SUBMERGED ARC WELDING

Increased demands in shipbuilding paired with more infrastructure projects have driven technology advancements in submerged arc welding.

Submerged arc welding (SAW) is so named because the weld and arc zone are submerged beneath a blanket of flux. The flux material becomes conductive when it is molten, creating a path for the current to pass between the electrode and the workpiece. The flux blanket prevents spatter and sparks, while shielding ultraviolet light and fumes that are normally a part of shielded metal arc welding. The flux usually is supplied to the welding head via a small hopper. A collection system gathers the excess flux for reuse.

The process uses one or more continuously fed electrodes (wires) to maintain an arc. SAW is known for its ability to deposit large amounts of metal quickly, consistently, and safely. The basic SAW equipment is a power source, control unit, wire unit, and nozzle.

INNOVATION FUELED BY NECESSITY

Although in the late 1920s numerous patents were filed for specialized fluxes and a process with no visible arc, credit goes to the National Tube Works Co., McKeesport, Pa., for developing in 1930 what is today known as submerged arc welding. The company needed to achieve higher deposition rates in welding pipe seams.

In the late 1930s the development of the process ramped up with the demand for battle ships and other military equipment to support the war. It is reported that a letter from then President Roosevelt to Winston Churchill even mentioned 'a welding technique which enables us to construct merchant ships with a speed unequaled in the history of merchant shipping," and that this welding process was 'up to 20 times faster" than previous welding processes.1Since ship hull construction favored this process, wartime manufacturing pushed the newly born sub-arc technology to the forefront of the welding world.

It was not widely used, however, because only heavy-plate manufacturers and other high-production ferrous metal operations that required welding in a flat or horizontal position could really benefit. Also, at times there were limitations on municipal power supplies. The process always was viewed as reliable and high-quality, so it did experience steady growth.

During the unprecedented manufacturing boom from the 1950s to the 1990s, the need to be industrious was obvious, but no compelling reasons could be seen for long-term efficiencies because the U.S. had plenty of raw material, space, labor, energy, and profit. SAW continued to be used for certain applications, but there were no real business drivers to make it better.

DEVELOPMENTS FUELED BY DEMAND

Deposition rates in SAW can be upward of 100 lbs. per hour, which allows the process to weld large joint areas with fewer passes and minimal preparation.

Fast-forward to the year 2000, and the stage is set for the modern evolution of SAW. There is no question that manufacturers need to make better use of resources in today's ultracompetitive manufacturing environment. With the industrialized world growing exponentially, the need to manufacture with both speed and efficiency stands greater than at any other period in history. Add into the climate more demands to ship products worldwide; growing infrastructure projects like bridge-building, steel construction, and spiral pipe; and anything to do with energy, such as wind towers, offshore oil rigs, and mining equipment, and the time is ripe for the SAW process to become all that it can be.

Driven by modern welding requirements, SAW advances in the last five to 10 years have created

significant advantages. Deposition rates of more than 100 lbs. per hour are now reported in certain cases. It is also possible to weld very large joint areas with fewer passes and minimal preparation. SAW users have partnered with the equipment manufacturers to create an industry that has responded to its own needs.

WHERE IS SAW HEADED

What does the new technology look like Today's user-friendly workplace is far different than the Spartan shop floor dad occupied 50 to 75 years ago. SAW naturally lends itself to the more civilized surroundings. It has always been an environmentally friendly, safe process with minimal fume to be ingested and no arc rays to be shielded from, making it one of the more pleasant welding environments to work in. It is the technology advances in the power equipment and controls that have made it a reality to perform SAW with greater ease and precision than previously possible.

AT THE ARC

Because SAW produces no visible arc and fumes to be ingested are minimal, it provides a comfortable work environment.

SAW's ability to use multiple arcs in one puddle leads to its extremely high deposition rates, which allows for more rapid heat penetration and stability of the arc. In traditional power supplies, when the wave passes from positive (EP) to negative (EN) in its half-cycle, a lag or interruption may occur in the arc, subsequently causing problems in the weld. While this factor and its related input and output issues previously limited speed and productivity, now it is resolved in advanced power equipment.

For starters, it is now possible to weld AC and DC polarity in the same puddle, using the same power source. In the past different machines were necessary, and sometimes the DC and AC welds had to be laid down in different passes. Now two or more machines can be connected together or disconnected to be used alone in other operations. Today's SAW can put up to five wires in one puddle, offering the opportunity to create a weld faster and with unique, specialized properties. The benefits of AC for high deposition, stability, and the elimination of arc blow can be realized, while DCEP/DCEN enable stable penetration at much faster speeds.

Because of what is happening on the back end of these new machines, welders now have many more options at the arc. Older equipment ran according to a limited set of parameters; today's power sources run and react.

'The machine does most of the work," said Mike Flagg, SAW manager for the Lincoln Electric Co., Cleveland. 'The user just has to adjust the parameters when necessary. The new equipment is fairly simple for the operators to run."

POWER AND CONTROL

On the input side, it is no longer necessary to use single-phase power only. The new machines can connect to three-phase power and the same power supply used for both. This is achieved simply by modifying a plug so current and voltage remain stable and consistent. Inverters make it possible to use the same piece of equipment anywhere in the world.

State-of-the-art SAW controls are all digital, allowing constant feedback for monitoring and changing voltage, amperage, wire feed speeds, and so forth Digital PLCs are set up to interface with the application selected at the power source, and in some cases one controller can handle any choice of AC, DC CV, or DC CC.

Storable settings allow the operator to input three or four different programs, and put them down one after

another, without having to remember optimal heat and power ranges for a given job. Once the parameters are entered, they can be recalled and used again in the same application. Deposition and heat ranges can be programmed, and the system will ensure that the operator stays within those ranges.

The programmability of the controllers allows companies to deal with real-world business conditions. For some applications, experienced operators can coach and manage inexperienced welders without having to risk losing control of one or more variables.

Reporting capability is also available through monitoring software using network communications. Like a CNC machine, the welding power source can be programmed remotely and monitored on a network. What can be viewed locally also can be viewed anywhere in the world. Data about penetration and deposition heats, rates, and quality can be e-mailed.

TRAVEL SPEEDS AND CONSUMABLE MATERIALS

The flexibility of the new power sources allows manufacturers to focus on faster travel speeds, which enhance quality in high-deposition welds.

'In the '50s and '60s the tractors were huge. Now they are much smaller and can work faster," Fisher said.

One of the concerns with early SAW was variable feed speeds of the tractor. Now tractors equipped with speed control can change speed when the load changes, keeping other variables more constant. Adaptability is still the name of the game, so even modular tractors can be taken apart without tools to be passed through small spaces where they are reassembled to perform necessary operations. These high-end tractors are extremely versatile in what they can do.

In the same way the industry has improved the power and application systems, so too have the consumable materials been updated to meet current requirements.

Tubular wires, also called metal-cored wires, have a metal wire on the outside and metal powder on the inside composed of alloys that are application-specific, such as a flux mixture. These wires allow operations that previously required multiple passes to be completed in one or two passes. They also enable the use of more generic and less expensive flux.

Flux manufacture and delivery also have stepped up to match the production demands of SAW. Tubular-cored flux can be application-specific and provide additional strength and quality to the weld. Regular flux now can be purchased in bags as large as 3,000 lbs., and in some cases can be stored for up to five years, and still maintain its properties.

SAW also makes good of strip cladding, a process that debuted in the 1960s. The consumable is a metal or alloy strip—measuring 0.79 to 4.72 in. wide and about 0.020 in. thick—which is used in place of a common wire electrode. The arc passes between the strip and the workpiece, while the flux shields the weld from the atmosphere and the operator from spatter. This is another option to achieve high deposition and eliminate a number of passes.

BARRIERS

SAW is not suitable for every application. Since it is a flat or horizontal process, there are limits to the type of operations it can benefit. Also, it is mostly specific to ferrous metals. On some materials such as aluminum, problems with caustic flux negate the environmental and safety advantages of SAW and require a different process. Manufacturers should consider the costs of entry when evaluating SAW for their operations. While the control technology offers broad capabilities, it comes at a price. Production volumes will determine if the equipment is justified. Inexpensive power sources are available, but many do not have the most sought-after capabilities.