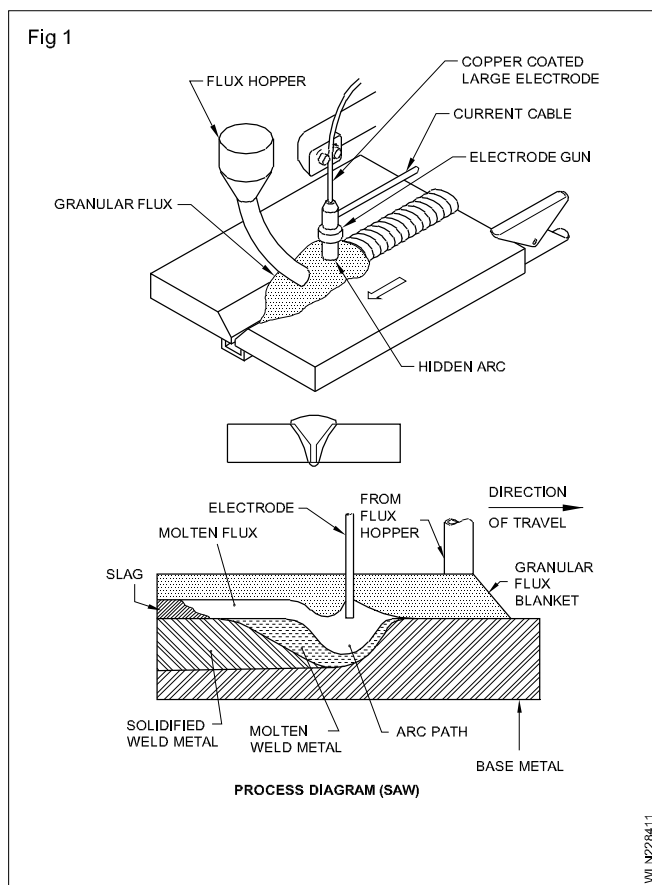


Submerged arc welding process principles

Objectives: At the end of this lesson you shall be able to

- explain the principles and applications of submerged arc welding
- explain the SAW
- describe the welding procedure of the above processes
- state the advantages and limitations of the above processes.

Principles of submerged arc welding: Submerged arc welding is an arc welding process that uses an arc between a bare metal electrode and the weld pool. The arc and the molten metal are hidden by a blanket of granular flux on the workpieces. (Fig 1)

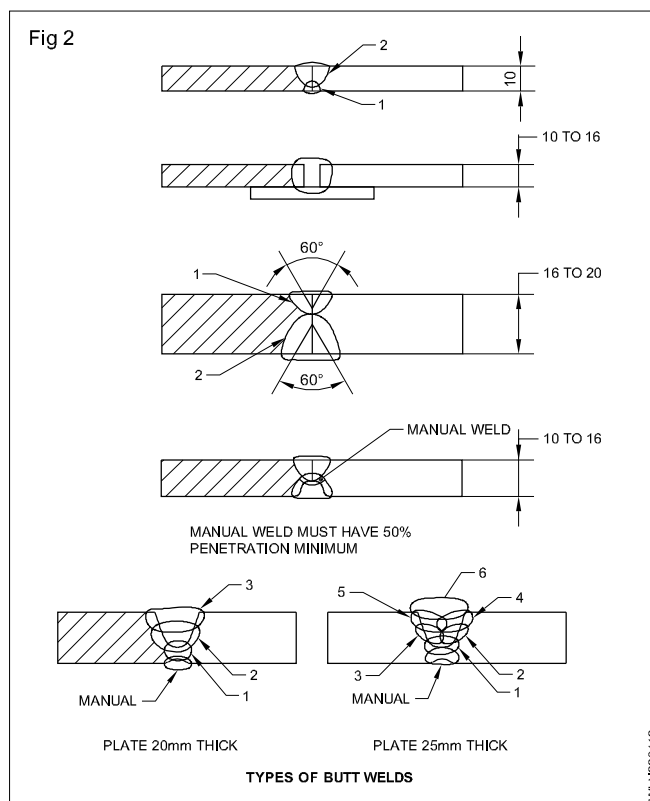


Metals which can be welded by SAW: In submerged arc welding, low and medium carbon steels, low alloy steels, high strength steels, quenched and tempered steel and stainless steel can be welded.

Metals weldable by saw

Base metal	Weldability
Wrought iron	Weldable
Low carbon steel	Weldable
Low alloy steel	Weldable
High and medium carbon	Possible but not popular
High alloy steel	Possible but not popular
Stainless steel	Weldable

Edge preparation in SAW process: The edge preparation for Butt welds are as shown in Fig.2.



For plate thicknesses higher than 25mm a double Vee or single U or double "U" edge preparation is done Fig.3 shows fillet welds done by submerged arc welding.

The "T" and Lap joints shown in Fig.3 are tilted to 45° to weld them in flat position. If the thickness of plates are more than 16mm in T fillet joint then the edge of the vertical plate is bevelled by 45° and the joint is welded without a root gap.

Types of submerged arc welding process

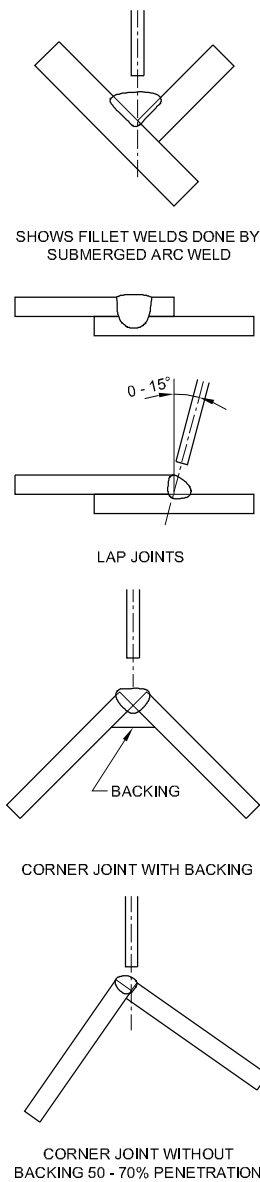
There are two types of SAW.

- Automatic
- Semi-automatic

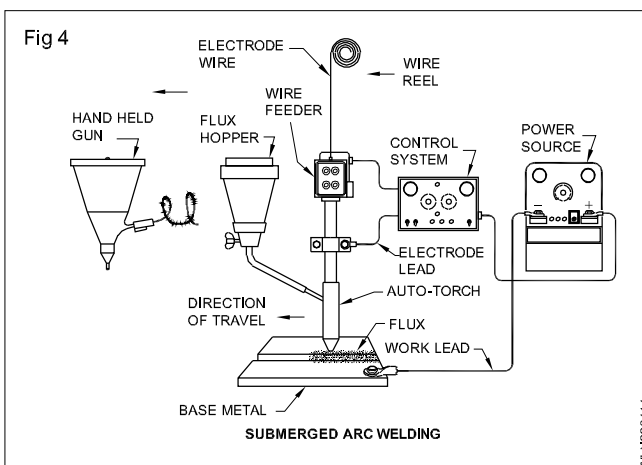
Automatic SAW: In this type the arc voltage, arc length, speed of travel and electrode feed are automatically controlled.

Semi-automatic SAW: The arc length, flux feeding and electrode feed are automatic but the speed of travel is controlled by the operator.

Fig 3



Parts of a SAW machine and their functions (Fig 4)



A wire feeder to drive the electrode to the work through the contact tube of the welding gun or welding head.

A welding power source to supply welding current to the electrode at the contact tube.

Arrangement for holding the flux and feeding it on the head of the arc.

A means of traversing the joint.

Fluxes: Fluxes used with submerged arc welding are granulated fusible mineral materials which are free from substances capable of producing large amount of gas during welding.

Flux when cool is non-conductive, but when molten it is highly conductive and allows high current.

The flux protects the weld pool from atmospheric contamination and influences deep penetration.

Electrode: Bare or lightly copper coated rods or wires are used as electrodes in SAW. These electrodes are available in coil or reel form.

Standard reels with diameters 2 to 8 mm are available.

Welding procedure (for striking the arc): The electrode momentarily contacts the work and is withdrawn slightly.

Arc start: Arc starting is difficult in submerged arc welding because of the flux cover. It is important to start the weld at a specific point on the joint.

Method of starting arc by using steel wool or iron powder: A rolled ball of steel wool 10 mm in dia. is placed at the required spot on the joint and the electrode wire is lowered on to it till it is lightly compressed. The flux is then applied and when the welding is commenced the steel wool or iron powder conducts the current from the wire to the workpiece, while at the same time it melts away rapidly as the arc is formed.

Clean the prepared workpiece and place it in position with provision for backing up. Fill the hopper with flux and insert the electrode ends into the welding head.

Adjust the voltage, the current and the welding speed as indicated in Table 1 and 2.

Start welding by striking an arc beneath the flux on the work.

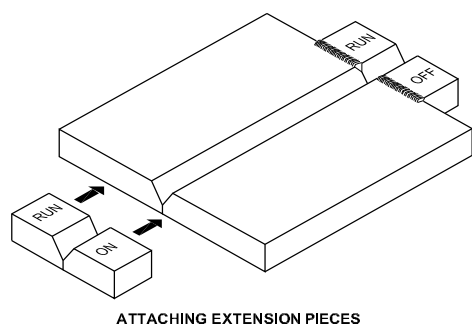
The entire welding zone is buried under a blanket of flux and longitudinally it travels along the seam.

Use 'run on' and 'run off' pieces for starting and ending to avoid formation of crater and beginning and ending faults. (Fig 5)

Advantages of SAW

- High quality weld metal
- High deposition rate and speed
- Smooth, uniform finished weld
- No spatter
- Little or no smoke
- No arc flash
- High utilization of electrode wire
- No need for protective clothing

Fig 5



Limitations: The submerged arc welding process is limited to flat position and horizontal fillet position.

Table 1
Submerged arc welding parameters for single electrode
(For fillet welds by automatic welding)

Weld size (mm)	5	6	8	10	12	16	20
Plate thickness (mm)	6	8	10	12	16	20	25
Electrode size (mm)	3.2	4	5	5	5	5	5
Current (amp) DC	520	620	720	800	870	920	970
Volts	30	32	34	36	38	39	40
Welding speed (m/min.)	1.4	1	0.7	0.56	0.36	0.25	0.20
Electrode req'd (Kg/m)	0.10	0.18	0.28	0.40	0.70	1.1	1.6
Flux req'd (Kg/m)	0.05 - 0.09	0.75 - 0.12	0.14 - 0.18	0.18 - 0.27	0.33 - 0.45	0.53 - 0.75	0.83 - 1.2
Total time (hr/m of weld)	0.012	0.016	0.0024	0.03	0.047	0.67	0.09

Table 2
Submerged arc welding parameters for single electrode
(For Butt welds by Automatic welding)

Plate thickness (mm)	6		10		12		16		20	
Pass	1	2	1	2	1	2	1	2	1	2
Electrode size (mm)	5		5		5		5		5	
Current (amp) DC+	600	750	650	800	750	850	750	850	800	900
Volts	31	33	33	35	35	36	35	36	36	37
Welding speed (m/min)	1.8	1.8	1.2	1.2	0.9	0.9	0.6	0.6	0.5	0.5
Electrode consumed (Kg/m)	0.13		0.23		0.35		0.56		0.63	
Flux consumed (Kg/m)	0.14 – 0.16		0.19 – 0.25		0.3 – 0.4		0.5 – 0.65		0.55 – 0.72	
Total time (hr/m of weld)	0.019		0.028		0.038		0.059		0.06	

Electro slag welding and electro gas welding

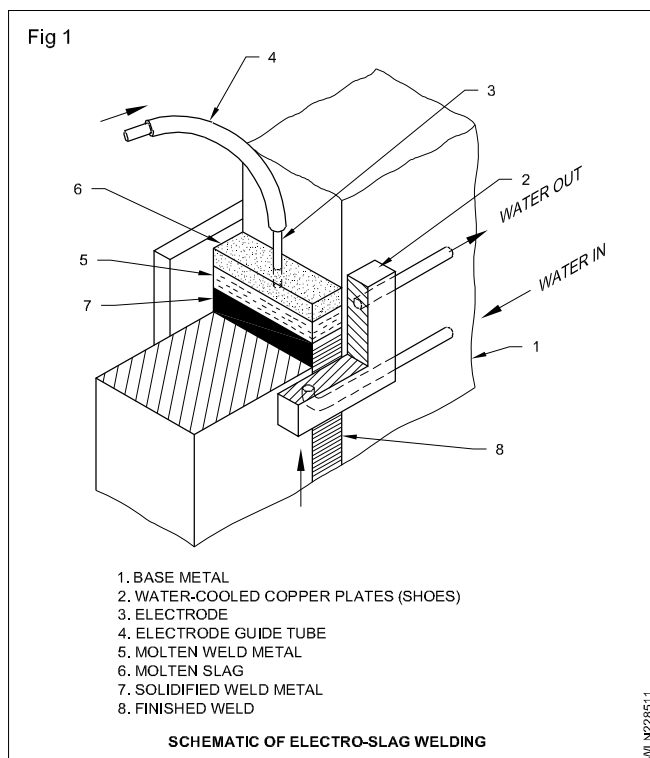
Objectives: At the end of this lesson you shall be able to

- state the principle of electro slag welding & electro gas welding
- explain the procedure
- state the advantages of electro slag welding
- state application and limitations.

Introduction

Electro slag welding process is considered as a further development of submerged arc welding and developed for the welding of thick plates with a single pass. With this process, plates of 25mm or more can be joined without multiple passes and without edge preparations such as bevel joints, 'V' joints and 'J' joints and 'U' joints and reduced the twice in the fabrication.

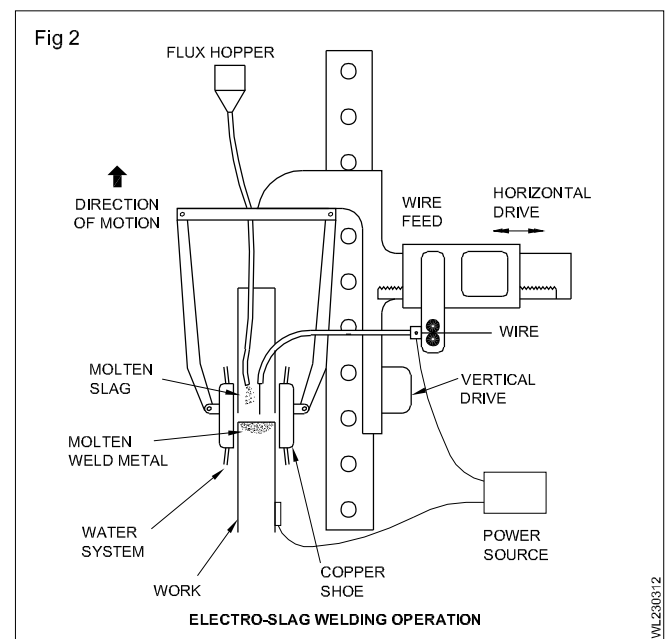
Principle: The electro-slag process is fully automatic. The plates to be joined are kept in vertical position. (The axis of the weld joint is vertical) The flux is continuously fed into the area being welded where it forms a cover of molten slag over the weld metal. This covering of molten slag serves as a major source of heat for the electro-slag welding process. The welding takes place in the flat or down hand position with vertical upward travel of the weld pool. (Fig 1)



Operation: An electric arc is struck between the electrode and the joint bottom with the help of a piece of steel wool.

Welding flux is added which melts by the heat of the arc. When a thick layer of hot flux or molten slag is formed, the arc action stops and the electric current passes from the electrode to the workpieces through the conductive slag pool.

The conductive slag pool remains molten because of its resistance to the electric current passing between the electrode and the work through it. The temperature of this molten slag pool is 1650°C at the surface and 1930°C inside under the surface. The heat fuses the edges of the workpiece and the welding electrode. Fig 2 shows an electro-slag welding process in progress.



The function of welding flux: The welding flux shields the molten metal and reduces oxidation. It cleans impurities from the molten metal. The flux is added in small quantities periodically.

Copper dams or shoes

Water-cooled copper shoes contain and confine the molten slag and molten welding metal until it solidifies. The copper shoes accelerate solidification of the weld metal.

Advantages

- Less edge preparation.
- Thicker steels can be welded in a single pass.
- High deposition rate.
- Residual stresses and distortion low.
- Less flux consumption.
- No spatter.

Application

- Forging and castings of heavy thickness can be welded.
- Some alloys such as low carbon and medium carbon steels can be welded.
- High strength structural steels can be welded.
- High strength alloy steel such as stainless steel and nickel alloy can be welded.

Limitations: This process can be used only for welding of very heavy plates.

Equipments

- 1 AC Power Source
- 2 Wire Feeder
- 3 Electrode Guide Tube
- 4 Control Panel
- 5 Travel Carriage
- 6 Water cooled Copper Shoes

1 AC power source

Electro Slag Welding requires a Power Source, capable of delivering the AC welding current, recommended for the process. The Power Source is stationary.

2 Wire feeder

The function of the wire feeder is to deliver the electrode wire through the guide tube to the molten flux.

3 Electrode guide tube

The tube is insulated materials to avoid short circuiting. It is made of beryllium copper alloys because this alloy can withstand high temperature and retains its strength.

4 Control panel

It consists a mounting near the welding head which as the following components

- a Ammeter, Voltmeter and a remote control for each of the Power Source.
- b A speed control for each wire drive motors.
- c Alarm Systems for equipment mall functions.

5 Travel carriage

All functions of the machine are controlled from a Panel located at the vertical transport carriage assembly.

6 Water cooled copper shoes

The Copper Shoes accelerate solidification of the weld metal. The functions of the Copper Shoes are to maintain the molten metal and molten slag until it solidifies.

Electro gas welding

Electro Gas Welding is an automatic welding Process that uses a Carbon Di-oxide (CO_2) or a mixture of CO_2 and Argon Shielding Gas to protect the Arc and molten weld metal from Atmospheric Contaminants. A Consumable Flux cored or Solid electrode wire is continuously and mechanically led into the arc and molten pool. Edge Preparation is not necessary. This process may be carried out by two methods

- 1 Solid Electrode Process
- 2 Flux Cored Electrode Process

Solid electrode process

In this Process, generally single electrode is fed into the joint. Two electrodes can be used for welding of thick plates. The Shield is done by the CO_2 gas and no extra flux is required.

Flux cored electrode process

In this Process, electrode with flux is fed into the joint and a thin layer of Slag on the top of molten pool. The Shielding is done by Flux.

Electro gas welding equipment and supplies

The Equipments of Electro Gas Welding are similar to Electro Slag Welding but the difference is Shielding Gas.

- 1 AC power source
- 2 Water cooled copper shoes
- 3 Welding gun
- 4 Wire feeder
- 5 Shielding gas and
- 6 Control panel

Applications

It is used for welding of thick plates in vertical position. It can be applied on Carbon Steel and Alloy Steels.

Advantages

- 1 Welder can see the welding pool easily.
- 2 Restarting the weld is easier.

Disadvantages

It is not suitable economical for welding metal lesser than 25 mm. thick.