## *Magnetic Stir Welding Offers Promising Alternative to Application of Alloy 52/52M Welds*

### *Weld demonstrations and laboratory investigations show that magnetic arc stirring can significantly reduce weld metal grain size and improve ultrasonic examination capabilities.*

High-chromium nickel-base weld metals such as Alloys 52 and 52M provide significant resistance to stress corrosion cracking (SCC) in primary water systems of nuclear power plants. These weld metals are routinely used for dissimilar metal weld joints, SCC mitigation, and repairs. Unfortunately, high-chromium nickel-base metals can be difficult to weld and are susceptible to cracking at the microscopic scale. In addition, the grain structure of these weld metals when applied with conventional welding practices is typically less than optimal for ultrasonic examination.

In response to these challenges, the EPRI Welding and Repair Technology Center (WRTC) is investigating innovative processes such as magnetic stir welding. Stirring the weld metal by magnetically deflecting the welding arc produces a smaller and more uniform weld metal grain size than conventional gas tunsten arc welding, resulting in a more optimum structure that could solve both the weldability and ultrasonic examination challenges. The equipment is relatively simple and could be adapted to existing gas tungsten arc welding equipment and power supplies with little or no impact on current productivity requirements. The process, however, has not been extensively researched or applied with high-chromium nickel-base weld metals.

WRTC worked with welding researchers from Ohio State University and Ishikawajima-Harima Heavy Industries (IHI) to model and demonstrate the fundamental mechanism of magnetic arc stirring. Weld demonstrations and laboratory investigations showed that optimized magnetic arc stirring of Alloys 52 and 52M reduced the weld grain size, and investigations at EPRI's Nondestructive Evaluation Center showed that the ultrasonic examination capability was significantly improved. By reducing the grain size from 150.6 microns (average diameter) with conventional welding to 97.3 microns with magnetic stir welding, the ultrasound attenuation perpendicular to the weld increased from 8:1 to as high as 20:1 signal-to-noise ratio. Finally, research and testing of materials suceptible to weld metal cracking have shown a reduction in cracking susceptibility when magnetic arc stirring is applied.

WRTC will continue evaluating magnetic arc stirring and other alternative techniques that potentially minimize the grain size and improve weld metal cracking resistance for repair applications in operating nuclear power plants and for manufacturing of new vessel and piping components in the next generation of nuclear power plants.

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***Grain size comparison for conventional welding parameters (left) and magnetically stirred process (right).***