New SpinArc™ Welding System Delivers Productivity & Quality
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Introduction
Rotating arc welding, also known as SpinArc™, is a new technology being used to solve challenging technical problems across many industry segments. The system is “plug ‘n play” into any existing welding equipment, so it’s easy to use and provides instant value.

Utilizing a unique welding torch and control system, the welding electrode precesses in a circular motion at a high rate of speed. Centrifugal force propels smaller molten droplets angularly, creating a consistent and sound weld bead.

The high-speed rotation enables drastic productivity gains in a variety of applications. Because of the associated physics, welds that were impossible previously with conventional technology are now achievable. For example, welding out-of-position with metal core CV spray transfer would never be considered an option. However, with rotating arc, exceptionally high quality welds are produced with marked productivity gains.

The rotation enables the use of high wire feed speeds, and associated deposition rates, in all positions for significant production gains. Additionally, because of the exceptional sidewall fusion, a narrow groove weld can be made to drastically reduce the volume of filler metal and associated welding time. In many cases, the weld joint can be modified to reduce or eliminate beveling altogether. Finally, the stirring effect of the arc also agitates the molten weld puddle, producing a cleaner weld.

Figure 1: High-Speed Rotating Arc
**New Technology**

The process is simple to understand. The electrode is fed from the wire feeder into the welding cable and torch. As the wire passes through the torch body, the contact tip, tip holder and end of the wire spin in a conical shape. During 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 minimizes lack of fusion, porosity and undercut.

![Image of MA-400™ Air-Cooled, Machine Torch]

**Figure 2:** MA-400™ Air-Cooled, Machine Torch

**Set Up**

The SpinArc process works with both standard CV and pulse MIG power sources. In fact, this plug 'n play system can be added to any existing welding equipment for an instant upgrade using either robotic, mechanized or manual welding torch products. Three variables, specific to rotating arc, are set prior to welding: spin speed, diameter, and direction.

The spin diameter is set on the torch, while the other variables are dialed in on an additional small control box included with the torch. The exact spin diameter, at the arc, is also a function of rotational speed, electrical stick out, electrode diameter and stiffness. The spin diameter is adjustable from 0 to 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 welding progresses from root to cap, the spin diameter can be easily adjusted as needed. For example, 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 work done with rotating submerged arc welding, as well as TIG welding. For welding procedures, the process may be thought of as “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 included on the welding procedure.

**Applications**  
The benefits of rotating arc are found across a multitude of welding applications. Throughout the welding industry, there are ongoing technical challenges where this technology may be helpful, including in industry segments such as aerospace, automotive, heavy construction, pipe mills, pipeline construction, offshore structures, and ship building.
Narrow Groove Welds
One application where this technology fits exceptionally well is in narrow groove welds. These types of weld joints are commonly used today in offshore and cross-country pipeline construction with mechanized welding systems. Other industries are also beginning to utilize narrow groove welds for increased productivity.

Figure 4: 2G Pipe Welding with Rotating Arc

Quality is equally important for these applications. For example, in the building of subsea flowlines and steel catenary risers (SCRs), the flaw acceptance criteria for these welds is often less than a millimeter, and every weld is 100% inspected with automatic ultrasonic testing (AUT). This high-resolution inspection leaves no room for error.

Figure 5: ER80Ni-1 on X65 Pipe with Rotating Arc
Figure 5 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 a 1.0 mm (0.040 in) ER80Ni-1 solid wire. For this case, the wire feed speed was 585 in/min (23 m/min), resulting in a deposition rate was 12 lbs/hr (5.5 kg/hr), and the travel speed was 19 in/min (48 cm/min).

When 0.045 in (1.1 mm) metal core electrodes are used in similar joint, the deposition rate increased to 15 lbs/hr (6.8 kg/hr) with a wire feed speed of 550 in/min (14 m/min). The same wire feed speed is utilized throughout the weld, even in the overhead position. There was sound fusion with a consistent bead profile both into the previous pass as well as into the sidewall.

**Joining Clad Lined Pipe**

One of the biggest challenges for offshore pipeline welding is with joining clad lined pipe. Most offshore pipeline contractors prefer to use a narrow J-bevel weld joint to connect the pipe sections on the lay barge “firing line.” To maintain corrosion resistant properties, nickel-based welding alloys such as 625 (ERNiCrMo-3) are typically used. The challenge is that these alloys are “sluggish” and difficult to weld. Sidewall lack of fusion is the biggest struggle with these alloys in narrow grooves. Rotating arc forces the droplets into the sidewall and provides a nice, clean high alloy weld deposit with a consistent and narrow heat affected zone.

**Open Root Welding**

Development of rotating arc solutions for open root pass welding is ongoing. Preliminary findings are positive with travel speeds of 30 in/min (75 cm/min) range.

**Clad Overlay**

Another application is weld overlay of corrosion resistant alloy (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 content of 10% 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 minimizes 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 7 shows an example of a weld overlay with a 1.2 mm 625 metal core electrode. Solid wire 625 alloys (ERNiCrMo-3) can also be used with equally beneficial results.

Figure 7: Iron dilution levels <2% with one pass

The welds were made with a pulse waveform at 18.5 in/min (47 cm/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 approximately 0.5 mm. This process can be utilized for cladding both plate and pipe.

**Square Butt Joints**

The process has been used to fabricate complete joint penetration groove welds made from one side with a square-edge butt joint. These weld joints require little to no beveling. Plates from 3/16 in (4.8 mm) up to 2 in (50 mm) have been welded successfully within a zero to three-degree bevel prep.

Figure 8 shows an example of 3/16 in (4.8 mm) steel plate. In this case, the plates were fit tight with no gap and no edge bevel. The process is able to achieve 30 in/min (76 cm/min) travel speed at 15 lbs/hr (6.8 kg/hr) deposition rate with a nice back bead profile and complete penetration in a single pass.
Figure 8: 3/16 in (4.8 mm) Plate, Welded with Zero Gap and No Bevel

**Dual Torch**

Figure 9 is a 1/2 in (12 mm) thick complete penetration groove weld made from one side on DH/EH36 plate with an 0.045 in E80C-Ni1 H4 metal-cored electrode, 90Ar/10CO₂ and Miller’s Accupulse™ waveform. A 3/16 in (4.8 mm) gap with a square-edge butt joint and ceramic backing were used for this example. Two passes were used, both at 18.5 in/min (47 cm/min), which opens up the option to run dual torches, for a single run, two-pass weld.

Figure 9: Square Butt Joint Welded from One Side with Two Passes
Fillet Welds
The torch can be used to produce fillet welds by hand, mechanized systems or robots. The spin diameter, speed and direction can be tailored to the specific weld requirements. With a tight spin diameter, high-speed fillet welds are possible. While increasing the spin diameter and speed can deliver large fillet welds with equal leg sizes.

Dual torches are used to produce a multiple-pass fillet weld in one run. The first torch, with a tighter rotation, hits the root and establishes a flat face for the second torch. The trailing torch has a much wider rotation, which nails the toes and finishes off the fillet weld with a flat face and smooth toes.

Benefits
Increased Productivity
There are a number of benefits available when utilizing SpinArc. Increased productivity is the first and most obvious benefit. This is made possible by the physics of the rotating 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 out-of-position in spray transfer mode. 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 realized by maximizing the wire feed speed. Wire feed speeds for 0.045 in (1.0 mm) metal core wires in the 500 – 600 in/min (12 – 15 m/min) range are typical with rotating arc technology. The corresponding deposition rates are between 13 and 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 beveled joint. Eliminating the plate preparation significantly reduces labor costs while minimizing safety risks associated with handling large plates and beveling 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 minimizes 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.

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