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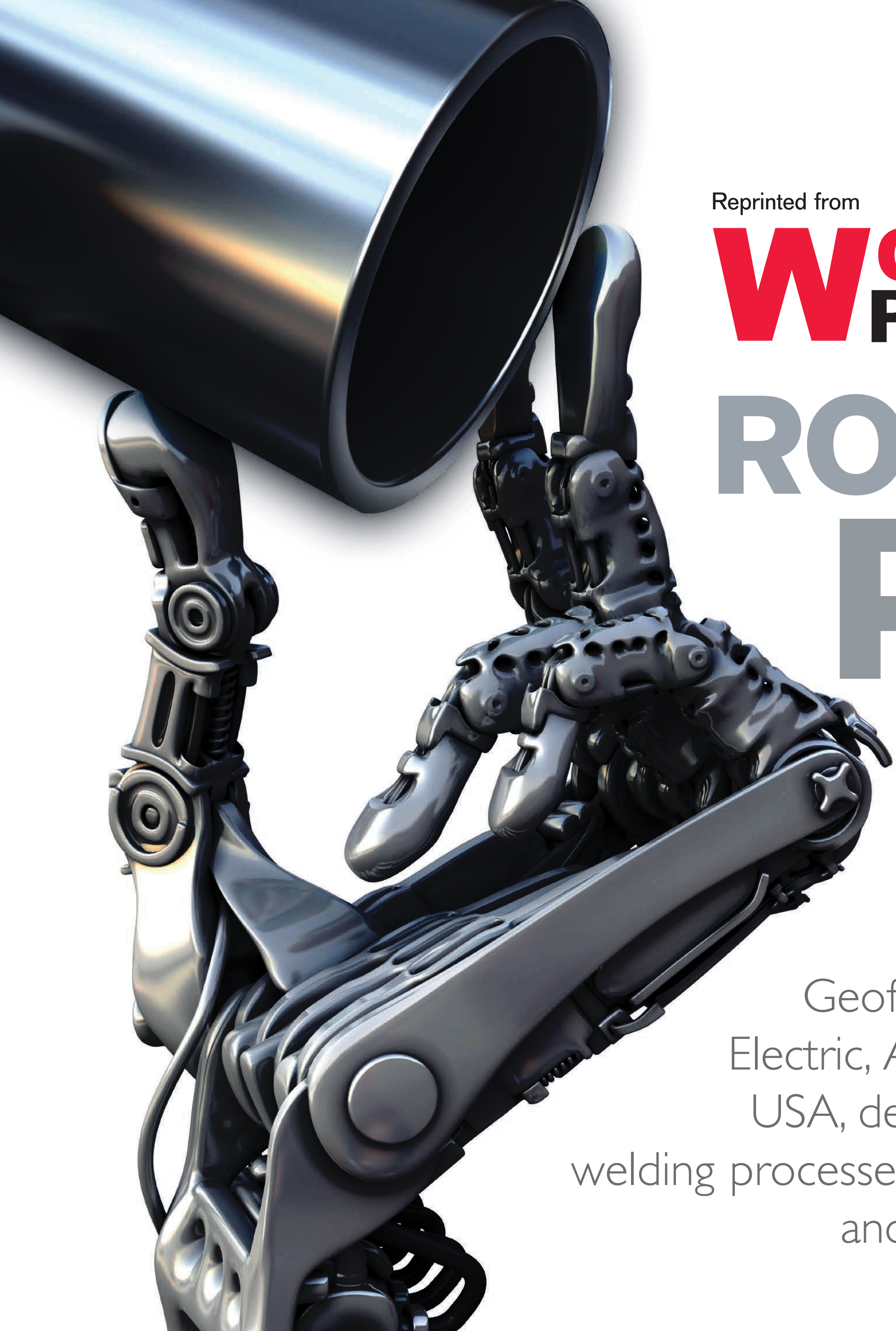

ROBOTIC PIPE WELDING

Geoff Lipnevicius, Lincoln Electric, Automation Division, USA, describes robotic pipe welding processes for higher strength and new alloys of steel.

Process pipe fabrication is anticipated to continue its upward growth trend. According to the Bureau of Labor Statistics (USA), outlook for the industry will remain stable, and employment prospects are expected to be very good, especially for workers with welding experience.

For the welding industry, the biggest challenges are three-fold: finding qualified welders; a shift to higher-strength pipe; and keeping up with industry demand.

The skill required to weld on open root pipe is high, and the overall labour pool of skilled welders is decreasing. The average welder is in their mid-50s, and many will retire within the next 10 years, creating a tremendous need for a new generation of skilled welders supplemented with new tools to rapidly gain efficiency.

Higher-strength pipe materials are being rapidly introduced by the industry to provide for a significant improvement of the mechanical properties of pipe at elevated temperatures. These special materials are more difficult, time consuming and, subsequently, are more expensive to weld when compared to carbon and austenitic stainless steel process pipe. Welding and cutting techniques for new materials such as P91 steel, duplex and super-duplex stainless steels, nickel-based alloys, and aluminum alloys of pipe, are not as widely known

Keeping up with the number of active projects has also been an issue. During periods of economic expansion, the number of projects has often outpaced the number of contractor spreads that can do the work, leading to project backlogs and longer timelines. During slow periods, demand can appear suddenly requiring a rapid response to a short-term escalation for resources.

These challenges and the opportunity for significant productivity improvement have intensified the pursuit of an automated solution for welding and cutting of pipe.

Productivity

Productivity starts with automation of the upstream processes, including material handling, cutting and bevelling.

Pipe cutting technology has advanced rapidly since the days of hand-held torches and wrap-around paper templates. A single cutting machine can now supply enough pipe to satisfy 5 - 10 fit-up and welding stations. Pipe can be power fed into the cutting area, hydraulically lowered onto powered turning rolls, cut, hydraulically raised from the turning rolls, and then discharged out of the cutting area, all from one operator console.

Cuts profiles are nearly unlimited and include straight cuts, T, K, and Y profiles, saddles, miters, slots, and holes.

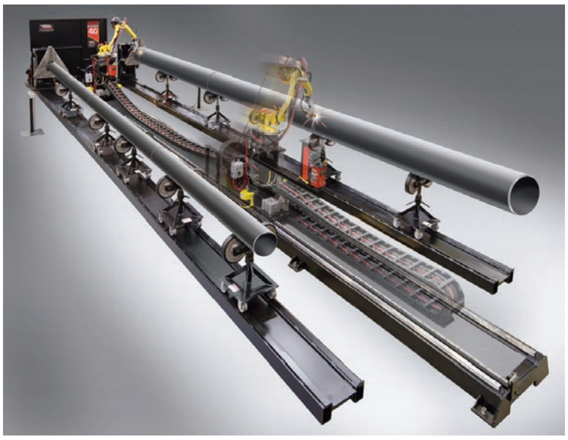

Figure 1. Fully automated robotic pipe welding system with horizontal travel carriage.

Figure 2. Mechanism of cutting improves the speed and repeatability of each contour. All cutting operations are controlled by one person from the operator console.

Figure 3. The pipe self-centres in the turning rolls. Only the torch needs to be raised and lowered to accommodate different pipe diameters.

The principal benefits of automated cutting are safe material handling, faster cutting speeds, repeatability of each contour, and very accurate weld preparation angles that lends itself to robotic welding of process pipe.

Robotic welding of steel, stainless steel, and nickel-based alloys of pipe

Steel pipe joints are commonly welded using an open-root joint geometry, typically a 60 - 75° included angle. Robots can apply gas tungsten arc welding (GTAW), or gas metal arc welding (GMAW) in a controlled surface tension transfer process, which has been proven to be very tolerant of joint preparation variation. Tolerances of the joint preparation for a robot typically require a 2 - 3 mm gap for the root, 0 - 2 mm for the land thickness, and misalignment no greater than half of the root gap.

The two processes, GTAW and GMAW, typically require unique torches, and when required, an automated tool changing station and automated gas solenoid can be integrated to transition the shielding gas to support the process.

A robot can then fill the joint on subsequent passes using a variety of welding processes, often dictated by code and/or procedure qualification records, including GTAW, GMAW-P (Pulse), Sychronised Tandem MIG, FCAW (Flux-Cored Arc Welding), or SAW (Submerged Arc Welding). All of these processes are applicable when the pipe joint is welded in the flat rotated (1GR) position for maximum productivity.

The appeal of a robot is the flexibility of six axes of movement (plus additional servo-driven axes to control elevation and rotational pipe movement) and the precision that an integrated solution offers. The robot can apply a series of mathematical offsets so that the operator needs only to establish a starting position for the robot, and automatically the robot can initiate the welding arc on the sidewall, drag the puddle to the centre of the root, and then apply a weld with consistent parameters and speed, all while monitoring weld quality attributes, inter-pass temperature, and adjusting the torch location to maintain a constant electrical stick-out for out-of-round pipe profiles.

A robot includes the ability to weave with multiple motion types, and has the ability to store hundreds of programmes for quick retrieval of qualified welding procedures. A variety of accessories can be added, including manual joy-stick control, through-the-arc seam tracking, and integrated vision with adaptive welding control.

Robotic welding of aluminum pipe

Aluminium's high thermal conductivity means that the weld pool is larger than it is in steel. The weld pool is also more fluid, so it is harder to control the molten pool. The only areas where the arc strips the aluminium oxide from the surfaces to be welded are those where the welding arc is directed. As a result, the filler material will not melt and flow out easily for adequate penetration or a consistent backbead.

Robots can be applied to weld aluminium pipe using either a permanent or temporary backing ring or using an extended-land joint geometry and when either of these are applied, the robotic welding technique becomes fairly simple.

The two pieces of aluminium pipe are pneumatically held together, or pre-tacked. Without a root gap, a root pass can be applied with the appropriate filler material using the GTAW-AC (Alternating Current). Once the root pass is completed, the robot can successfully fill the remainder of the weld joint using GMAW-P.

Figure 4. Inside of 8 in. x 0.372 wall API 5L-X52 pipe, welded in 5G position. Photo shows open root welded in the 3 to 6 o'clock position.

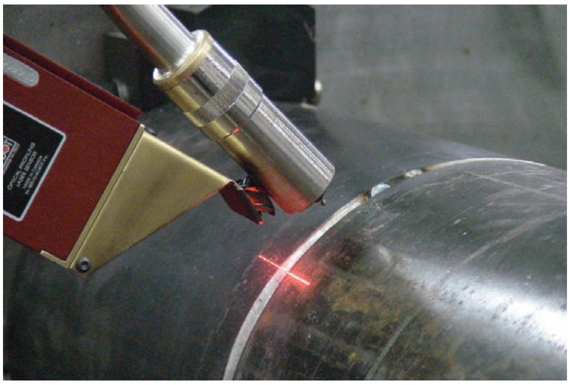

Figure 5. Laser vision systems are used for joint tracking, adaptive control, verification of part fit-up prior to welding, and real-time weld inspection.

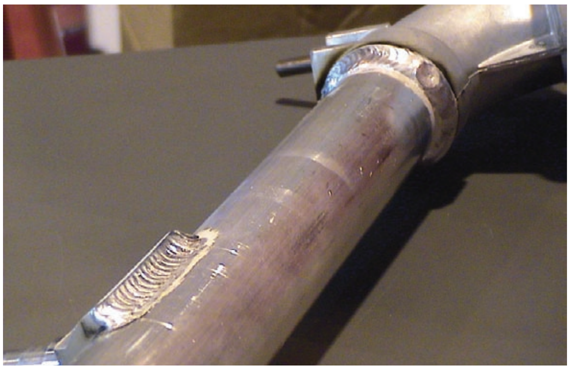

Figure 6. Aluminium pipe can be welded using an extended-land joint geometry. Uniform aluminium weld bead using MIG Welding that approaches the level of quality, appearance and integrity commonly associated with TIG welding.

Conclusion

Robots can weld about 80% of normal pipe shop production. Flame-cut, plasma-cut, or hand-ground, and machined preparation are common preparation techniques for steel, stainless, and nickel alloys, whereas a machined, extended land geometry is preferred for aluminium. The flexibility of the robot arm easily accommodates welding on straight cuts, elbows, Ts, and fittings such as nozzles or weldolets. The industry dynamics of a growing skilled labour shortage, and the introduction of new materials requiring strict quality control have come together and been met head on by manufacturers that have invested the time and resources to make robotic pipe welding economically viable. WP