Development and Application of the Ultrasonic Stir Welding Process

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Presentation will cover …

- Describe the ultrasonic stir weld (USW) process
- Background study of US friction reduction
- Prototype USW system
- Advanced USW system

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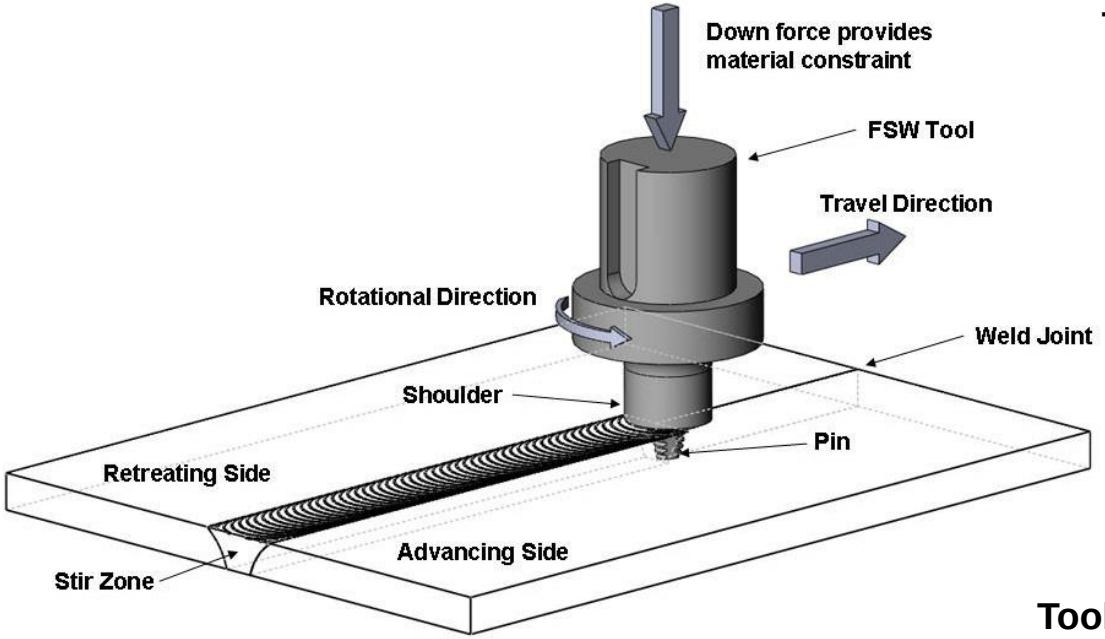
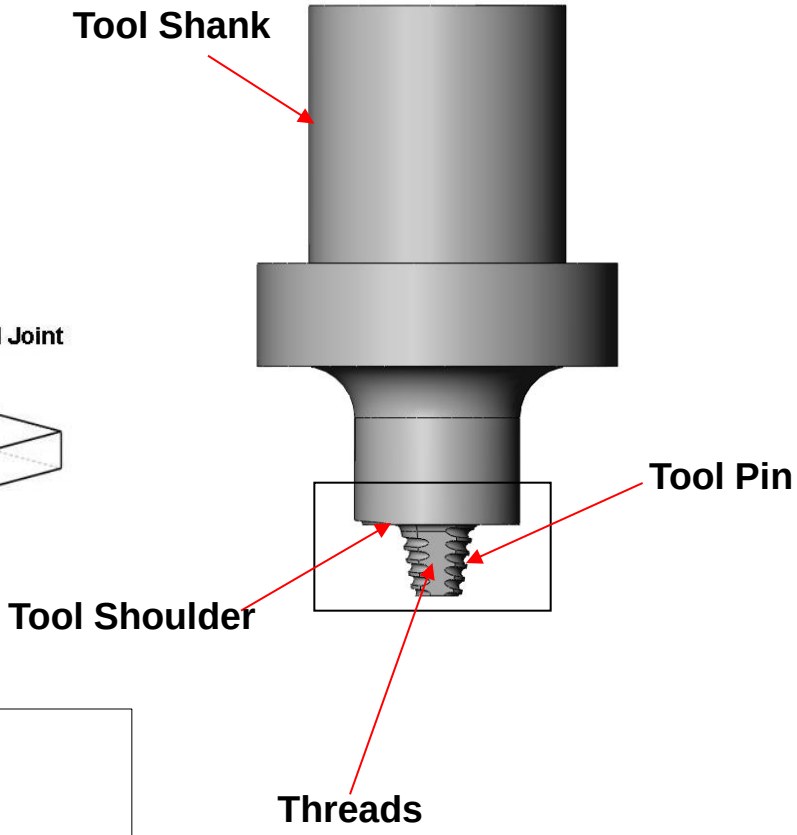
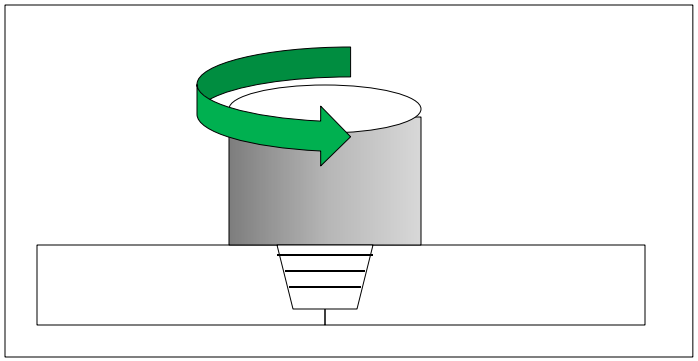
Basic Friction Stir Welding Process







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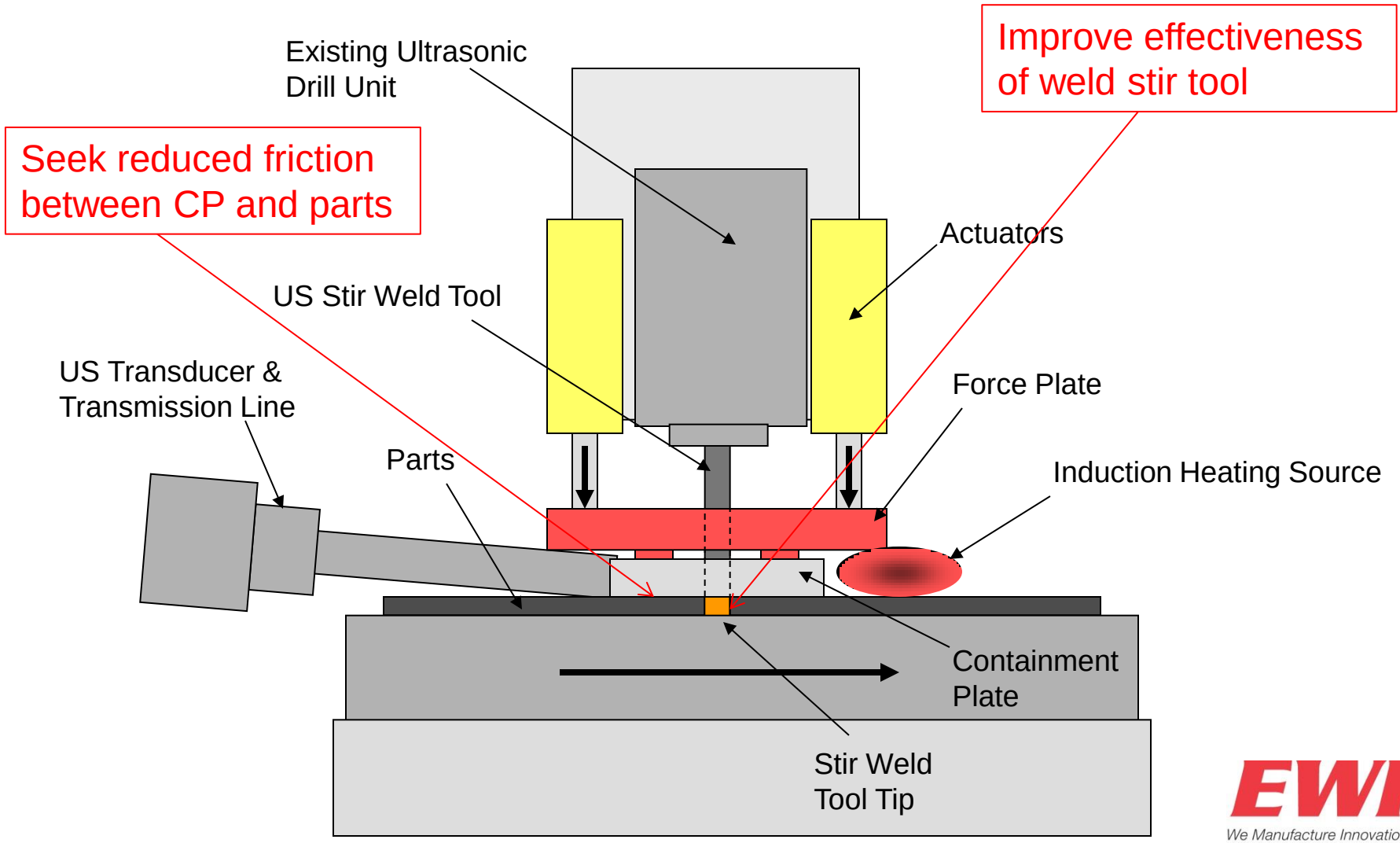
Concept for Ultrasonic Stir Weld System



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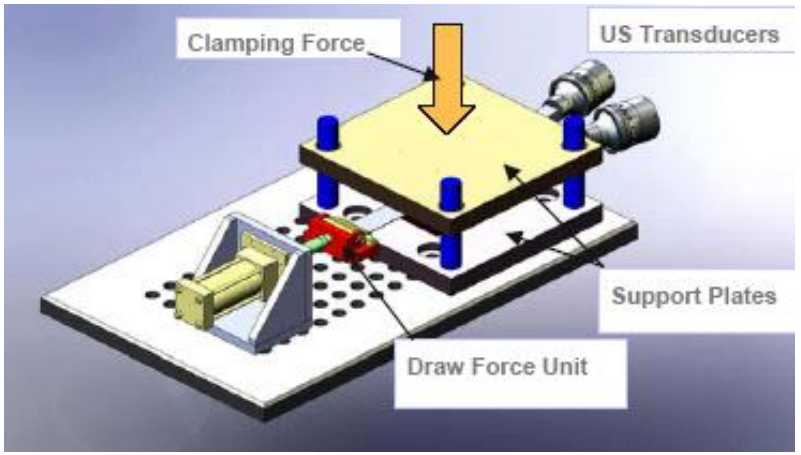
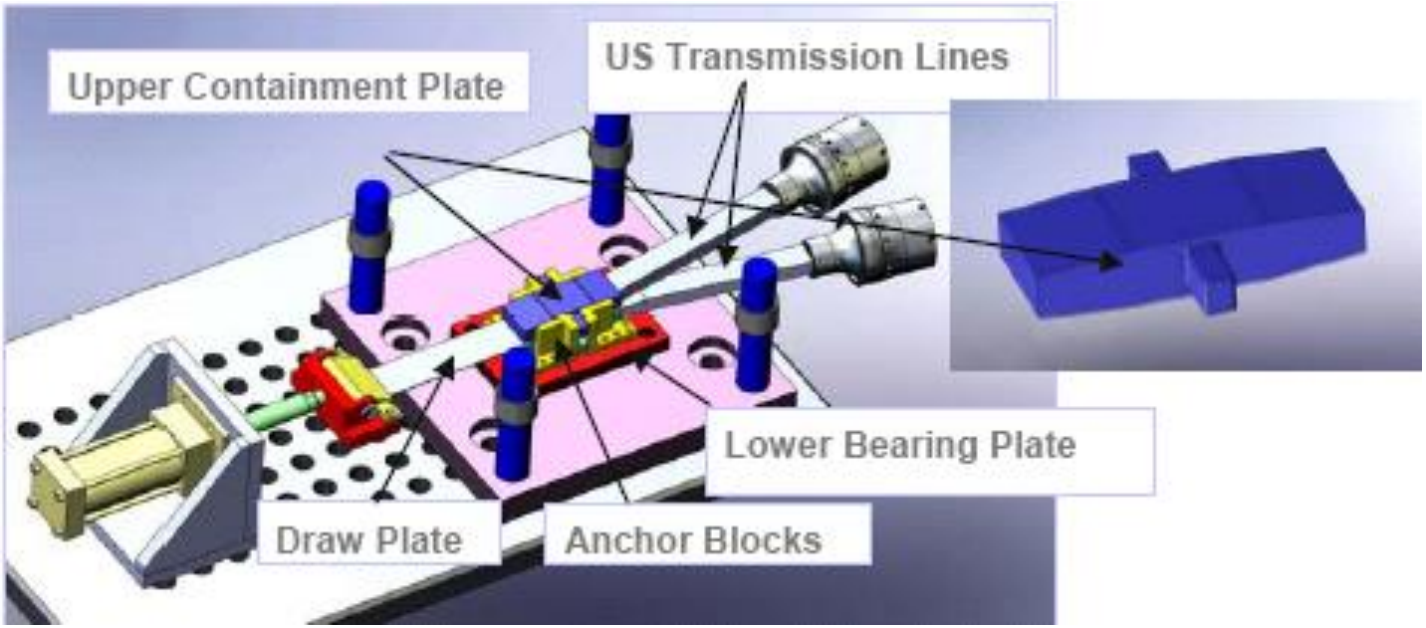
Friction Reduction at Containment Plate

- **Strip draw test permitted US friction reduction to be evaluated**





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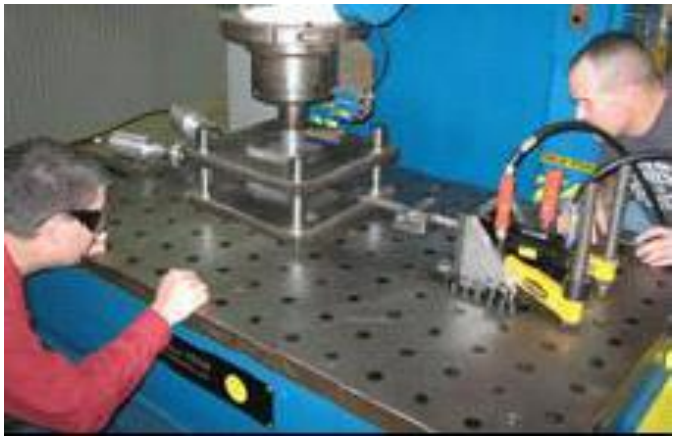
Draw Force Reductions



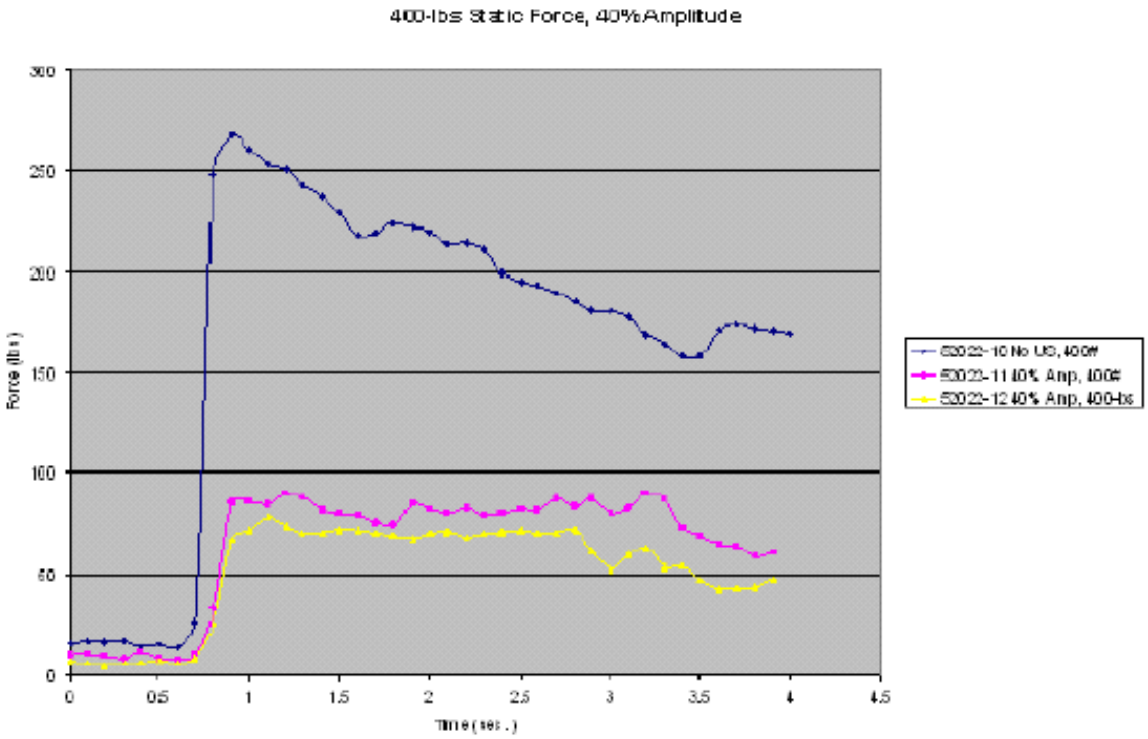


Figure 15. Example data from tests 52022 – No. 10,11,12. Clamping force, 400lbs. – without ultrasonics (No. 10) and at 40% amplitude (No. 11, 12).

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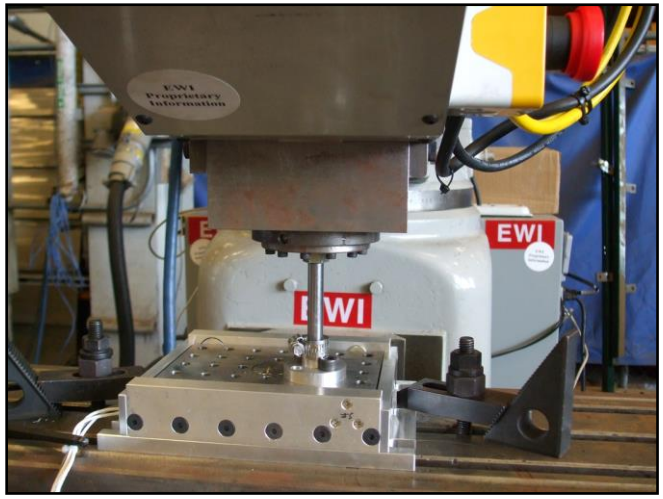
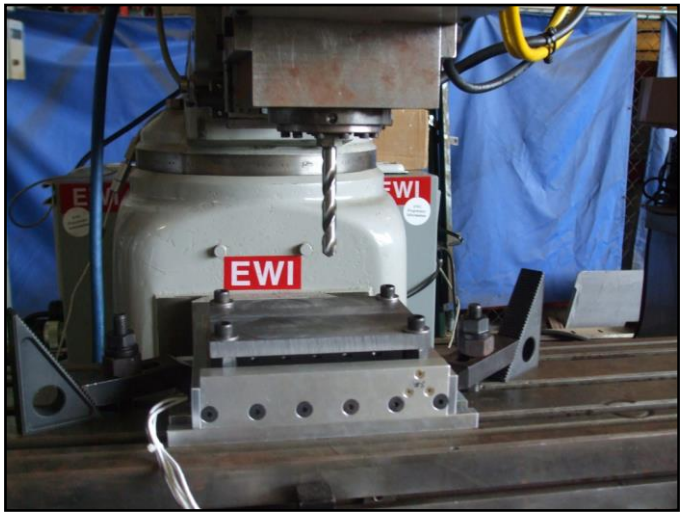
NASA friction reduction tests



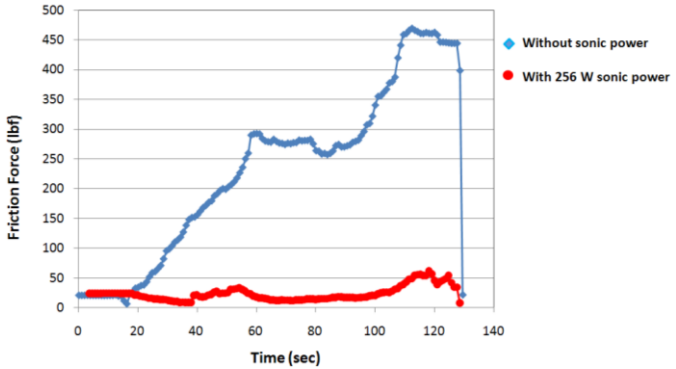
2008
Experimentation
at MSFC

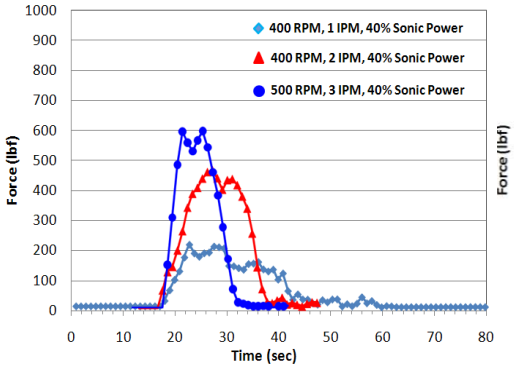
Leased EWI
twist drill system

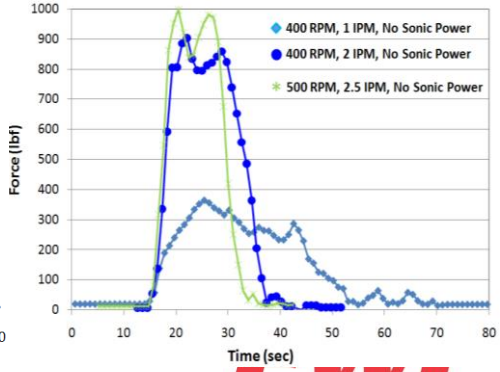


FRICTION REDUCTION

PLUNGE FORCE REDUCTION







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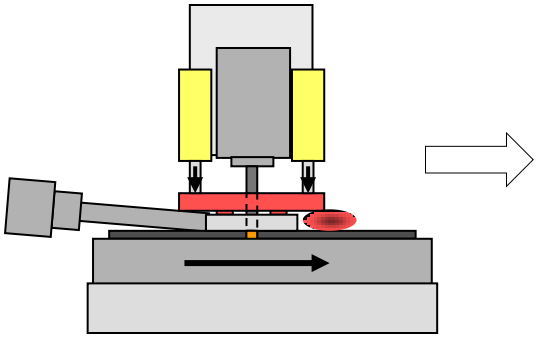
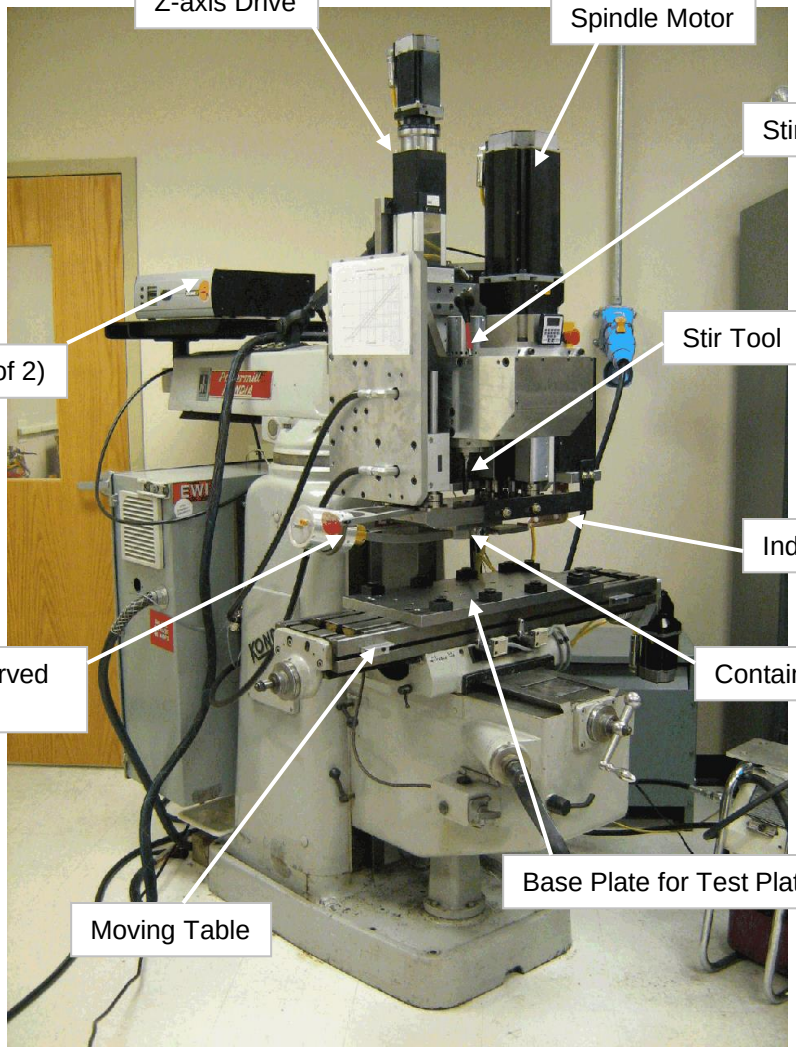
USW Prototype System





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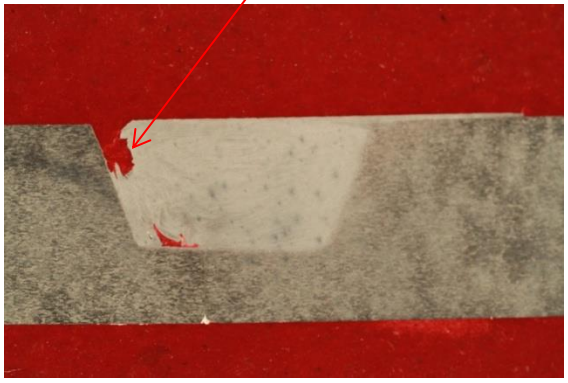
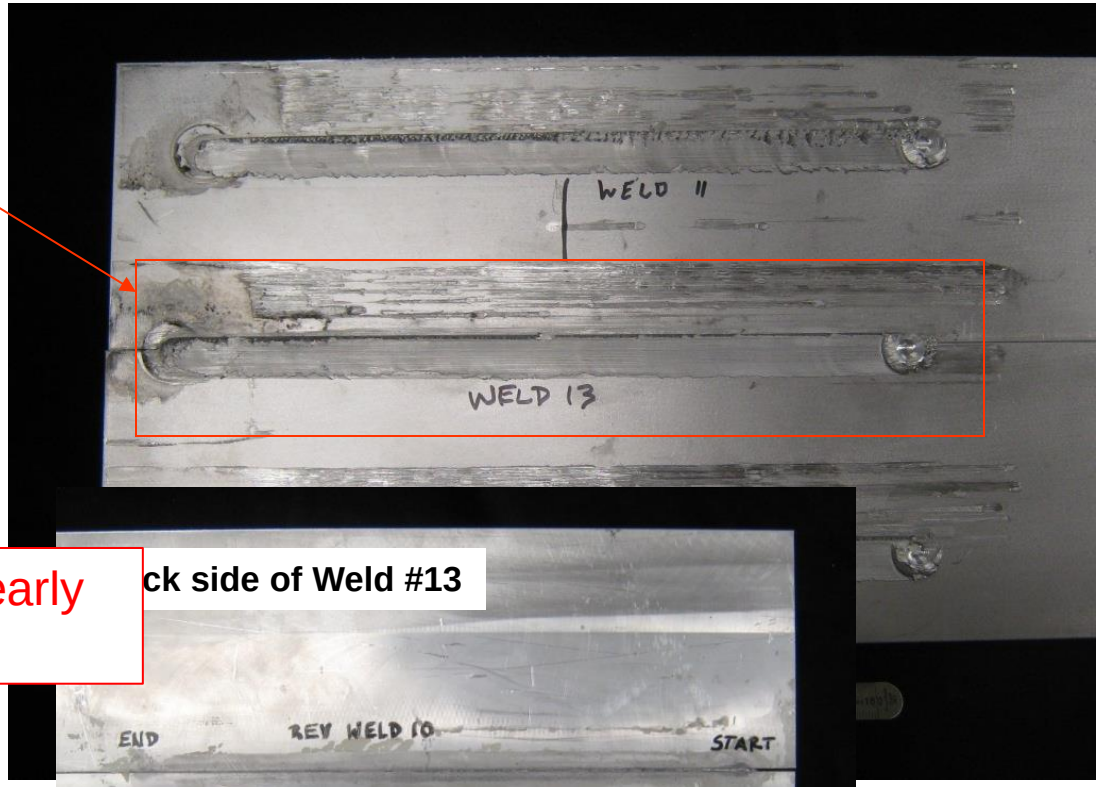
Early Weld Data

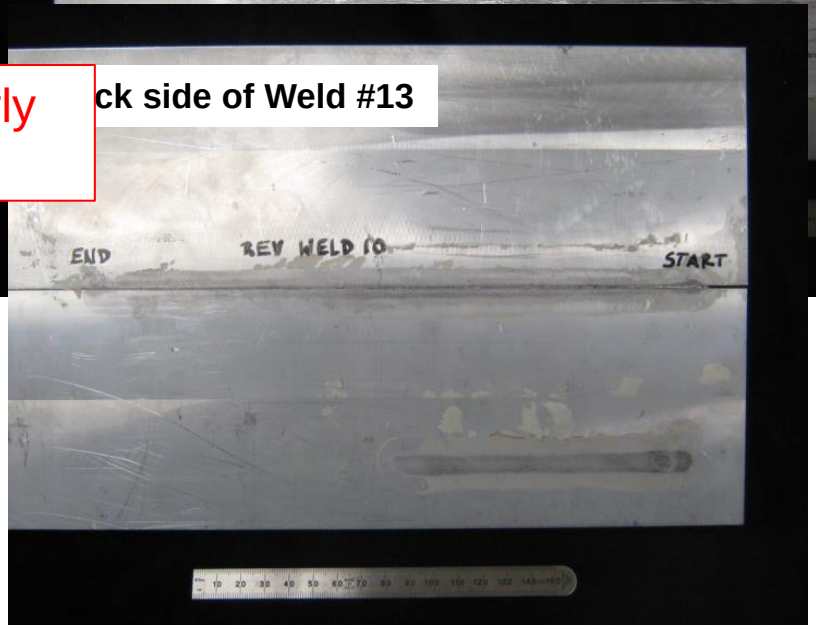
Weld # 13	
Parameters	Settings/Readings
Plate Material	Al 2219
Weld Type	Weld Plates
US Stir Tool PS Setting & Power	65%, 1043W
US CP PS Setting & Power	90%, Overload
Stir Tool RPM	600
CP Force	3000 lb.
Table Speed	10 ipm
Weld Depth S	
Induction: Sett	

Despite discontinuities, early results seen as positive





ck side of Weld #13



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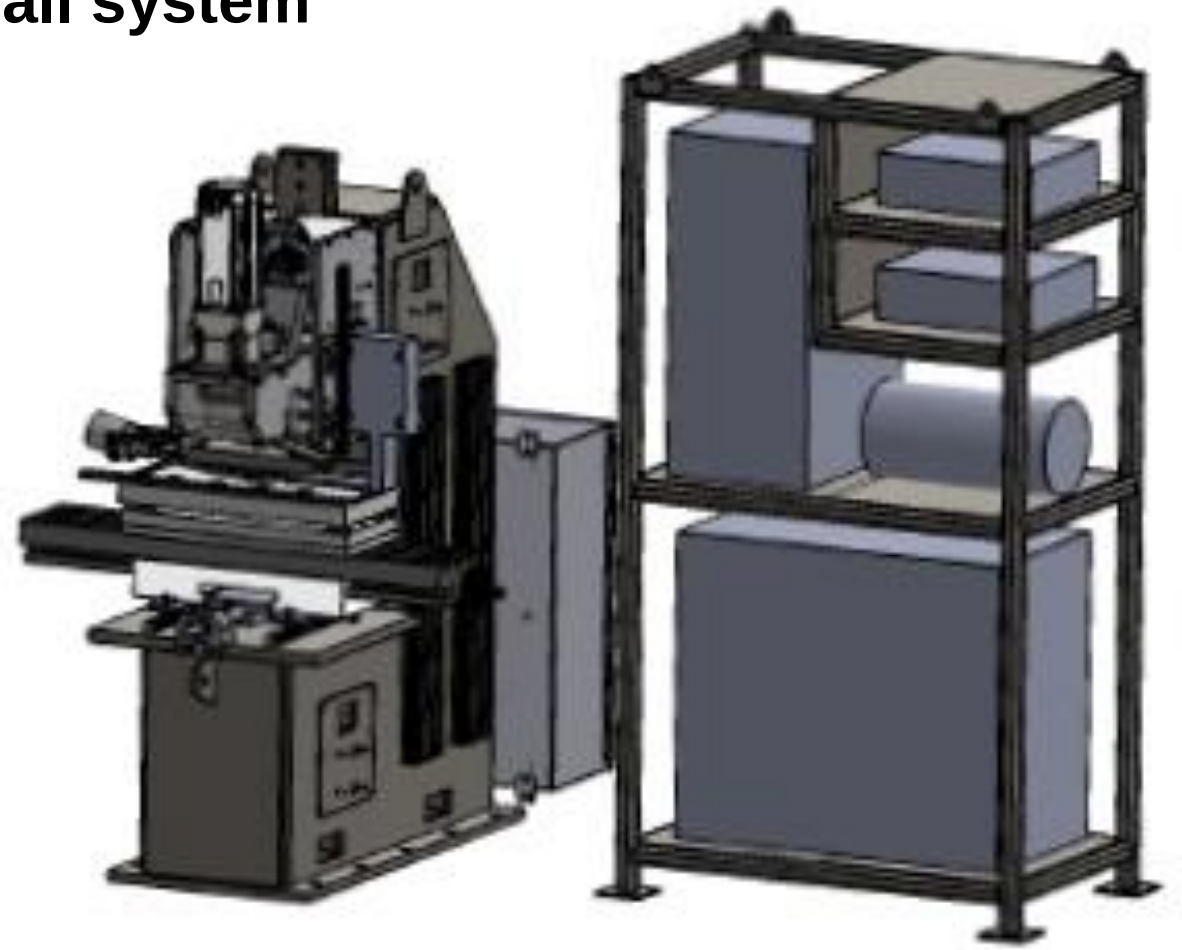
Advanced USW System

- **Overall system**



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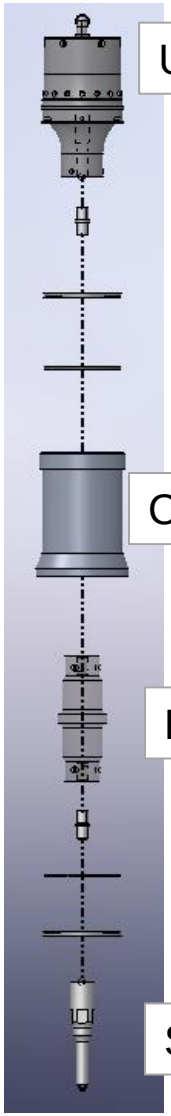
Ultrasonic Components

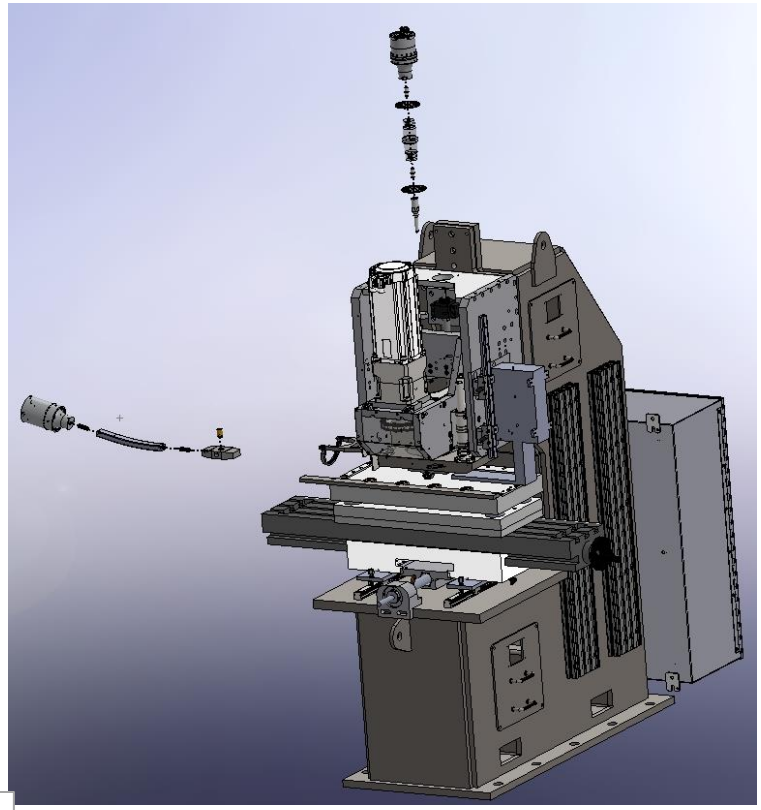


US Transducer

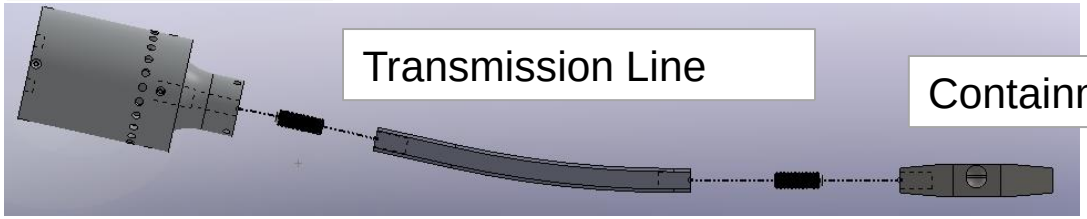
Case

Booster

Stir Tool



US Transducer



Transmission Line

Containment Plate

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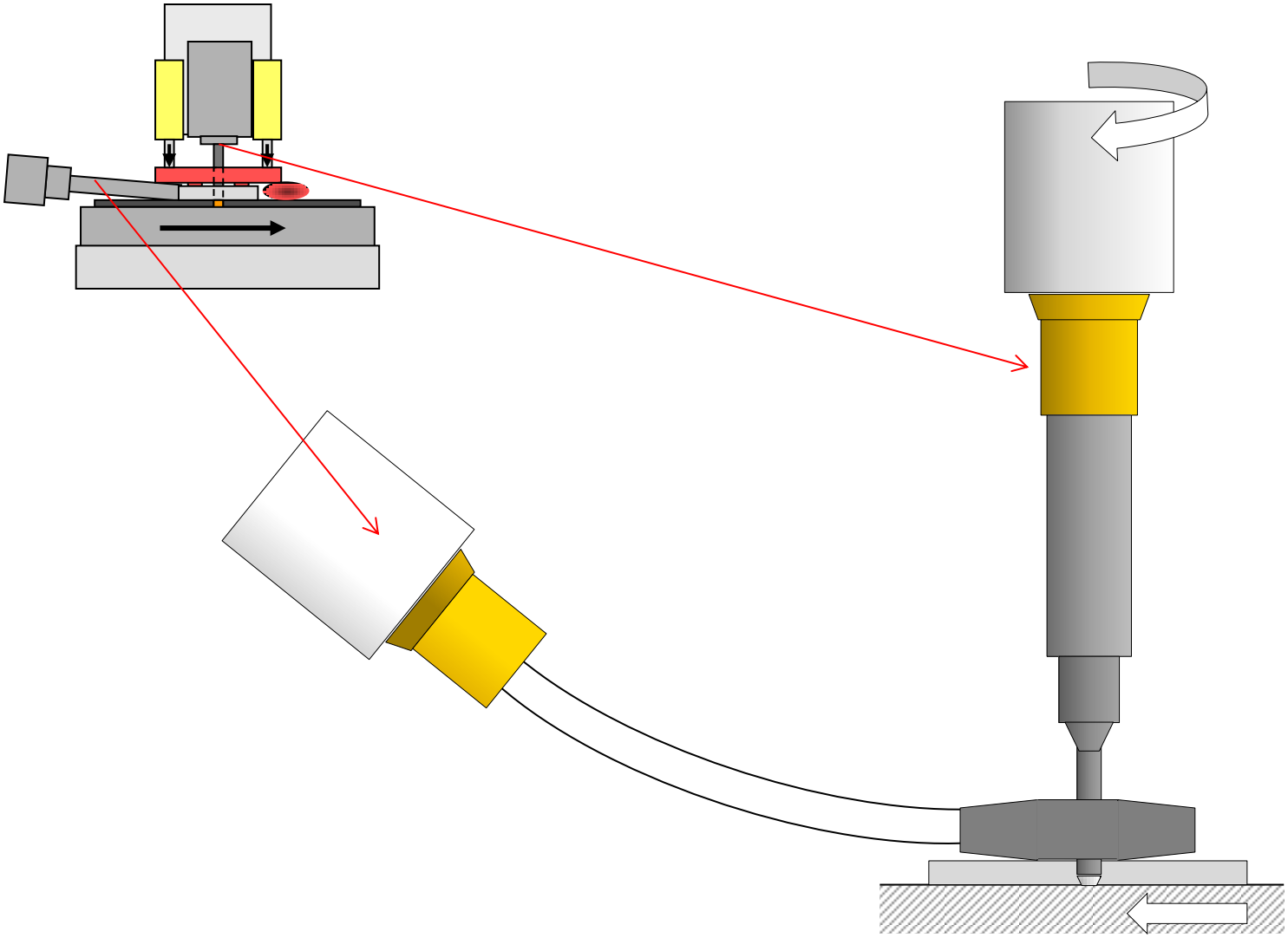
Stir Tool/CP System



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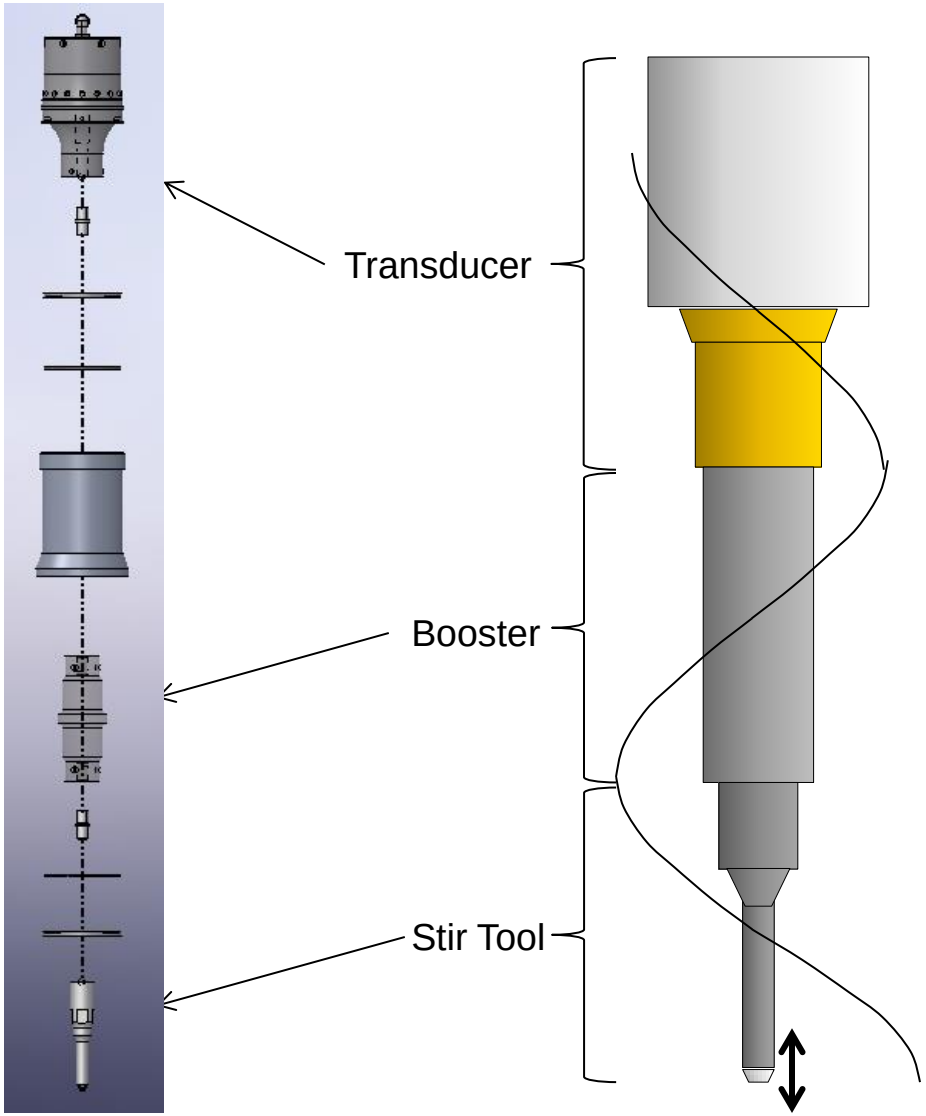
US Stir Tool Details



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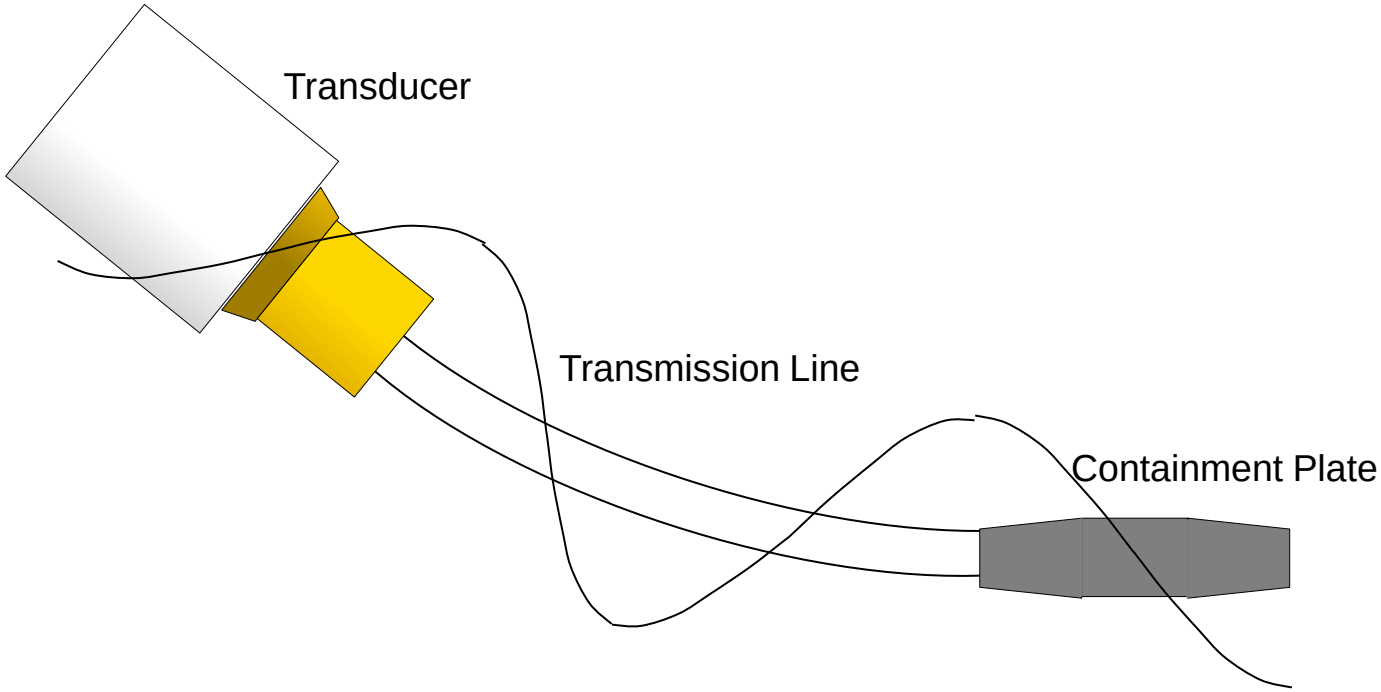
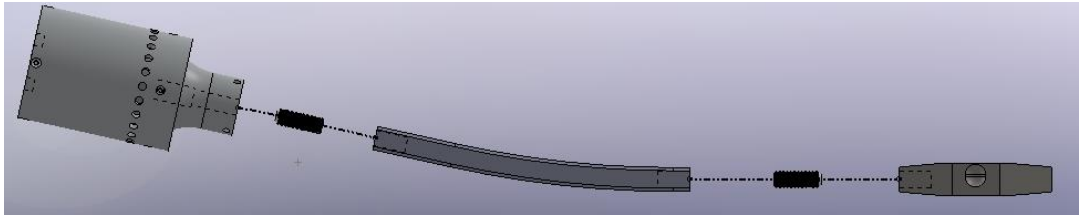
Containment Plate Details





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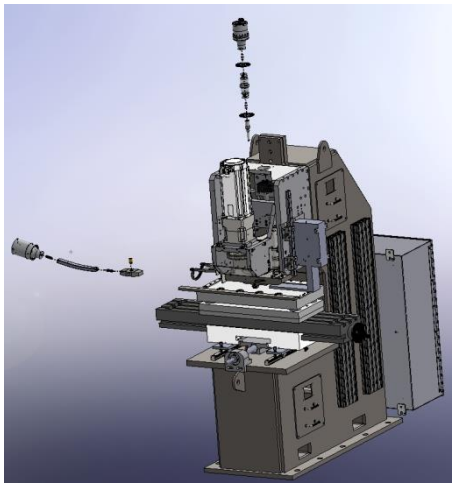
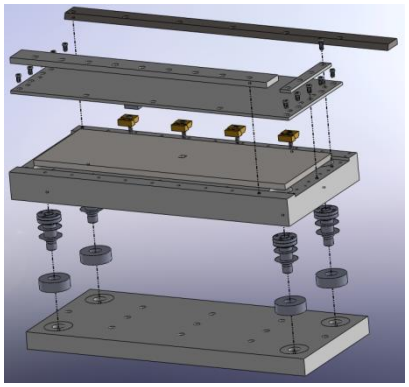
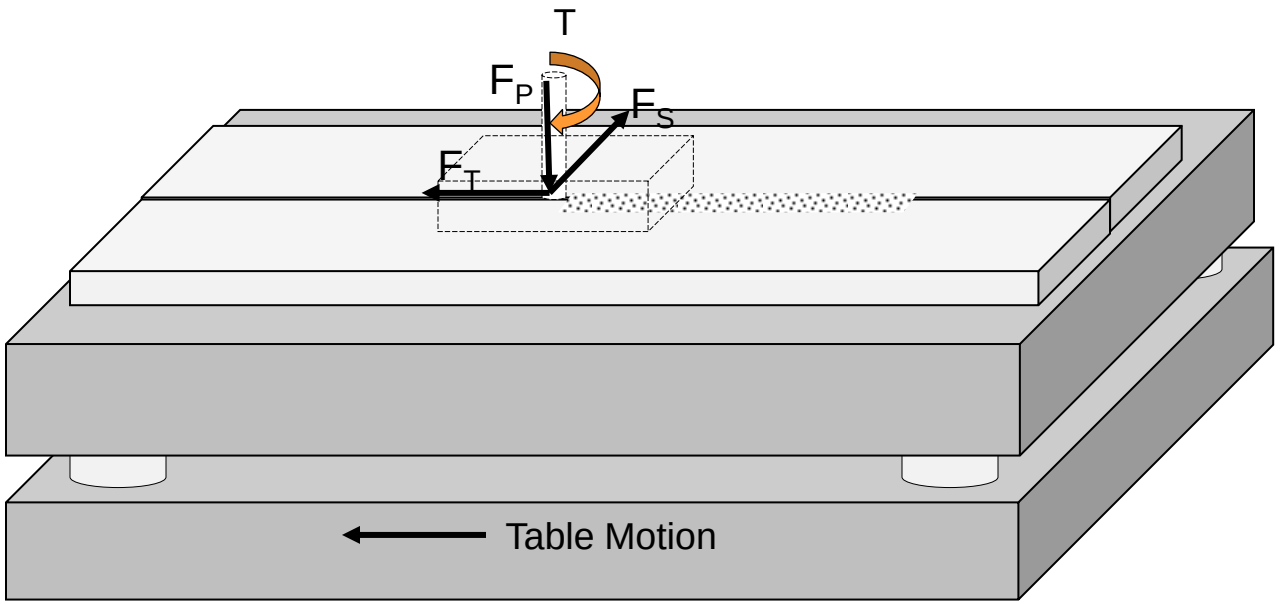
Force, Torque Measurement

- **Load Cell – measure US FSW forces/torques**







F_P = Plunge Force
F_T = Transverse (Drag) Plunge
F_S = Side Force
T = Torque

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USW Data Files

- **Data file contains information on**
  - Machine Parameters (Command & Actual)
    - Execution Time, Distance, Weld Operation, Spindle Speed, Path Max. Force Limit, Plunge Depth, Travel Speed, Plunge Speed, Laser Height Sensor Data, Induction Power,
  - Process Feedback
    - Forces: Path Force, Cross Path Force, Plunge Force, Torque
    - Ultrasonic Frequency, Power and Amplitude
    - Ultrasonic Containment Plate Force
    - Individual outputs from each of the charge amplifiers
- **Sampling Rate of 20 samples per second.**
- **Usually Plotted vs. Time or Distance**
  - Plotted vs. Time includes plunge data
  - Plotted vs. Distance for direct weld comparison

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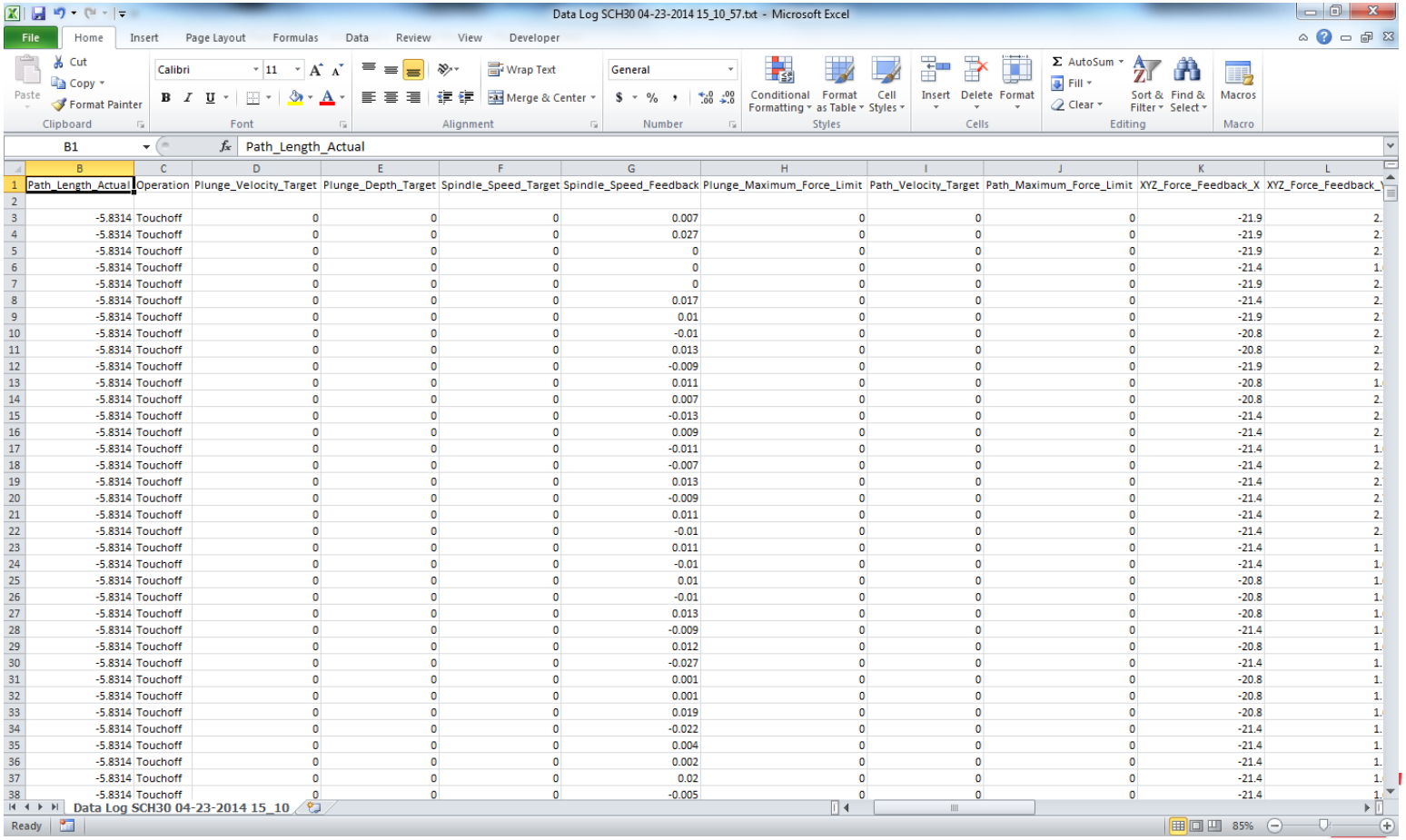
USW Data Files

- **Created as a .txt file that is opened by Microsoft Excel.**



Path_Length_Actual	Operation	Plunge_Velocity_Target	Plunge_Depth_Target	Spindle_Speed_Target	Spindle_Speed_Feedback	Plunge_Maximum_Force_Limit	Path_Velocity_Target	Path_Maximum_Force_Limit	XYZ_Force_Feedback_X	XYZ_Force_Feedback_
-5.8314	Touchoff	0	0	0	0.007	0	0	0	-21.9	2.
-5.8314	Touchoff	0	0	0	0.027	0	0	0	-21.9	2.
-5.8314	Touchoff	0	0	0	0	0	0	0	-21.9	2.
-5.8314	Touchoff	0	0	0	0	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	0	0	0	0	-21.9	2.
-5.8314	Touchoff	0	0	0	0.017	0	0	0	-21.4	2.
-5.8314	Touchoff	0	0	0	0.01	0	0	0	-21.9	2.
-5.8314	Touchoff	0	0	0	-0.01	0	0	0	-20.8	2.
-5.8314	Touchoff	0	0	0	0.013	0	0	0	-20.8	2.
-5.8314	Touchoff	0	0	0	-0.009	0	0	0	-21.9	2.
-5.8314	Touchoff	0	0	0	0.011	0	0	0	-20.8	1.
-5.8314	Touchoff	0	0	0	0.007	0	0	0	-20.8	2.
-5.8314	Touchoff	0	0	0	-0.013	0	0	0	-21.4	2.
-5.8314	Touchoff	0	0	0	0.009	0	0	0	-21.4	2.
-5.8314	Touchoff	0	0	0	-0.011	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	-0.007	0	0	0	-21.4	2.
-5.8314	Touchoff	0	0	0	0.013	0	0	0	-21.4	2.
-5.8314	Touchoff	0	0	0	-0.009	0	0	0	-21.4	2.
-5.8314	Touchoff	0	0	0	0.011	0	0	0	-21.4	2.
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-5.8314	Touchoff	0	0	0	0.011	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	-0.01	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	0.01	0	0	0	-20.8	1.
-5.8314	Touchoff	0	0	0	-0.01	0	0	0	-20.8	1.
-5.8314	Touchoff	0	0	0	0.013	0	0	0	-20.8	1.
-5.8314	Touchoff	0	0	0	-0.009	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	0.012	0	0	0	-20.8	1.
-5.8314	Touchoff	0	0	0	-0.027	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	0.001	0	0	0	-20.8	1.
-5.8314	Touchoff	0	0	0	0.001	0	0	0	-20.8	1.
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-5.8314	Touchoff	0	0	0	-0.022	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	0.004	0	0	0	-21.4	1.
-5.8314	Touchoff	0	0	0	0.002	0	0	0	-21.4	1.
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-5.8314	Touchoff	0	0	0	-0.005	0	0	0	-21.4	1.

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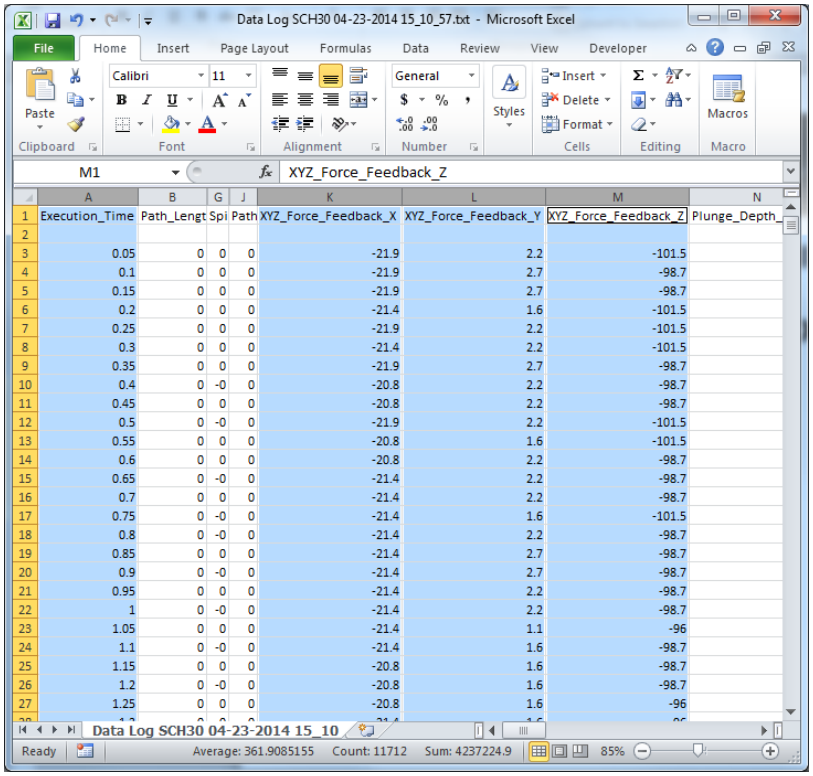
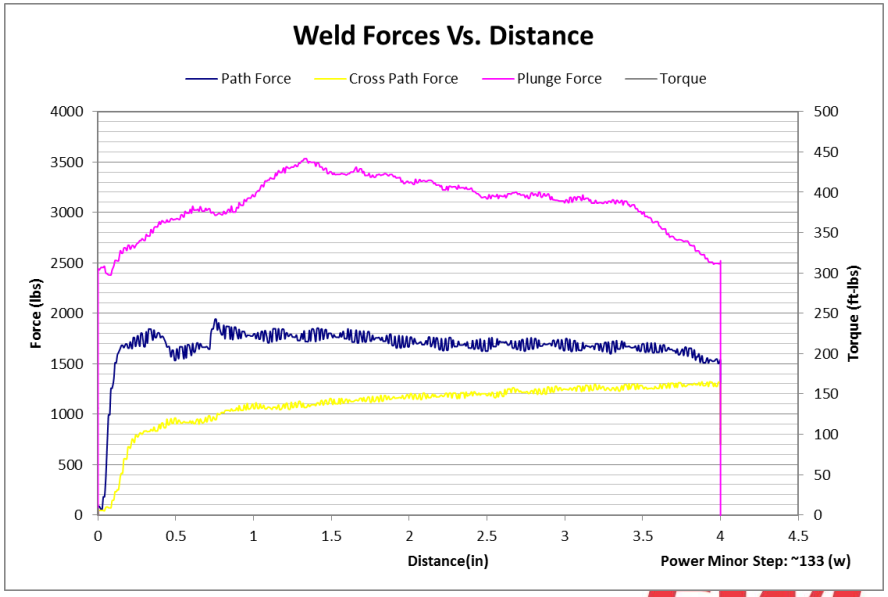
USW Data Files

- Columns can be selected to ‘drill down’ into parameters of interest.
- These are usually plotted as an X-Y Graph





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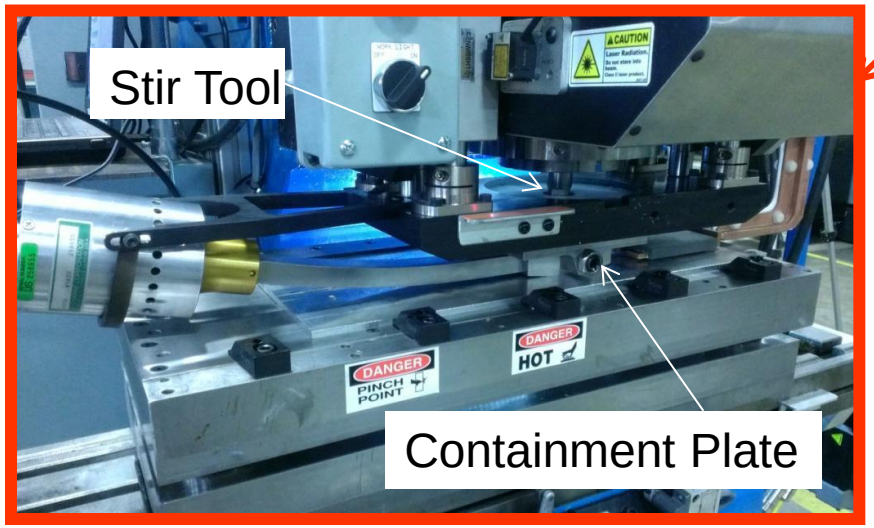
Capabilities Summary

- Ability to “pulse” US energy on/off; adjust parameters real-time (travel speed, spindle RPM, US amplitude, X and Z axis position, plunge and pin axis force)
- Force, torque measurement
- Record US power versus time
- Head deflection control - two laser height sensors.
- Linear encoder to better control tool penetration
- Ultrasonic energy integrated into stir rod and containment plate.
- Maximum 600 RPM, maximum Z force 15,000 pounds.
- Independent control of heating capability via induction technology.

NASA USW System



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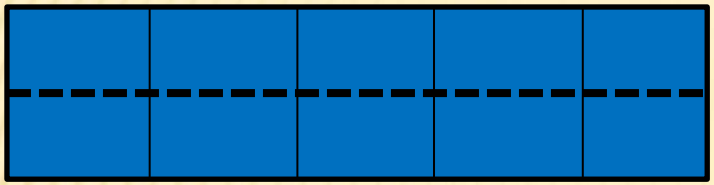
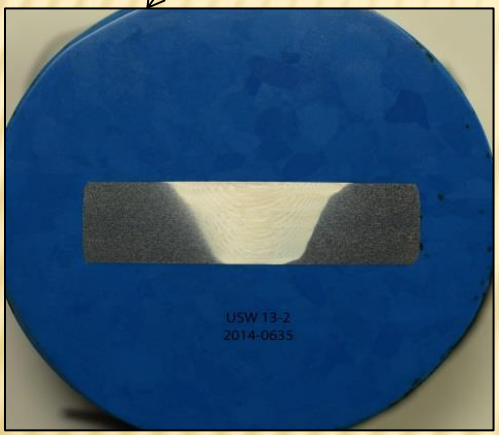
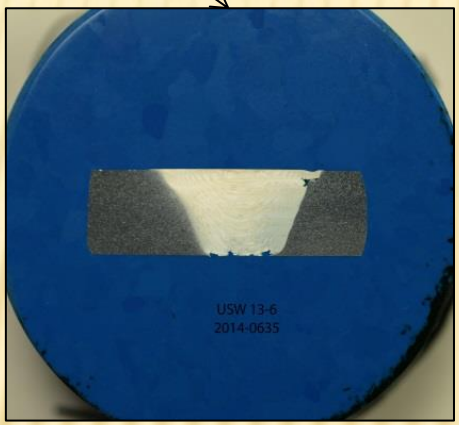
Initial NASA Tests



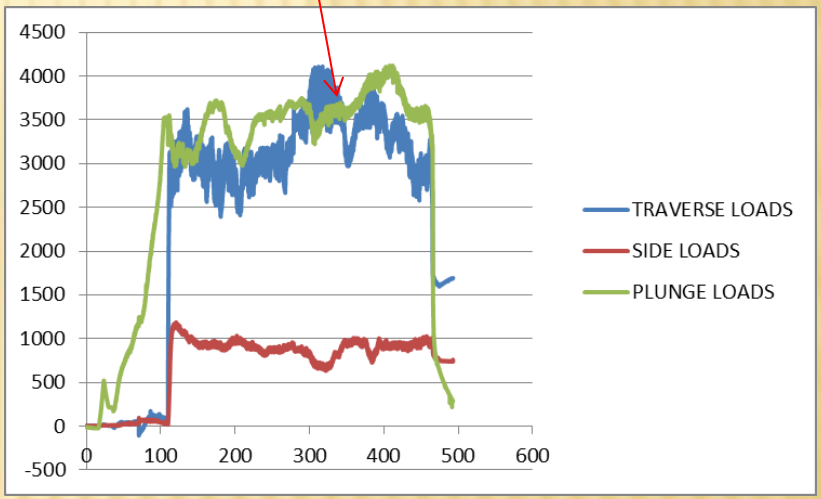




T_{ult} = 46.65 ksi
T_{yld} = 31.16 ksi

T_{ult} = 33.91 ksi
T_{yld} = 31.12 ksi

Increasing force with decreasing US



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FUTURE WORK

- Begin induction coil pre-heat
- Characteristics of hot weld versus cold weld
- Pulse ultrasonics on/off
- Determine upper limit of CP amplitude
- Faster travel rates
- Develop parameters for heat resistant alloys

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Goal …

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EWI is the leading engineering and technology organization in North America dedicated to advanced materials joining and allied manufacturing technologies. Since 1984, EWI has provided applied research, manufacturing support, and strategic services to leaders in the aerospace, automotive, consumer products, electronics, medical, energy & chemical, government, and heavy manufacturing industries. By matching our expertise in materials joining, forming, and testing to the needs of forward-thinking manufacturers, we are successful in creating effective solutions in product design and production.

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