UNIT: 7
FORGING AND WELDING

STRUCTURE

Introduction

Supporting Tools

Hand Forging Equipment

Forging Operations

Machine Forging

Welding: Arc Welding & Gas Welding

INTRODUCTION

Forging is defined as the shaping of a headed metal by hammering and pressing. The components produced in this way are called forgings. This process is carried at the above re-crystallization temperature.

SUPPORTING TOOLS USED IN FORGING

1. **Anvil:**

Anvil is used for supporting the work while hammering. It has a round hole (pritchel hole) for bending rods, a square hole (hardie hole) for holding Square shanks of various tools such as swages, fullers, hardie chisels etc. The body is made with mild steel and a grip of high carbon steel about 20 mm thick is welded on top to provide hard face. To attain proper height, it is placed on wooden block.

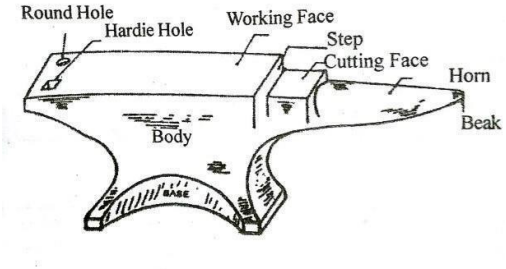

Fig. 7.1 Anvil

2. **Swage block:**

The swage block is made with cast iron and is placed at a suitable height on wooden stand. It has grooves on face sand holes in the body. It is used for holding bars while bending and knocking up heads. It can also use for finishing round, square and hexagonal forms.

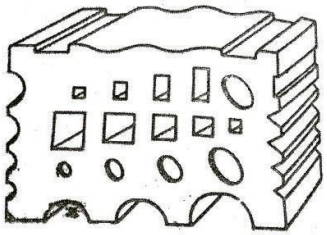

Fig. 7.2 Swage block

3. Tongs:

Tongs are used for holding the job in hand forging operations. They are made with mild steel. The jaws of the togs are used to hold the parts while hammered on the anvil. The various types of tongs are

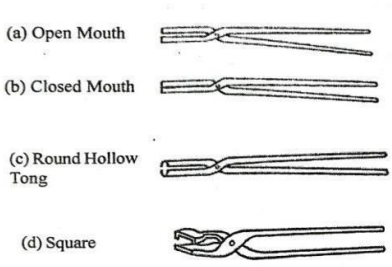

Fig. 7.3 Types of tongs

1. **Flat tong**: It is used for holding flat jobs along its length.
2. **Hollow bit tongs**: These are used for hold the roundbars.
3. **V- mouth & square mouth tongs**: They are used for to grip square bars.
4. **Pick up tongs**: they are used for picking up hot workpieces.
5. **Ring tong**: It is used for hold small circular works such as rivets, bolts etc.

4. Hammers:

Hammers are used to deform the workpiece into required shape. Two types of hammers are used. 1). Hand hammer 2). Sledgehammer.

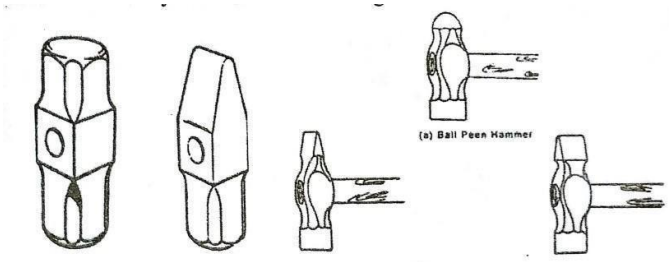

Fig. 7.4 Types of Hammers

5. Chisel:

Chisels are used for cutting metal and for nicking prior to breaking .They are hot chisel and cold chisel. Hot chisel is used for cutting the when hot. Cold chisel is used for cutting cold material.

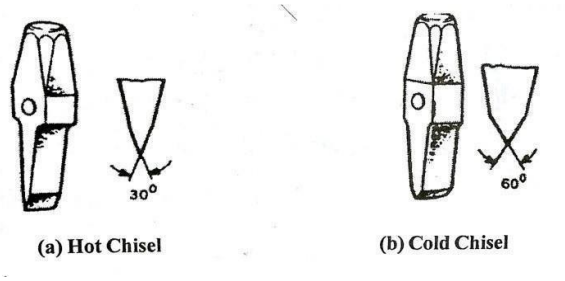

Fig. 7.5 Types of Chisels

6. Hardie tool:

It is a cutting tool with square shank to fit in the square hole of the anvil. It is used in combinations with hot or cold chisel.

Fig. 7.6 Harddie tool

7. Swages:

Swages are used for reducing and finishing the round, square and hexagonal shapes.

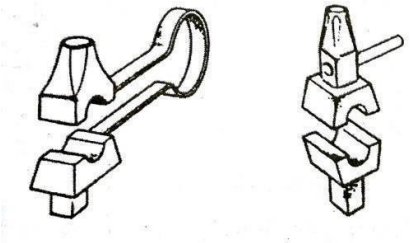

Fig. 7.7 Types of swages

8. Fullers:

Fullers are used for necking or grooving operations. These are made in various shapes and sizes. The bottom fuller has square shank to fit in the hardie hole and top one is provided with handle.

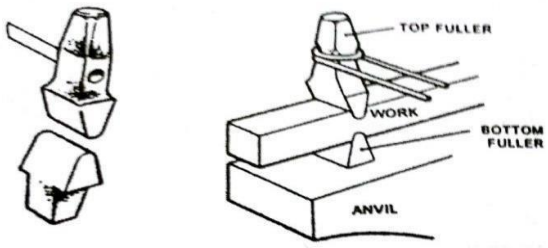

Fig. 7.8 Fullers

9. Flatters and Set hammers:

Flatters are used to obtain smooth and finished flat surface. Set hammers are used to finish corner and confined space.

10. Punches:

Punches are used for making holes in a metal. They are made in various shapes for punching holes of round, square and oval shapes.

11. Drift:

Drift is a tool used for enlarging the holes made bypunch.

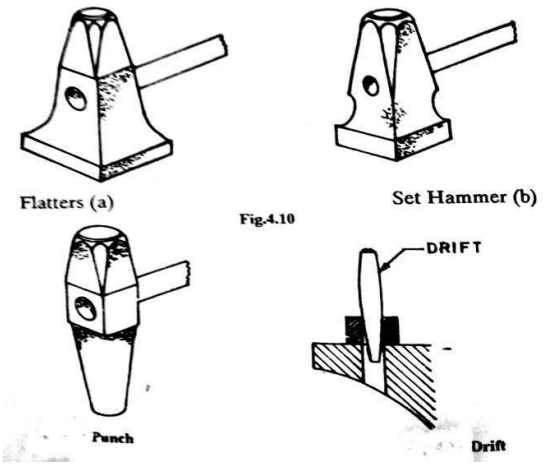

Fig. 7.9 (a) Flatter (b) Set hammer (c) Punch (d) Drift

HAND FORGING EQUIPMENT:

HEATING DEVICES:

The stocks are heated to the correct forging temperature in a smith hearth or in a furnace. Open or closed hearths are used. Gas and oils are used as fuels. The hearth is made of thick steel sheets. It is lined with fire bricks. It holds the coke and provides with tuyere and a tank containing water. Air is supplied through a fan or blower.

The air is admitted into the hearth may be regularized by valve arrangement. The hood at the top collects the fumes from the air.

Smoke and gas finally goes to the atmosphere. After firing the hearth the work piece is kept under the fire. When it becomes hot, it is removed from the hearth for shaping.

FORGING OPERATIONS:

Shapingtherawmaterialintodesiredshaperequiresdifferentoperations.The various operations are upsetting, drawing down, setting down, fullering, swaging, punching, drifting, bending, cutting and welding.

12. **Upsetting**:

It is the process of increasing cross sectional area at expense of its length. It is achieved by heating the bar at the middle and striking the end with hammer.

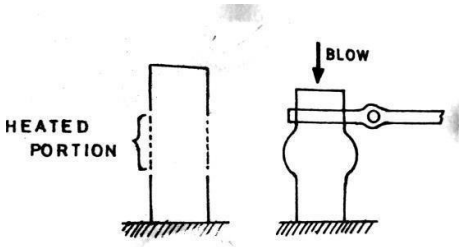

Fig. 7.10 Upsetting

13. **Drawing down:**

It is the process of decreasing the cross sectional area with corresponding increasing in length. It is carried out by using the edge, the horn of the anvil or fullers.

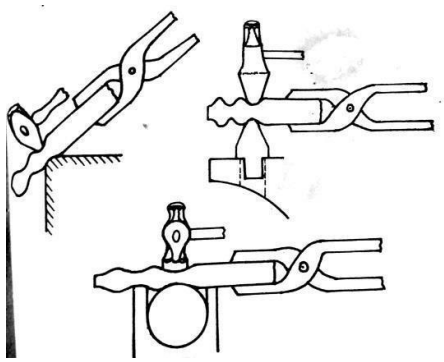

Fig. 7.11 Drawing down

14. **Setting down:**

It is the process of decreasing the thickness rather than general reduction of area. It is initiated with fullers and finished with flatters or set hammers.

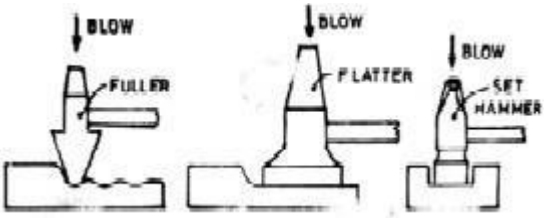

Fig. 7.12 Setting down

15. **Fullering:**

It is the process of increasing the length by necking the bars between the two fullers.

16. **Swaging:**

It is an operation by which a smooth and accurate shape by desired size is obtained. In this case the work is reduced between the swages.

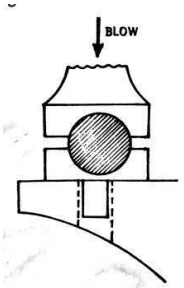

Fig. 7.13 Swaging

17. **Punching:**

It is the operation of obtaining through hole in the metal by using hot punch. It is carried on the pritchel hole of an anvil. It is carried in two steps. In the first step, the punch is driven half through one side of the metal, in the second step the work is turned over and the whole is completed.

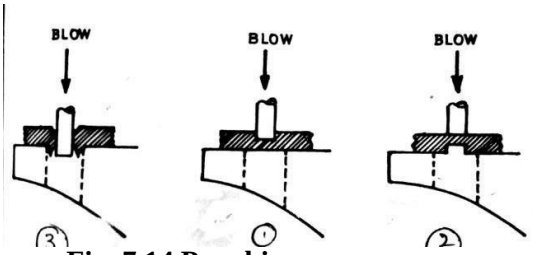

Fig. 7.14 Punching

18. **Drifting:**

It is the process of enlarging the punched hole.

19. **Bending:**

In this operation, the workpiece is bent in specified shape. It is carried on the horn of an anvil.

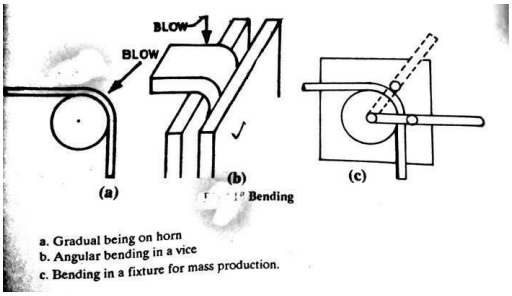

Fig. 7.15 Bending

20. Cutting:

It is the process of removing excess metal from the work piece with the chisel.

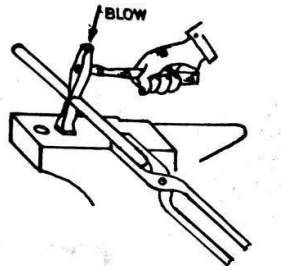

Fig. 7.16 Cutting

21. Welding:

It is the process of joining two pieces of metals. It is done by heating the work pieces to the plastic state and hammering them together. The two ends of the parts are shaped before welding.

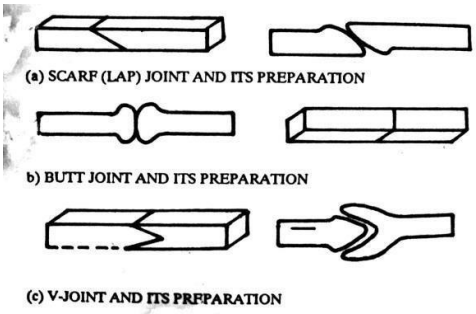

Fig. 7.17 Types of Forge Welds

MACHINE FORGING:

Heavy and medium forgings are made in machine forging. In this case power driven by forging hammer and forging press are used.

Forging hammer:

Forging hammers are used for upsetting and drawing down operations. Due to eccentricity at the driving end, spring oscillates. As the spring oscillates, the ram moves up and down to strike the work placed on the anvil. By adjusting the eccentricity, the required ram movement can be obtained. Forging hammers are

A. **Spring hammer**

B. **Pneumatic hammer**

C. **Air or steam hammer**

D. **Drop hammer.**

A) Spring Hammer:

It is adopted for upsetting and drawing out operations. Due to eccentricity at the driving and spring oscillates. As the spring oscillates the ram moves up and down in the guides to strike the work placed on the anvil. By adjusting the eccentricity the required ram movement can be obtained.

B) Pneumatic Hammer:

It is employed for forgings of small parts. It has two units. 1. Compressor cylinder and Ram cylinder. Air is compressed on both upward and downward strokes of the piston in compressor cylinder. This air enters into the ram cylinder through a controlled valve. Hammer falls due to its own weight and the pressure exerted above the piston. The upward stroke of hammer is obtained by exhausting the air above the piston and admitting it beneath the piston.

C) Steam or Air-Powered Hammers:

Steam or air-powered hammers are similar to air-lift hammers except that the hammer is raised either by steam or air, and is powered down onto the work piece by pressurized steam or air, adding controlled energy and speed beyond gravity. Striking force can be varied on each stroke over the entire range from a light tap to full power. The complete control of each work stroke places higher requirements on operator skills than for other types of hammer. In a growing number of cases, they are being controlled by programmable systems.

D) The drop forging hammer can be powered by gravity alone or additional sources of force can augment the hammer's power.

Forging Presses:

Forging presses are used for large variety of forged products. They employ a slow squeezing action. It results deeper penetration into metal. Forging presses are operated by mechanically or hydraulically.

A) Mechanical Presses:

These are widely used for manufacture of impression- die forgings from steel and non-ferrous alloys. In this type the ram is forced down by a crank and toggle joint mechanism, which is usually driven by electricmotor.

B) Hydraulic Press:

It is used for large steel forgings. The ram is moved by the pressure of the fluid (oil or water). Oil is mostly used in modern press. The pressure of oil is increased by pump and is transmitted to the cylinder in order to lift the ram or force it down.

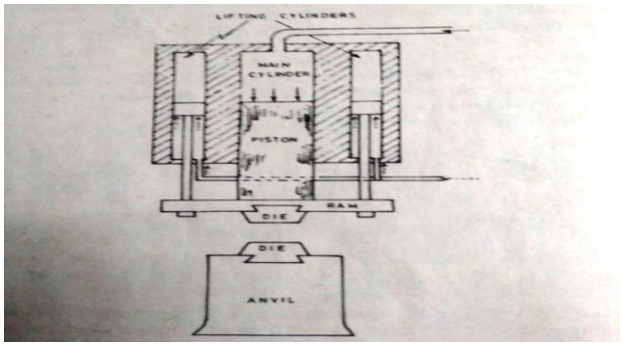

Fig. 7.18 Hydraulic Press

WELDING:

It is the process of making joint two metals by using heat with or without pressure.

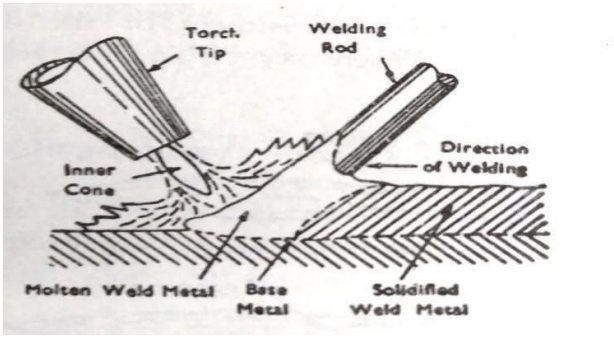

Fig. 7.19 Welding

Types of welding:

1. **Plastic or Pressure Welding:** It is the process of joining metals by heating in plastic state with applying the pressure.

2. **Fusion Welding:** It is the process of making joint by heating the metal and allow to solidify.

Arc Welding: Arc welding is most extensively employed method of joining metal plates. Here the source heat is an electric arc.

Arc Welding Equipment:

1. AC or DC welding machine
2. Electrode
3. Electrode holder
4. Cable, Cable connectors
5. Cable plug
6. Chipping hammer
7. Earth clamps
8. Wire brush
9. Helmet
10. Safety goggles
11. Hand gloves
12. Apron and sleeves.

Arc Welding Procedure:

Before starting the welding the joint should be prepared well and thoroughly cleaned to remove dirt, grease, oil etc. from the work surface. Edges of the thickened section should be beveled. The work piece should be firmly held. Make sure that the connections are given properly to main supply and electrode rod.

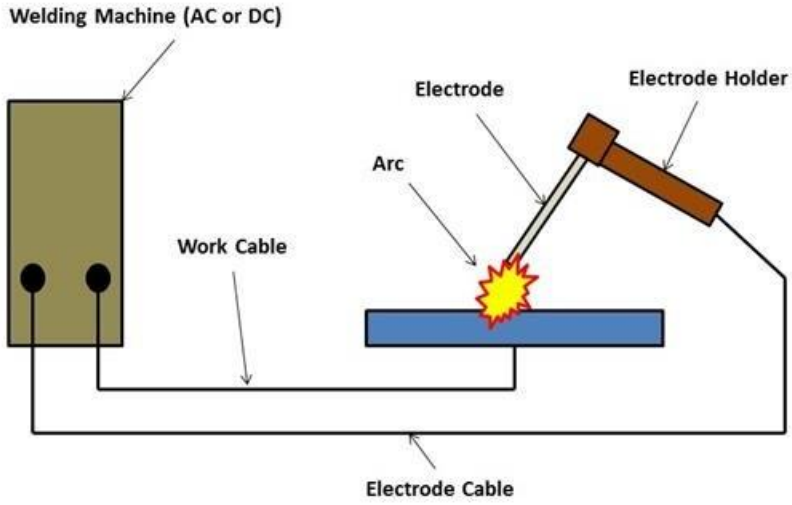

Fig. 7.20 Arc Welding

The arc column is generated between the anode and cathode. When these two conductors of an electric circuit are brought together and separated for a small distance i.e., 2-4 mm such that an electric arc is formed. Heat is generated as the ion strike the cathode. The heat of the arc raises the temperature of the parent metal which is melted forming a molten metal. The electrode rod is also melted and transferred between metal pieces to be welded. The welding may be proceeding by maintaining a gap2-4mm between the electrodes. After desired length has to been welded, the electrode holder should be lifted quickly to break the arc. Clean the welded joint with brush.

Gas Welding:

Gas welding is done by burning a combustible gas with air or oxygen in a concentrated flame of high temperature. The purpose of the flame is to heat and melt the parent metal and filler rod of a joint.

Gas Welding Equipment:

1. Welding torch
2. Pressure regulator
3. Welding tip
4. Hose and hose fitting
5. Goggles, gloves and spark lighter
6. Gas cylinders which are oxygen cylinder black in colour and Acetylene cylinder maroon red in colour.

Gas Welding Procedure:

- Arrange the work pieces and two cylinders in proper position.
- Blow out both cylinder valves before fitting the regulator so that all dirt may be cleaned.
- The regulator and valve fitting thoroughly checked that there is no oil grease.
- Fix the oxygen and acetylene regulator and pressure gauges to cylinders.
- Connect hose fittings of O2 andC2H2.
- Open the cylinder valves slowly.
- Check for leaks at all joints before starting.
- To start the work turn on the acetylene first and allow it to pass through the nozzle.
- Then turn on oxygen slightly and allow the mixture to flow through hoses and blow pipes are full and cleared off air.
- Adjust the required pressure of two gases and light the mixture.
- Adjust the flames by regulating the supply of the gasses in correct proportions.
- After the work is completed the oxygen gas valve should be closed first and followed by the acetylene gas valve.
- Flux: Flux is a chemical component to prevent oxidation of molten weld material. The materials used in flux are zinc chloride and aluminum chloride.

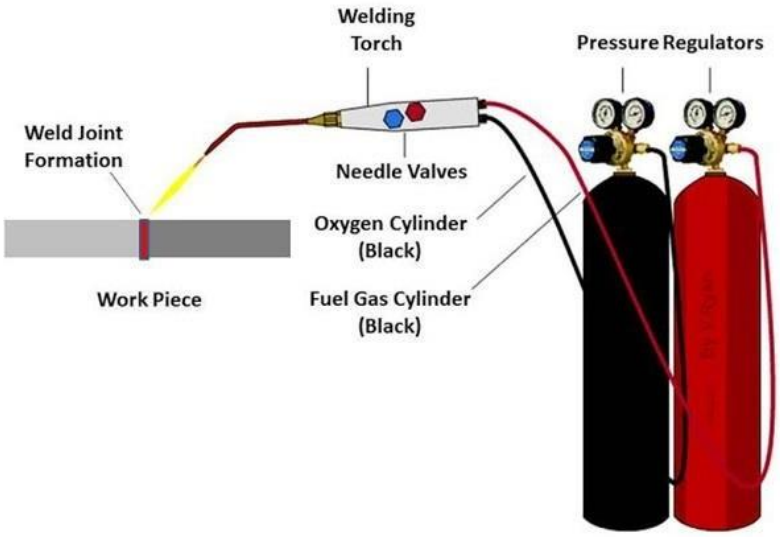

Fig. 7.21 Arc Welding

Submerged Arc Welding:

Submerged Arc Welding is used for the production of long continuous welding. In this case, a bare electrode (1.54 – 10mm) in the form of continuous wire is used and the arc is struck between electrode wire and work piece under the flux, consisting of lime, silica, magnesium oxide, calcium fluoride and other elements. The flux is fed as a powder in front of the electrode. The flux near the arc melts and forms a protective coating of slag, which is easily detached from finished weld. The rate of cooling of t he weld metal is slow and it is protected from atmosphere while cooling. The principle of submerged arc welding is shown in the fig. in this case, an automatic feeding device ensure that the gap between the electrode and the base metal is constant. Electric current usually range between 300A and 2000A. The power supply is from a standard single or three phase power lines with a primary rating upto 440V.

Developed in the 1940's submerged arc welding (SAW) process is best suited for the continuous welding of components having 12 to 50mm thickness. This process is used to weld a variety of carbon and alloy steel and stainless steel sheets. Typical applications are the welding of pressure vessels, boiler plates and pipes.

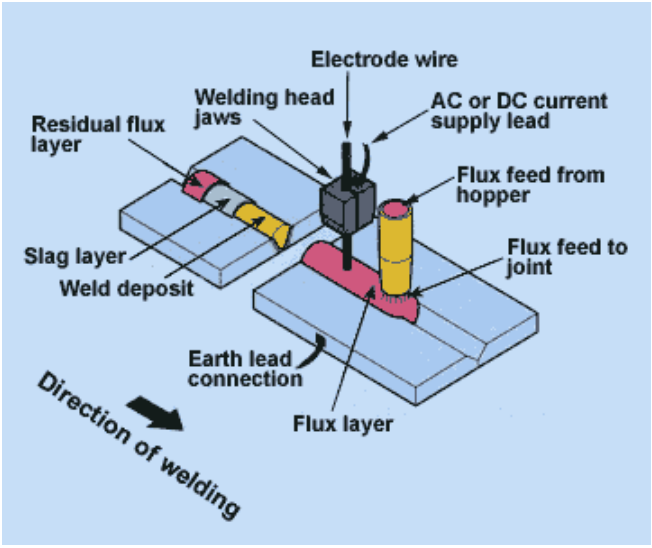

Fig. 7.22 Submerged Arc Welding

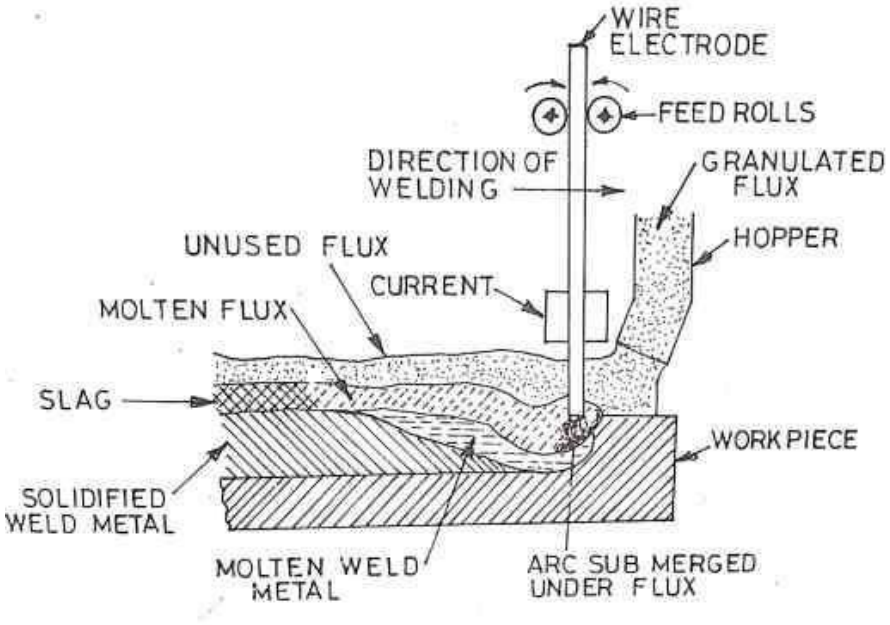

Fig. 7.23 Submerged Arc Welding

TIG Welding:

The tungsten inert gas (TIG) welding is an improvement of basic electric arc welding process. In TIG welding the intense arc is drawn between the work and non-consumable tungsten electrode. The arc and the welding zone are shielded by an inert gas (argon or helium) to avoid atmospheric contamination in the molten weld pool. Depending on weld materials, any standard AC or DC machines may be used to maintain electric arc.

TIG welding is used for welding all metals and alloys having various thickness. It is extensively used for welding aluminium, stainless and titanium. The process is employed for fabrication of missiles, air crafts and rockets. It is also used for fabrication of chemical plant and high pressure stem pipes.

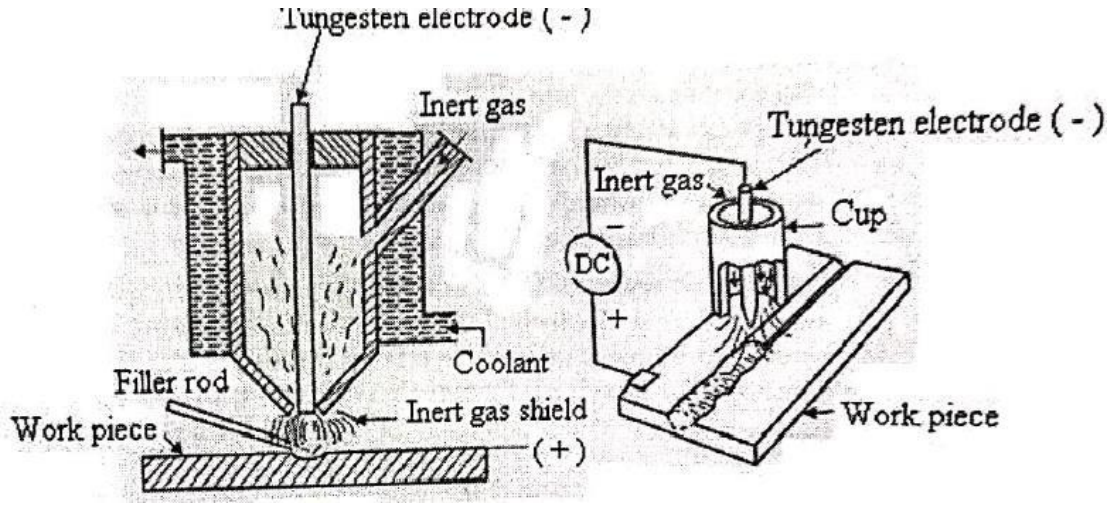

Fig. 7.24 TIG Welding

MIG Welding:

Metal Inert gas (MIG) welding is an arc welding process in which metal electrodes in the form of continuous wire is fed into the arc at the same rate at which it is being melted and deposited in the weld. The arc and the welding zone is shielded by inert gas to prevent atmospheric contaminations. T is also referred as gas metal arc welding (GMAW).

Direct current reverse polarity (DCRP) is generally used in MIG welding . Direct current straight polarity (DCSP) is sometimes used, but AC is not used in MIG due to unequal burn off rates of electrode wire.

MIG welding is used for welding carbon and low alloy steels, stainless steel, heat resistant alloys, magnesium alloys, copper and aluminium alloys. With special techniques (pre heating and post heating), the process can be employed for welding cast iron, titanium and other refractory materials. MIG welding is widely used in aircraft and automobile industries.

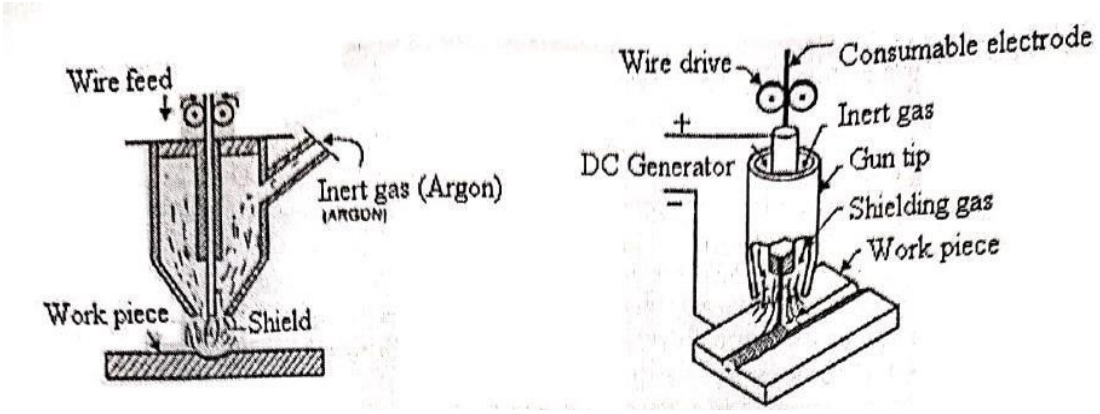

Fig. 7.25 MIG Welding

Thermit Welding:

Thermit welding is an exothermic chemical reaction for the purpose of developing a high temperature. It is a fusion process in which weld is effected by pouring super heated liquid thermit steel around the parts to be united. The heat of "thermit" reaction is utilised to bring the surfaces of metal to be welded into plastic state and mechanical pressure is then applied to complete the weld.

It is based on the chemical reaction between aluminium and iron oxide. The proportions are approximately three parts of iron oxide or magnetic iron scale and one part of aluminium. The reaction that takes place is represented by the following chemical equations.

$$8\ Al + 3\ Fe_3O_4 \rightarrow 9\ Fe + 4\ Al_2O_3 + heat$$

During the reaction, oxygen from iron oxide separates from it and combines with aluminium (which has strong affinity for it) to form aluminium oxide or slag or super heated thermit steel. During the reaction a very high temperature of the order of 2700^0C is developed. Thermit welding is applied for the repair of heavy parts such as tracks, spokes of driving wheels, broken motor casings, connecting rods and especially in the welding of pipes.

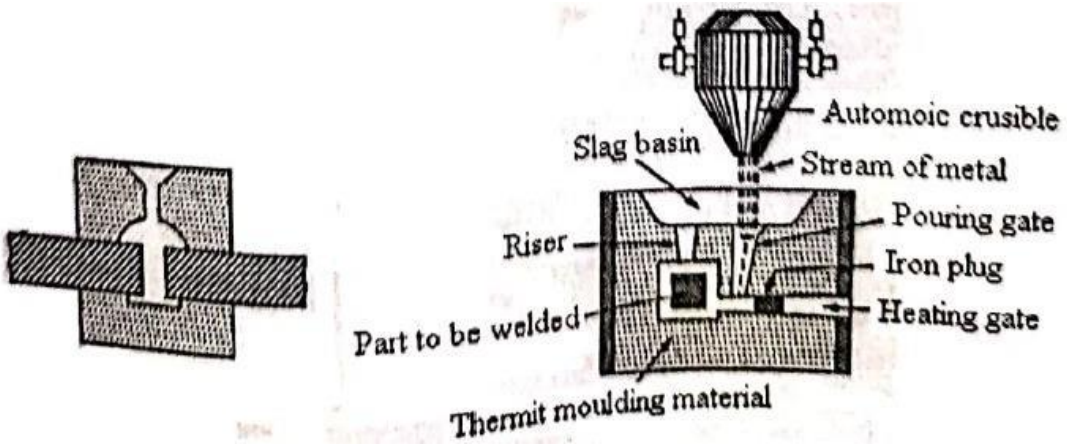

Fig. 7.26 Thermit Welding

Plasma Welding:

It is also called Plasma arc welding. Plasma is defined as a gas heated to at least practically ionized condition, enabling it to conduct an electric current. Plasma arc refers to a constricted electric arc which is achieved by passing the arc through a water cooled copper orifice. Its aim is to obtain high power density of the arc stream.

The plasma arc welding is similar to TIG with the exception that it employs a pilot arc starting circuit and constricting orifice. The arc is collimated and focused by the constricting nozzle made of copper block with cooling water duct and is less sensitive to variation of torch to work distance. The two important dimensions in the construction are orifice diameter and throat length.

Plasma arc welding is widely used for welding stainless steels, nickel alloys, refractory metals in aerospace industries. The plasma arc is not affected by magnetic field and its temperature is around 10,000-14,000^{0}K

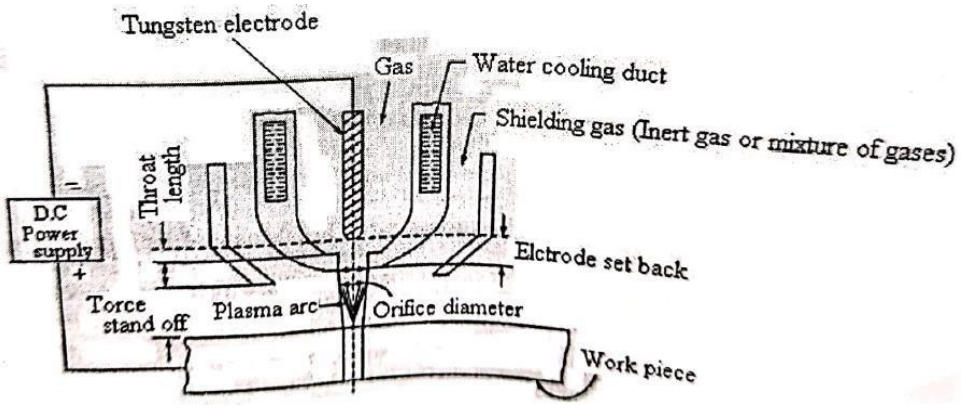

Fig. 7.27 Plasma Arc Welding

Safety Precautions in Welding Shop:

- Always wear a proper face shield.
- Always wear close-toed shoes.
- Always wear a long-sleeved, non-flammable shirt.
- Always wear proper welding gloves.
- Always wear ear protection (earplugs or muffs) to prevent sparks from entering your ear canal. An eardrum punctured by a spark will instantly cauterize and never heal.
- Never weld on or near anything that's been cleaned with a chlorinated hydrocarbon like brake-cleaner. When combined with UV light, chlorinated hydrocarbons can create phosgene gas, which can cause serious injury or death. Ventilation will not prevent poisoning.

SHORT ANSWER QUESTIONS

1. Write the tools used in Forging.
2. Write the forging operations.
3. Write the hammers used in Machine forging.
4. Write about forging presses.
5. Write about plastic and fusion weldings.
6. Where submerged arc welding is used.
7. Draw the Thermit welding and label the parts.
8. Draw Plasma welding and label the parts.

LONG ANSWER QUESTIONS

1. Write the working principle of Arc welding with sketch.
2. Explain the Gas welding principle with sketch.
3. Write the working principles of TIG and MIG welding with sketches.
4. Write the safety precautions required in welding shop.