Objectives
Characterization of friction drilling process including:
- Mechanical and thermal aspects
- Mathematical and FEM modeling
- Material behavior
- Tool wear
- Friction drilling of new light-weight materials

Motivation
- One of the major problems in manufacturing engineering is joining sheet metal, tubing, or thin walled profiles in a simple, efficient and cost-effective way
- Methods currently employed: 1) Include J-nuts, weld-nuts, clench nuts, and other threaded inserts, 2) Require welding or attaching by some other means, a small part to a piece of sheet metal that has been stamped or drilled
- A method to eliminate production steps, while at the same time eliminating waste and clutter from countless nuts and inserts, is presented

Approaches
Mathematical Model
- Find temperature dependent material properties
- Develop equations for thrust force and torque
- Verify the model with experiments

Finite Element Model (FEM)
- Form constitutive boundary equations for model
- Investigate effect of coefficient of friction in model
- Output information about work-material behavior

Experimental Analysis
- Design experiments and record data
- Verify FEM results and scientific hypotheses

Accomplishments
- The analytical model matched well to experimental results of thrust force and torque.
- The FEM accurately predicted the workpiece temperature and the workpiece shape.
- Effects of friction drilling on material grain micro-structure and material properties were characterized.
- Temperature was measured with infrared camera system throughout the friction drilling process.

Future Work
- Create a more accurate friction model with experimental measurement of the coefficient of friction dependent on temperature, pressure, sliding speed, etc.
- Incorporate self threading fasteners with the resulting hole from friction drilling

Sponsor
- U.S. Department of Energy

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Objectives

- To investigate fundamental understanding, underlying scientific and technical challenges of UaFSW process
- To develop a methodology to investigate the effect of weld quality and tool life in applying ultrasonics to FSW of high temperature materials

State-of-the-Art

- Since invented in 1991, FSW has been successfully used for joining low melting temperature materials
- Applications in high strength alloys, such as titanium and stainless steel, remain limited due to problems in terms of required force and tool life
- Ultrasonic assisted processes have been coupled with tooling in machining, drilling, and welding in order to reduce static deformation force, increase processing rate, and improve product quality
- UaFSW will enable to reduce welding force, reduce weld time, reduce power requirement, avoid tool fracture, and increase the range of material choices.

Approaches

- UaFSW system should be constructed in such a way that the ultrasonic energy is effectively transmitted into the workpiece. Therefore, guidelines for the design of ultrasonic system should be developed
- Predictive models for rapid and reliable evaluation will be developed and parameters optimization will be conducted to achieve successful process conditions for UaFSW
- Numerical model and experimental investigations will be incorporated with the basic knowledge of this process

Accomplishments

- In-house CNC drilling machine was successfully used to demonstrate FSW, and reasonable welds were obtained for 6061-T651 aluminum alloy
- It was observed that welding conditions such as rotational speed, translational speed, and plunge depth significantly influenced the weld quality

Future Work

- Ultrasonic vibration table, which can add controlled ultrasonic actuation to the workpiece, will be fabricated
- Preliminary DOE analysis on process parameters will be conducted to investigate the effect of ultrasonic parameters such as frequency, amplitude, and directions of vibration
- Effect of ultrasound on tool fracture and wear mechanisms will be investigated in applications with high temperature materials