Underwater Laser Beam Welding

Background

In the past, underwater welding typically utilized an arc welding process and possibly even a diver. Underwater welds were also typically performed manually or using mechanized welding equipment.

Today, however, Westinghouse is adding laser beam welding to its toolbox as a viable underwater repair option for use in the nuclear power industry. Underwater laser welding offers significant advantages when compared to traditional welding methods in several possible nuclear applications. In fact, underwater laser welding is uniquely suited to performing inlays and cladding for stress corrosion cracking (SCC) mitigation and to the welding of highly irradiated components.

Description

Laser welding is a remote welding process that uses a laser beam (rather than tungsten) and a filler wire. Underwater laser welding can produce accurate and repeatable welds with first-time quality in many demanding applications. For example, the process can be used to deposit a corrosion-resistant layer or inlay for the mitigation of SCC. It can also seal existing cracks up to approximately 0.020 in (0.5 mm).

ULBW Compared to GTAW

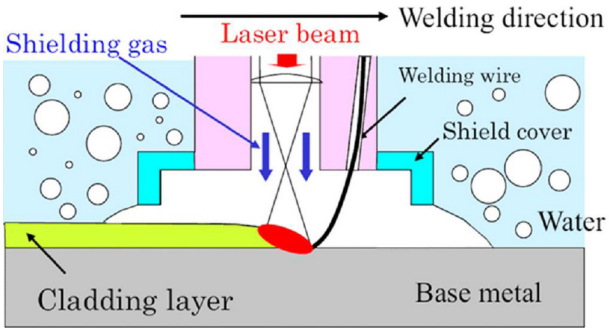
The filler metal used for underwater laser beam welding (ULBW) is the same as that for gas tungsten arc welding (GTAW), and is selected for suitability for the application and base material being joined. It is introduced into the pool created by the laser beam in a manner very similar to that seen during welding with a gas metal arc welding machine; however, ULBW is a completely automatic welding process. In this respect, ULBW differs from GTAW performed with a machine, where the operator makes adjustments during welding.

Reliable Weld Characteristics

The laser beam's precise heat input and dilution controls result in consistent weld quality. Weld chemistry testing shows high deposit purity as a result of the low heat input.

Various Application Uses

The optical fiber delivery of the laser light minimizes weld system complexity and allows weld heads to be developed for tight and remote applications. Being an automatic process also makes it ideal for use in locations such as the high-radiation areas found in nuclear power plants.



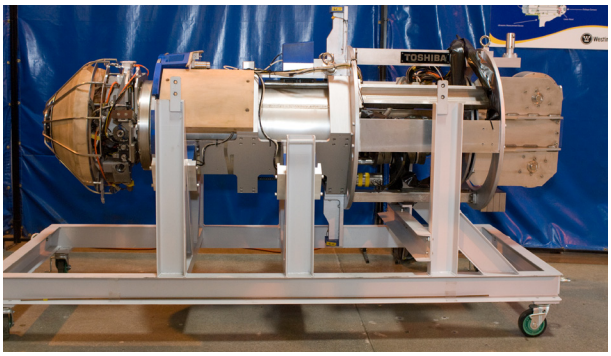
Underwater laser beam welding diagram

Westinghouse

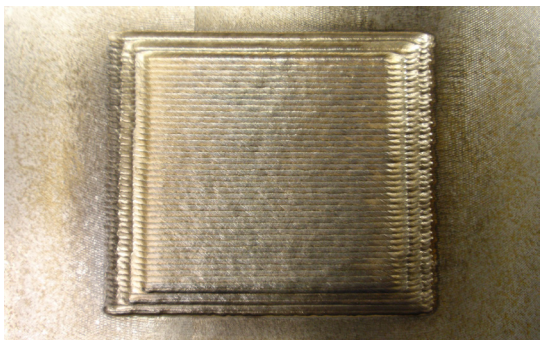
Potential Applications
ULBW is intended primarily for repair/maintenance applications where the unique advantages of laser welding may provide for reduced schedule, dose or rework over conventional welding methods. Westinghouse is presently developing procedures to perform Alloy 600 mitigation in reactor vessel nozzle to safe-end welds that are susceptible to primary water stress corrosion cracking (PWSCC).

Temperbead Welding
The American Society of Mechanical Engineers has completed a code case addressing requirements for ambient temperature temperbead welding of low-alloy steels using ULBW. Hardness and Charpy impact testing have shown that tempering can be successfully achieved using the ULBW process. The results exceed those taken from the original base metal.

Successful results have been obtained in tensile tests, side bend tests, diffusible hydrogen testing, delta ferrite and micro examination. Detailed results are available upon request.



Underwater laser welding machine for RV nozzles


Three-layer Alloy 52MS deposit on low-alloy steel

Benefits

- The weld head is compact and can be fit to various geometries.
- Low-heat input to base metal: approximately 2.5-7.6 kJ/in (1-3 kJ/cm). This is approximately 10 percent of the heat input of standard tungsten inert gas welding.
- The process will not sensitize surrounding material.
- The sealing capability can be used to eliminate small cracks and possibly negate the need for an expensive hardware repair or replacement.
- Laser welding has produced promising results for welding of highly irradiated components.
- The laser unit can be located far from the work area, up to 1,000 ft away (300m).

Experience

Westinghouse has several years of development experience with ULBW and other laser based processes:

- ULBW was successfully applied to repair a jet-pump in 2006.
- Fiber laser peening was successfully applied to reactor vessel (RV) main nozzles. This equipment was similar to that being built for the application of ULBW to RV nozzles for mitigation of PWSCC.
- Fiber laser peening has been successfully applied to various penetration nozzles and core shrouds at 10 plants.

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