Flexible Hybrid Friction Stir Joining Technology

Improved Efficiency and Flexibility through the Development of Hybrid Friction Stir Joining Technology

Welding is one of the most important and widely used fabrication technologies in modern industry. Traditional fusion welding processes (e.g. arc welding and laser welding) require significant heat inputs and frequently lead to property deterioration, such as cracking and porosity during solidification.

Friction Stir Welding (FSW) is a solid-state joining process invented in the 1990s to overcome fusion welding limitations. FSW is significantly less energy intensive than competing technologies, while offering cost savings and increases in productivity. However, the inability of FSW to be used on-site and for thick-section welding has so far limited its widespread adoption in industry. FSW technology is currently used exclusively in specialty markets, representing a small fraction of the overall welding market.

Researchers intend to address this problem by developing a prototype welding system that will demonstrate the field deployment capabilities of flexible hybrid friction stir welding technology. This effort will advance the FSW process as a manufacturing technology that can be deployed for on-site construction of large, complex and typically thick-sectioned structures made of high-performance and high-temperature materials.

Benefits for Our Industry and Our Nation

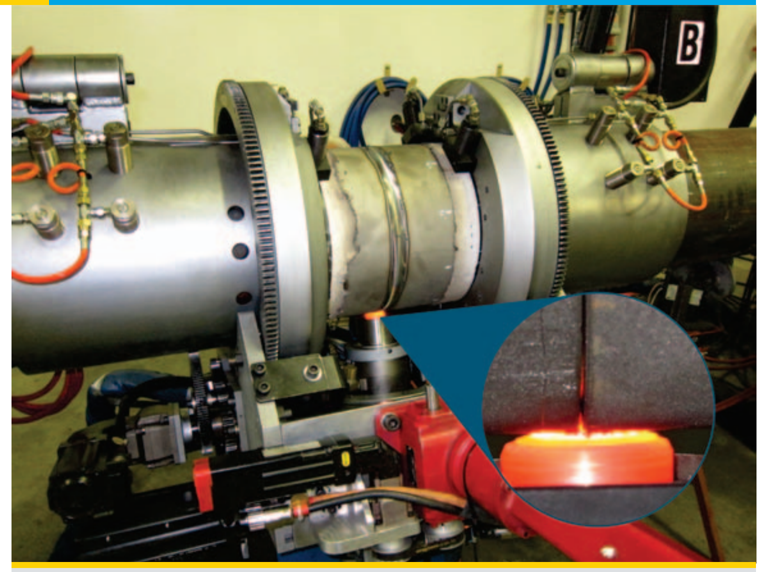
When compared to conventional arc welding, FSW technology reduces energy consumption during welding by as much as 70%.

There are other significant economic advantages to FSW technology. FSW eliminates the need for expensive and labor intensive pre- and post- weld heat treatments, and reduces material use.

Applications in Our Nation's Industry

Successful development of this technology can be widely applied to the aerospace, automotive, chemicals, oil & gas, power generation, and shipbuilding, among other sectors.

Specific applications of FSW include: construction of high strength steel pipelines; fabrication and repair of aero engine components made of Ni-based super-alloys and mechanically alloyed materials; titanium-alloy intensive aircraft, spacecraft, and ship superstructures; and ultra-high-strength steels for light weight, high performance auto vehicle body-structures.



Friction stir welding of high-strength steel pipe with improved weld microstructure and properties

Image Courtesy of Oak Ridge National Laboratory.

Project Description

The goal of this project is to advance the FSW process as a manufacturing technology that can be deployed for on-site construction of large, complex and typically thick-sectioned structures made of high performance and high-temperature materials (such as high-strength steels, Ti alloys and super-alloys). This would transform FSW from a specialty joining process into one with pervasive application potential across a number of industrial sectors where the payoff of energy reduction, environmental and economic benefits would be significant.

Barriers

- Ability to develop a FSW system that overcomes current machine limitations to geometrically simple structures.
- Creation of FSW machine that can, unlike current models, be used for on-site welding such as pipeline construction and shipbuilding.
- Reduce the process loads when welding high-temperature materials and thick sectioned structures and enhance FSW technology to overcome "single" pass process that limits current technology to joining thin-section structures only.
- Increase durability for joining high-melting temperature materials such as widely-used structural steels.

Pathways

Researchers will begin by further developing the multi-pass and multi-layer FSW (Oak Ridge National Laboratory's patent) technology for application on on-site constructions. A method to ensure that the rotating tool of the FSW machinery works with high-temperature materials is a critical next step. The next step involves evaluation and analysis of the type of materials that could be used in the FSW tool. Analysis of the microstructural characteristics of the bonding region will also take place to ensure optimal property results before the design and construction of a field-deployable FSW prototype system is undertaken.

Milestones

This project started in September 2008.

- Conduct proof-of-concept studies to confirm the feasibility of the hybrid approach. (Complete)
- Develop hybrid FSW process to ensure compatibility with industry uses involving steel and other high-temperature materials.
- Construct a field-deployable FSW prototype system utilizing knowledge gained from laboratory research.
- Conduct an on-site field system demonstration on steel pipeline energy transmissions and assess property and quality performance that results.

Commercialization

Commercialization efforts consist of selecting a specific demonstration application of portable FSW technology and producing a field ready prototype capable of high-level performance. The welding target is large diameter steel pipes, a critical business interest of the project's industry partners. The project has enlisted the help of MegaStir Technologies, and ExxonMobil, an oil and gas company interested in employing FSW technology for pipeline construction.

Project Partners

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