A new spin on WELDING

Scott Funderburk, Chief Operating Officer, Weld Revolution LLC, USA, discusses productivity and quality improvements with rotating arc technology.

Rotating arc welding, also known as SpinArc™, is a newly emerging welding technology. Utilising a unique welding torch, the welding electrode rotates in a circular motion at a high rate of speed. Centrifugal force propels molten droplets across the arc creating a consistent and sound weld bead. This enables high deposition rate welding for significant increases in productivity. Other valuable benefits include enhanced quality and safety.

Figure 1. SpinArc™ on pipe.

Background

State-of-the-art systems for pipe welding were originally developed in the late 1960s. Over the past 20 years, there have been a number of improvements in these tools.

The original research and development of rotating arc welding dates back to the 1980s. At that time, much of the development focused on mechanised pipeline welding. Like other new technologies, research was limited to a few field trials and was never commercialised. However, this early work provided a good understanding of the science and proved that the concept works well.

Today, a revolutionary new welding solution is available based on this science known as rotating arc welding, or SpinArc. Since the early days of this technology, there have been numerous developments related to control systems, welding power sources, wire feeders and filler metals. These advancements now make this process viable and affordable with significant gains in safety, quality and productivity.

Weld Revolution LLC, based in Houston, Texas, USA, is focused on delivering this new technology to the market.

A new technology

SpinArc™ welding

The process is simple and easy to understand. The wire is fed from the wire feeder into the welding cable and torch itself. As the wire passes through the torch, the tip of the wire spins in a conical shape. While welding, the molten droplets are propelled from the wire to the base metal in a circular pattern.

Like other arc welding processes, the molten droplets experience the same electromagnetic and gravitational forces. With SpinArc, however, the centrifugal force created by rotation cleanly detaches each droplet from the wire and angularly propels it into the joint. This directs the arc into the sidewall of the bevel, providing thorough fusion and a consistent penetration profile into the base metal. This effectively minimises lack of fusion, porosity and undercut.

Figure 2. Rotating arc welding torch.

Set up

The SpinArc process works with both standard CV and pulse MIG power sources. In fact, this plug-and-play system can be added to any existing welding equipment for an instant upgrade using either robotic, mechanised or manual welding torch products. Prior to welding, the welder sets three variables specific to rotating arc: rotation speed, spin diameter and the direction of rotation. The spin diameter is set on the torch itself, while the other variables are dialled in on an additional small control box included with the torch. The final and actual spin diameter at the arc is also a function of rotational speed, wire diameter and wire stiffness. The spin diameter is adjustable from 0 - 8 mm, with adjustments every 1 mm.

The required spin diameter depends on the application. For example, in a narrow and deep welding groove, a small spin diameter may be required. As the welding progresses from the root pass, fill passes, and finally the cap passes, the spin diameter can be easily adjusted as needed. In most cases, pipeline contractors have multiple welding stations, each of which is responsible for depositing a specific pass, or in some cases multiple passes. The spin diameter is adjusted and remains fixed at each of the welding stations in accordance with the qualified welding procedure.

In other cases, such as depositing corrosion resistant alloys, it is advantageous to increase the spin diameter. As the wire spins, the system controls the rotational speed through a feedback circuit to ensure that the set speed is maintained. As with all arc-welding processes, the welding operator also sets the typical welding parameters, such as wire feed speed, travel speed, and voltage.

Welding processes

SpinArc is used with solid MIG wires in CV or pulse modes, along with metal core and flux core welding wires. There has also been some limited work done with rotating submerged arc welding, as well as TIG welding. On the welding procedure specification the process is essentially a 'controlled oscillation'. Instead of oscillation width, stroke speed (sometimes referred to as beats per minute) and dwell time, the spin diameter and rotation speed are listed.

Applications

There are a number of pipe welding applications where this tool can be applied, including pipe mills, spool bases, lay barges, cross-country pipeline construction and in the fabrication of ancillary piping components.

Narrow groove welds

One application where this technology works well is in narrow groove pipe welds. These are found both in offshore and cross-country pipeline construction projects.

The potential reduction in repair rates and associated increased quality are especially valuable for offshore work.

Quality is an absolute must for building subsea flowlines and steel catenary risers (SCRs). The flaw acceptance criteria for pipe girth welds in these applications represent some of the most stringent in the welding industry. Every weld is 100% inspected with automatic ultrasonic testing (AUT), which provides high resolution and little room for error.

When used in narrow groove welds that are typically found in modern spool bases, the rotating arc torch can provide high speed productivity, while meeting the demanding acceptance criteria for SCR welds.

Figure 3 shows a weld cross-section from an X65 grade pipe, with an outside diameter of 10 in. (273 mm), and a wall thickness of 1.25 in. (30 mm). In this project, the focus was on fill and cap pass development using metal core with a wire feed speed of 550 in./min. (14 m/min.). The deposition rate, even in the overhead position, was 15 lbs/hr. (6.8 kg/hr). Throughout the weld there was sound fusion with a consistent bead profile both into the previous pass as well as into the sidewall.

Similar welding procedures can be used on cross-country pipeline construction as well. Using essentially the same bevel design found with mechanised welding systems, contractors can upgrade to SpinArc and achieve even higher deposition rates when using a metal core electrode.

Figure 3. Fill passes on X65 pipe.

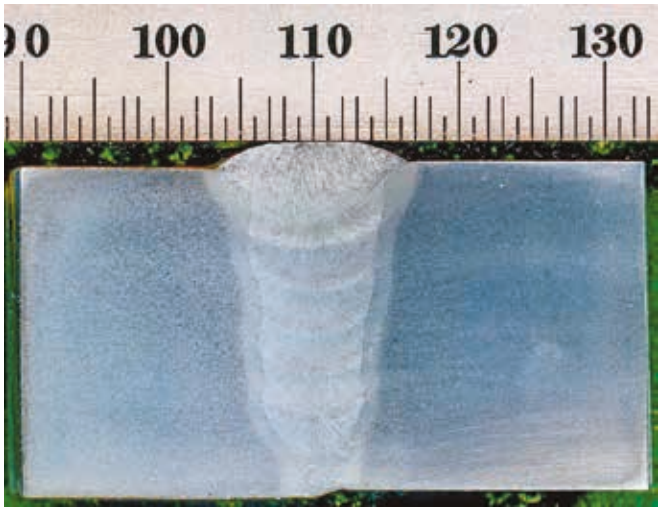

Figure 4. Open root weld.

Tie-in welds

Additionally, SpinArc torches can be utilised for tie-in welds with standard API factory bevels. In this case, the spin diameter is increased appropriately to fill the joint. Today, flux core gas shielded wires are often used on mechanised welding systems for tie-in welds. Previously, metal core products would not work in this application with the welding power sources that are typically used in the field. A fast freezing slag system is generally required to hold the molten weld metal in position as the weld solidifies and fills the joint.

With a rotating arc, centrifugal forces hold the molten puddle in place, allowing conventional welding power sources that are commonly found in the field to be utilised. This produces a high deposition rate process, utilising standard equipment. Additionally, switching from a flux cored, to a metal-cored electrode, provides additional savings by eliminating the need to remove slag between welding passes.

Open root welding

Development of rotating arc solutions for open root pass welding is ongoing. Preliminary findings are positive with travel speeds in the 20 - 30 in./min. (50 - 75 cm/min.) range. If contractors successfully implement this technology on open root passes with mechanised systems in the field, this will forever change the way pipelines are built.

Clad overlay

Another application is weld overlay of corrosion resistant alloys (CRA) materials. There are numerous methods of overlaying, including submerged arc and electroslag welding. Both of these methods are limited to the flat position only, which requires the parts to be positioned and rotated while welding. These methodologies require expensive equipment, turning rolls, and manipulators. Another method used today is gas tungsten arc welding (GTAW) or TIG welding. TIG is known for its high quality welds, but it is extremely slow.

Weld overlay with corrosion resistant alloys such as 625 is a common requirement in the oil and gas industry. For sour service environments, specifications typically require a maximum iron (Fe) content of 10 - 12% on the weld overlay surface. With standard arc welding processes, achieving this requires multiple weld passes, and two or three weld layers are common.

With rotating arc, a consistent and shallow penetration is possible. This minimises the amount of base material chemistry that is pulled into the weld puddle. Additionally, the rotating arc flattens the weld bead and provides for a gradual taper at the weld toes even with alloys that are typically 'sluggish' like 625 and other nickel-based

alloys. This increases the quality and enables good fusion between beads.

SpinArc is a preferred alternative for either of these methods. It easily plugs into existing welding power sources found in all fabrication shops today. Figure 5 shows an example of a weld overlay with a 1.2 mm 625 metal core electrode.

In this example, the iron content after a single layer is measured to be 8.79%, which is less than the typical maximum allowed value of 12%. With a two-pass weld overlay procedure, this value drops to 3.8% Fe.

The welds were made with a pulse waveform at 18.5 in./min. (470 mm/min.) travel speed and 500 in./min. (12.7 m/min.) wire feed speed. Each weld bead is approximately 0.625 in. (16 mm) wide, and the penetration into the base metal is limited to a consistent 1 mm. This process can be utilised for cladding both plate and pipe.

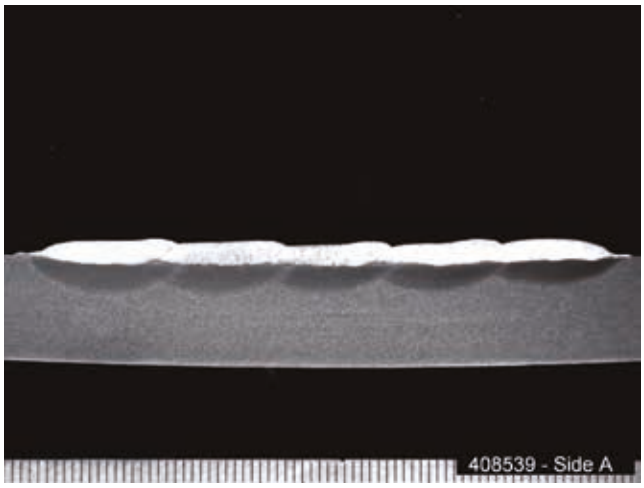

Figure 5. 8.79% Fe with one pass.

Figure 6. Four passes, square-edge butt weld on ¾ in. (19 mm) plate.

Benefits

Increased productivity

There are a number of benefits available when utilising SpinArc. Increased productivity is the first and most obvious benefit. This is made possible by the physics at the arc. The centrifugal droplet transfer enables increased wire feed speeds in all positions, which opens up new options for fabricators.

It is normally impossible to weld in spray transfer mode out of position. Metal core electrodes are typically limited to flat position welding only. With SpinArc, welding in all positions with metal core electrodes is straightforward, even on standard CV power supplies.

All-position, high-deposition rate welding is realised by maximising the wire feed speed. Wire feed speeds for 0.045 in. (1 mm) metal core wires in the 500 - 600 in./min. (12 - 15 m/min.) range are typical with rotating arc. The corresponding deposition rates are between 13 - 16 lbs/hr (5.9 - 7.3 kg/hr), which are similar to those seen in submerged arc welding.

Enhanced quality

This process enhances the quality of the weld by the centrifugal arc directing the energy into the sidewall of the joint. Changing from a standard weld joint, to a narrow gap, adds to the productivity gains. In some cases, square-edged butt joints, which require little to no preparation, can be used in place of a bevelled joint. Eliminating the plate preparation significantly reduces labour costs while minimising safety risks associated with handling large plates and bevelling equipment.

With a narrow gap, distortion of the fabricated pieces is significantly reduced along with the associated residual stresses. Angular distortion is a function of the number of weld passes, the welding procedure and the geometry of weld joint. Using fewer passes and narrow gap joint geometry, results in less longitudinal and angular distortion.

Improved quality is another benefit. Agitation of the weld puddle caused by the rotation provides for a cleaner weld. There is a consistent penetration profile throughout the weld that minimises lack of fusion related defects for improved robustness.

Conclusions

SpinArc, also known as rotating arc welding, is poised to deliver significant increases in productivity, quality and safety through the unique physics of a rotating arc. High deposition rate welding is possible in all positions with torches that plug into existing welding systems for immediate improvements.