Welding Technology 6

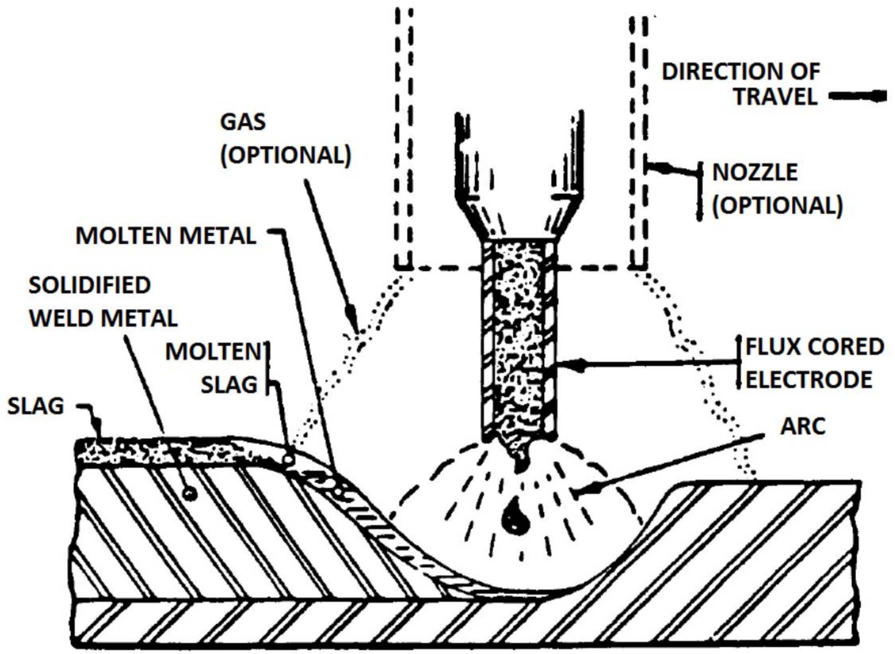
Flux-Cored Arc Welding

Flux-cored arc welding is a variation of gas metal arc welding (GMAW). In fact, the only feature that makes it distinct from the GMAW is the flux-cored wire that is used as the filler as well as electrode. As the name suggests, the flux-cored wire is cored with flux. It is a tubular electrode, with a metal sheath surrounding a column of flux – throughout the length of the wire.

The presence of flux improves arc action, improves deposition efficiency, bead appearance, and mechanical properties of the weld. Also, at high currents, the arc is more smooth and stable in comparison to when high diameter filler wire is used in GMAW. However, since flux is involved, some smoke and spatter are generated, and a layer of slag is formed at the top of solidified weld metal, which has to be removed by the welder.

Flux-Cored Arc Welding

The flux provides shielding to the electric arc. Sometimes an externally supplied shielding gas is also used to supplement the flux shielding. The diagram below illustrates the welding action with FCAW process.



Flux-Cored Arc Welding Electrodes

The electrodes used in flux-cored arc welding are made up of a flux core, surrounded by a metal sheath. The primary function of flux at the core of the wire is to provide shielding to the arc from the oxidizing gases in the atmosphere such as oxygen and nitrogen. The metal sheath accounts for 75 to 90% of the weight of the wire.

For some FCAW electrodes, a supplemental shielding is also provided in the form of a shielding gas. The composition of the wire, flux in the core, and the shielding gas determine the ultimate chemical and mechanical properties of the deposited weld metal with that wire.

Flux-Cored Arc Welding Electrodes

A typical wire used in FCAW process is illustrated in the figure below. For carbon steel electrodes, the flux at the core simply performs the function of providing shielding to the arc.

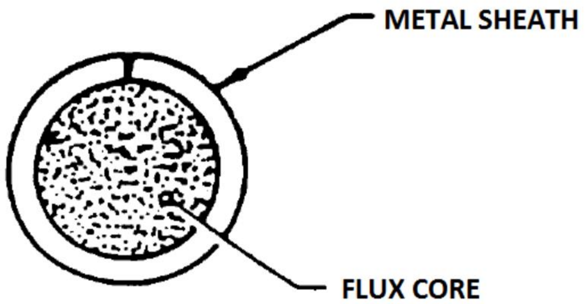


FIGURE 1: CROSS SECTION OF A FLUX-CORED ARC WELDING WIRE

Flux-Cored Arc Welding Electrodes

In some low alloy electrodes, the flux also acts as vehicle for delivery of some alloying elements. Some metal powders are added as additives in the flux. These metals get added in the weld metal, thus improving its' properties.

Functions Of Flux Ingredients In The Core

Some of the electrode functions are as follows:

It contains ingredients that induce the formation of slag over the molten weld metal. The slag settles at the top of deposited metal, and protects the solidifying metal from oxidation by atmospheric gases.

The flux contains oxidizers such as silicon, manganese, etc. that help purify the molten metal, and make it free of oxygen.

The flux contains arc stabilizers that stabilize the arc, so that a smooth operation can be achieved. A stable arc gives off lesser spatter.

The flux can also be used as a vehicle for delivery of certain alloying elements to the weld metal. This reduces the need for these elements to come from the wire. The desired chemistry can thus be achieved through the flux route, instead of depending on the wire. This allows sourcing of the wire easily and cheaply.

Submerged Arc Welding (SAW)

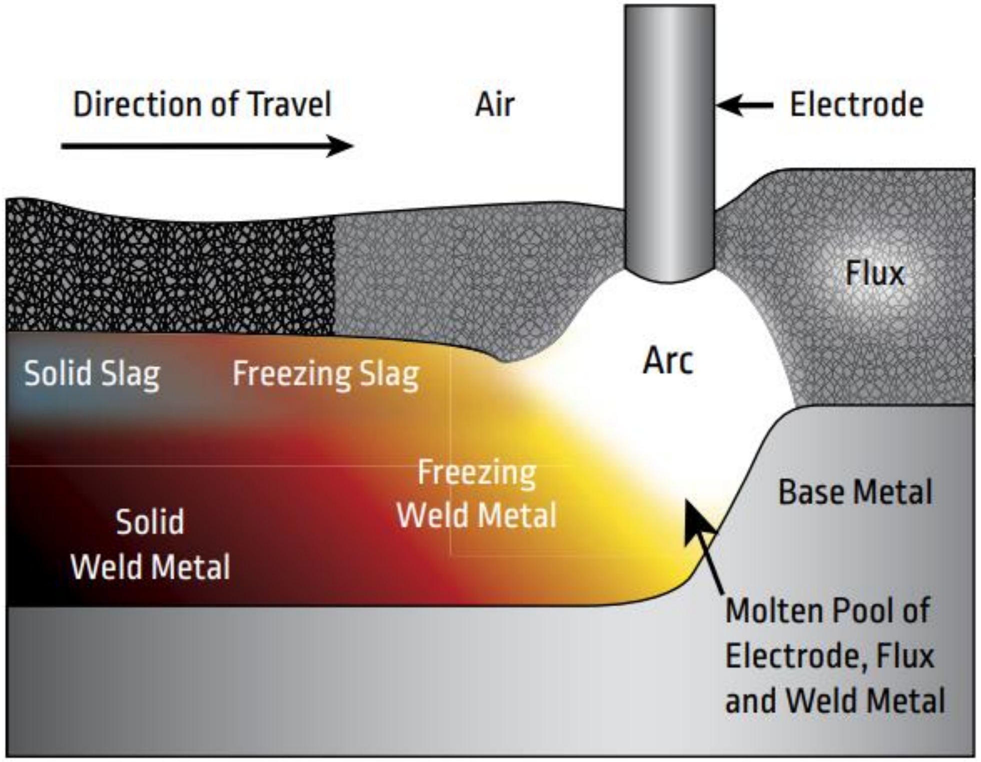


Figure 1-1: Cross Section of a Typical Submerged Arc Weld

Submerged Arc Welding (SAW)

Submerged arc welding (SAW) is a welding process that predates gas metal arc welding (GMAW) and flux cored arc welding (FCAW) by a number of years. First patented in 1925, submerged arc welding is generally indicated on welding documents as “SAW,” and is commonly referred to as "subarc.«

Submerged arc welding consists of continuously feeding a solid or cored electrode through a bed of granular material called flux. This flux covers and protects the arc that is established between the electrode and the workpiece. A certain amount of flux is melted and may function to add or remove alloy from the weld, as well as provide fluxing agents to assure clean, dense weld deposits.

Submerged Arc Welding (SAW)

The term submerged arc accurately describes one of the major advantages of the process;

the absence of a visible arc that is present with other forms of electric arc welding.

With no need for dark welding glasses or a welding helmet to protect the operator from arc radiation and weld spatter, operator comfort and safety are optimized.

The relatively small amount of smoke and fume generation is another advantage to the subarc process. Because the arc is submerged, the lack of visibility can also be a limitation as the welder is limited in his or her ability make changes to the weld “on the fly,” relying more on correct setup and fixturing.

Advantages of SAW

Minimal fumes and arc visibility (radiation),

Well suited to welding thick sections,

Delivers highest deposition rates and deepest penetration of any arc welding process,

Produces high-quality welds,

Excellent repeatability from weld to weld.

Disadvantages of SAW

Relatively high initial startup cost,

Limited portability,

Granular welding flux must be used,

Complex equipment setup,

Lack of visibility limits ability to make corrections during welding,

Limited to flat and horizontal welding only.

Applications of SAW

The subarc process produces weld metal that is suitable for

low- and medium-carbon steels,

high-strength alloys,

stainless steels,

and some nickel steels.

The subarc process may be applied in the construction, fabrication or repair of the materials:

Applications of SAW

Pipe, pressure vessels, and cylindrical or conical items

Ship construction,

Hardfacing overlays including strip cladding,

Structural steel for structures and bridges,

Earth moving, mining, and construction equipment,

Farm equipment,

Heavy machinery components,

Transportation equipment,

Offshore.

Fluxes

Fluxes with alloying properties and neutral fluxes that provide protection to the molten pool from atmospheric oxygen and other impurities. Therefore welding consumable manufacturers produce fluxes depending upon the type of steel to be welded.

Fluxes come in three different forms;

agglomerated,

fused,

and sintered.

Fluxes

Fused fluxes are homogeneous where the components of the flux are fused to form a glass like mass which is crushed, ground and finally sieved to obtain a suitable grain size.

Agglomerated fluxes can absorb moisture (hygroscopic). They are made in a completely different manner than fused fluxes. The components in agglomerated fluxes are bonded together with potassium or sodium silicate and rotating the compound in a cone shape or drum and finally dried in a rotating tubular kiln at temperatures between 800 and 900°C. When dry the granules are sieved to the required grain size. Sintered fluxes are form baked and dried into discs that are later crushed to the required grain size.

Fluxes

Fused fluxes are non hygroscopic meaning that they do not absorb dampness from the atmosphere and are ideal for welding outdoors and in environments having high relative humidity. Agglomerated fluxes are hygroscopic and do absorb moisture. These fluxes must be handled in a manner where moisture is kept from them by storing in a special flux drier. Agglomerated fluxes should always be dried before use.

FLUX TYPE	BENEFITS	DRAWBACKS
Fused	Non-hygroscopic High grain strength	Alloying elements such as Cr and Ni cannot be incorporated in the flux High specific density (approx. 1.6 kg/l)
Sintered	Relatively low hygroscopicity Relatively low density (approx. 1.3 kg/l)	Alloying elements cannot usually be included in the flux Relatively low grain strength
Agglomerated	Alloying elements such as Cr and Ni can be included in the flux Low specific density (approx. 0.8 kg/l)	Hygroscopic Relatively low grain strength

Parameters

Arc voltage

The arc voltage is decisive in determining the shape and width of the arc and, to some degree, also in determining its penetration.

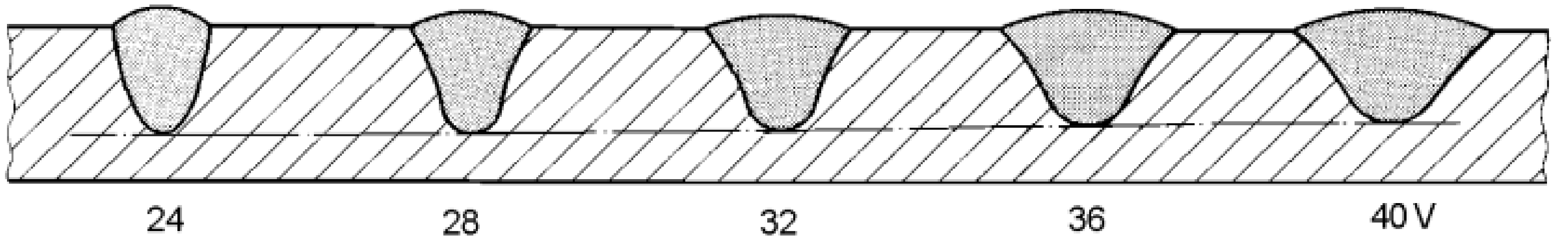


Figure 2. How a change in arc voltage affects the shape of weld. Welding current is constant.

Parameters

<u>Welding current</u>

Welding current is the parameter that is of greatest importance for penetration. The current setting depends on the thickness of the metal and the type of joint. The current has no effect on the width of the bead, but too high a current can result in burn-through, while too low current can result in insufficient penetration with resulting root defects.

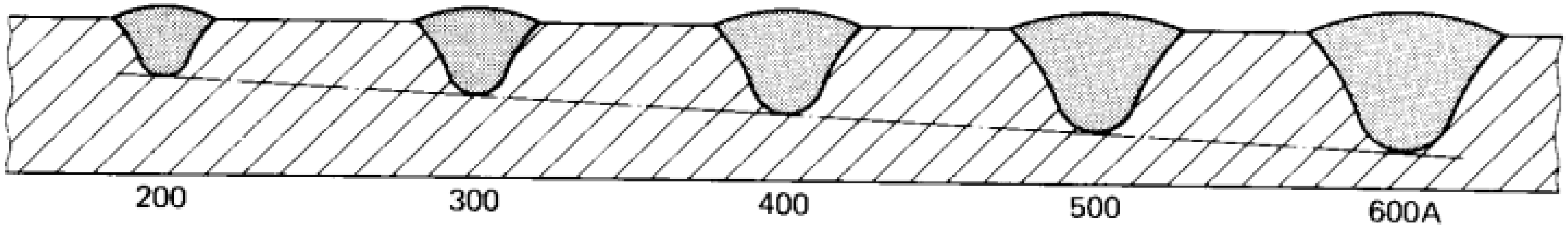


Figure 3. Increasing welding current results in deeper penetration.

Parameters

Welding speed

The welding speed also affects the penetration. If the speed is increased relative to the original value, penetration will be decreased and the weld will be narrower. Reducing the speed increases penetration and results in a wider weld (cf. manual welding). However, reducing the welding speed to about 20–25 cm/min (depending on the actual value of the current) can have the opposite effect, i.e. a reduction in penetration, as the arc is prevented from transferring thermal energy to the parent metal by the excessive size of the weld pool. If the welding speed is to be changed while penetration is kept constant, it is necessary to compensate by adjustment of the welding current, i.e. to increase or decrease it.

Parameters

Wire diameter

For a given current, a change in wire size will result in a change in current density. Greater wire diameter results in a reduction in penetration and, to some extent, also the risk of burning through at the bottom of the weld. In addition, the arc will become more difficult to strike and arc stability will be adversely affected. There is a risk of root defects if too large an electrode is used in V-joints.

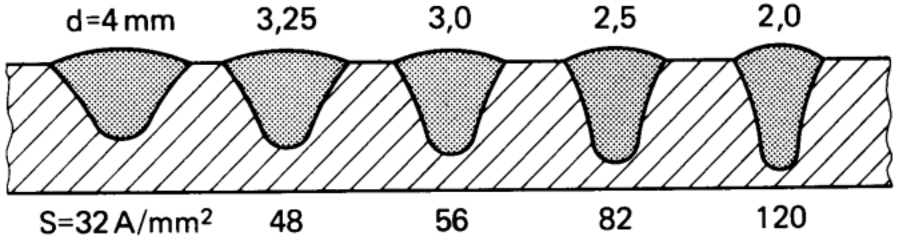


Figure 4. The effect of different wire diameters at constant welding current.