7. Submerged Arc Welding

7.1. The Process

Submerged arc welding (SAW) is so called because the arc is submerged under a layer of granular flux, delivered from a hopper. The arc is struck between a continuous wire electrode and the workpiece. The arc develops most of the heat of the process, although some may be from resistance heating of the slag.

Most submerged arc welding involves little manual skill. There are various levels of mechanisation.

Semi-automatic Welding

The welder controls the position and travel speed of the arc. A hand-held gun that feeds flux and wire is used.

Mechanised or Machine Welding

The equipment controls travel speed, flux and wire feed, but the welder must start, closely monitor and stop the process. This is the most common degree of mechanisation.

Automatic welding

The equipment performs the entire welding operation without the operator being required to adjust the controls. Sequence timers and adaptive control are necessary.

SAW is used mostly for carbon-manganese and low alloy steels in structural and pressure vessel applications. Welding of stainless steels and nickel alloys is also commonly undertaken with fluxes and wires specifically for these materials, although with limitations on heat input. Other materials (such as aluminium and copper) are not welded with SAW.

7.1.1. Features

The arc is protected under a blanket of flux, which eliminates arc flash, spatter, fumes and wind disruption. Current densities are high which results in high penetration. This means that joints can have a small gap (0 to 1mm) and large root face (4 to 6mm). The process is generally only suitable for material over 6mm thick, although there are special procedures for thinner material using high travel speeds.

Deposition rates are typically 3 to 15kg per hour and travel speeds are typically 300 to 1500mm/min, so SAW is a high productivity process.

The flux acts as a scavenger and deoxidiser, removing contaminants (particularly oxygen, nitrogen, sulphur) from the joint. The process can cope with some rust or contamination, depending on the flux used. Some flux-wire combinations give low

hydrogen welds. The skill level required is low, and the fatigue level on the welder is low, but it is a big mistake to allow unskilled workers to operate the process.

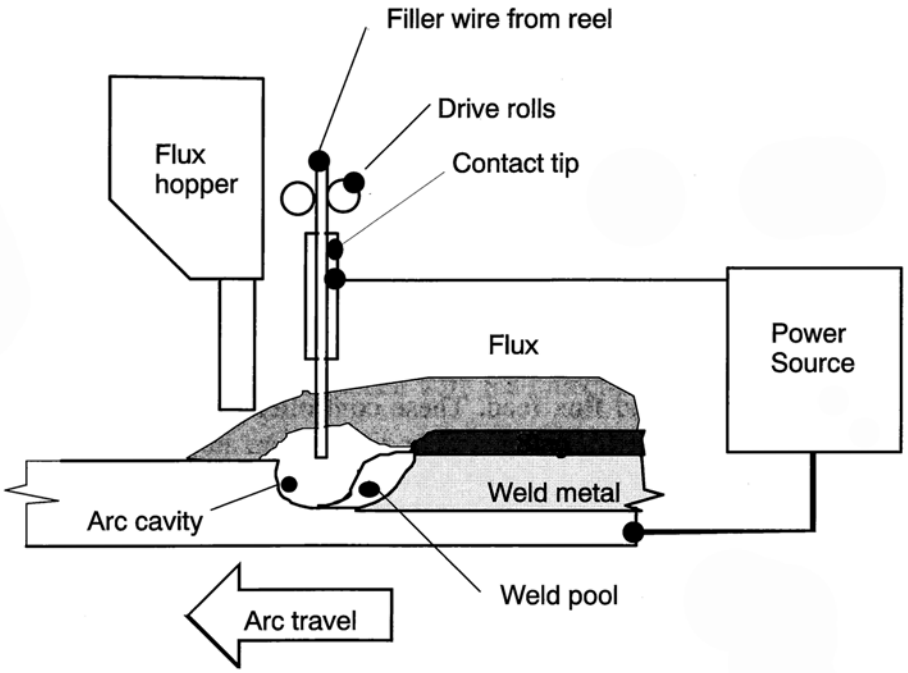

Figure 27 Submerged Arc Welding

7.1.2. Limitations of Submerged Arc Welding

The process uses equipment with a high capital cost. It although the travel speeds and deposition rates are high, it may take so long to set up that it is uneconomic. Generally, submerged arc welding is uneconomic for welds less than 1 metre long.

The process only can be used in the flat and horizontal positions. The bulky equipment cannot reach joints with restricted access. It either has to be mounted on a heavy manipulator or on a portable tractor.

Submerged arc welding is only suitable for simple geometric shaped welds in flat plate or cylindrical sections. More complicated shaped welds are difficult to track, although robotic welding has been used.

7.2. Equipment

7.2.1. Power Sources

SAW uses steady (not pulsed) ac or dc current up to 1500A.

7.2.1.1 Constant Voltage (Flat Characteristic)

CV power sources provide a self-correcting arc length like GMAW and a simple wire feed mechanism can be used. Those with analogue control are limited to a current density of less than 62 A/mm^2. They are traditionally for currents less than 1000A with smaller wires and higher travel speeds. Modern equipment with microprocessor digital control allows a much wider range of conditions.

7.2.1.2 Constant Current (Drooping Characteristic)

CC power sources can only be used with wire feeders with a voltage-sensing variable wire feed speed mechanism. The controls are analogue, and are used for high current density only.

7.2.2. Control Box

The SAW control box controls and meters the welding current by varying the wire feed speed. A control over arc voltage is also provided. It is mounted close to where the welder is watching the arc.

The traditional analogue controllers are robust, cheap and easy to maintain. The simplest analogue controller adjusts wire feed speed and is used for CV power sources. More sophisticated controllers have voltage feedback, and can be used with CC power (for example Lincoln LT-7 tractor, Lincoln NA-3). The current, voltage and travel speeds are read from dial gauges.

Typical microprocessor digital controllers (for example Lincoln NA-5) have light emitting diode meters for voltage, current and wire feed speed, and it is possible to accurately preset welding conditions. They also offer automatic and manual control of travel, crater fill, burn back and flux feed. These controllers operate with CC power sources only, but offer a much wider range of conditions than analogue controllers.

7.2.3. Welding Head

The welding head comprises a wire (or strip) feed motor, wire feed rolls, wire straightener, contact tip assembly and adjusters for positioning the contact tip assembly. It has a flux nozzle either ahead of or concentric with the wire. Different heads are available for multiple electrodes, narrow gap, and strip cladding and semi-automatic systems.

7.2.4. Accessory Equipment

The following equipment is used for mechanisation of submerged arc welding. Further details of mechanisation are given in Section 11.

7.2.4.1 Weld Head Travel

Welding head travel or adjustment is achieved by mounting it on a side beam travel carriage, tractor or column and boom (manipulator). The controller and flux hopper are mounted close to the head. Robots have been used where complicated movement is required. Nozzle welders are made to rotate the welding head around vessel nozzles.

7.2.4.2 Flux Recovery Equipment

Surplus flux and fused slag removal can be mechanised using a pneumatic or mechanical- vacuum-recovery system. Slag and oversized particles are usually screened from the recovered flux, and a magnetic separator is used to pick up spatter, grinding debris and scale. Surplus flux is recycled to flux hopper to be mixed with fresh flux. Fused slag is usually discarded.

7.2.4.3 Positioners and Fixtures

Positioners and other fixtures can be used for workpiece adjustment or rotational travel. Different designs are available: head-tail stocks, turning rolls, and tilting-rotating positioners.

7.3. Welding Consumables

Submerged arc weld metal is a product of both the flux and the wire. Different combinations will produce different properties, and indeed not every combination will

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