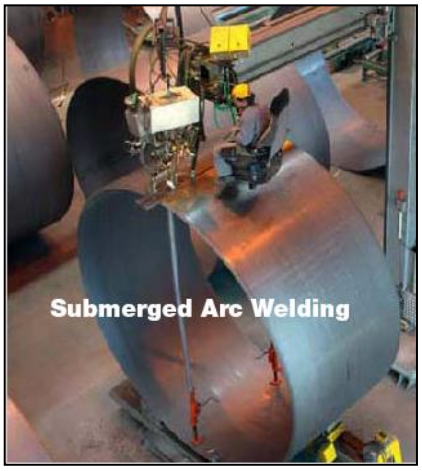
HAND-OUT

FOR

MECHANICAL ENGINEERING DEPARTMENT

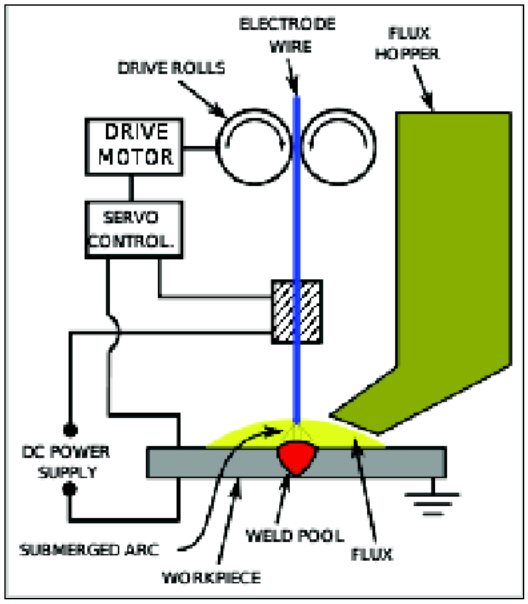
ON

SUBMERGED ARC WELDING



Presented By
STC/NBQ/NFR

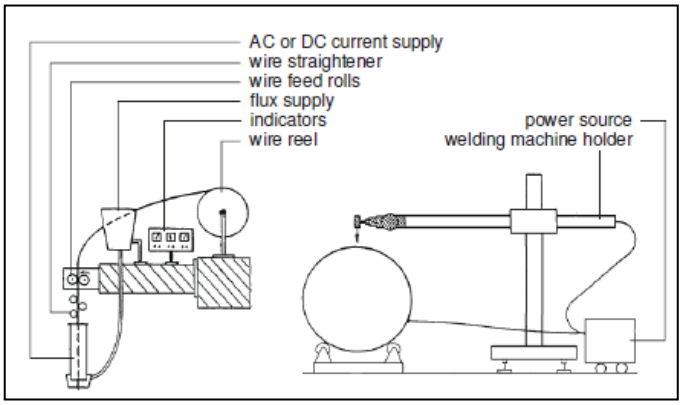
Submerged Arc Welding(SAW):



Submerged arc welding (SAW) is a common arc welding process. The first patent on the submerged arc welding(SAW) process was taken out in 1935 and covered an electric arc beneath a bed of **Granulated flux** [(1)]. Originally developed and patented by Jones, Kennedy and Rothermund, the process requires a continuously fed consumable solid or tubular (metal cored) electrode. The molten weld and the arc zone are protected from atmospheric contamination by being "**submerged**" under a blanket of ***granular fusible flux*** consisting of lime, silica, manganese oxide, calcium fluoride, and other compounds. When molten, the flux becomes conductive, and provides a current path between the electrode and the work. This thick layer of flux completely covers the molten metal thus preventing spatter and sparks as well as suppressing the intense ultraviolet radiation and fumes that are a part of the shielded metal arc welding (SMAW) process.

SAW is normally operated in the automatic or mechanized mode, however, semiautomatic (handheld) SAW guns with pressurized or gravity flux feed delivery are available. The process is normally limited to the flat or horizontal fillet welding positions (although horizontal groove position welds have been done with a special arrangement to support the flux). Deposition rates approaching 45 kg/hr.(100 lb/h) have been reported — this compares to ~5 kg/hr.(10 lb/h) (max) forshielded metal arc welding. Although currents ranging from 300 to 2000A are commonly utilized, currents of up to 5000 A have also been used (multiple arcs).

Main components of a Submerged Arc Welding unit :



The wire electrode reel, the wire feed motor equipped with grooved wire feed rolls which are suitable for the demanded wire diameters, a wire straigthener as well as a torch head for current transmission, Figure

Flux supply is carried out via a hose from the flux container to the feeding hopper which is mounted on the torch head. Depending on the degree of automation it is possible to install a flux excess pickup behind the torch. Submerged arc welding can be operated using either an A.C. power source or a D.C. power source where the electrode is normally connected to the positive terminal.

Welding advance is provided by the welding machine or by workpiece movement.

Features :

Welding head:

It feeds flux and filler metal to the welding joint. Electrode (filler metal) gets energized here.

Flux hopper:

It stores the flux and controls the rate of flux deposition on the welding joint.

Flux :

The **Granulated flux**[(1)] shields and thus protects molten weld from atmospheric contamination. The flux cleans weld metal and can modify its chemical composition also. The flux is granulated to a definite size. It may be of fused, bonded or mechanically mixed type. The flux may consist of fluorides of calcium

and oxides of calcium, magnesium, silicon, aluminium and manganese. Alloying elements may be added as per requirements. Substances evolving large amount of gases during welding are never mixed with the flux. Flux with fine and coarse particle sizes are recommended for welding heavier and smaller thickness respectively.

Granulated flux [(1)] :

Granular flux used in welding is a type of flux that is made up of numerous small particles. In Submerged Arc Welding (SAW), the granular flux provides a blanket over the weld, which protects against sparks and splatter.

In SAW, the granular flux is frequently the means for achieving high deposition rates. The flux is also instrumental in producing the type of quality weld that is common in this particular welding process.

Functions of Flux in Submerged Arc Welding:

The effect of gravity on the flux feeding into the weld area and the molten weld pool limits the versatility of Submerged Arc Welding. This process must be performed in the flat and horizontal fillet positions only, except in special cases. These special cases include vertical and horizontal welds using special equipment, such as belts or shoes, to hold the flux in position.

The granular flux used in SAW serves several functions. In addition to providing a protective cover over the weld, the flux shields and cleans the molten puddle. The flux also affects the chemical composition of the weld metal, the weld bead shape, and the mechanical properties of the weld.

Another function of granular flux is to act as a barrier that holds the heat in and concentrates the heat into the weld area to promote deep penetration.

Types of Granular Fluxes:

The methods used to manufacture fluxes determine the flux types. There are ***fused fluxes, bonded fluxes, agglomerated fluxes,*** and ***mechanically mixed fluxes***.

When manufacturing ***fused fluxes***, raw materials are melted into a liquid state with a high temperature electric furnace. The material is then cooled and crushed or ground into the desired particle size.

When making ***bonded fluxes***, the ingredients are dry mixed, then glued together with a liquid binder. This binder may be a liquid such as sodium silicate. After the particles are bonded, they are baked and then sifted through a sieve to attain flux particles of the desired size.

Agglomerated fluxes are manufactured much the same way that bonded fluxes are made. However, instead of a liquid binder, a ceramic binder is used. A higher drying temperature is used, too. (The higher drying temperature limits the use of deoxidizers and alloy elements.)

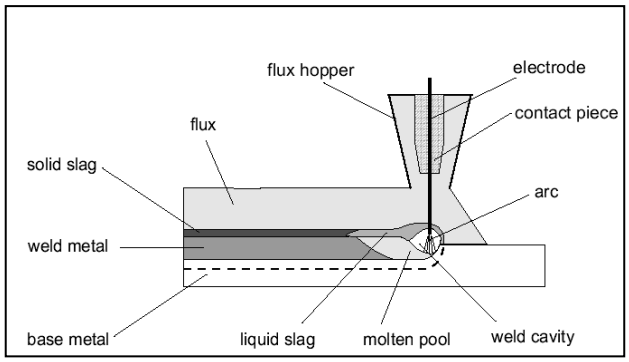
Fluxes that are ***mechanically mixed*** are combinations of two or more bonded or agglomerated fluxes. Although mechanically mixed fluxes make it possible to create special mixtures for more sensitive welds, these fluxes may separate during storage, use, and recovery of flux.

Electrode:

SAW filler material usually is a standard wire as well as other special forms. This wire normally has a thickness of 1.6 mm to 6 mm . In certain circumstances, twisted wire can be used to give the arc an oscillating movement. This helps fuse the toe of the weld to the base metal. The electrode composition depends upon the material being welded. Alloying elements may be added in the electrodes. Electrodes are available to weld mild steels, high carbon steels, low and special alloy steels, stainless steel and some of the nonferrous of copper and nickel. Electrodes are generally copper coated to prevent rusting and to increase their electrical conductivity. Electrodes are available in straight lengths and coils. Their diameters may be 1.6, 2.0, 2.4, 3, 4.0, 4.8, and 6.4 mm. The approximate value of currents to weld with 1.6, 3.2 and 6.4 mm diameter electrodes are 150–350, 250–800 and 650–1350 Amps respectively.

Welding Operation:

In **submerged arc welding** a mineral weld flux layer protects the welding point and the freezing weld from the influence of the surrounding atmosphere, Figure 3.1. The arc burns in a cavity filled with ionised gases and vapours where the droplets from the continuously-fed wire electrode are transferred into the weld pool. Unfused flux can be extracted from behind the welding head and subsequently re-cycled.

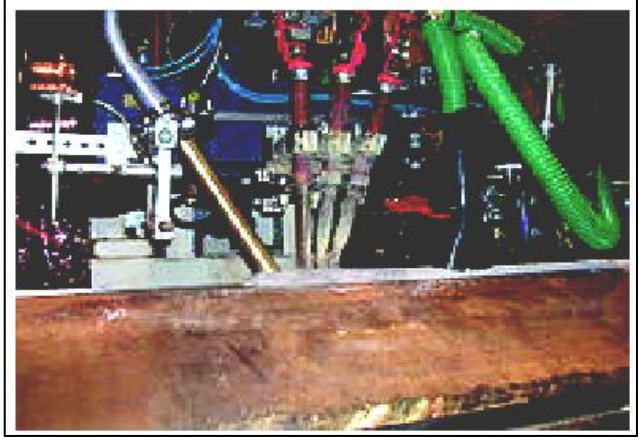


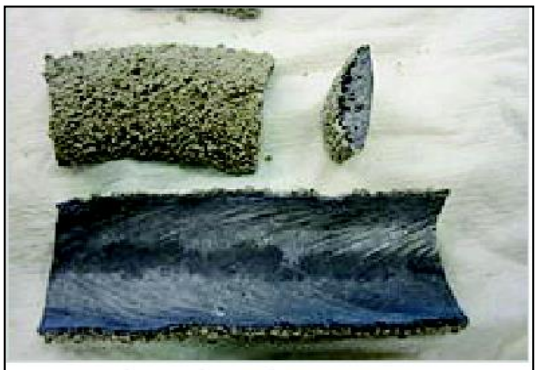
The flux starts depositing on the joint to be welded. Since the flux when cold is non-conductor of electricity, the arc may be struck either by touching the electrode with the job or by placing steel wool between electrode and job before switching on the welding current or by using a high frequency unit. In all cases the arc is struck under a cover of flux. Flux otherwise is an insulator but once it melts due to heat of the arc, it becomes highly conductive and hence the current flow is maintained between the electrode and the workpiece through the molten flux. The upper portion of the flux, in contact with atmosphere, which is visible remains granular (unchanged) and can be reused. The lower, melted flux becomes slag, which is waste material and must be removed after welding.

The electrode at a predetermined speed is continuously fed to the joint to be welded. In semiautomatic welding sets the welding head is moved manually along the joint. In automatic welding a separate drive moves either the welding head over the stationary job or the job moves/rotates under the stationary welding head.

The arc length is kept constant by using the principle of a self adjusting arc. If the arc length decreases, arc voltage will increase, arc current and therefore burn off rate will increase thereby causing the arc to lengthen. The reverse occurs if the arc length increases more than the normal.

A backing plate of steel or copper may be used to control penetration and to support large amounts of molten metal associated with the process.





Pieces of slag from Submerged arc welding

Key SAW process variables :

- Wire feed speed (main factor in welding current control)
- Arc voltage
- Travel speed
- Electrode stick-out(ESO) or contact tip to work (CTTW)
- Polarity and current type (AC or DC) and variable balance AC current

Material applications:

- Carbon steels (structural and vessel construction)
- Low alloy steels
- Stainless steels
- Nickel-based alloys
- Surfacing applications (wear-facing, buildup, and corrosion resistant overlay of steels)

Advantages :

- High deposition rates (over 45 kg/hr. (100 lb/hr.) have been reported).
- High operating factors in mechanized applications.
- Deep weld penetration.
- Sound welds are readily made (with good process design and control).
- High speed welding of thin sheet steels up to 5 m/min (16 ft/min) is possible.
- Minimal welding fume or arc light is emitted.
- Practically no edge preparation is necessary.
- The process is suitable for both indoor and outdoor works.
- Low distortion
- Welds produced are sound, uniform, ductile, corrosion resistant and have good impact value.
- Single pass welds can be made in thick plates with normal equipment.
- The arc is always covered under a blanket of flux, thus there is no chance of spatter of weld.
- 50% to 90% of the flux is recoverable, recycled and reused.

Limitations:

- Limited to ferrous (steel or stainless steels) and some nickel-based alloys.
- Normally limited to the 1F, 1G, and 2F positions.
- Normally limited to long straight seams or rotated pipes or vessels.
- Requires relatively troublesome flux handling systems.
- Flux and slag residue can present a health and safety concern.
- Requires inter-pass and post weld slag removal.
