Hot Wire Laser Welding

**Background**
Hot wire laser welding (HWLW) combines heated filler material with a laser for welding without an arc, allowing for precise placement of weld location. HWLW is also a lower heat input process with a “quiet” molten pool; thus the welds have lower distortion, less residual stress and higher quality.

One key benefit of HWLW is the ability to perform ultra-narrow groove welding, having two-degree sidewall angles. This allows for significantly reduced weld volume (at least 70 percent less when compared to conventional grooves).

HWLW also can achieve higher deposition rates than gas-tungsten arc welding (GTAW), often five pounds per hour or more.

With reduced weld volume and increased deposition rate, HWLW can reduce the welding time of thick-section materials by up to 90 percent.

**Description**

**Process**
The HWLW process combines heated filler material with a laser beam. The filler material is heated to near melting by electrical resistance (“hot wire”). Special controls are used to prevent an arc from forming during welding. The laser is a coherent beam having slightly reduced power density when compared to keyhole welding. Together, the heated wire and laser beam create the heat necessary for welding.

Since there is no arc, HWLW can be precisely placed, even in very narrow and deep grooves. Often only one weld pass is needed per layer, even in thick materials. HWLW also has a very quiet molten puddle and can deposit weld metal at high rates, five times that of GTAW or more.

Because HWLW has lower heat input than GTAW, HWLW welds have lower distortion, a smaller heat affected zone and less residual stress.

As of March 2015, the HWLW process is covered in the American Society of Mechanical Engineers Section IX Code Case 2827 under “Low Power Density Laser Beam Welding.”
Equipment

Ultra-narrow groove HWLW is automated, resulting in consistent weld quality. This also can help reduce demands on the limited pool of skilled welders available.

Westinghouse’s HWLW tooling will incorporate special features that continuously monitor weld performance parameters and track the weld seam location in real time. Deviations from desired parameter ranges will be instantly identified for immediate corrective action.

Operator control stations and laser oscillators can be placed remotely using fiber-optic cabling to reduce crew dose.

Modern fiber-lasers are extremely robust, now having a mean time of uninterrupted operation exceeding three years. They generate significant power safely and efficiently in compact and robust enclosures that are suitable for field use.

Benefits

The benefits of HWLW include:

- Ultra-narrow grooves, resulting in 70 percent or more reductions in welding volume
- High deposition rates, five times that of GTAW or more
- Up to 90 percent reduction in welding time of thick-section plates and pipes
- Lower distortion and residual stress
- Reduced machining and nondestructive examination effort
- Automated process and real-time performance monitoring for consistent weld quality
- Improved welding performance on highly irradiated materials

Experience

As of June 2015, Westinghouse is operating prototype HWLW equipment at the Electric Power Research Institute laser lab in Charlotte, North Carolina (USA). Final field-ready equipment should be completed in 2016.

Extensive weld testing and analysis, using Design of Experiments methodology, has been performed to date on varied materials and configurations, proving the suitability of the HWLW process to perform welding in manufacturing, maintenance and construction applications.

Westinghouse expects to bring the benefits of HWLW to the nuclear industry by the end of 2016.