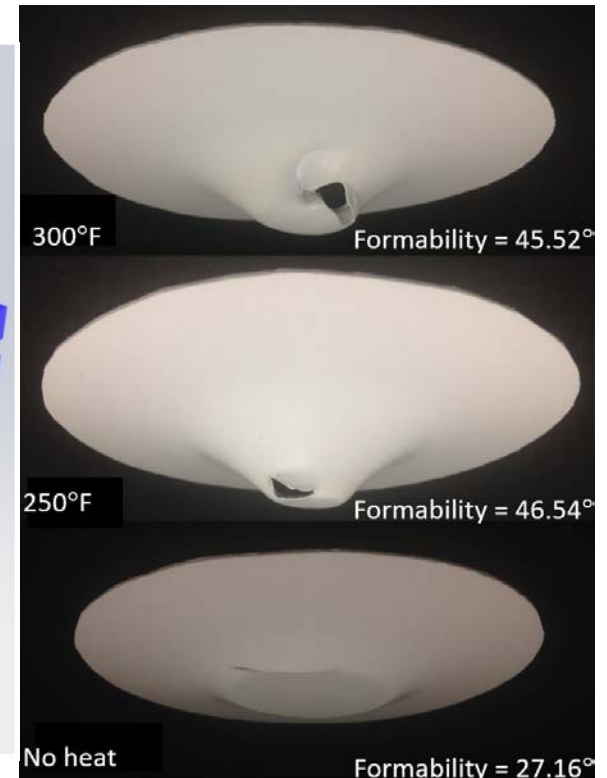
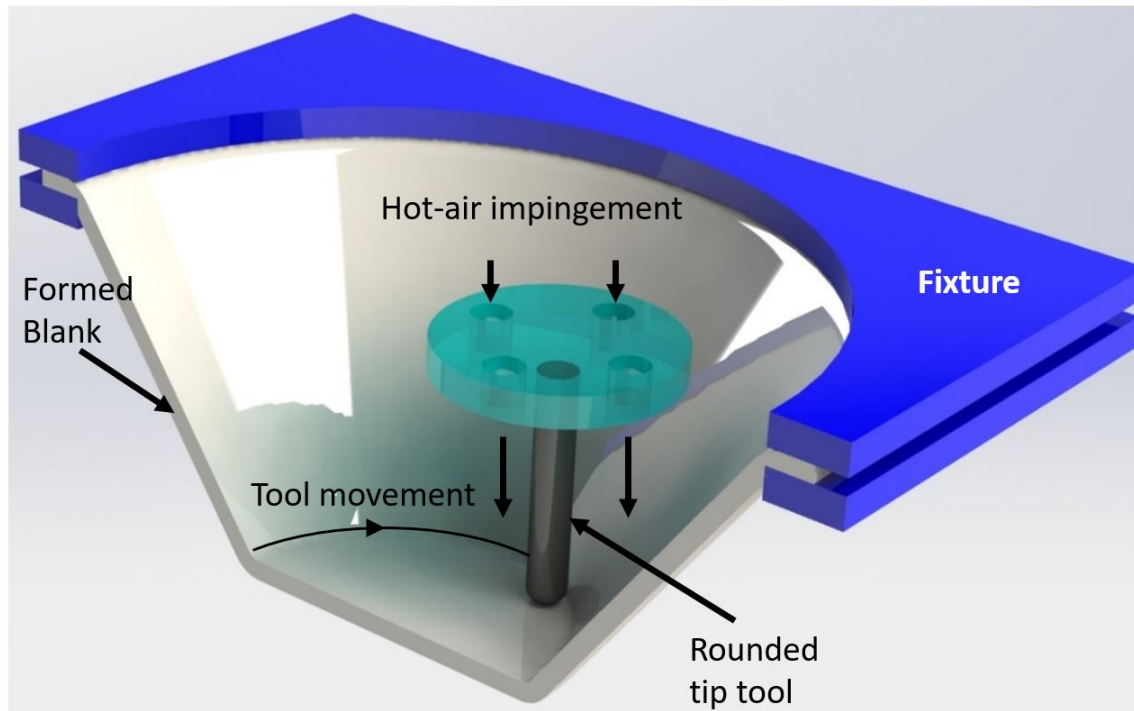

Simulation of Heat assisted Single Point Incremental Forming of polymer sheets

Shubhamkar Kulkarni

Advised by
Dr. Gregory Mocko

- Introduction
- Research objective
- Literature review
- Simulation model
- Results
- Conclusion & Future work

- Single point incremental forming is a process for dieless forming of sheets
- Localized heating has shown to improve the formability (HASPIF)



Objective: Simulation of HASPIF for improved understanding and planning

Structural
Simulation

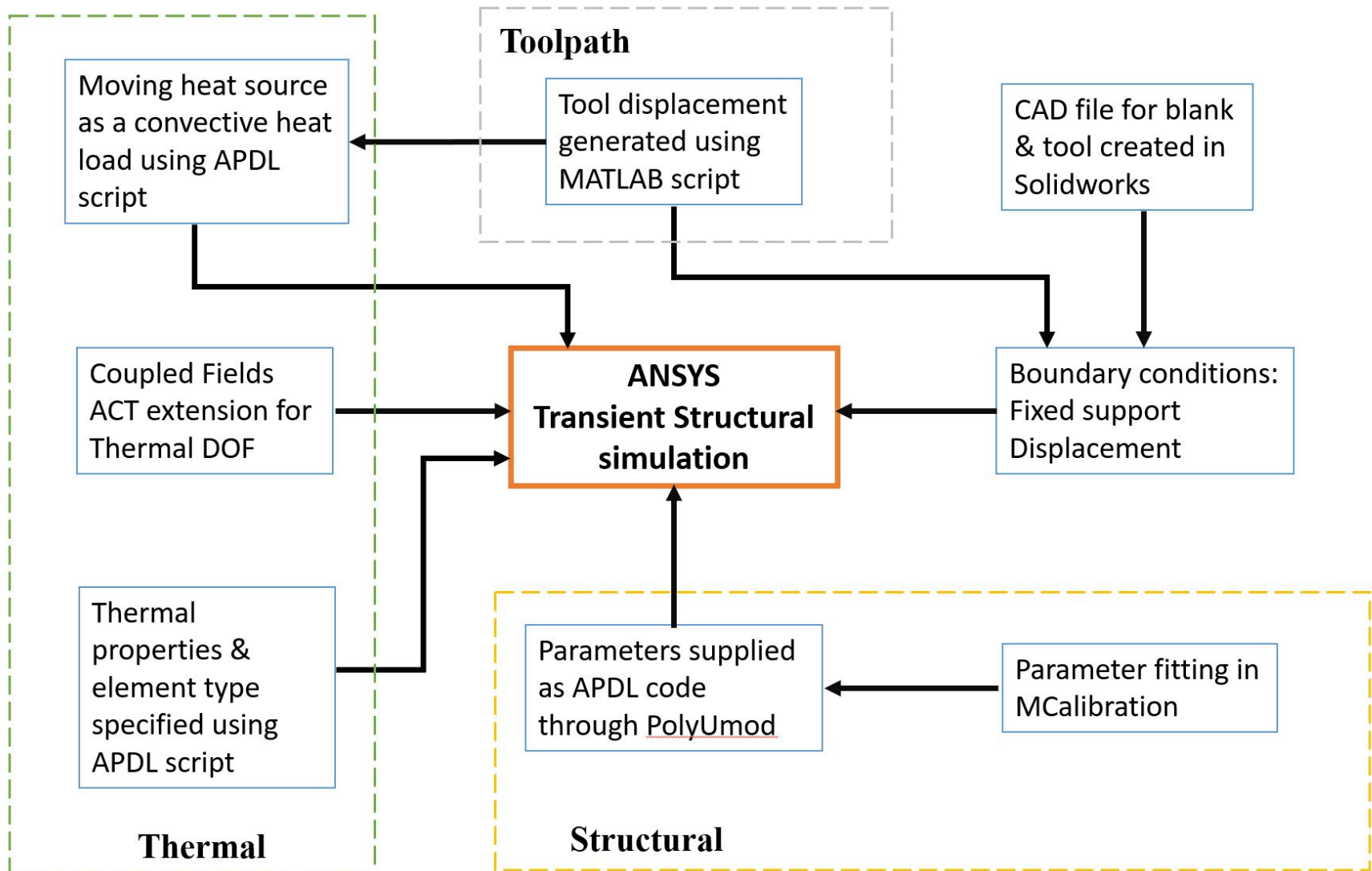
Coupled in ANSYS

Thermal
Simulation

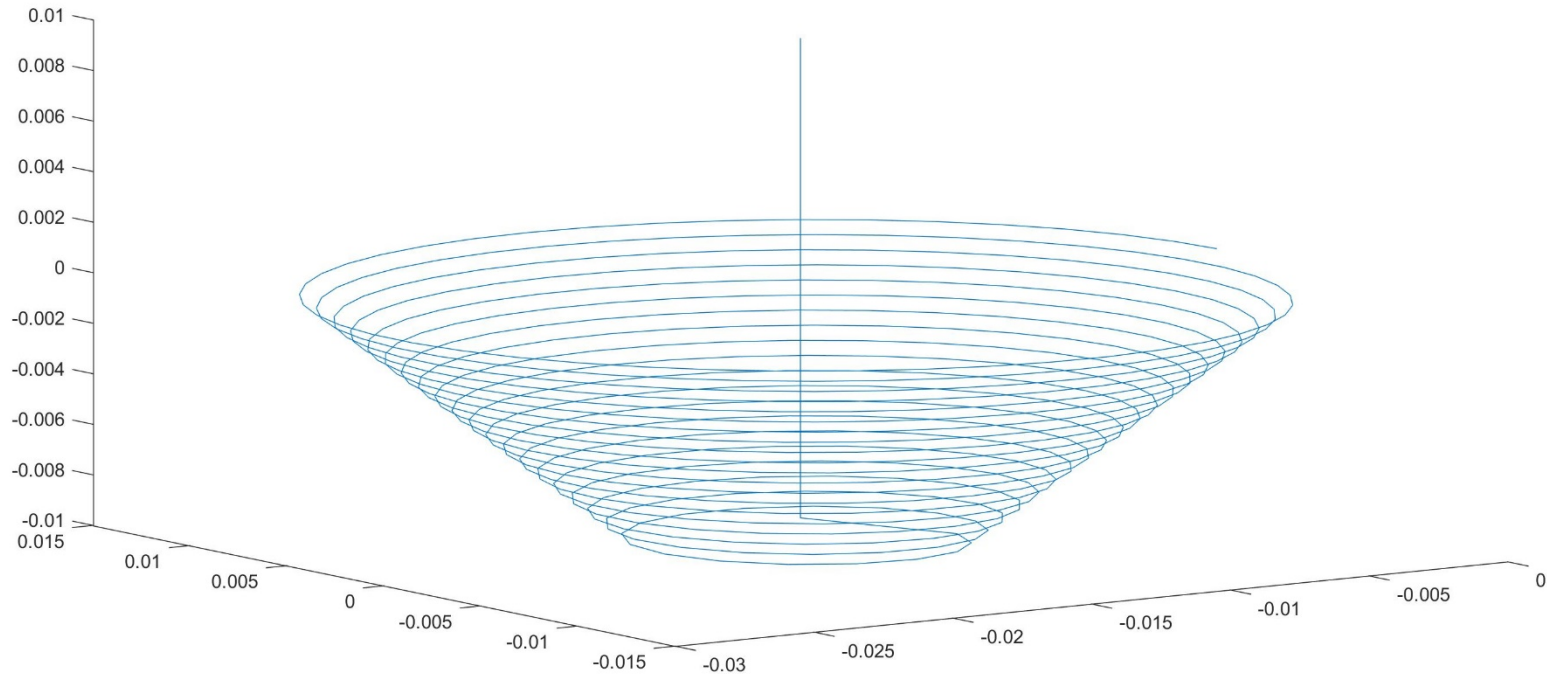
Validation

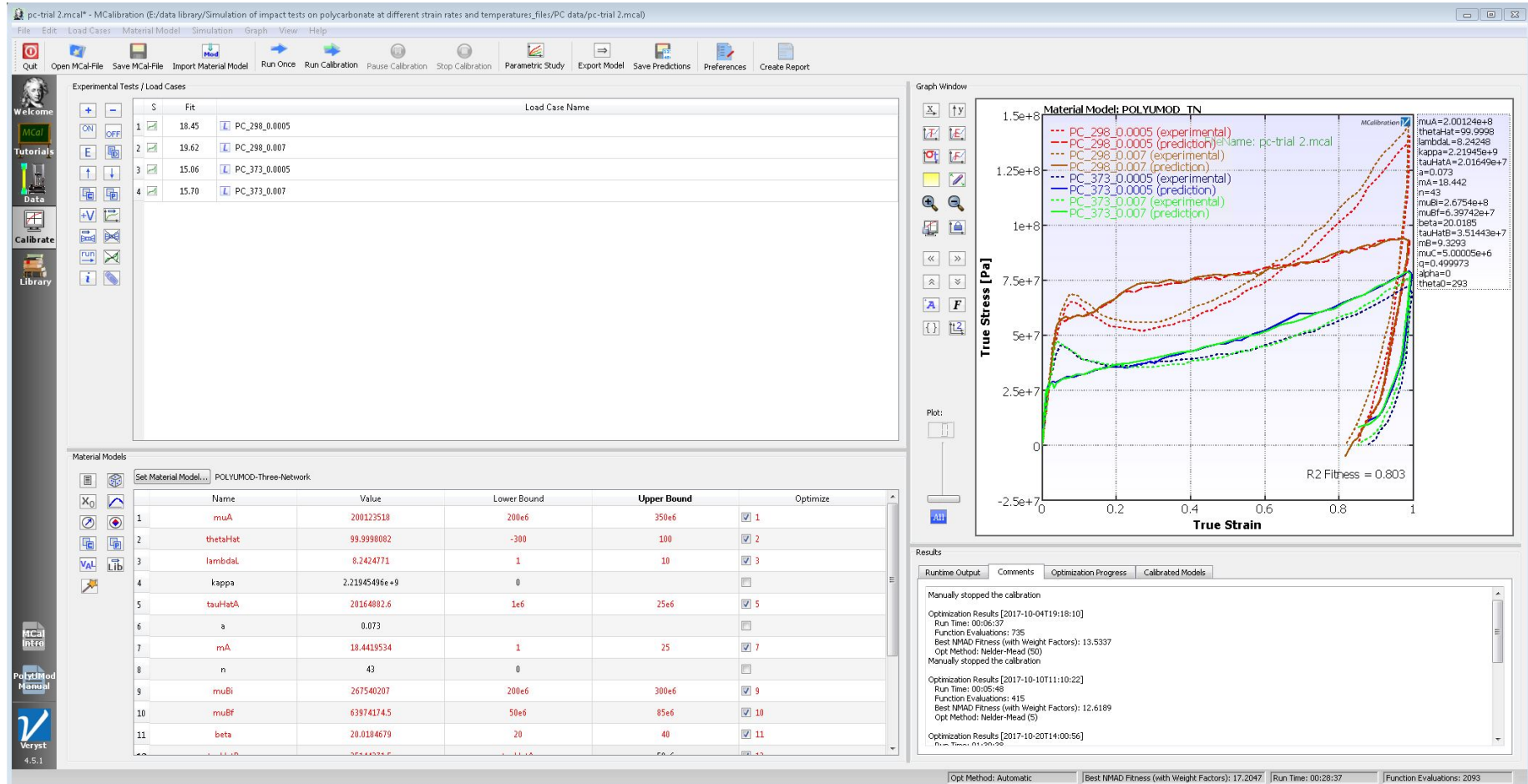
- Room temperature SPIF process has been simulated using polymer and hyperelastic material models. A clear conclusion about the best material model cannot be made
- Lack of common protocol for testing simulation models
- Computational time is high due to multiple nonlinearities (finite strains, material behavior and boundary conditions)
- Trend to develop models requiring lesser number of inputs, reduced computational time and resources
- Coupled thermo-mechanical simulations only developed for metals (only for laser assisted SPIF)
- Impingement heating using specially designed nozzle-tool has not been simulated

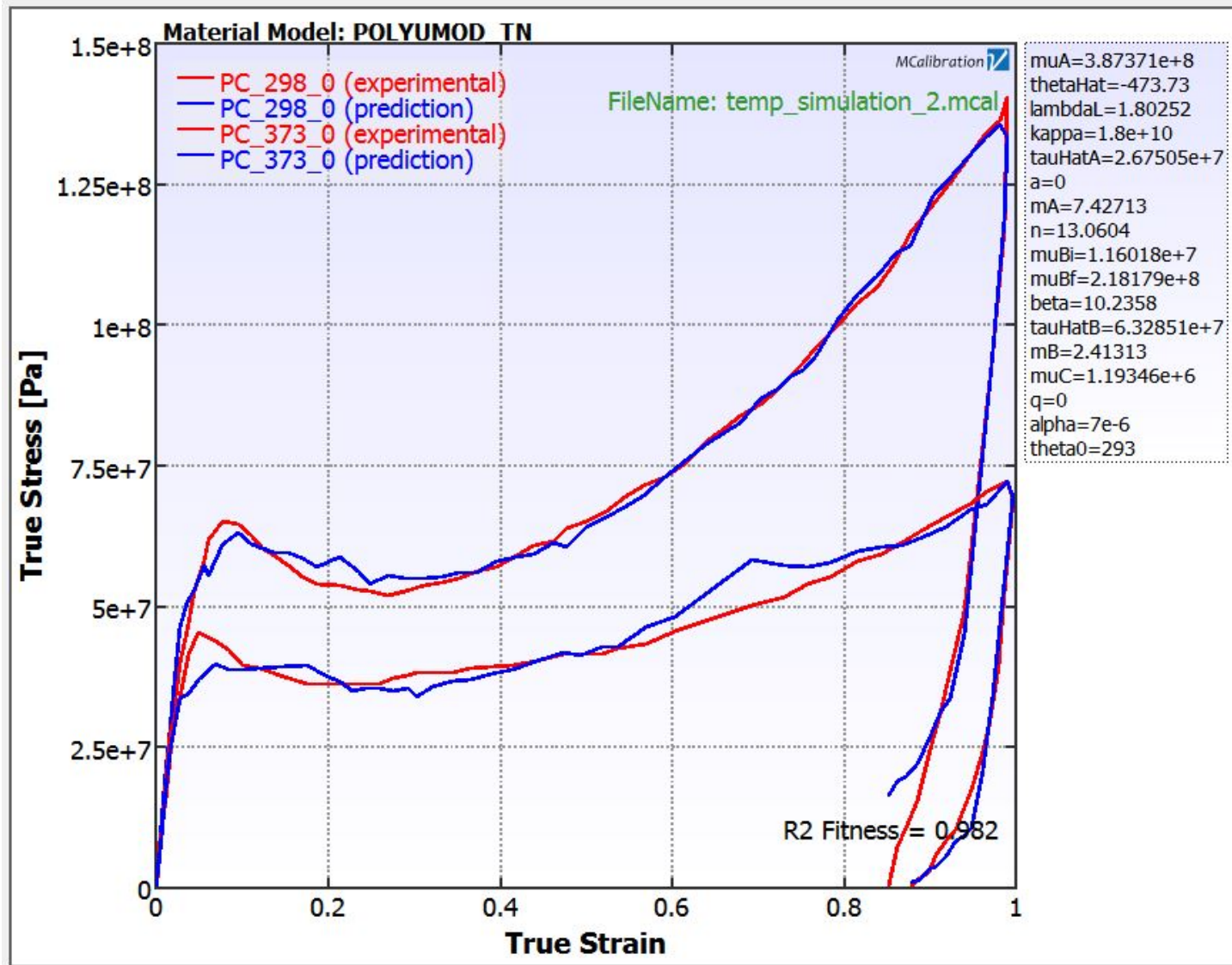
Sr.No	Model Name	Implementation
1	Gomma/Le	Usermat routine in ANSYS
2	Yonan	Usermat routine
3	Response Function	Inbuilt in ANSYS
4	Three Network Model	From Veryst, Inc.



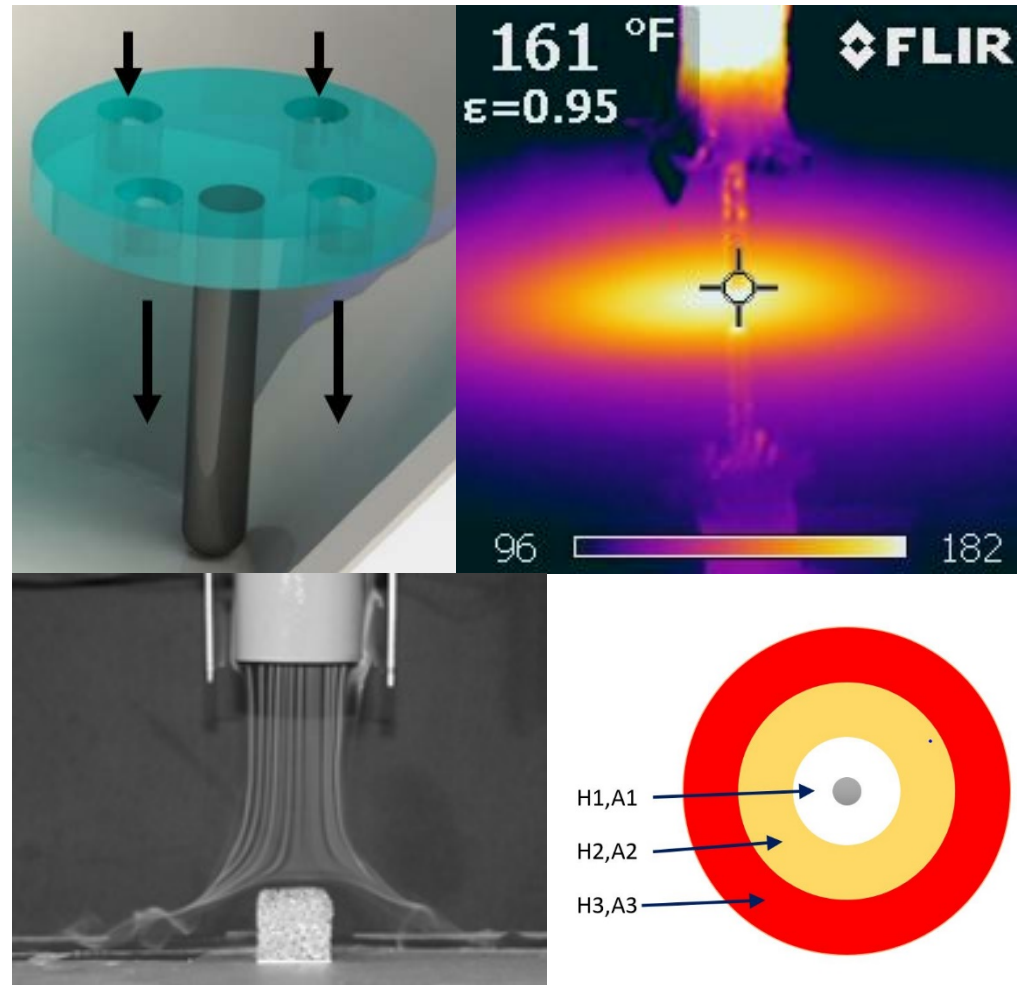
- MATLAB code for generating spiral type tool path for a cone
- Variables: initial radius, slope, layer size, feed and the duration
- Also generates the G-code







- Hot air impingement through nozzles around the tool heats the sheet
- Simulated as convective heat load (HTC distribution)
- Convective load applied in a circular region around tool
- Empirical correlations exist but presence of tool affects flow pattern



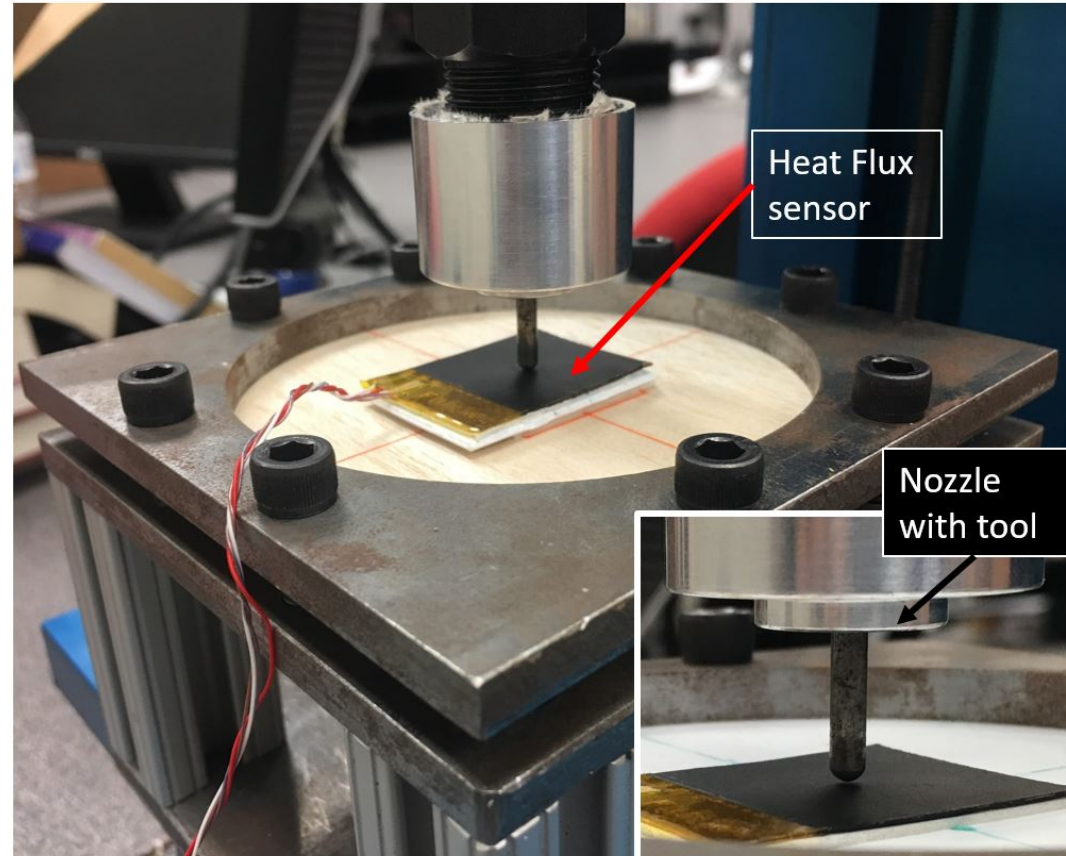
- Heat Flux sensor used

$$\text{Energy} = Q = hA\Delta T \quad (1)$$

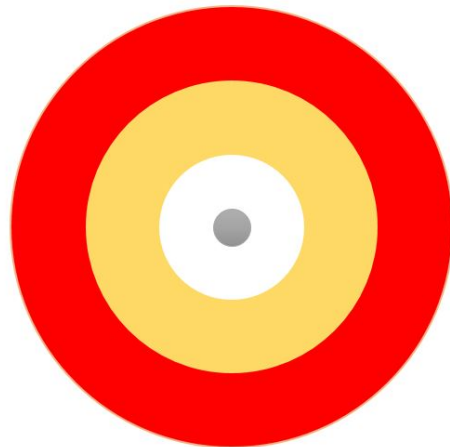
$$\text{Heat Flux} = \frac{Q}{A} = h\Delta T \quad (2)$$

$$\text{HTC} = \frac{Q}{A\Delta T} = h \quad (3)$$

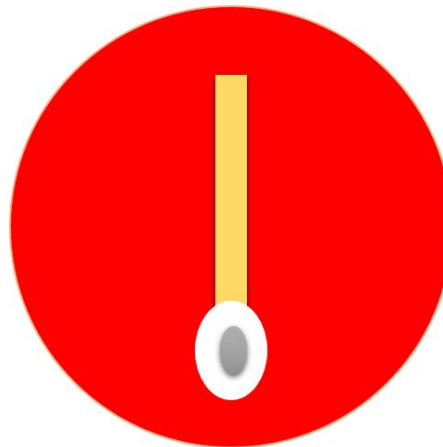
- Regression fit to get distribution of HTC as a function of distance from the center of the tool



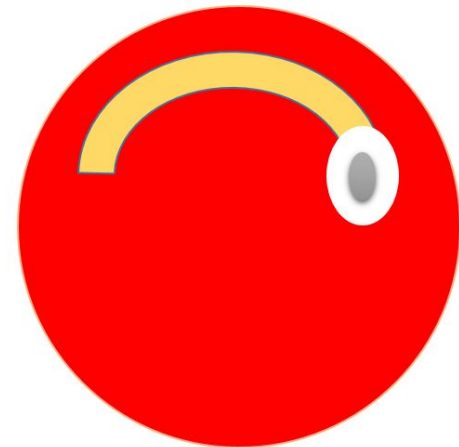
- Temperature distribution from thermal simulation would be compared with experimental data obtained using a thermal imaging camera
- Variation of temperature with time for a few key points would be compared
- Three different scenarios would be tested



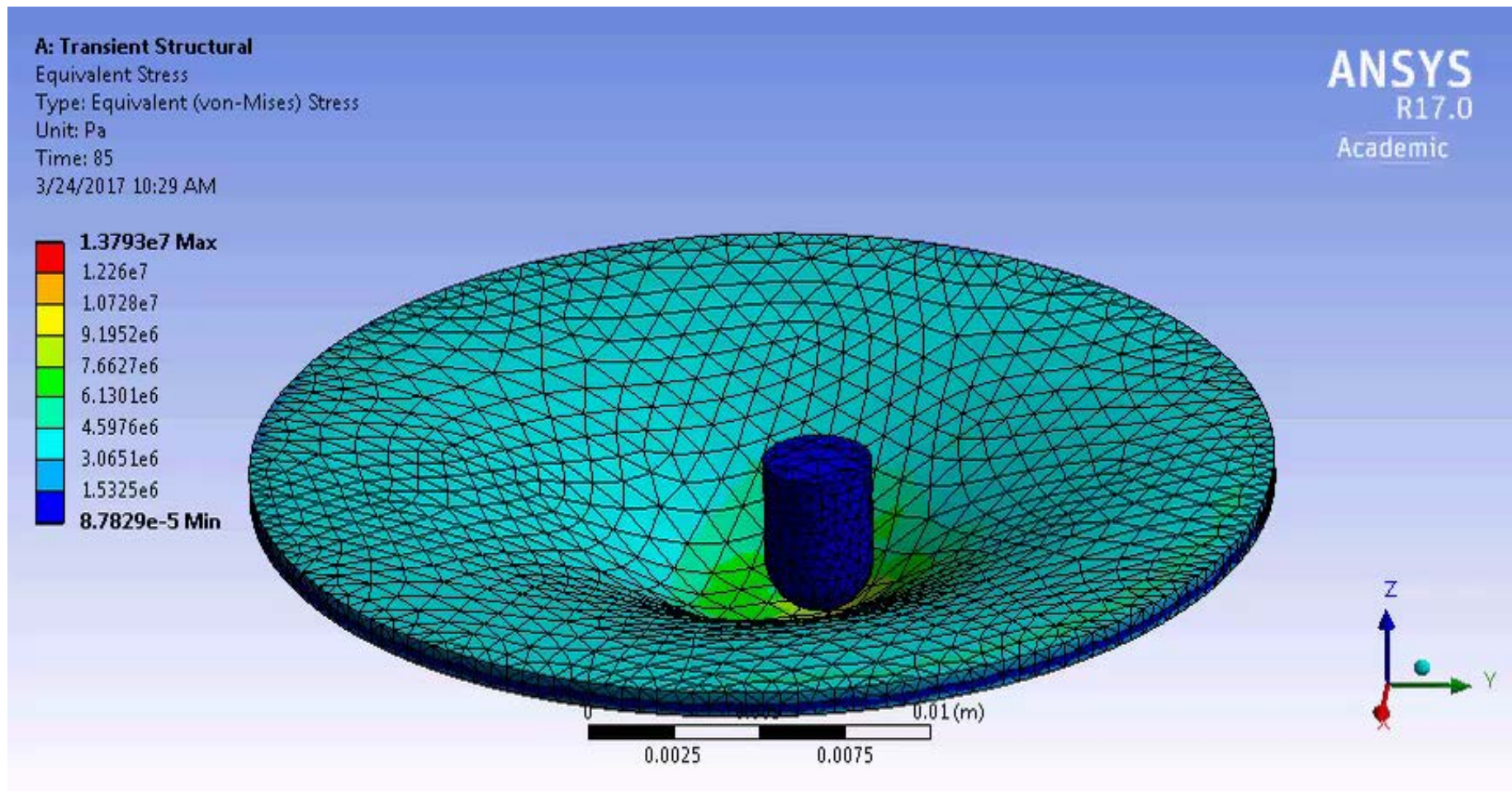
Center

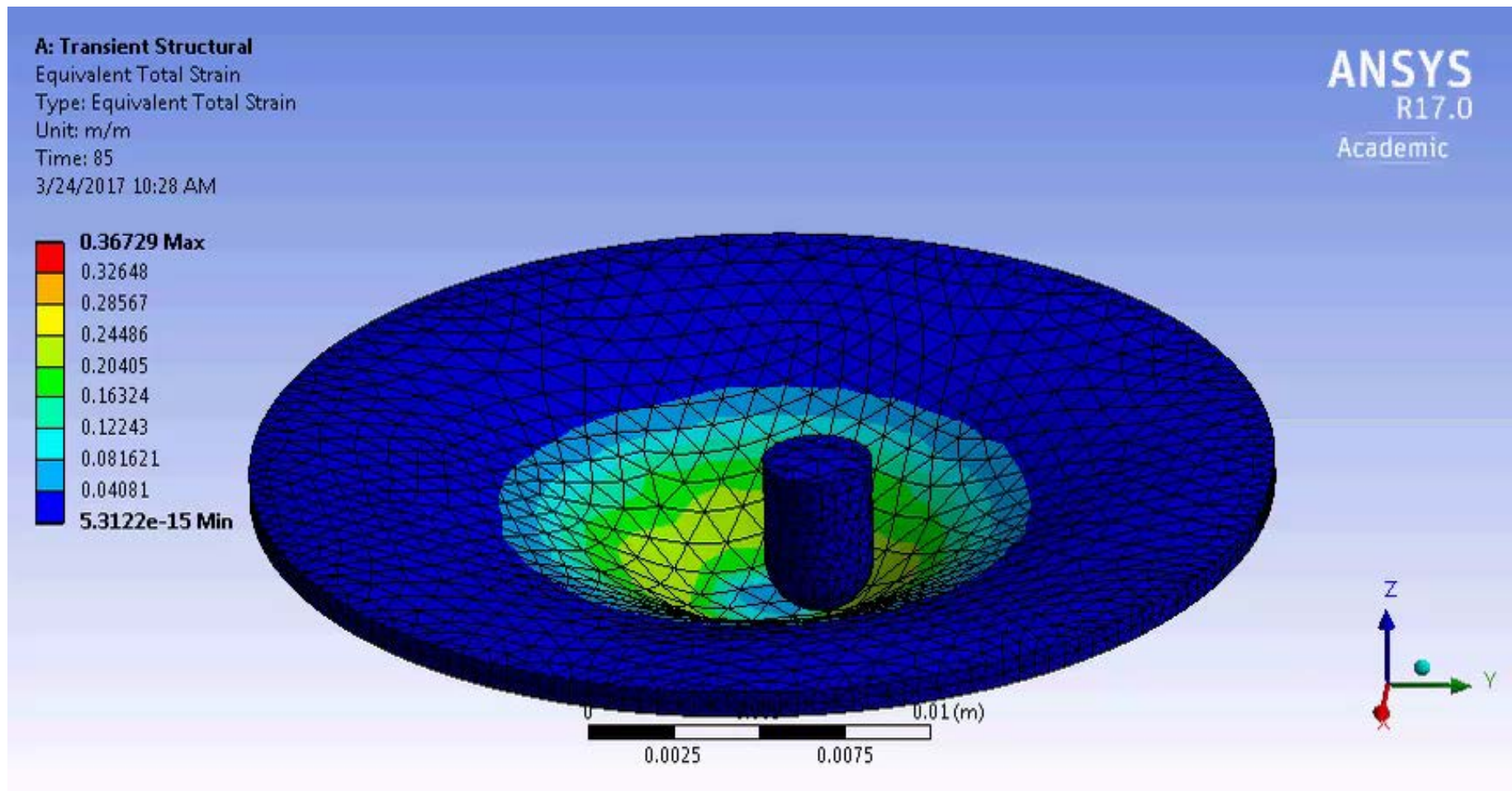


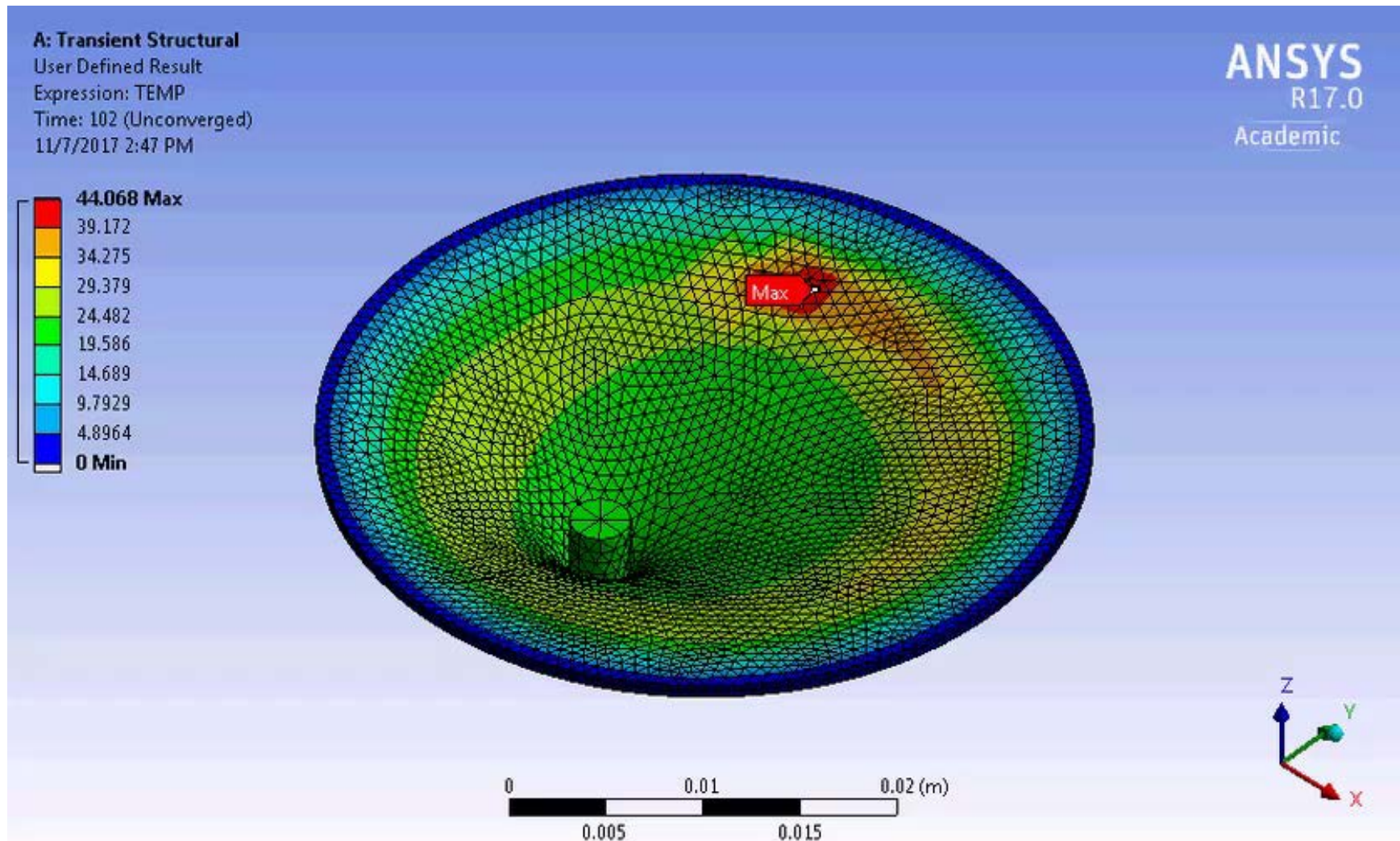
Linear

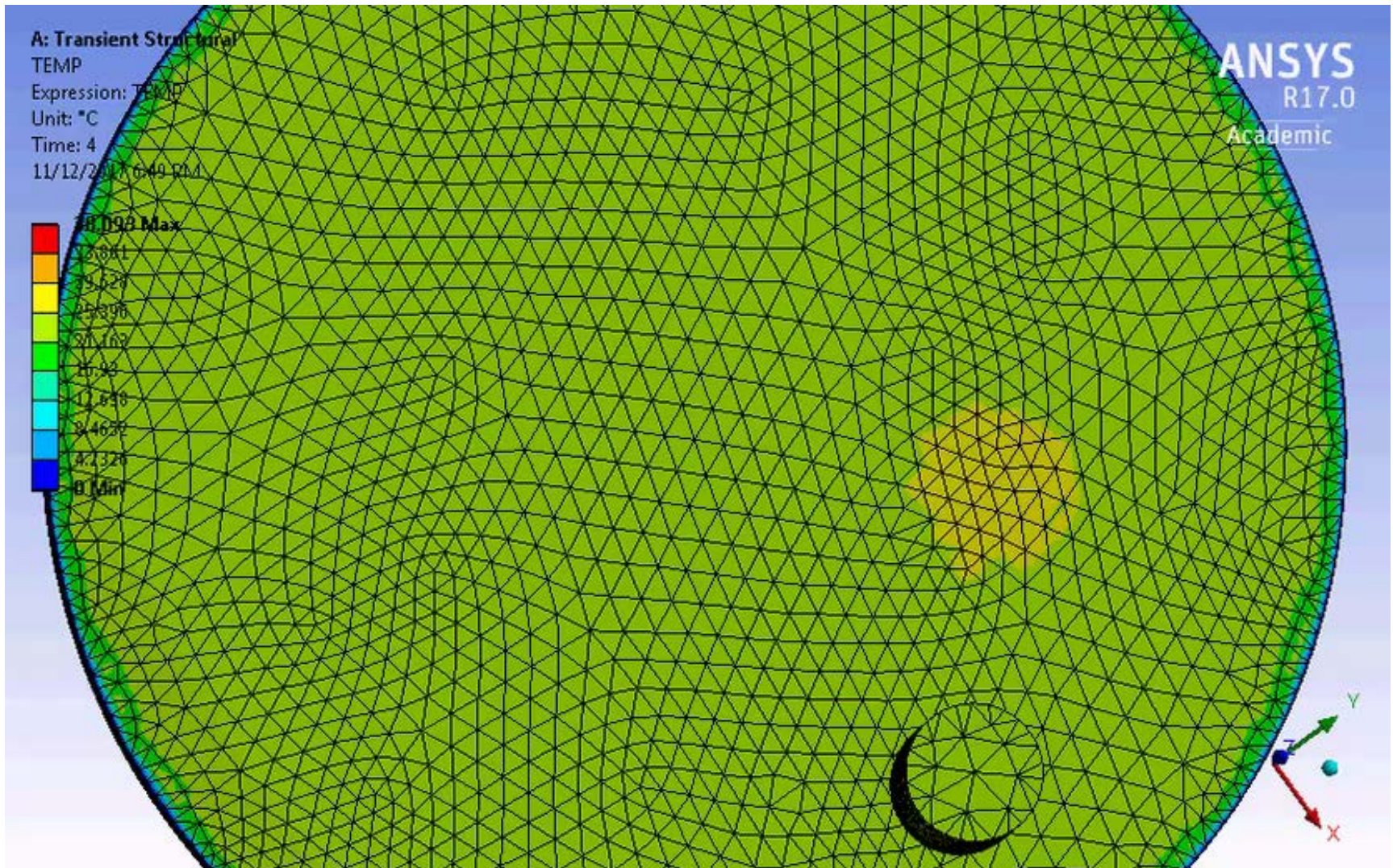


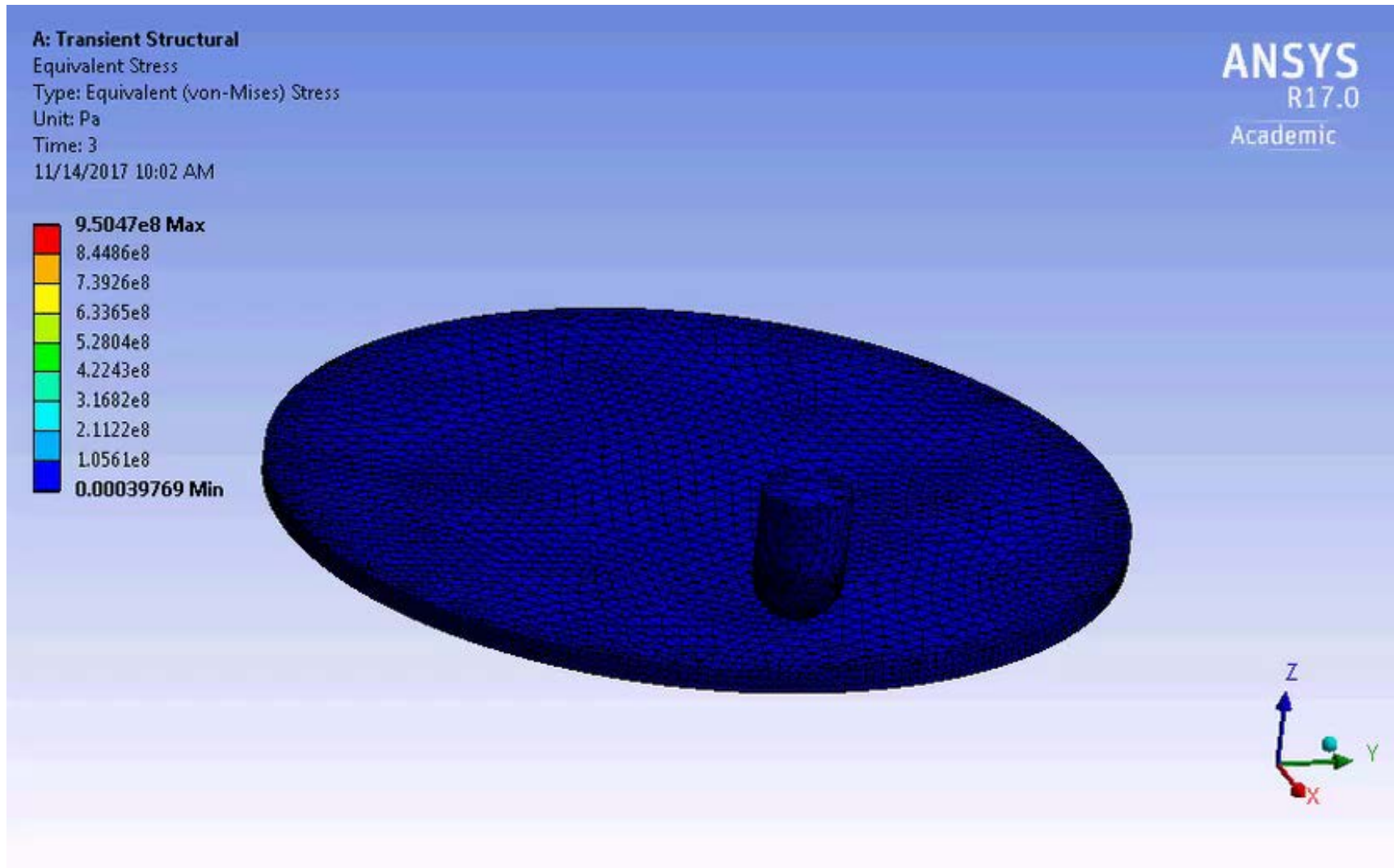
Circular





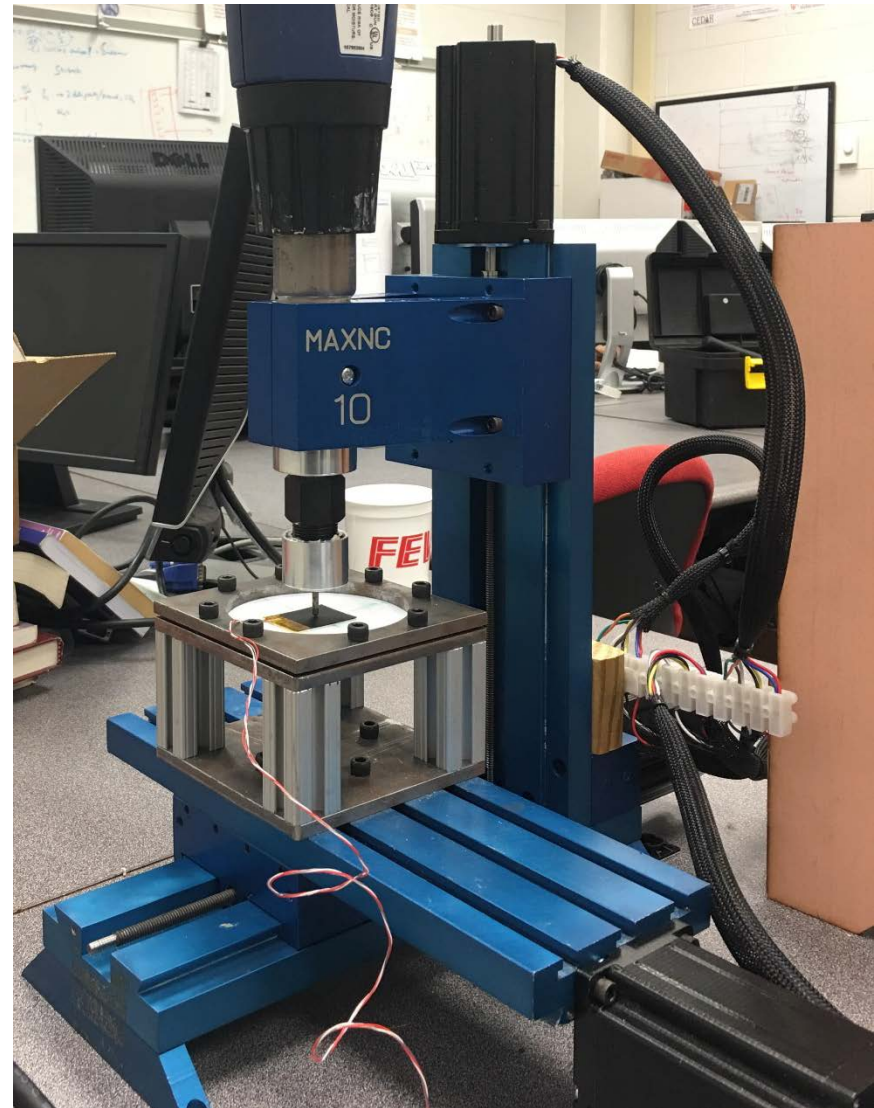






- Coupled thermo-mechanical simulation model for HASPIF has been developed using ANSYS
- Currently working on obtaining experimental data to evaluate the inputs required for the simulation
- Studies will be conducted to validate the simulation model

- Generated G-code will be used for fabricating test specimens
- Formed parts will be measured using CMM or laser scanner
- Comparison to ANSYS results



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THANK YOU