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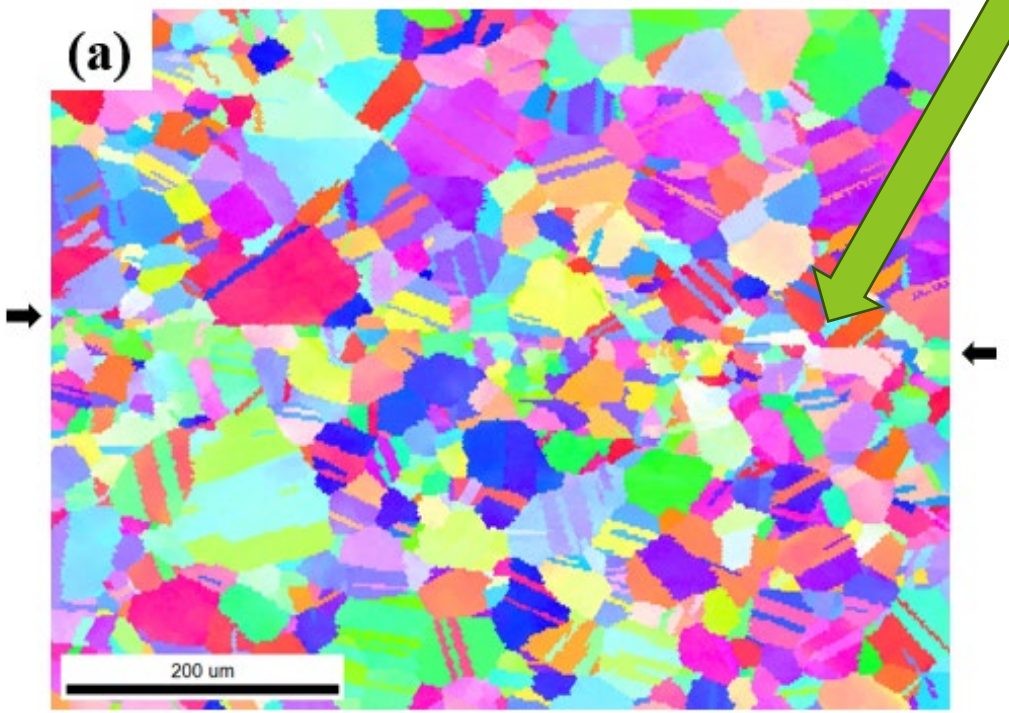
Electric Field Assisted Bonding Modeling Example Slides for Pratt & Whitney

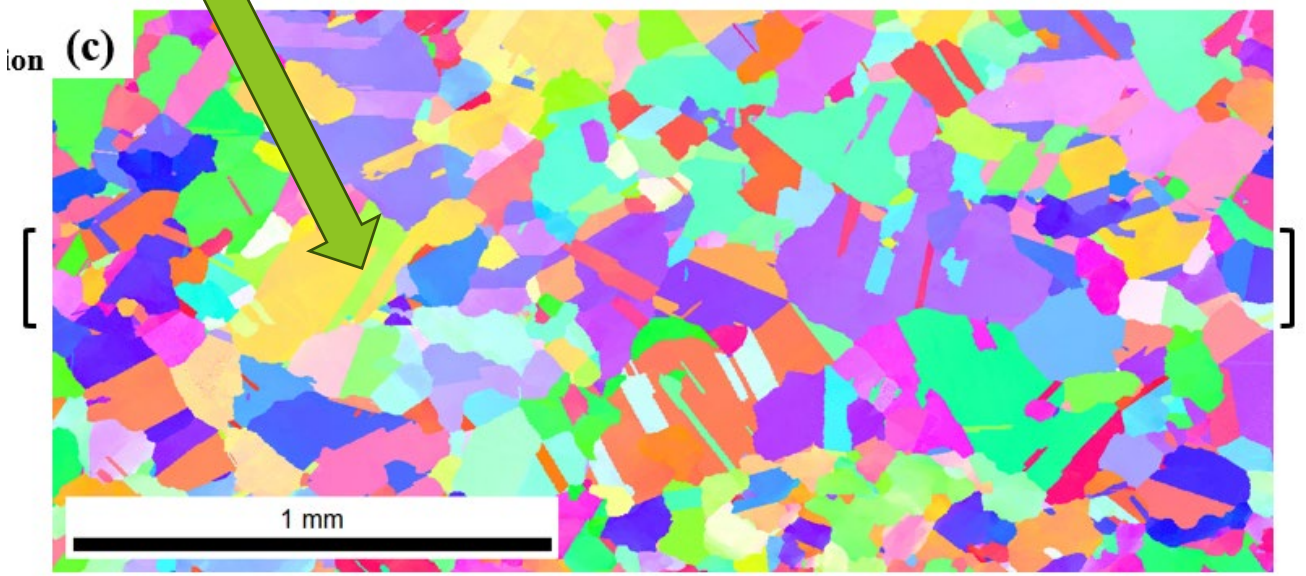
INL/MIS-23-74534 – cleared for external distribution

Idaho National Laboratory

Electric field assisted joining

When joining materials via diffusion welding, or like methods, the goal is to build and use digital tools *(models)* to shrink the experimental landscape to get from this…to this…in as few step/attempts as possible.





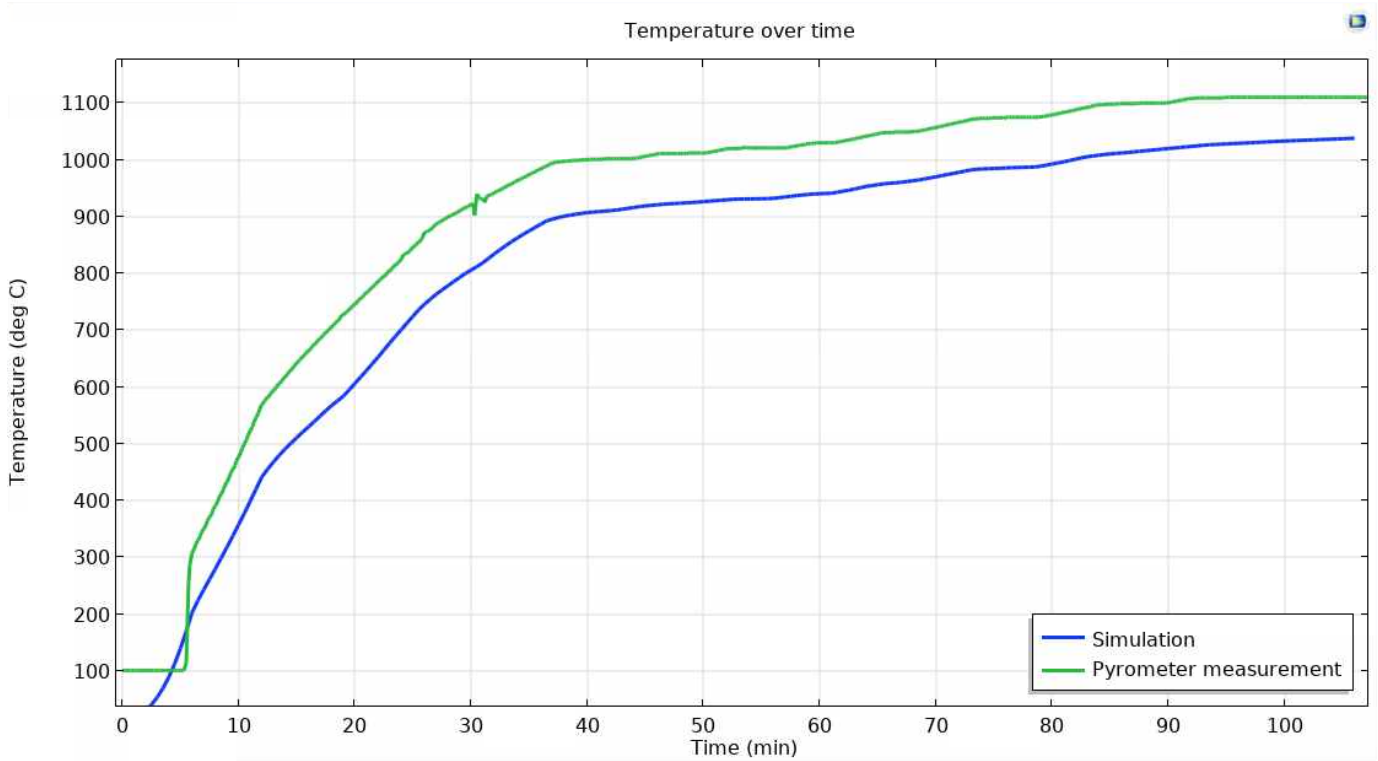
The right conditions dramatically improve grain growth across the interface.

Does the model follow the general trend of experimental data?

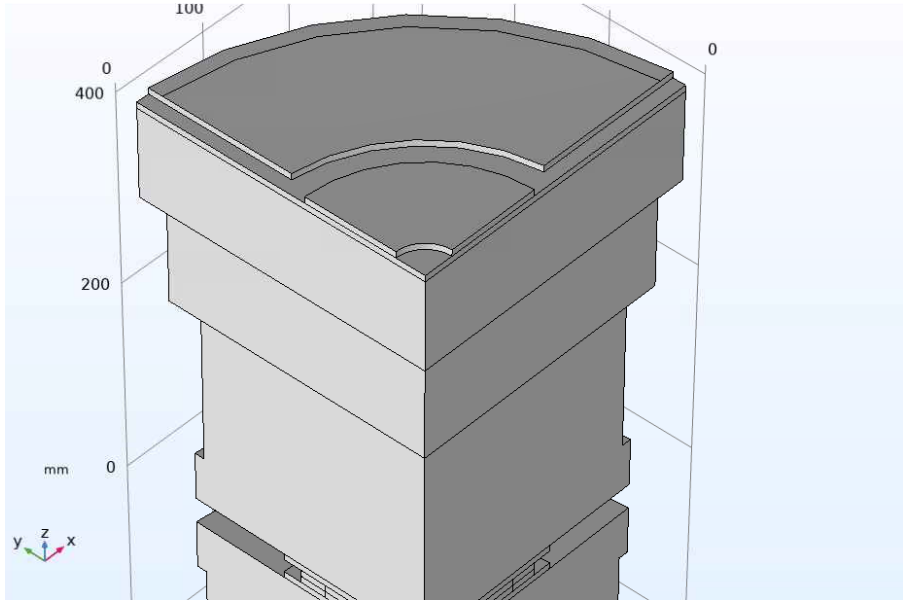
- Experimental (green) and simulation (blue) show similar behavior, but the simulation is not fully capturing the heat generated or has a heat sink that is over performing but the physics of the model make sense.

If results don't match exactly, what can we still learn?

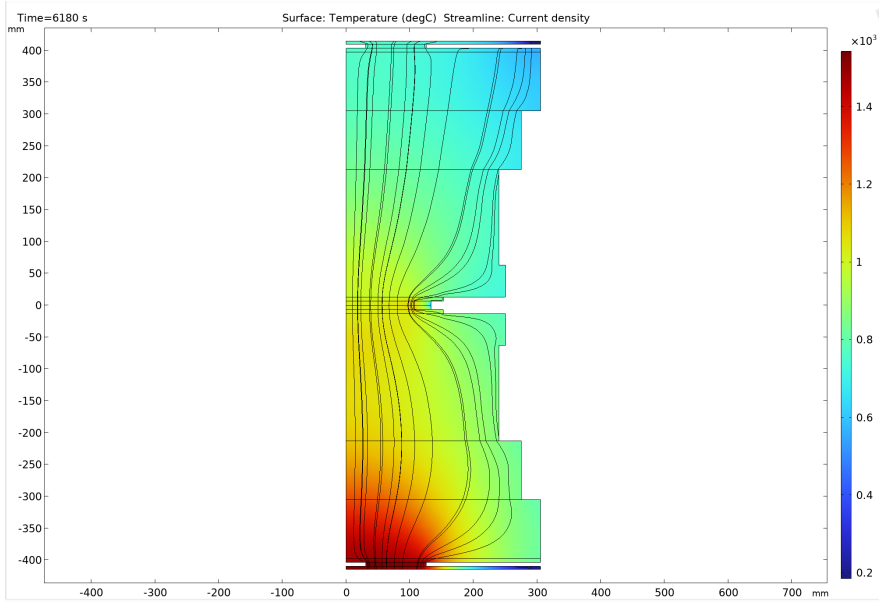
- With the simulation and experimental showing the same behavior we can make conclusions about trends rather than exact values but ***often that is enough to direct an experimental effort effectively.***



Building a model



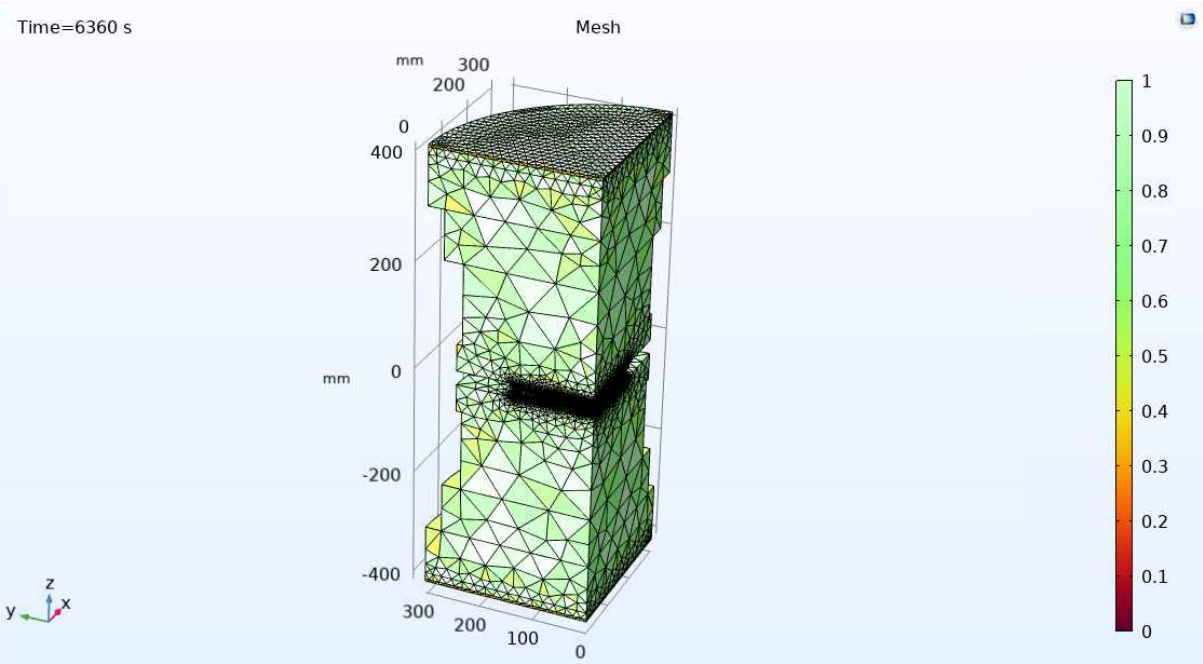
- Many details of sample, tooling, and equipment are required and need to be provided so a 3D model can be generated.

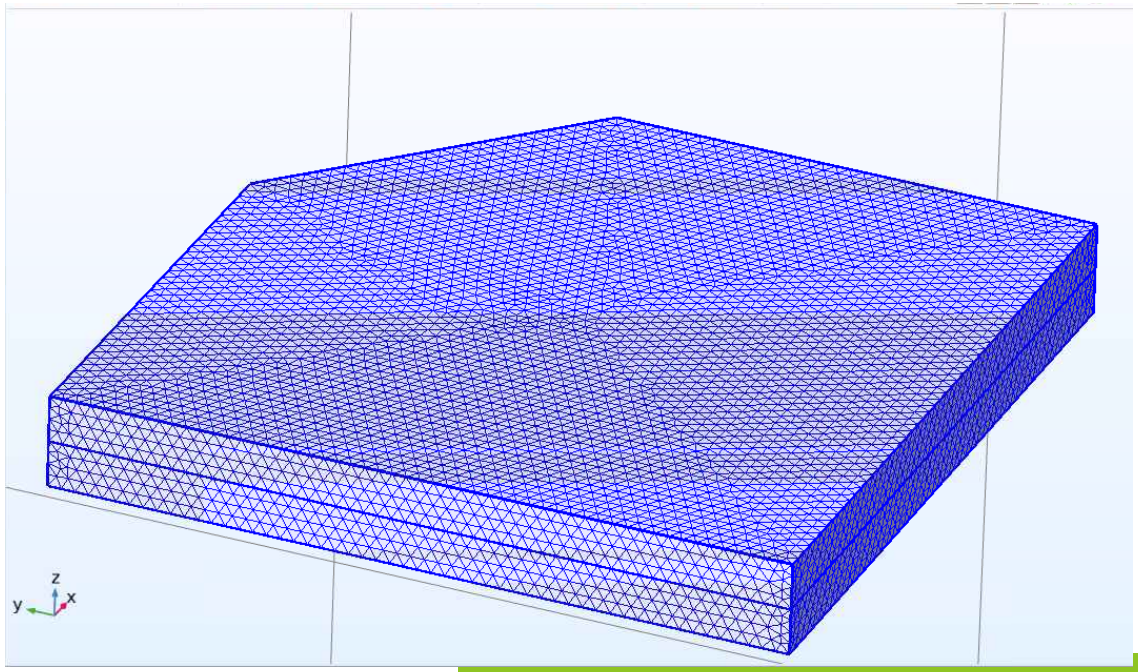


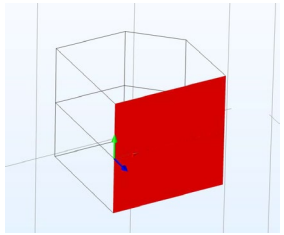
- Heat maps showing temperature profiles as well as current density are created once all the physics are incorporated.
- Temp. dependent material properties should be considered.

Determine appropriate meshing

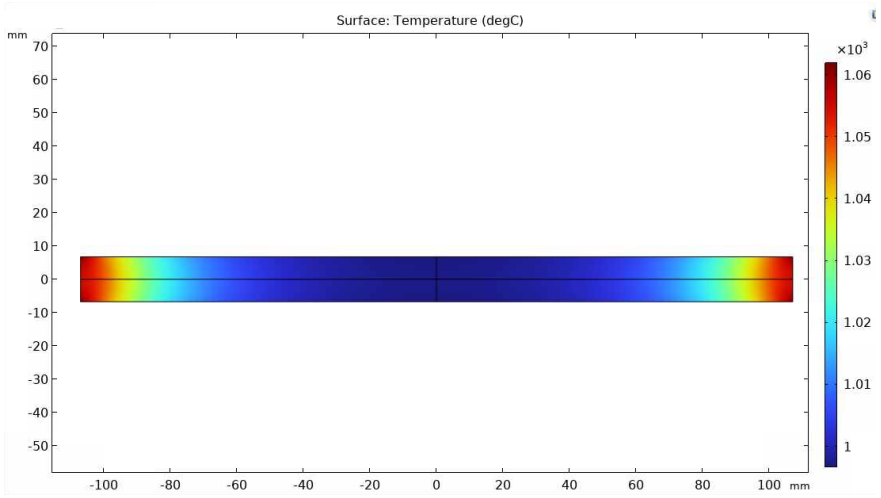
- The more complex the geometry, the finer the meshing needs to be in the model to capture what is happening accurately….HOWEVER
- Computationally expensive → **leverage INL Supercomputer Sawtooth**

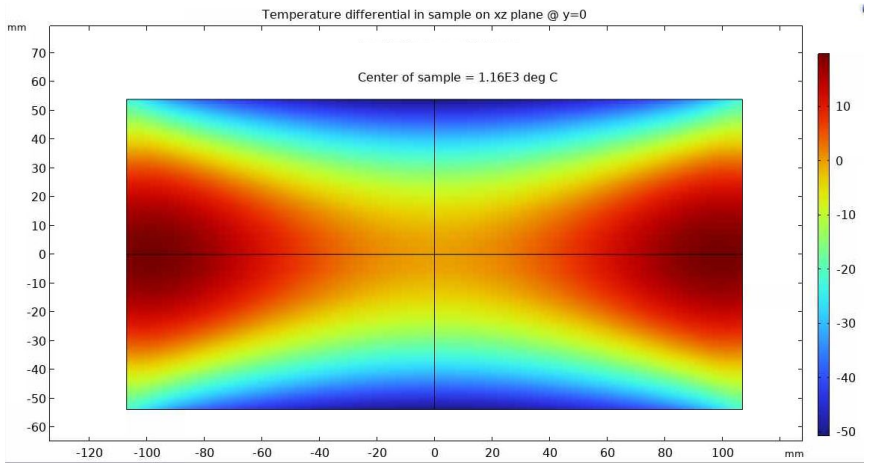


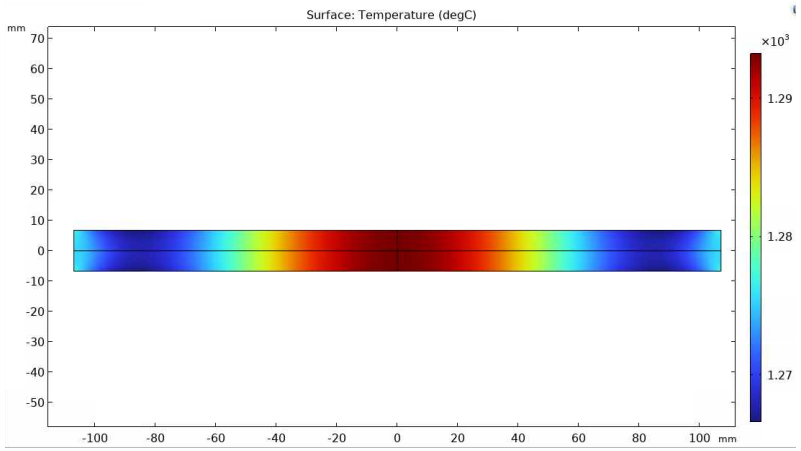


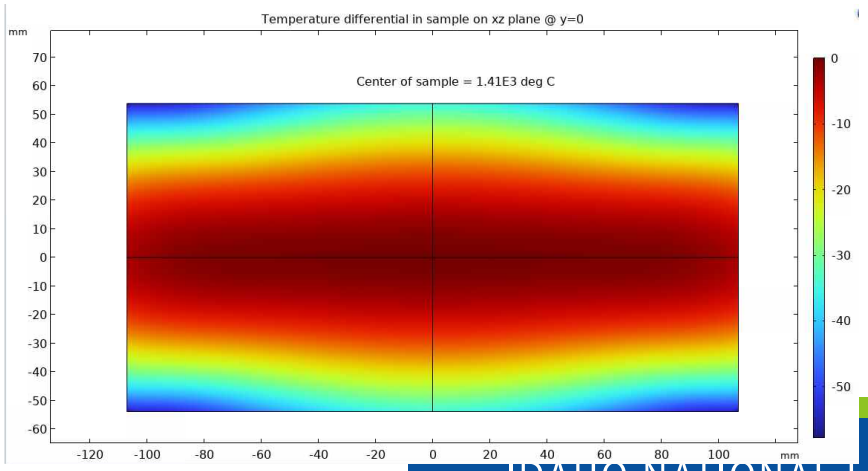


Through thickness heat profiles on thin or thick parts. Impact of punch size on vertical heat profile.

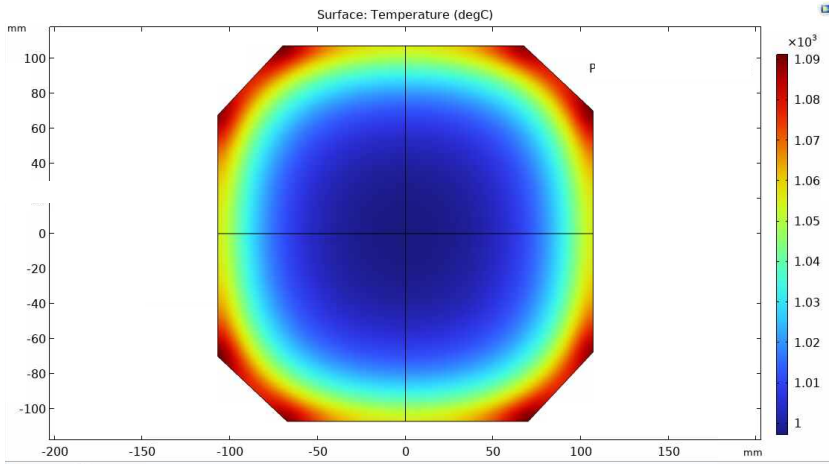


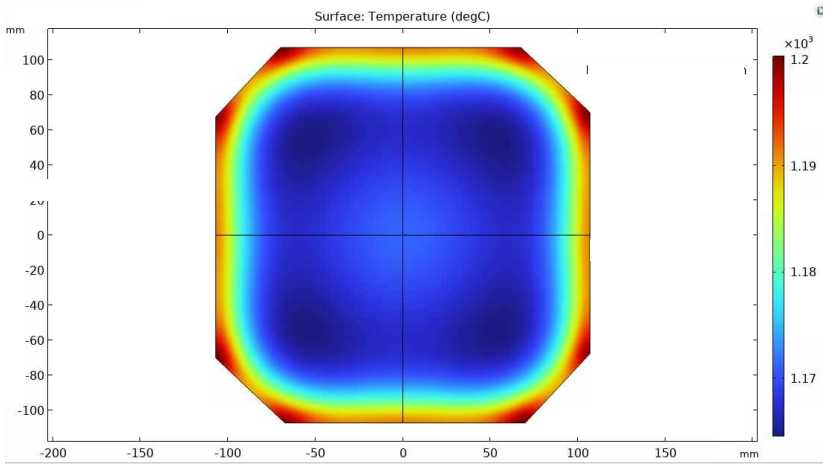


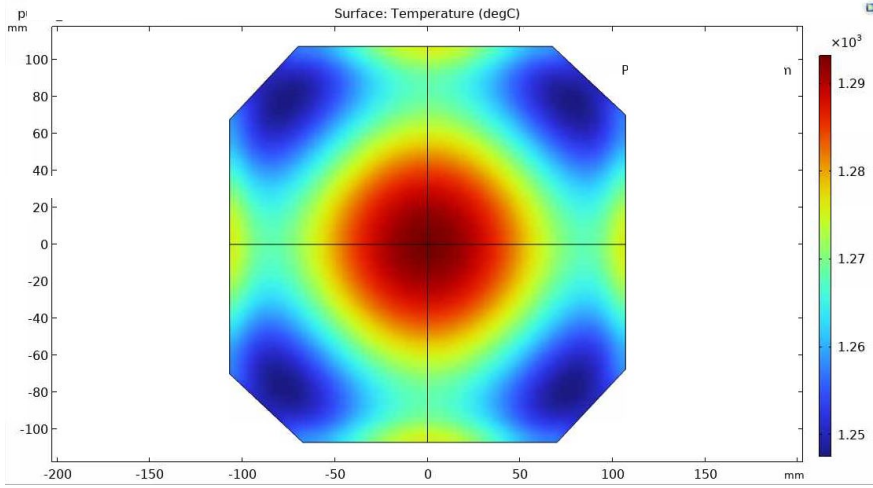




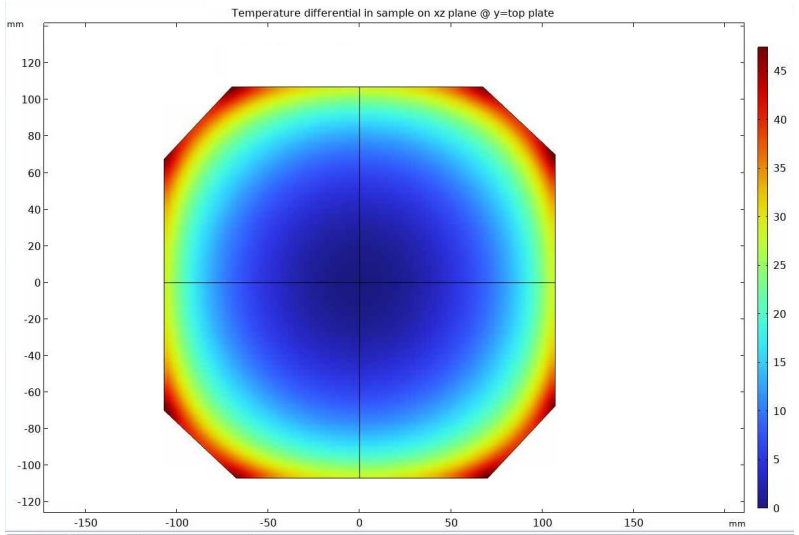
Horizontal (x/y) thermal profile through center cut of part when changing punch size.

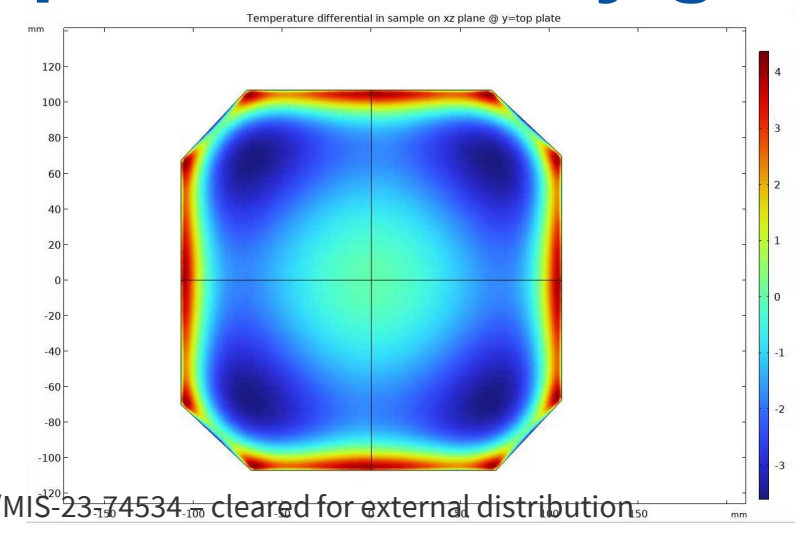


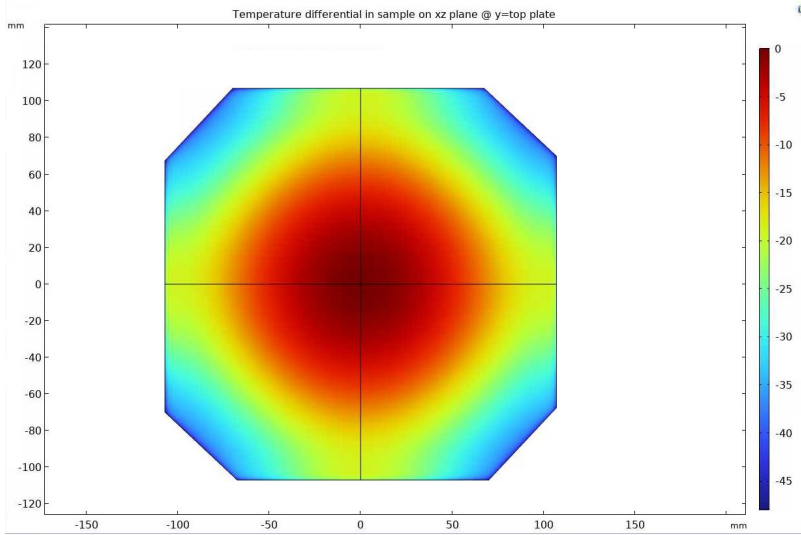




Difference in temperature at any given point

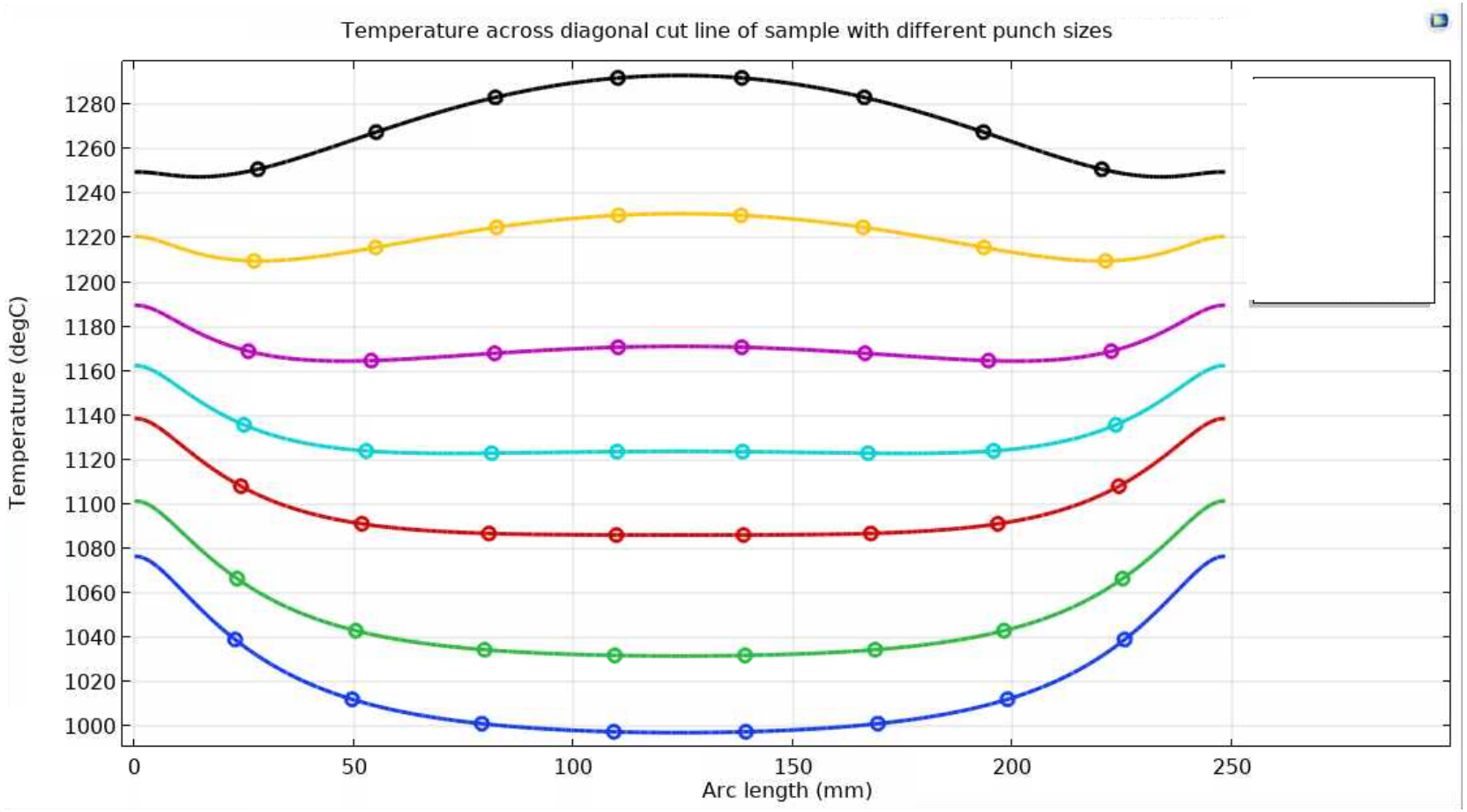


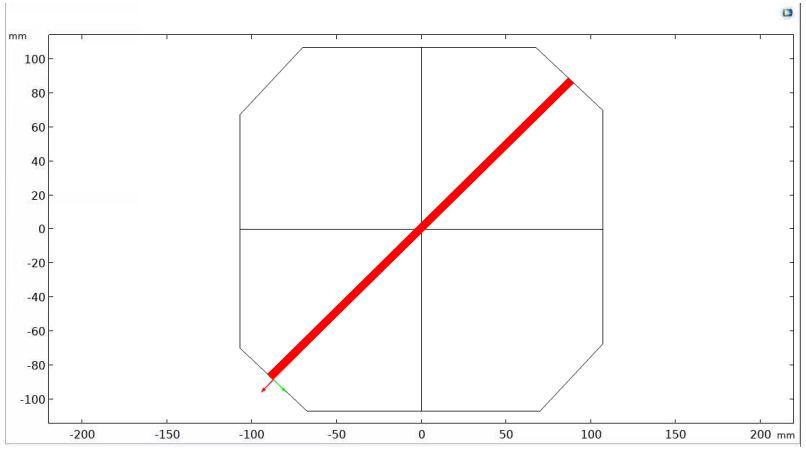




Temperature profiles with different punch diameters

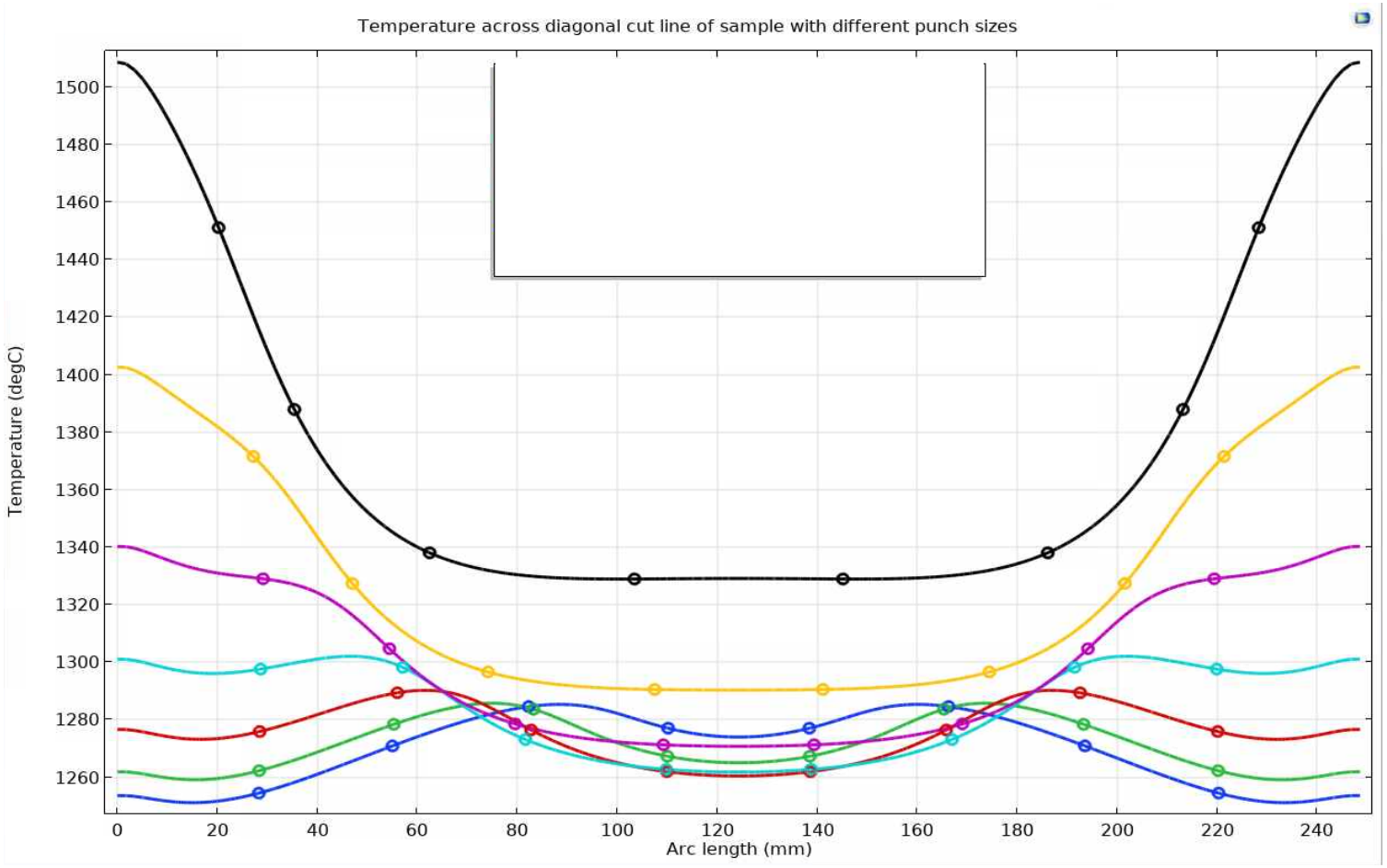
Center of the part

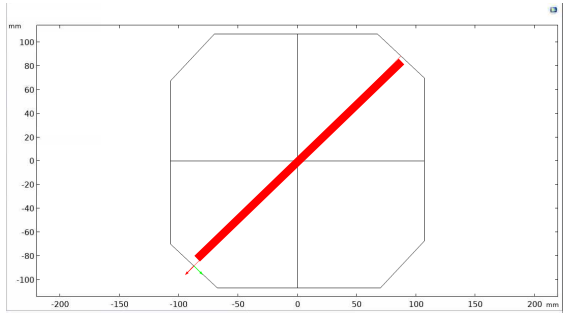




The circles are only for trend line representation (model data points separated by ≤ 2 mm)

Impact of different diameter of insulation on electrical current flow within the die/sample ensemble and resultant heating.





- Changing the size and shape of insulating area can impact heat uniformity within the mold, center to edge.