Wire brush is used after chipping for further cleaning of the welded surface. It is also used while preparing the workpiece for welding.
- The bristles are made from steel or stainless steel.



# Equipment and tools used in Arc Welding

## 8. Aprons and Hand Gloves

- These are flame-retardant/ flame-resistant outfits worn by a welder to protect the underclothing and the body from the sparks, molten metal and the hot metal being welded.



## Preparation of the workpieces before arc welding

- Before arc welding, the workpieces must be thoroughly cleaned of rust, scale and other foreign materials.
- Thin pieces of metal are generally weld without beveling the edges.
- Thick workpieces should be beveled to ensure adequate penetration and fusion of all parts of the weld.
- In either case, the parts to be welded must be separated slightly to allow better penetration of the weld.

# Common defects in welding

- **Cracks**

- ✓ Cracks may be microscopic scale or macroscopic scale depending upon their size.
- ✓ Cracks in the welded joint may arise from localized stresses set up by uneven heating and cooling, presence of high percentage of sulphur and carbon in the base metal.

- **Porosity and blowholes**

- ✓ Porosity is a group of small voids, whereas blowholes or gas packet is a comparatively bigger isolated hole or cavity which occur mainly due to entrapped gases.

- **Poor fusion**

- ✓ It is lack of thorough and complete union between the metal deposited by the electrodes and parent metal.

- **Inclusions**

- ✓ The presence of non-metallic substances in the metal is called inclusion.
- ✓ Inclusion lowers the strength of the joint.

- **Undercut**

- ✓ In undercut, a groove gets formed in the base metal along the sides of the welded joint.
- ✓ The reasons for under cutting are non-uniform feed of the welding rod, improper electrode or excessive heating.

# Sample process of arc welding

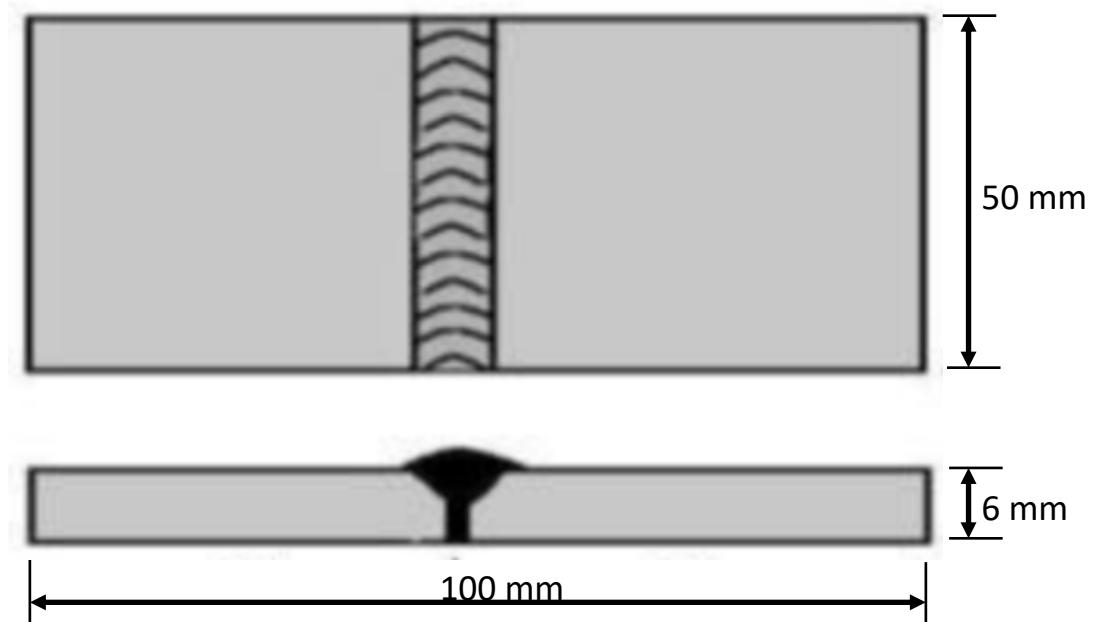
**Aim:** Executing a V-butt joint using arc welding process

**Apparatus required:**

Welding transformer, electrodes, tong, chipping hammer, wire brush, files, protective equipment.

**Material provided:**

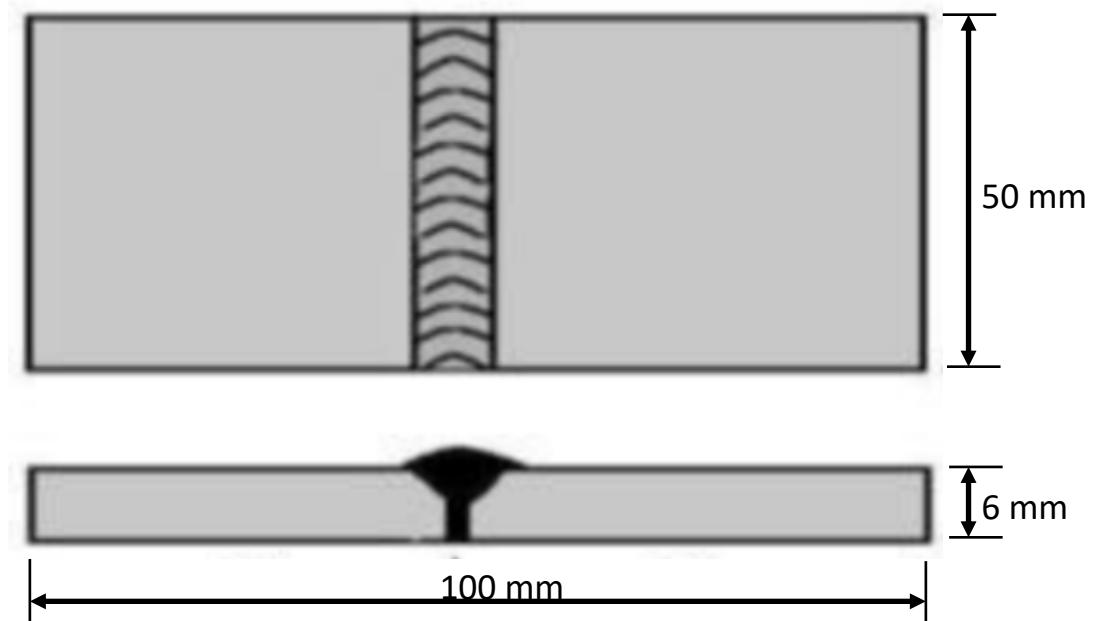
Mild steel flat of  $50 \times 50 \times 6$  mm – 2 Nos.



# Sample process of arc welding

## Precautions:

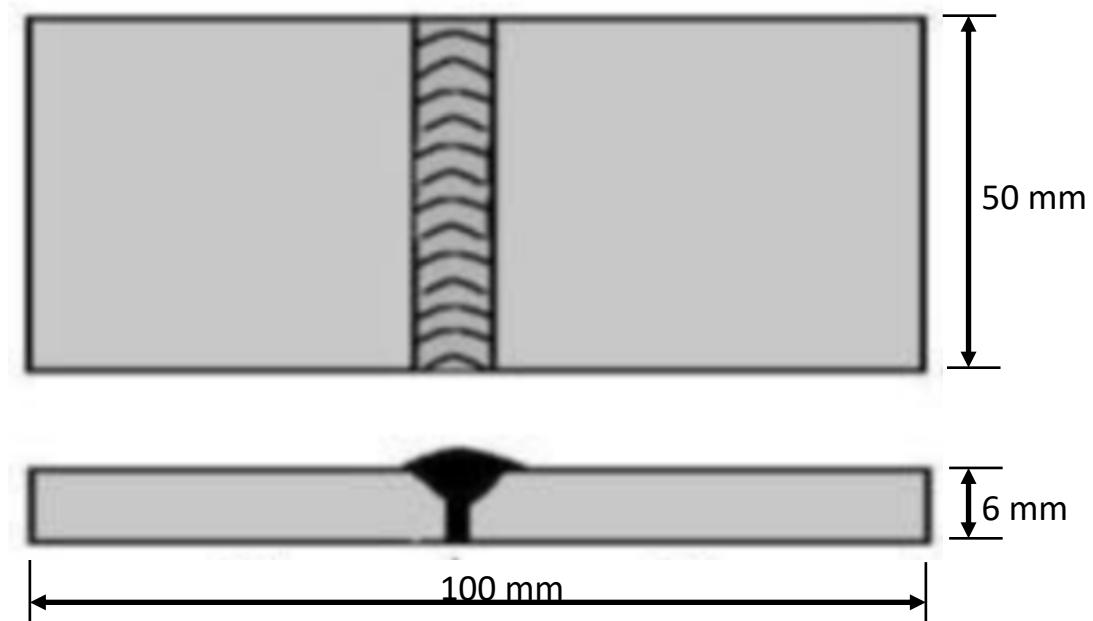
- Never look at the arc with the naked eye. Always use a shield while welding.
- Always wear the safety hand gloves, apron and leather shoes.
- Ensure proper insulation of the cables and check for openings.
- Care should be taken to avoid arc blow, which will cause serious defect in the weldment.
- Inflammable and combustible materials should be removed from the vicinity of welding operations.



# Sample process of arc welding

## Procedure:

1. Edges of the given workpieces are prepared to the required V-shape.
2. The welding machine is set to the required current (75 Amps).
3. Place the two work pieces on the welding table with required position.
4. To strike an arc, the electrode is brought in contact with the work at the point where the welding is to be started, after connecting the welding table to the welding circuit.
5. After a light contact, the electrode is immediately withdrawn to a distance of from 2 to 4 mm from the workpiece.



# Sample process of arc welding

## Procedure:

6. First run of welding is done to fill the gap and penetration of the weldment by holding the electrode at about  $70^{\circ}$  and moving the electrode to another end uniformly.
7. Second run of welding is done with proper weaving and uniform movement.
8. The scale formed is chipped with chipping hammer.
9. Filing is done to remove any spatter around the weld.

