2012 UTSR Fellowship Project Summary

06 Aug 2012
Mitch Busche
Industrial Turbomachinery Systems
Outline

• Background
  ▪ University Turbine Systems Research (UTSR)
  ▪ Gas Turbine Industrial Fellowship (GTIF)

• Dates/Projects
  ▪ Sparking
  ▪ Weld Database
  ▪ Next Generation GE Nozzle
  ▪ Others

• Conclusions
  ▪ Skills
  ▪ Acknowledgments
University Turbine Systems Research (UTSR) Gas Turbine Industrial Fellowship (GTIF)

• The UTSR Program is part of Advanced Turbine Program managed by the DOE Office of Fossil Energy

• “UTSR addresses scientific research to develop and transition advanced turbines and turbine-based systems that will operate cleanly and efficiently when fueled with coal-derived synthesis gas and hydrogen fuels.”

• “GTIF provides undergraduate- and graduate-level science and engineering students with the opportunity to conduct research, engineering, and design projects at leading gas turbine industry sponsors”
Dates/Projects

• Dates: 21 May 2012 – 07 Aug 2012

• Projects:
  ▪ Evaluate new alloy via spark test analysis for potential use on igniter center electrodes
  ▪ Compile data to develop weld database
  ▪ Assist with building/developing manufacturing procedures for the next generation GE nozzle
  ▪ Miscellaneous
Alloy Evaluation

- Purpose: To conduct and evaluate a controlled series of dry and wet spark tests using a center electrode comprised of the Iridium (Ir) Alloy
  - Current igniters have a significantly reduced life under wetted (quenched fuel) conditions
  - Woodward has samples of an Iridium Alloy
Dry Spark Test - Apparatus

- Dry Spark Test Plug
- Fiber Optics
- Cord from Exciter
- Breather
- Air Line
- Counter
Dry Spark Test - Igniter Tip Condition; Start

0 Sparks
Dry Spark Test - Igniter Tip Condition; End

567,838 Sparks

Minimal wear on the center electrode, majority of wear is on the outer electrode.
Wet Spark Test - Apparatus

- Cord from Exciter
- Aluminum Stops
- Steel Enclosure
- Breather
- Jumper Cord
- Oscilloscope
- Measuring Box
- Argon Line
Wet Spark Test – Enclosure

- Wet Spark Test Plug
- Expandable Bellows
- Breather
- Argon Line
- Oscilloscope
- Measuring Box
- Aluminum Stops
Wet Spark Test - Baseline Igniter Tip

142,254 Sparks - Fully Submerged
Wet Spark Test - Tip Condition; New Alloy

126,028 Sparks - Fully Submerged
Graphical Results - Spark Testing

$\Delta$Vol / Spark (cc/spark)

Dry
Wet
Baseline, Wet

$\Delta$ Volume

Sparks

$\Delta$ Volume Lost (cc) approx 140k Sparks

Dry
Wet
Baseline, Wet

Vol Lost (cc) approx 140k Sparks

Test
Results/Conclusions - Spark Testing

• **Dry Spark Test**
  ▪ There is minimal wear on the center electrode, majority of the wear is on the outer electrode

• **Wet Spark Test**
  ▪ **Baseline**
    ► Has a faster volumetric wear rate than new alloy, approx 2x faster
    ► Larger diameter: 0.123” vs. 0.100”
    ► Center electrode eroded to inside insulator
  ▪ **Alloy**
    ► Faster wear rate than dry spark, approximately 18 times faster
    ► More wear on center electrode versus dry

• **Appears that wear rate is a function of both material composition and geometry, not just linear function**
Weld Database

• Purpose: To create a database to be used in the quoting and estimation phases of a project to better access weld development cost and time
  - Woodward possesses extensive welding knowledge
  - A concern was raised as to the amount of money appropriated for weld coupons (blank parts similar to production parts) which are used for weld program development
  - By better estimating the number of coupons required, engineers will save time, material, and money in estimating/planning weld geometry

• Database contains the following parameters:
  - Component 1 and Material, Component 2 and Material, Joint Configuration, Type of Weld, EB Weld Parameters, Weld Thickness, etc.
  - Database created for both EB welds and TIG welds
### Weld Database - Example

<table>
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<tr>
<th>Material 1</th>
<th>Material 2</th>
<th>Wall Thickness</th>
<th>Joint</th>
<th>MA Speed</th>
<th>Focus</th>
<th>Circle</th>
<th>Freq.</th>
<th>Tooling*</th>
<th>Schedule</th>
<th>Reference Top Lvl Part #</th>
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<th>Detail 2</th>
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</table>

Proprietary Information
Next Generation GE Nozzle

• Contributed to set up and organization of work cell layout
  ▪ Moved and leveled modular build table
  ▪ Assembled and improved nozzle weld cart

• Assisted in build process due to accelerated timing
  ▪ Make braze samples
  ▪ Prepared and serialized nozzle flow tubes
  ▪ Applied Stop-Off (a braze flow prohibitor) to various components
  ▪ Verified diameters between nozzle tubes and mating plates holes
  ▪ Set up Nozzle in braze oven; provided pictures of process to create manufacturing worksheets
  ▪ Machined tapers on pins
  ▪ Measured and confirmed rod heights prior to use
  ▪ Polished and cleaned threads on nozzle tube support rods
Miscellaneous Tasks

- Performed fluid flow testing on multiple versions of fuel nozzle components (swirlers, housings)
- Assisted in teardown analysis of 5-2E PMXO fuel nozzles returned from field testing
- Performed air flow testing of Gen-2p swirlers
- Provided support in debugging a program used to transfer data from CMM to Excel
- Shadowed Kwasi Foli, a Woodward CFD/Fluent Engineer
- Attended DF-42 Water Nozzle Improvement Proposal Meeting between Woodward and customer; provided flow demonstration
Conclusions – Skills

- Flow testing
- SMD testing
- Refreshed skills on lathe
- Laser welding
- Laser engraving
- CMM
- EB welding
Conclusions - Thank you

• **Project Involvement and Support**
  - Jack Bardolph, Dan Burke, Bruce Harrar

• **Leaders**
  - Mentor: Mike Hackenberg
  - Supervisor: Mark Dieringer

• **All**
  - Thank for you making me feel very welcome at Woodward. It has been a great learning experience. I felt as though I was a Woodward employee and not just another summer intern.
Always innovating for a better future