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Qualifying Materials:

- The application of shoulderless conical tools in friction stir welding: An experimental and theoretical study
- The FSW of hemispheres- A technique for manufacturing hollow spheres
- Literature review: Computational modeling of FSW
- Proposed future work
Proposed Future Work:

Full penetration welds of 4.5” diameter, 1/4” thickness butted pipe sections will be made with various tools. Unfeatured shoulder and scrolled shoulder, threaded probe tools will be used along with some conically shaped tool\(^1\),\(^2\),\(^3\). Parameters will be determined based on the superficial appearance, lateral macrosection appearance, and tensile strength of preliminary test welds. Adjustments to all aspects of the setup will then be considered with emphasis on improving tensile strength. A matrix of welds will then be performed with each tool. Process forces will be recorded and the tool shank temperature will be recorded during the steady state portion of the weld using a thermal camera. Tensile tests and macrosectioning will then be performed. A CFD Fluent model will be creating for each geometry to compliment the experimental results. Conclusions will be drawn based on the experimental and theoretical findings.

Using process parameters discovered in the primary study on butted pipe sections, a similar experiment will be conducted concerning the closure zone of the weld on butted pipe sections. The closure zone is defined here as the area of the weld where the tool is removed from the material surface. In the case of a traditional, threaded, cylindrical probe tool this area is simply a probe sized hole left in the material. In the case of a conical tool a tapered retraction procedure can be used to gradual remove the tool from the work material without defect formation.

The conical tool will be gradually removed from the weld material following a full circumferential weld. This tapered retraction procedure will be conducted at a variety of parameter settings in an effort to maximize tensile strength in the over-welded, retraction zone. During the retraction period the rate of retraction, rate of tool travel (or the rate at which the pipe is rotated), and spindle rate may be varied to obtain a more ideal retraction zone strength and appearance. Movement in the direction perpendicular to the full circumferential weld path will also be considered. The final direction of the experiment will be determined by preliminary results and the process variables will be adapted to maximize weld strength.

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1 Friction Stir Welding Equipment and Method for Joining X65 Pipe; S M Packer, M Matsunaga; Proc. of the 14\(^{th}\) Int. Offshore and Polar Eng. Conf. 2004
2 Friction Stir Welding of API Grade X65 Steel Pipes; Z Feng, R Steel, S Packer, S A David; Oak Ridge National Laboratory, Oak Ridge, TN
3 Friction Stir Process Now Welds Steel Pipe; J Defalco, R Steel; ESAB Welding & Cutting Systems