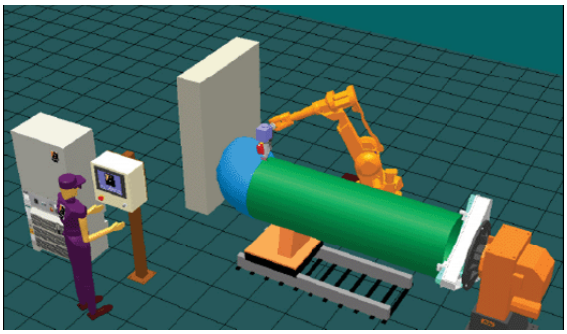
New Hybrid Laser/Gas Metal Arc Welding System

Many shipbuilding programs involve large amounts of pipe fabrication and installation, but when the ships in question are the new T-AKE class Combat Logistics Force Underway Replenishment vessels, the effort takes on another dimension. The vessel is 689 feet long and carries 18,000 barrels of cargo fuel, contains miles of pipe, some of it up to 30-inches in diameter, and involves thousands of welded joints. The labor required to weld all these joints with conventional pipe welding techniques is considerable, especially since the larger, thicker-walled pipes can require up to five passes. This project introduces a new technology that combines the keyhold weld penetration of laser beam welding (LBW) with the weld-metal deposition characteristics of gas metal arc welding (GMAW), providing the potential to make these same welds in a single pass. This will produce welding time savings of up to 80% or more, allowing increased throughout, improved process quality, and substantial cost savings. Additionally, fewer passes means reduced heat input, which in turn reduces residual stresses and distortion.

CNST is currently funding a project to design, build, and demonstrate a hybrid laser/gas metal arc pipe welding system. The project is led by researchers at the Applied Research Laboratory (ARL) at Penn State University. The system will initially be located at ARL Penn State for process development and testing. The system will be used for joining carbon steel pipe and butt-weld fittings. Pipe diameters between 4 inch NPS to 30-inch NPS, with wall thicknesses up to ½ inch are being investigated.



Concept drawing of hybrid laser pipe welding system

The project team has completed initial testing in which parameters such as laser-to-GMAW torch spacing and travel speed were varied to observe the effect on fusion zone geometry. Through experimentation, a set of hybrid laser-GMAW processing conditions was found for welding half inch (12.7 mm) thick A36 steel that produced a visually acceptable weld. Several samples were subjected to reduced-section tensile and bend testing (both face and root). In all tensile tests, the failures occurred outside the weld heat affected zone, indicating acceptable mechanical properties. The welds were also subjected to radiographic testing and although the majority of the weld was porosity free, a small degree of porosity near the beginning and end of the weld was detected. Ongoing investigations are being undertaken to determine the cause of this porosity and eliminate it.

ARL continues to optimize the welding parameters and will conduct additional tests using a 7kW fiber laser. In the meantime, Wolf Robotics of Fort Collins, CO has joined the team as the System Integrator. Wolf Robotics will design and assemble an integrated system that includes a joint tracking system, weld head manipulation system, rotary pipe positioner, the hybrid laser arc welding head, and the associated workcell control system (a sketch of the design concept is shown to the left). The completed system is expected to be assembled at Penn State in the fourth quarter of 2006 where it will undergo extensive laboratory testing. In the first quarter of 2007, the entire system will be shipped to the pipe shop at National Steel and Shipbuilding Company (NASSCO) in San Diego for benchmarking, demonstrations, and evaluation in a production environment.

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