SAND2017-5635PE

Designing Functionalized Hardware for Additive Manufacturing

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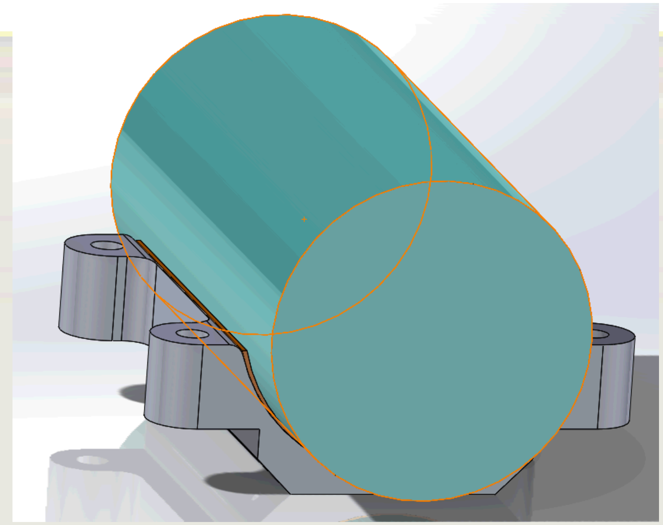
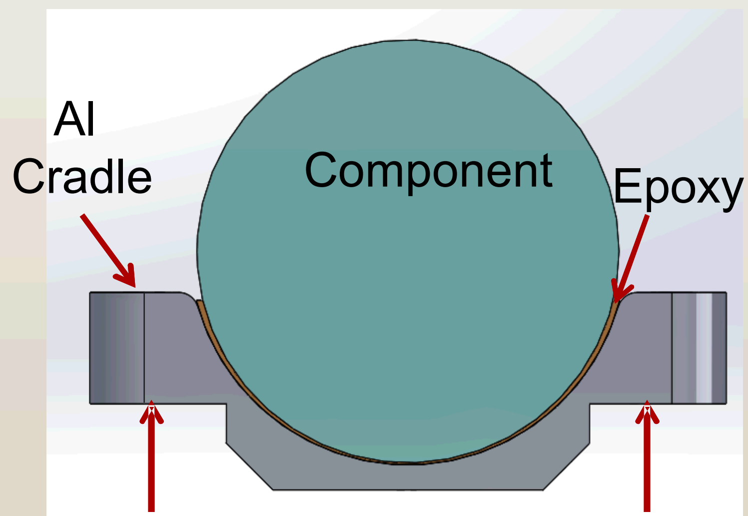
Objective

- Explore Application of Additive Manufacturing (AM) to Accelerate Thermal Degradation of Weak Link Components
  - Develop concepts for component/bracket to accelerate thermal degradation
- Evaluate Concepts to Validate Approaches
  - Perform transient thermal analysis to understand time dependent heating of component
  - Use analytical results to develop concepts to enhance weak link function

Approach

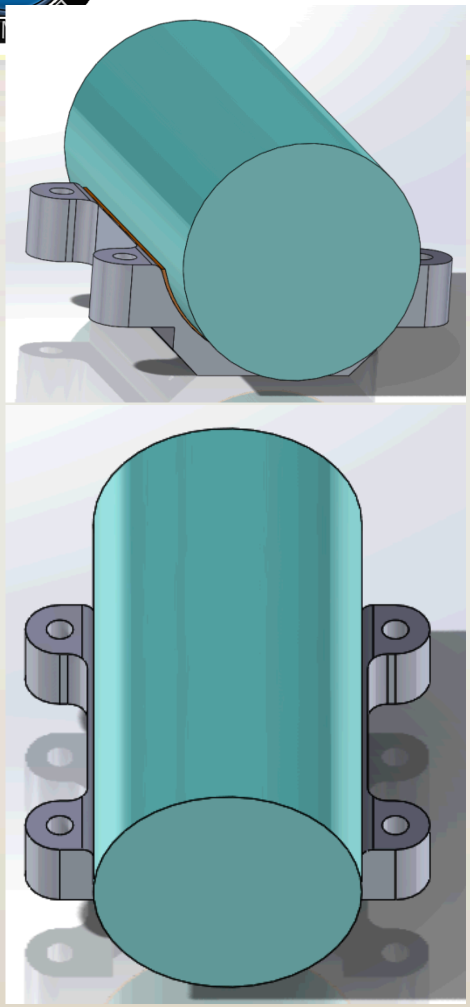
- Build Solid Models of Geometries
  - Traditional cradle
  - Thermal/Cold spray
  - 3D printed component
- After Analysis
  - Concentrating cradle



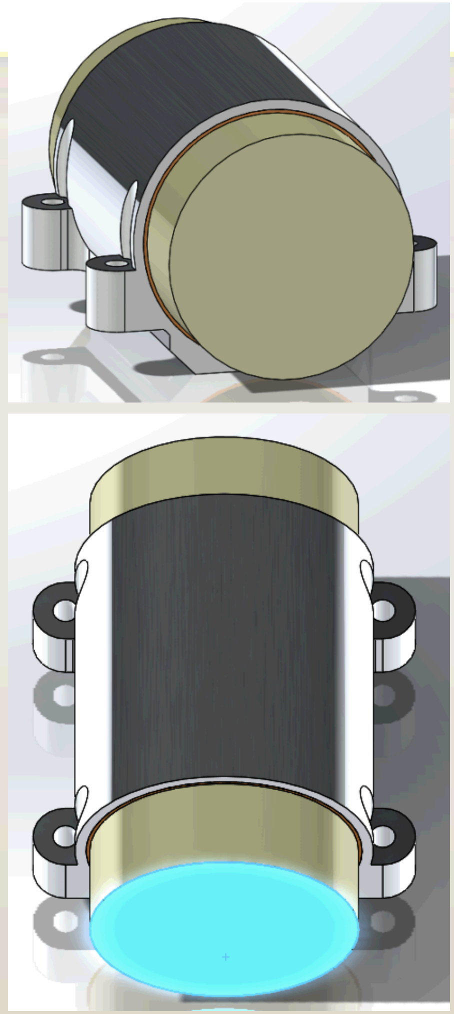


Thermal Input from Housing

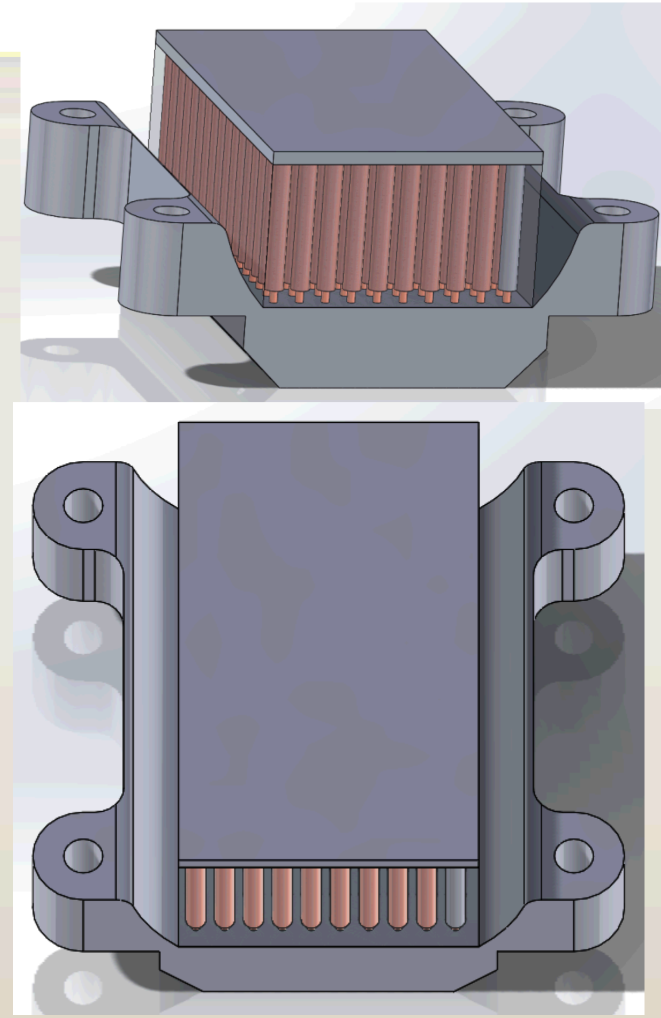
Component Geometries



Traditional Component and Cradle



Spray Coated Component Cradle



3D Printed Component (LDRD work)

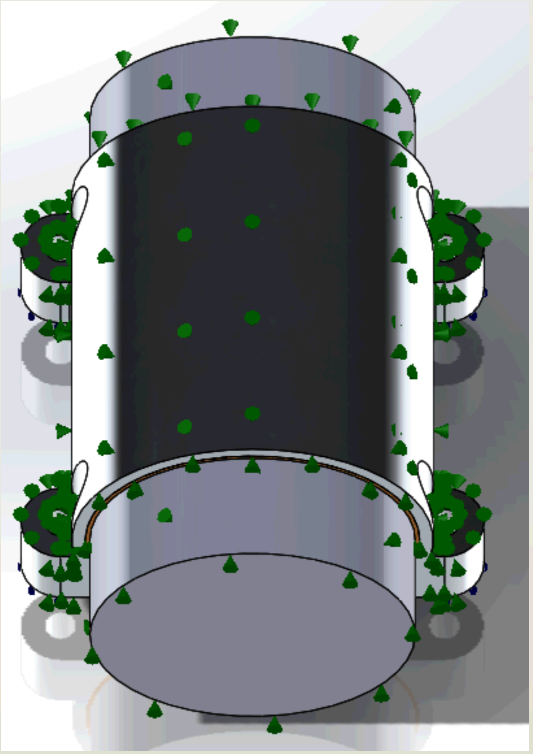
Model Conditions

- Materials
  - Component (Nylon)
  - Epoxy (Epoxy)
  - Cradle (Al, Cu, CuW)
- Input Conditions
  - 1200 W power input
  - Initial temperature - 300° K
  - Convection from Surfaces – $10 W/m^2K$
- SolidWorks Thermal Analysis Software

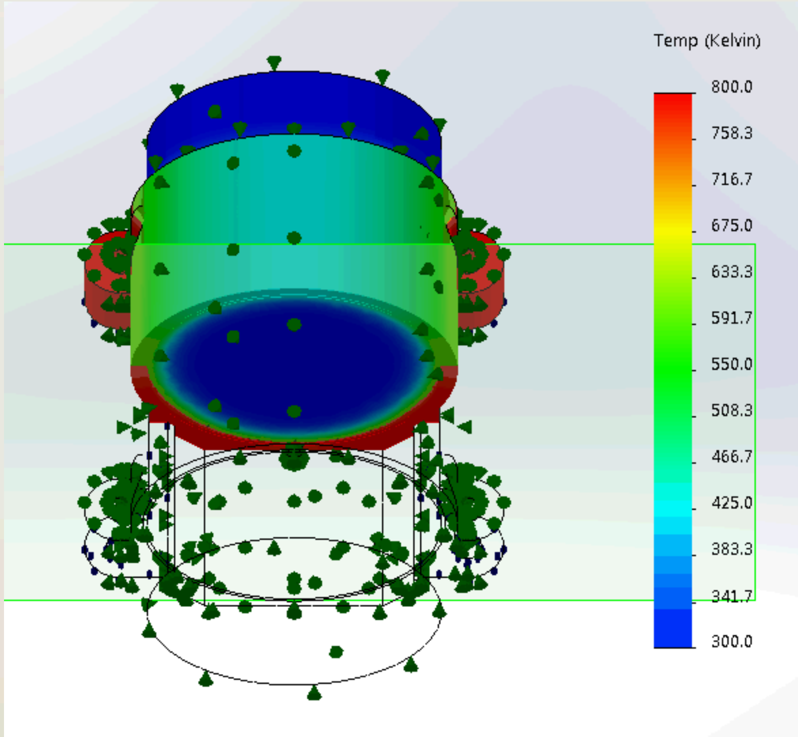
Assumptions

- Power Input to component Cradle in Mount Faces Only
- Constant Power Input to Cradle
- Initial Temperature 300K

Configuration Used for Thermal Analysis

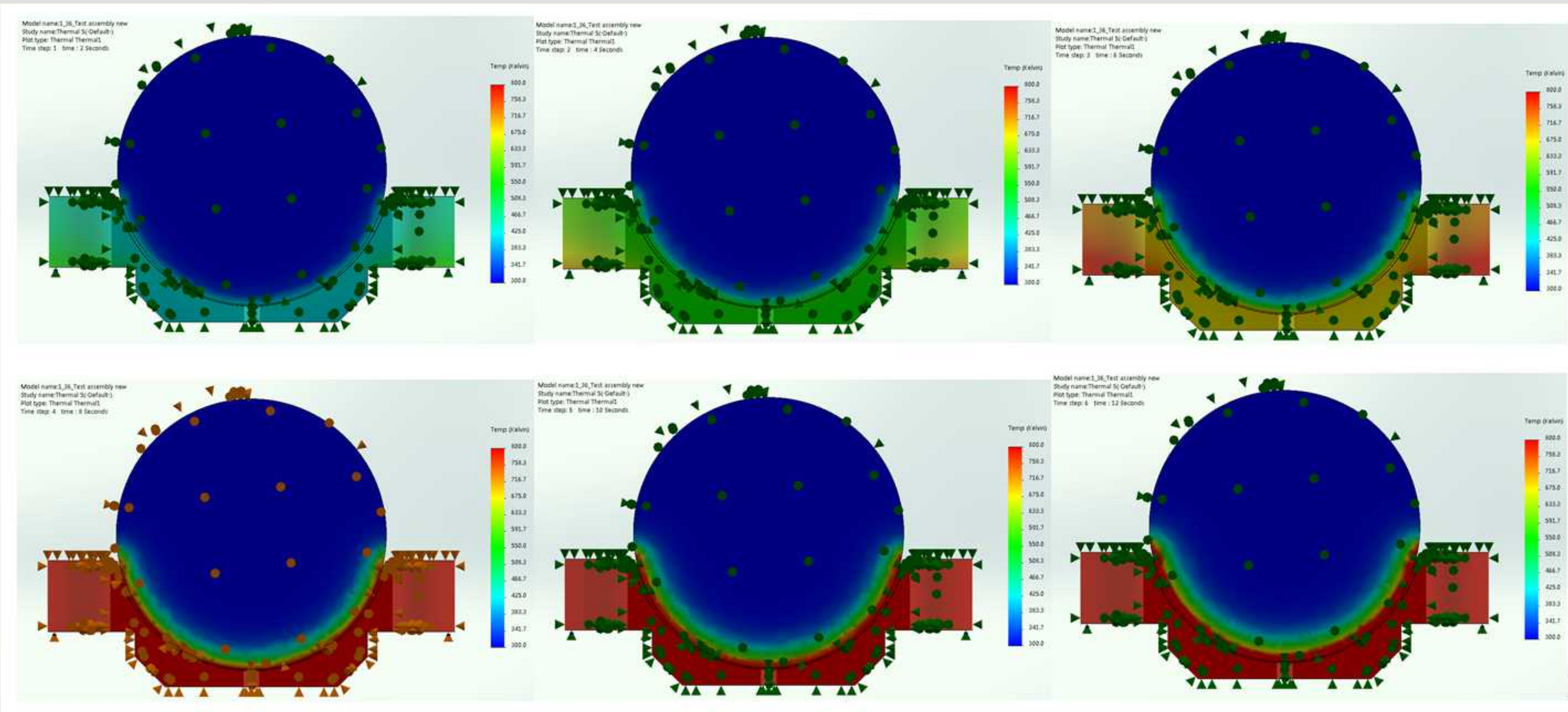


Example component geometry used in study (sprayed/machined cradle).



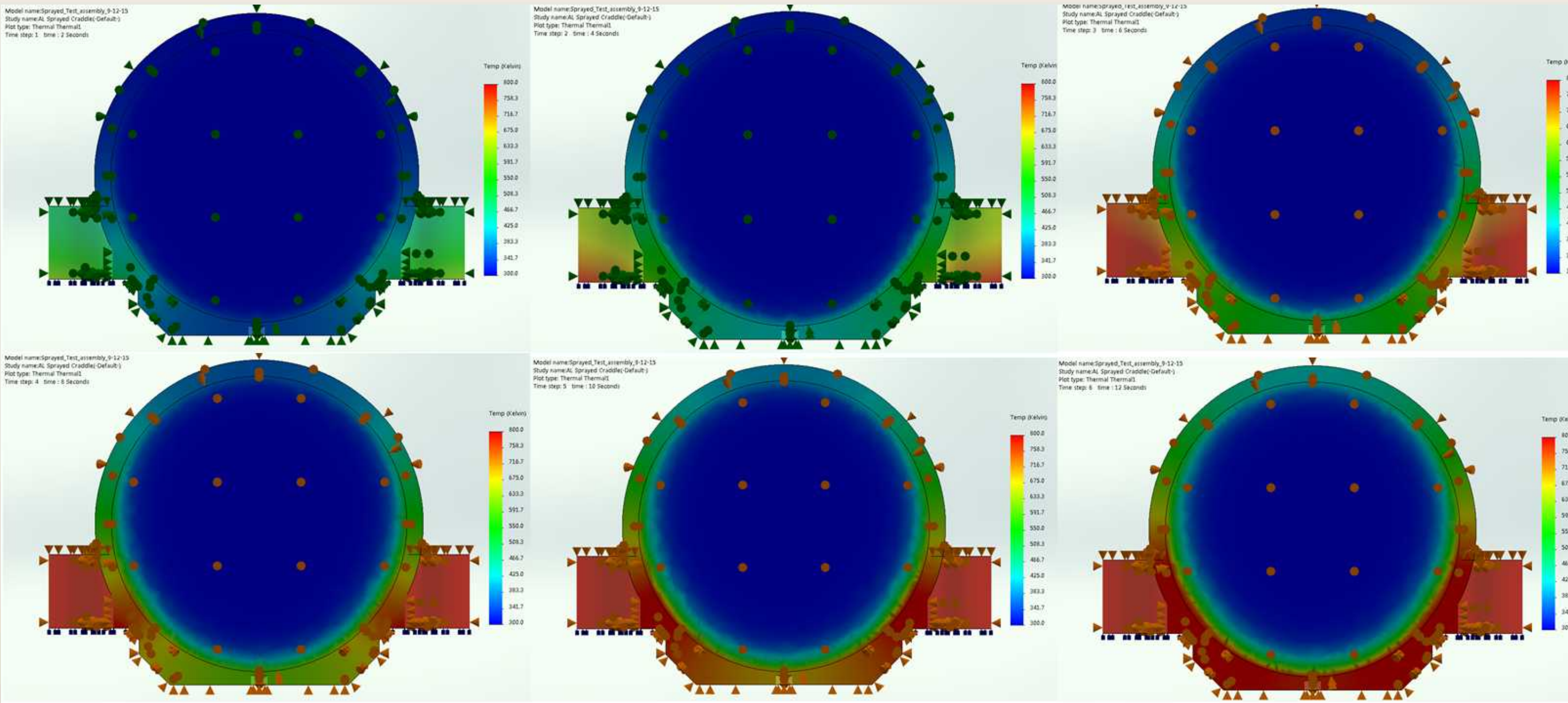
Cross-section through the middle of part showing location used for all analysis results.

Transient Thermal Analysis Results
Traditional Component/Cradle Assembly



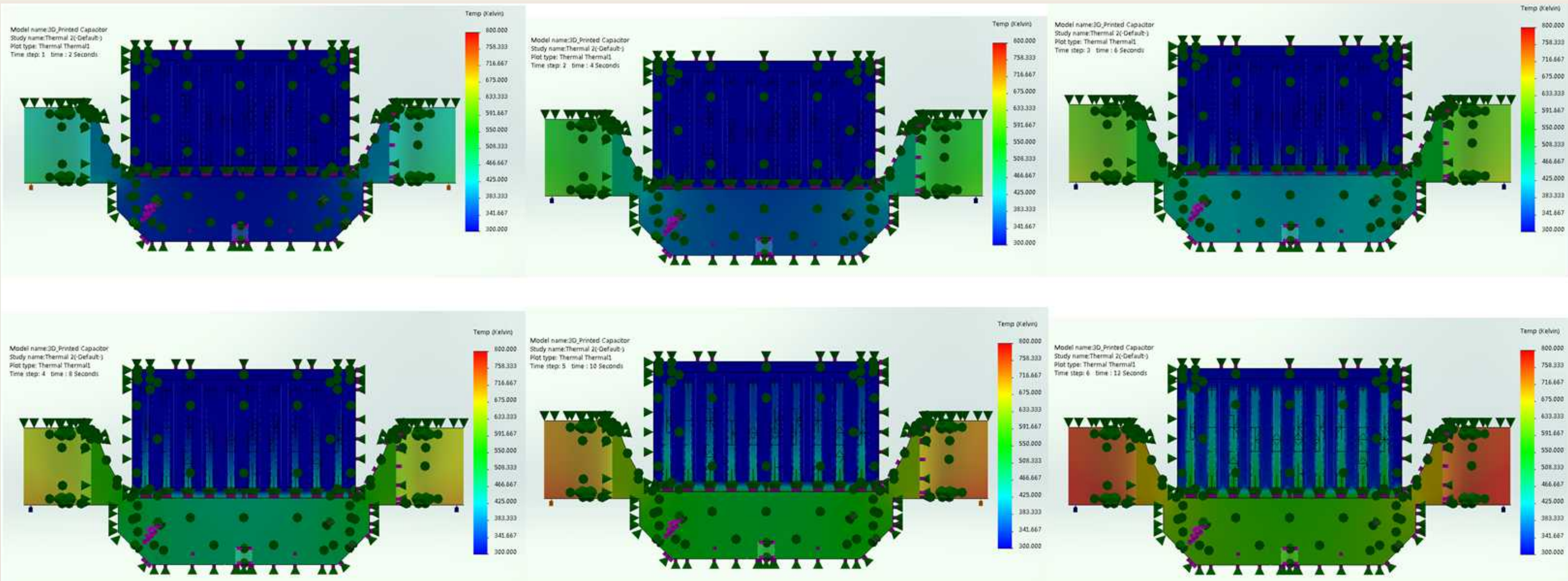
Time resolved images of predicted temperature distribution in traditional component/cradle assembly. Heat input to cradle mounting faces. Note time sequence is for 2 second intervals.

Transient Thermal Analysis Results
Sprayed Component/Cradle Assembly



Time resolved images of predicted temperature distribution in sprayed component/cradle assembly. Heat input to cradle mounting faces. Note time sequence is for 2 second intervals.

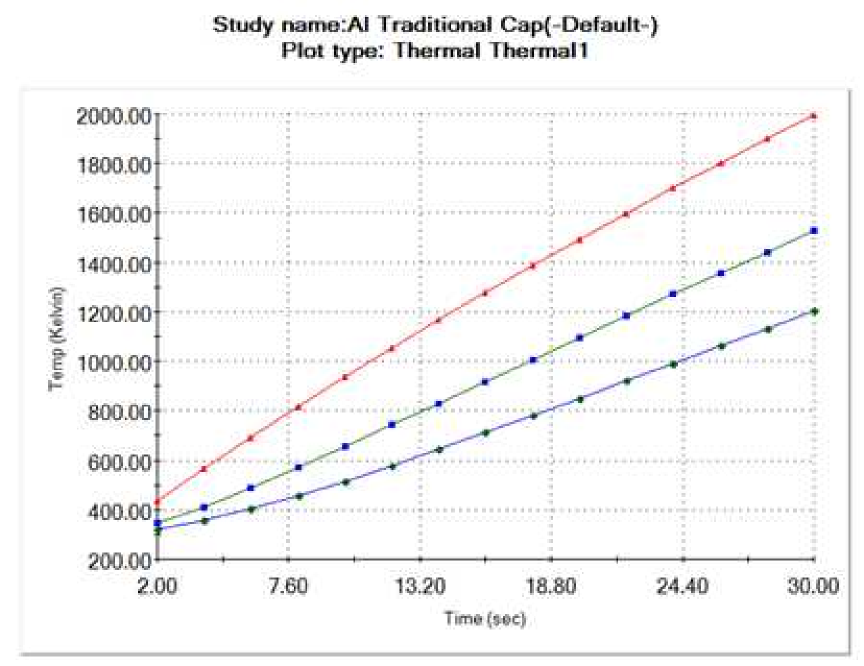
Transient Thermal Analysis Results
3D Printed Component/Cradle Assembly

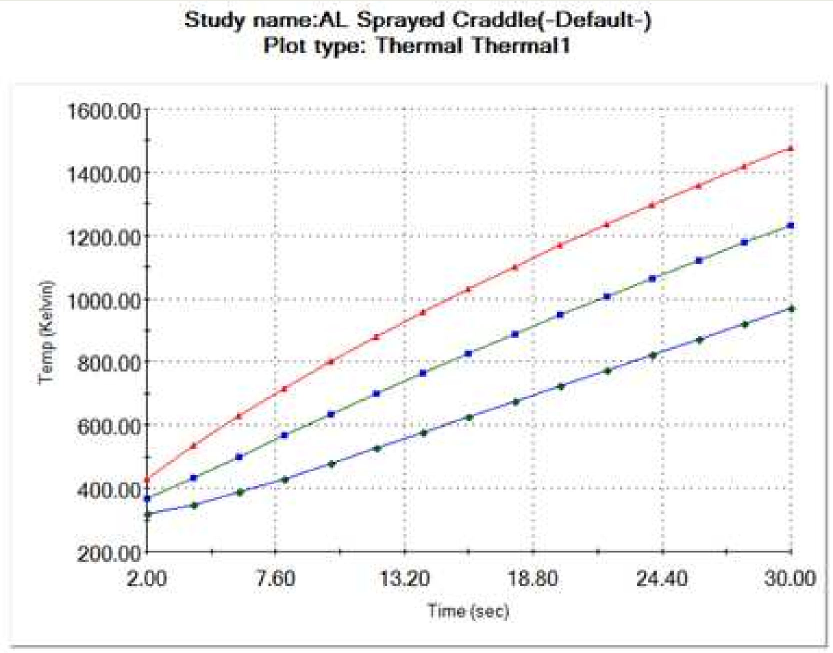


Time resolved images of predicted temperature distribution in 3D Printed component/cradle assembly. Heat input to cradle mounting faces. Note time sequence is for 2 second intervals.

Transient Temperature Results

Traditional Assembly vs. Spray Formed

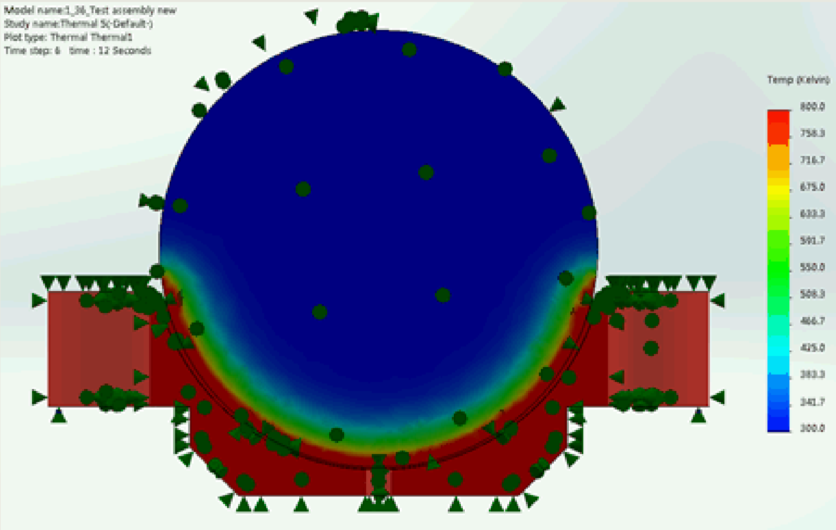


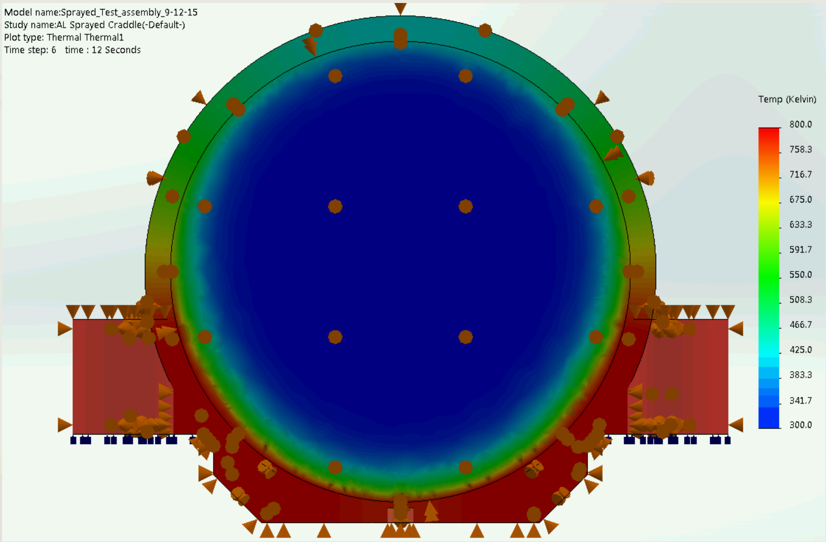


Predicted transient temperature response in traditional component/cradle assembly at points within the component.

Predicted transient temperature response in spray formed component/cradle assembly at points within the component.

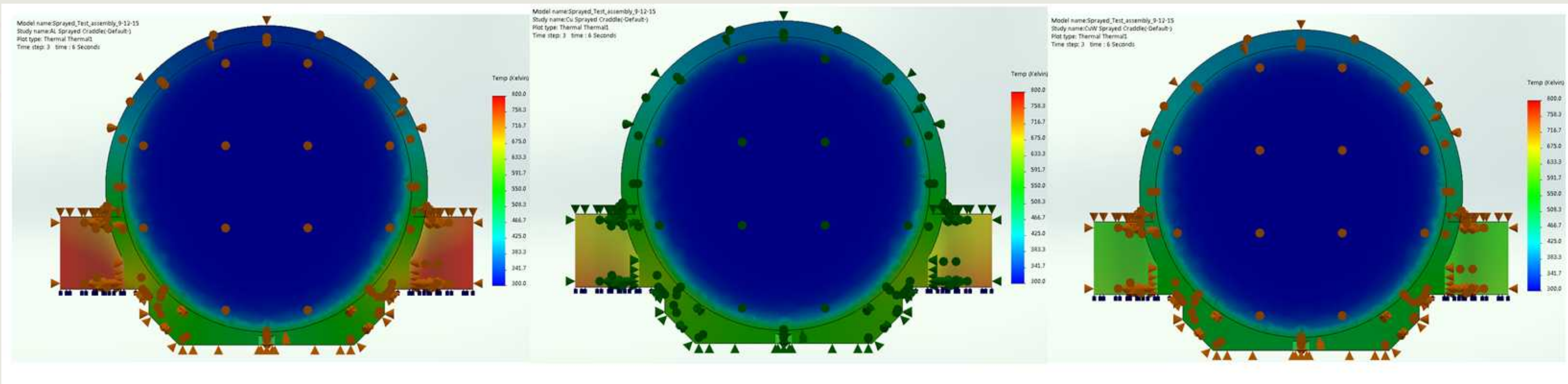
Understanding Results





It was assumed that surrounding the component would provide better thermal input to component but spray formed bracket distributes the thermal input around component resulting in a smaller ΔT and lower temperature in component.

Spray Formed Cradle with High Thermal Conductivity Materials



Spray formed Al cradle
TC = 170 W/mK

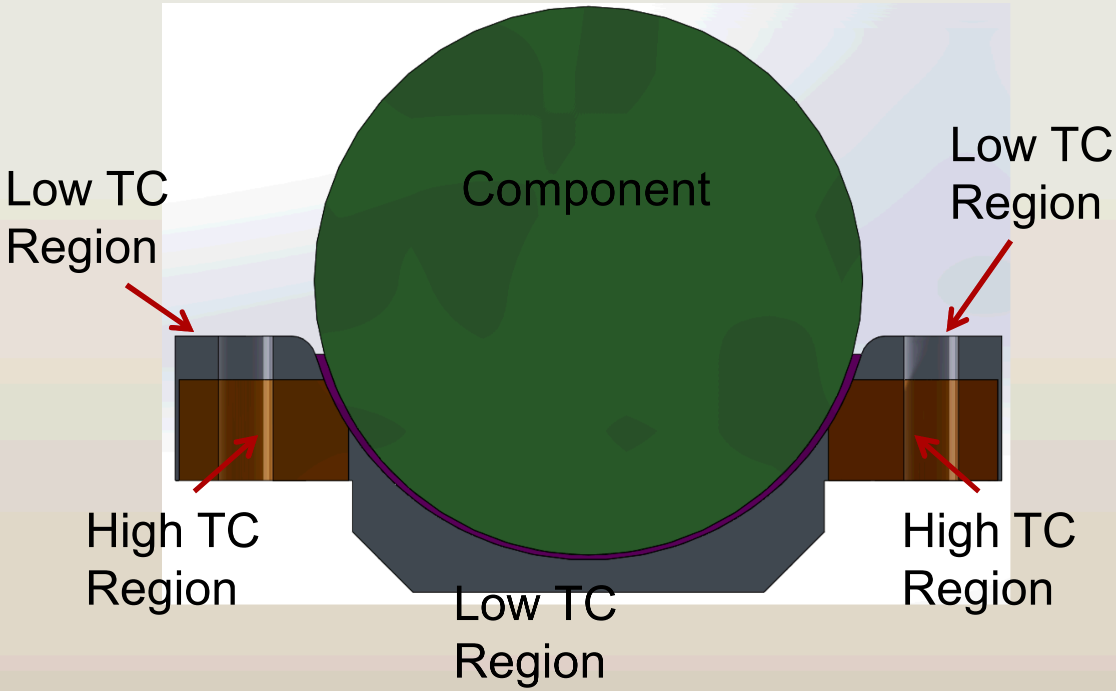
Spray formed Cu cradle
TC = 390W/mK

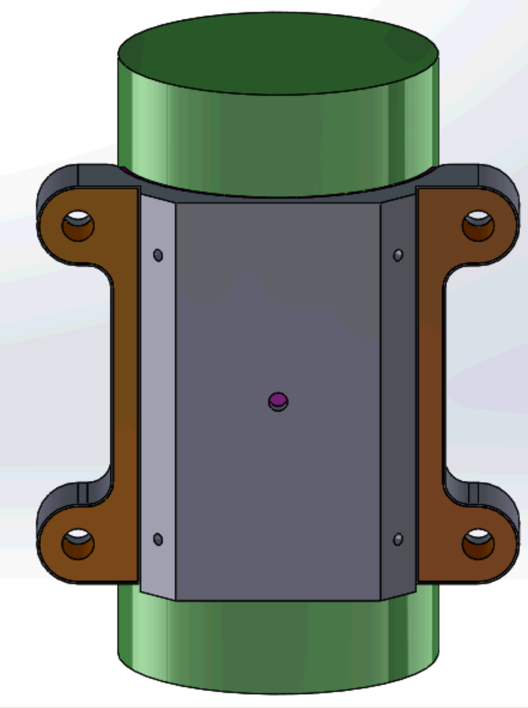
Spray formed CuW cradle
TC = 800W/mK

Result: Higher thermal conductivity serves to distribute heat more uniformly in cradle leading to lower ΔT across cradle/component.

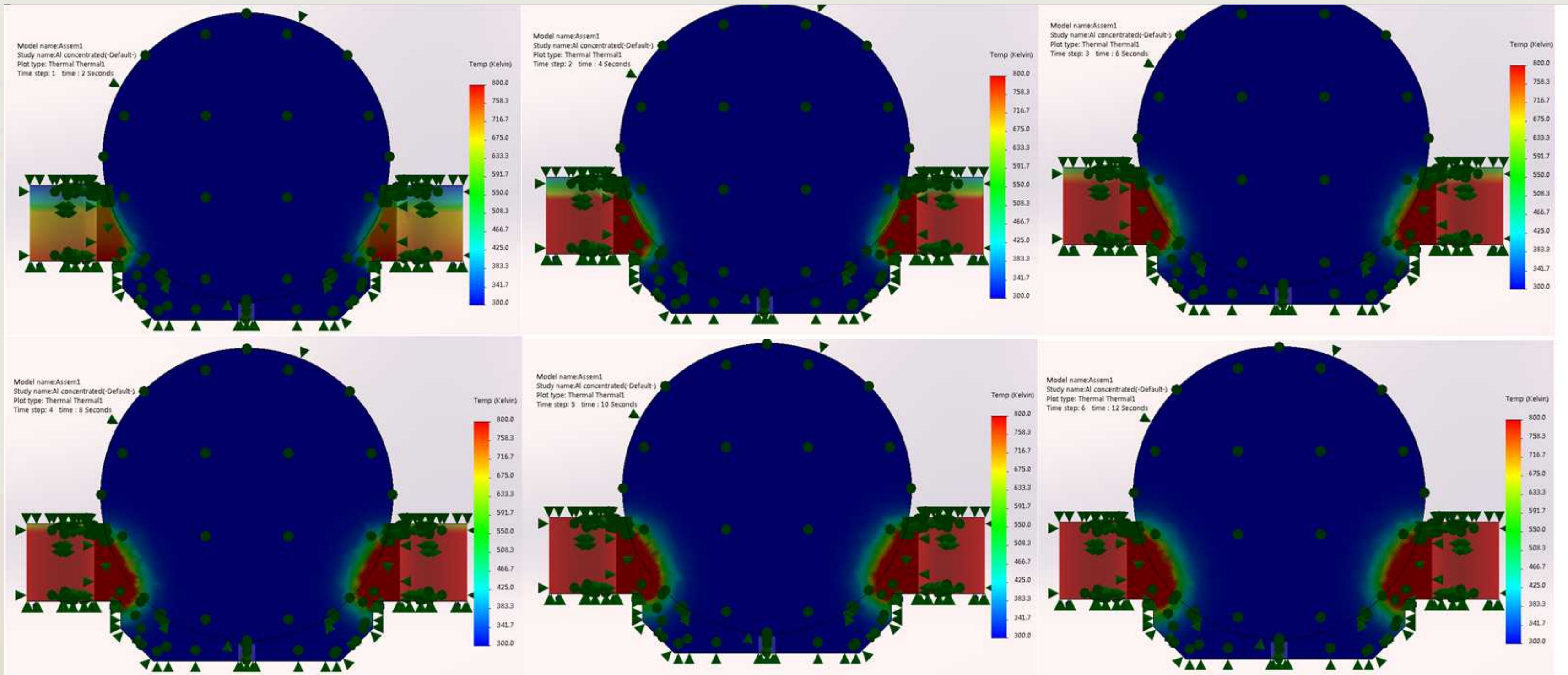
Reconsider Cradle Design

- Need to Create Larger ΔT
- Design Cradle – High Conductivity Regions Surrounded by Insulator to Direct Energy to Area of Interest to Concentrate Heat Input.



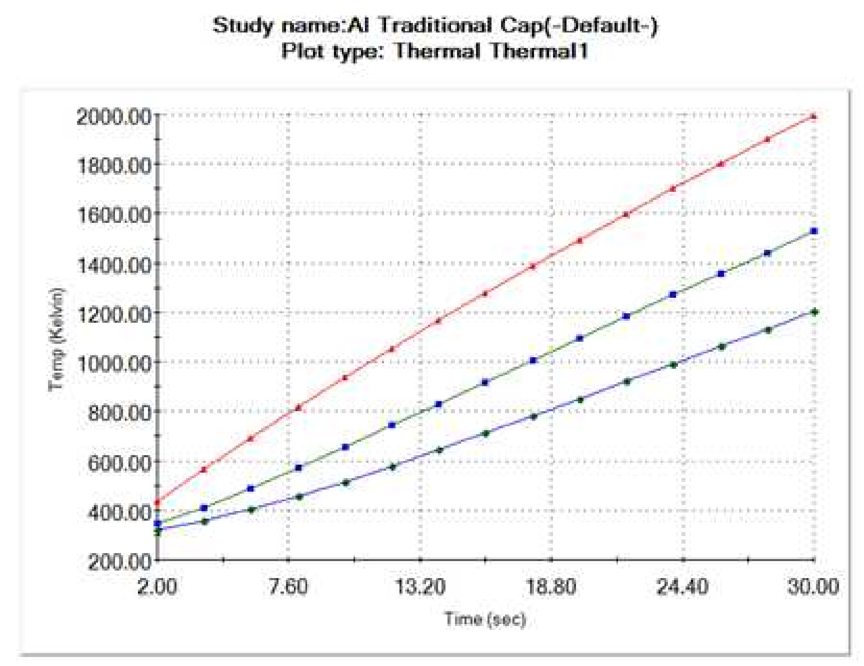


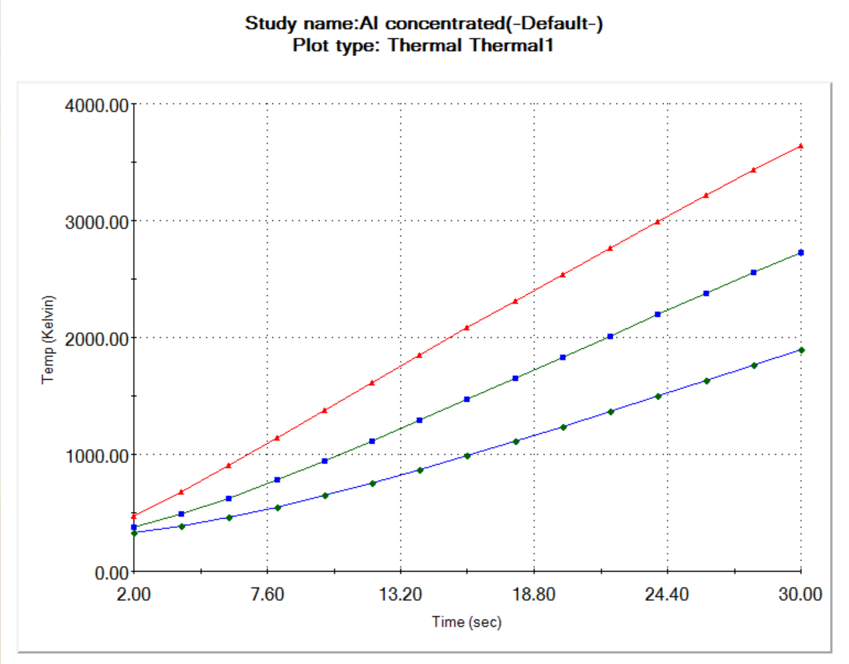
Results for Heat Concentrator Cradle Design



Time resolved images of predicted temperature distribution in concentrating cradle component/cradle assembly. Heat input to cradle mounting faces. Note time sequence is for 2 second intervals.

Transient Temperature Results
Traditional Assembly vs. Spray Formed





Predicted transient temperature response in traditional cap/cradle assembly at points within the component.

Predicted transient temperature response in concentrating cradle cap/cradle assembly at points within the component.

Summary

- Results are preliminary
- Spray formed high thermal conductivity material cradle increases time to heat component.
- Results provided insight into cradle design to enhance heat input to component.
- Analysis of concentrator design shows improvements in heat input to component.
- Concentrator design is based on AM capability.