SAND2019-6558PE

RFW Model Validation

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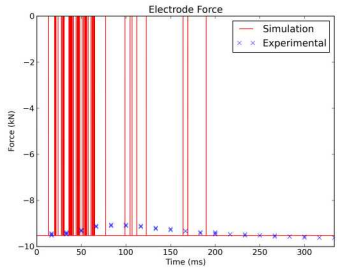
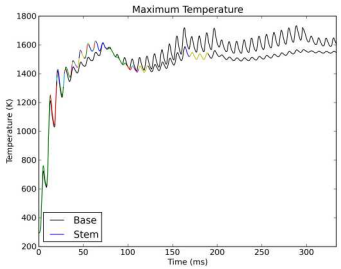
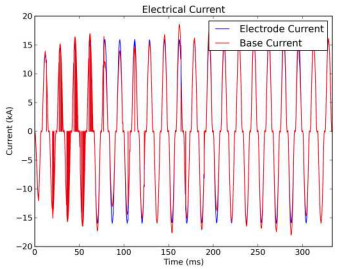
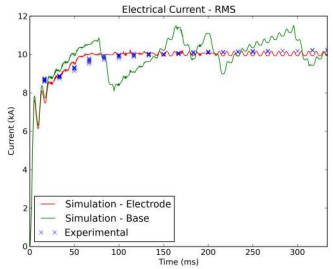
Model Validation

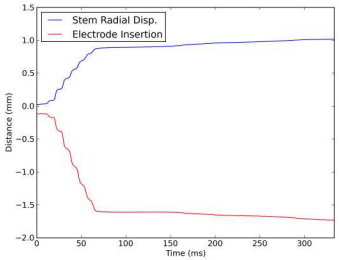
- Comparison against experimental data:
  - Measurements from Mike Maguire (Sandia)
    - Radial displacement, vertical displacement

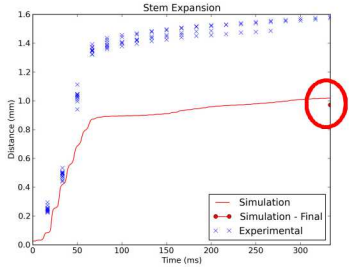


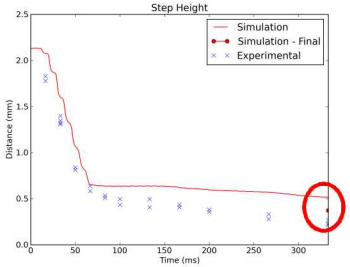








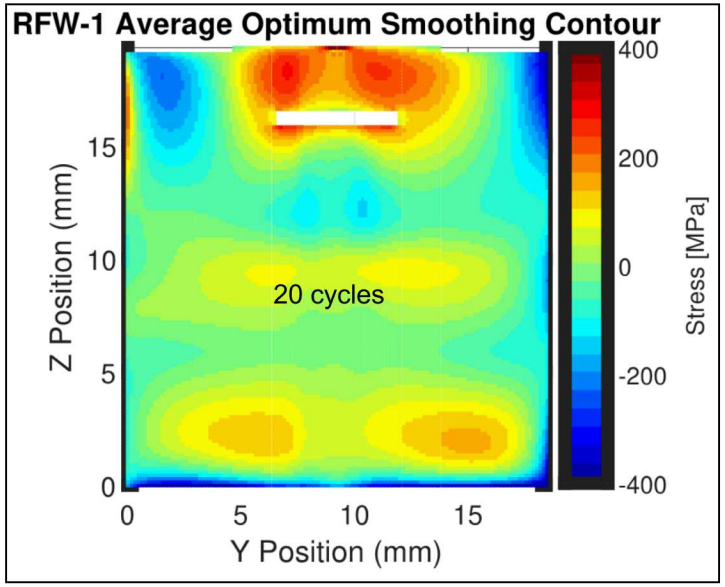




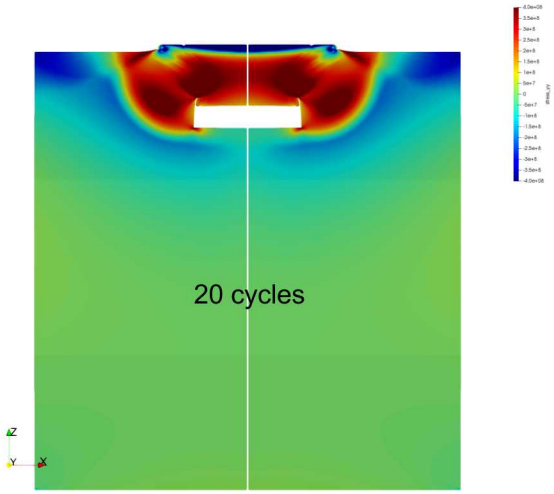
**note cooling effect

Model Validation

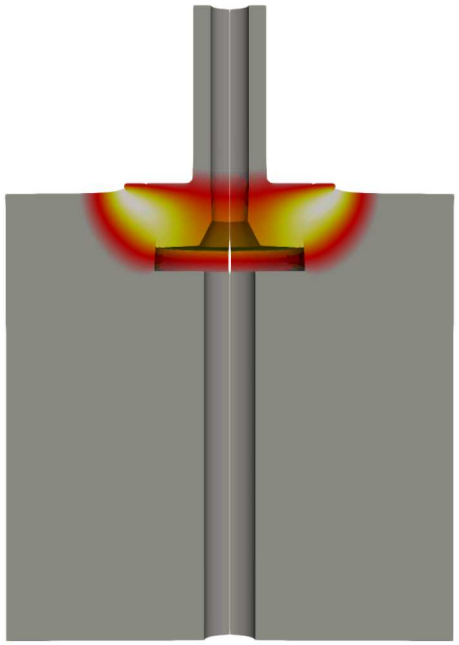
- Comparison of Residual Stress field:
  - Experimental imagery from Mike Hill & Chris D'Elia
  - Stress plotted -400 MPa to +400 MPa



Experimental Imagery (UC Davis / Hill Engineering)



Temperature
(at end of welding,
before cooling)



RFW Simulation (Sandia)

Model Validation

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- Current simulation status:
  - Simulation runs to completion!
  - Remeshes ~70 times
  - Still a few user interventions needed in remeshing
  - Real-time Run-time ~1 week
    - 16 processors on SRN cluster Eclipse
    - Queue time (after every remesh) greatly adds to total run-time

- Observations:
  - Less stem expansion than experimentally observed
  - Similar final step height as experimental observation
  - Residual stress field shows similar pattern, but different magnitudes
  - Experimental imagery doesn't seem to show stem/base crack that simulation generates

  - Difference between continuous sampling 0-20 samples & experimental observations:
    - Experimental observations are final values, were cooled
    - Cooling affects displacements
      - Thermal contraction causes slight reduction in stem expansion
      - Thermal contraction relieves pressure in interference fit, allowing for slightly more vertical displacement (step height change)
    - Best comparison to experimental data would be to run 0-1 cycle & cool, 0-2 cycles & cool, 0-3 cycles & cool, etc.
      - 0-20 cycle simulation results can be copied and adapted for this use with minimal duplicated effort!

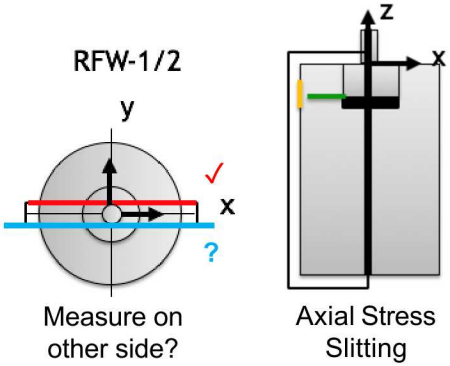
Model Validation

- Discussion Questions:
  - Similar stress field pattern, different magnitudes
  - Sources of difference between physical measurement and simulation?
  - Sources of error in physical measurement?

  - Repeatability - Possible to measure sample on other side?
  - Possible to measure axial stress via slitting? (listed on 1/22 UCD slides)
  - Possible to "point-measure" stress?
    - Areas of highest stress – both sides of weld
    - Base below cavity
    - Further up on stem

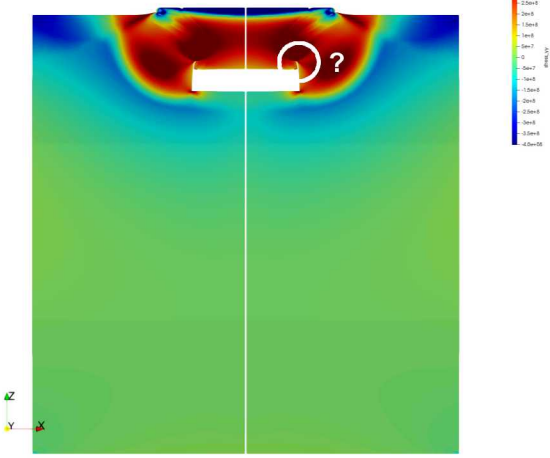
  - Any uncertainties or known spatial variation in manufacturing, measurement, simulation?
    - Cut plane location for measurement?

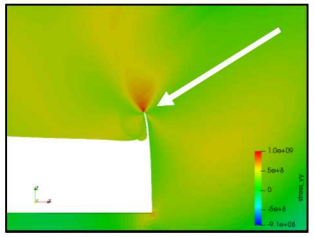
  - Experimental imagery resolution size?
    - Simulation element size = 10μm (fine) to 50μm (coarse)
  - Was a crack observed at interior corner joint between base & stem?



Measure on other side?

Axial Stress Slitting





Interior Base-Stem Joint Crack