MOR of Electro-Thermal Actuator using ANSYS and Simplorer

Under the guidance of :
Prof. Dr. –Ing. Tamara Bechtold
Msc. Yuan Chengdong

Ujjwal Verma (216100297)

Device – Electro-Thermal Actuator

- The conventional MEMS polysilicon electro-thermal microactuator uses Joule heating to generate thermal expansion and movement.[1]
- Electrical boundary conditions determine how the device is actuated. Mechanical boundary conditions control how the device is constrained from movement.

Applications:

- Switches
- Stepper motors[2]
- Safety Shut Off Devices
- Radiator temperature control.

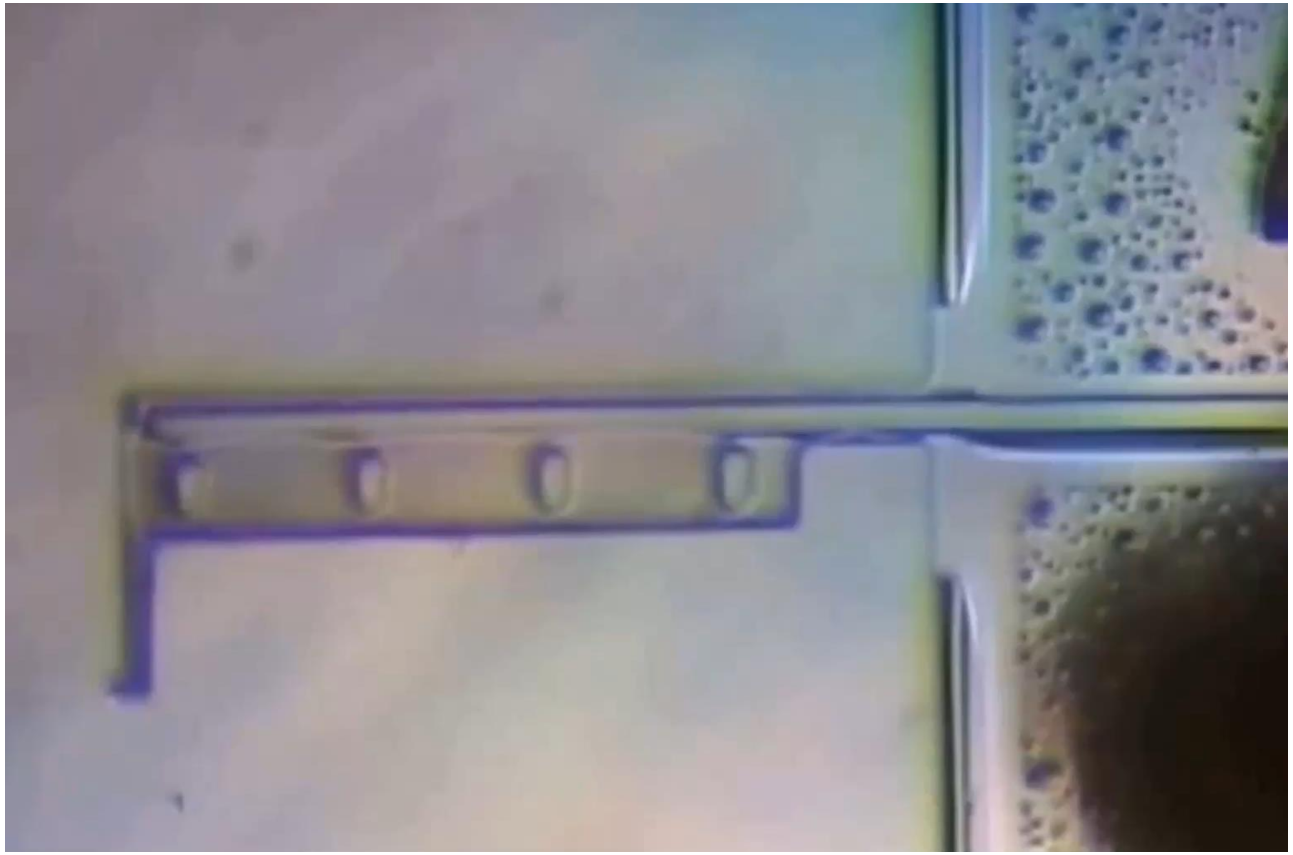


Fig.1: Thermal Actuator[*]

[*] Colorado Nanofabrication Lab., "*Thermal Actuator – 3*" . 2011, Available: https://youtu.be/N3lChvL3_Po

Objective

- Obtain the maximum temperature across the device based on the given BC.
- Reduce the full - scale ANSYS model using MORACT (Two inputs and an Extra output as T_max) and export the model to Simplorer.
- Compare the results of reduced model integrated in Simplorer with ANSYS transient solution using the expansion result button in ANSYS workbench.
- Develop a temperature control (operation at fixed temperature), using the PI controller library element in Simplorer
- Goal: Maximum actuator temperature should quickly increase to 300°C and show minimum overshoot (use optimization for controller parametrization in Simplorer 2017)

Case Setup

- Boundary Conditions
  - Thermal: 0 K temperature on both bottom pads.
- Mesh
  - 5455 Nodes
  - 844 Elements
  - Hexahedral mesh elements
- Transient-Thermal Analysis
  - Internal Heat generation
    - Narrow arms– 10^{13} W/m^3
    - Wide arm– 2.5×10^{12} W/m^3

Structural Height = 3 μm

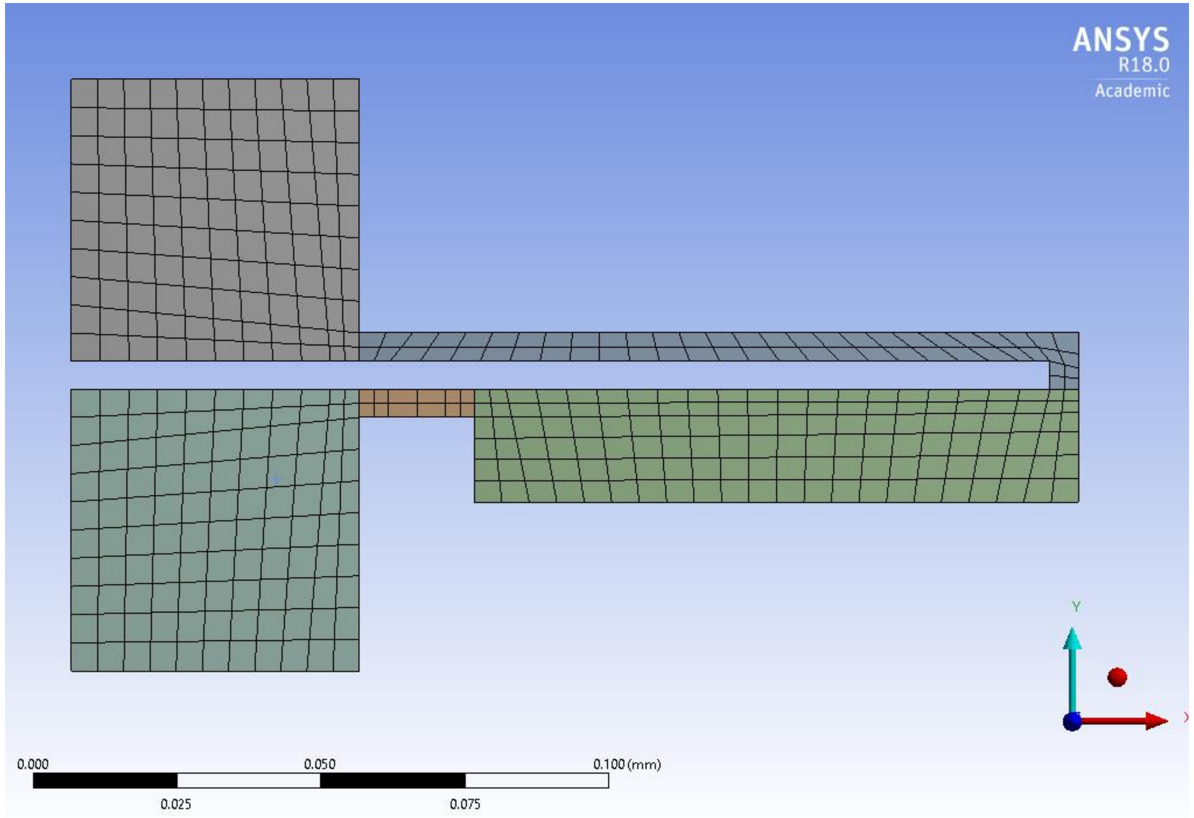
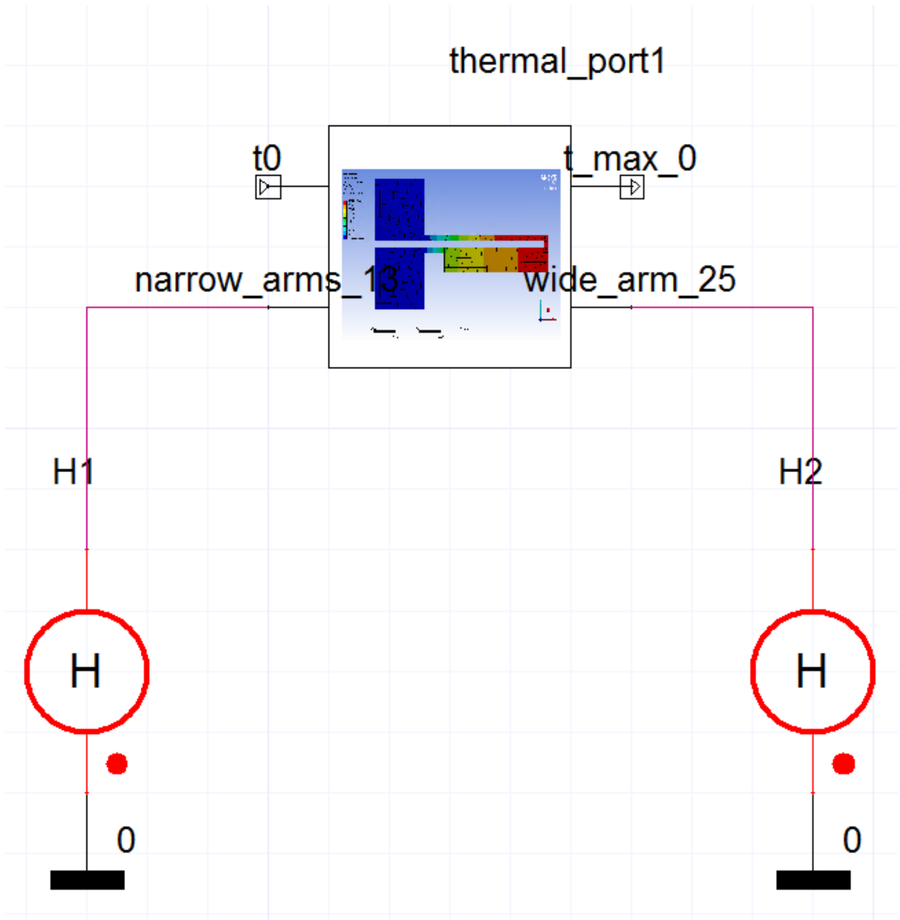


Fig.4: Mesh

Model in Simplorer



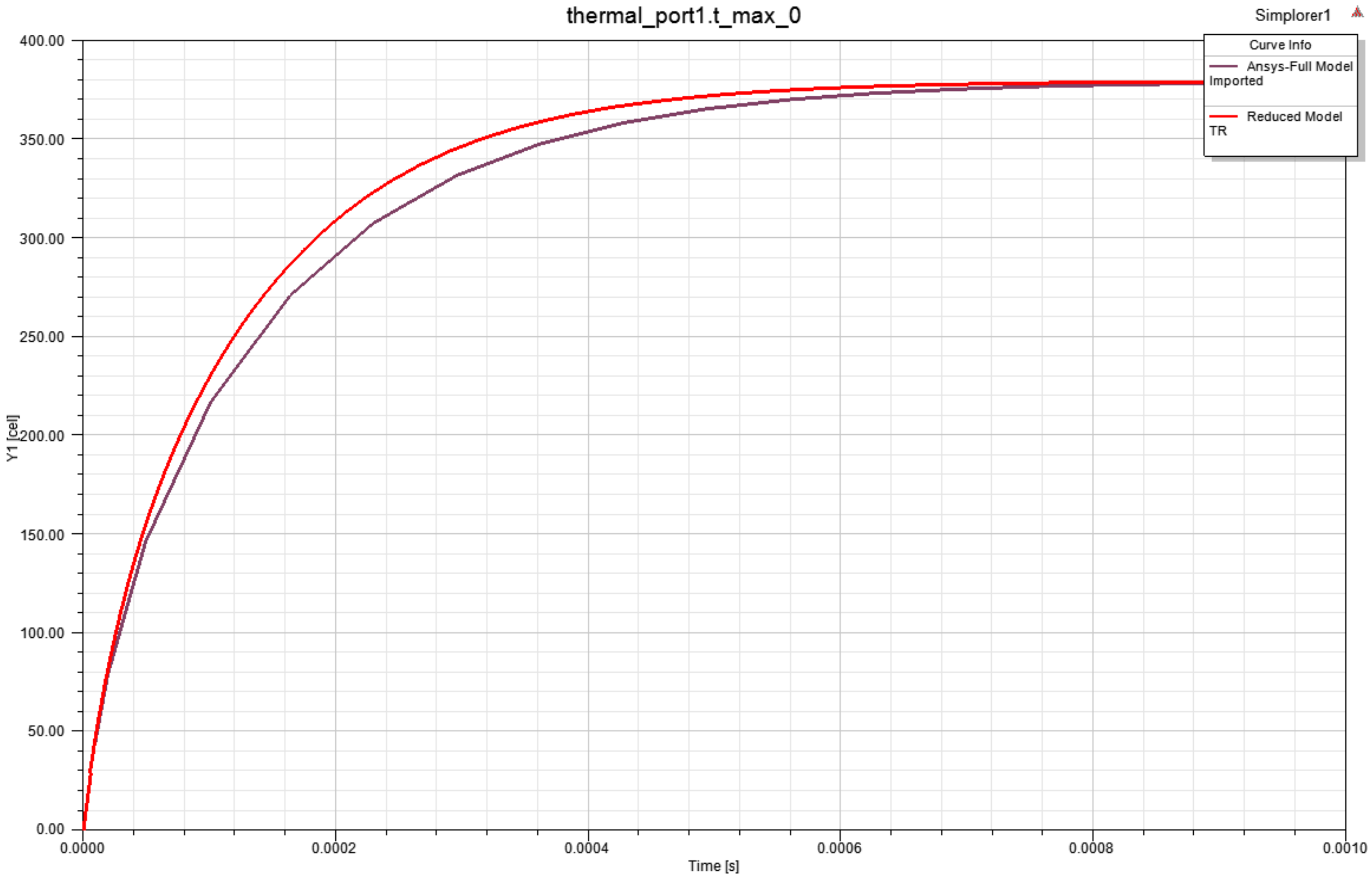


Fig.5: Simplorer model

Fig.6: MORACT Model vs Full Model

Temperature Control for Actuator

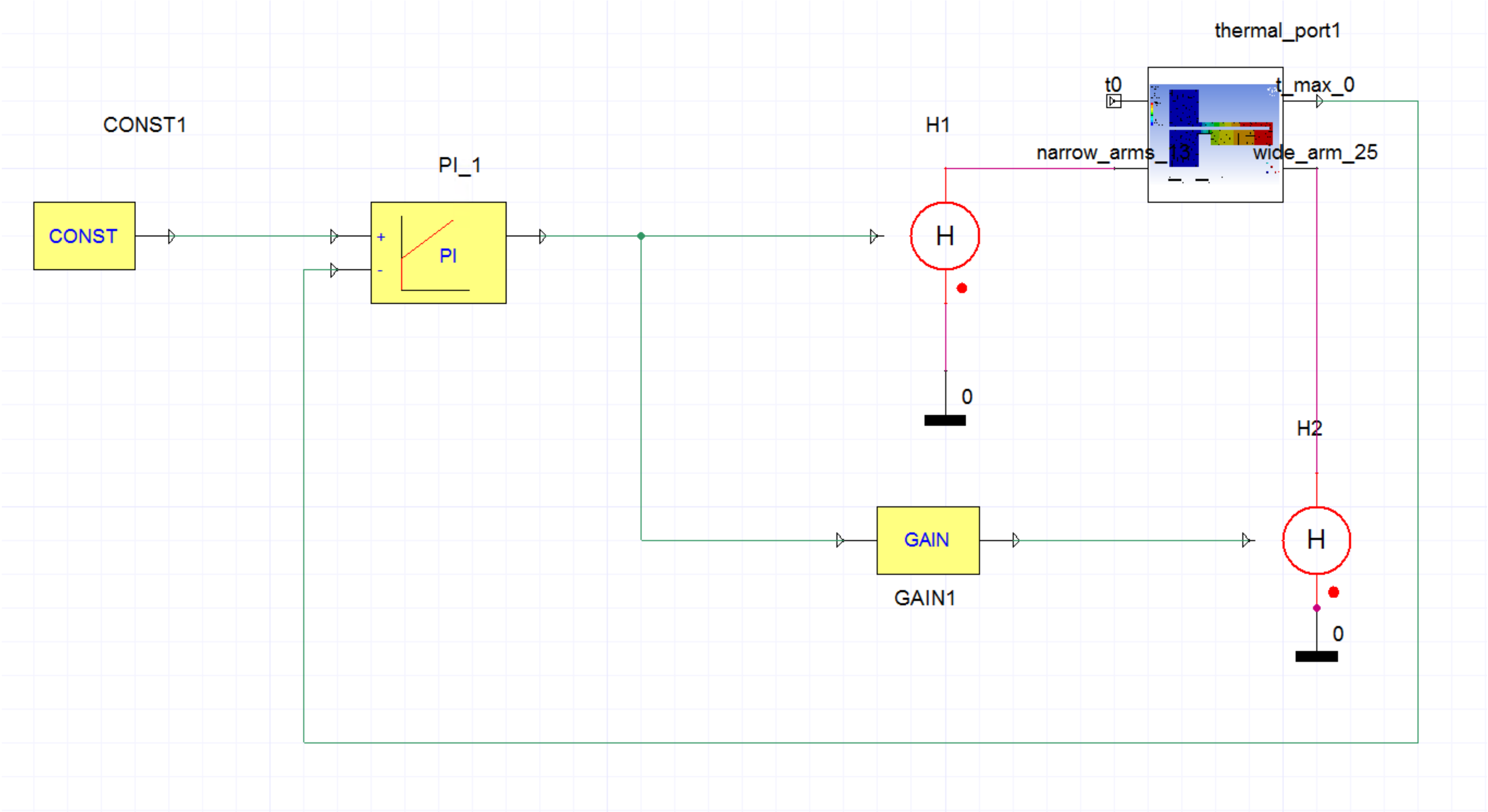


Fig.7: Temperature Control using PI controller

Optimization Curves

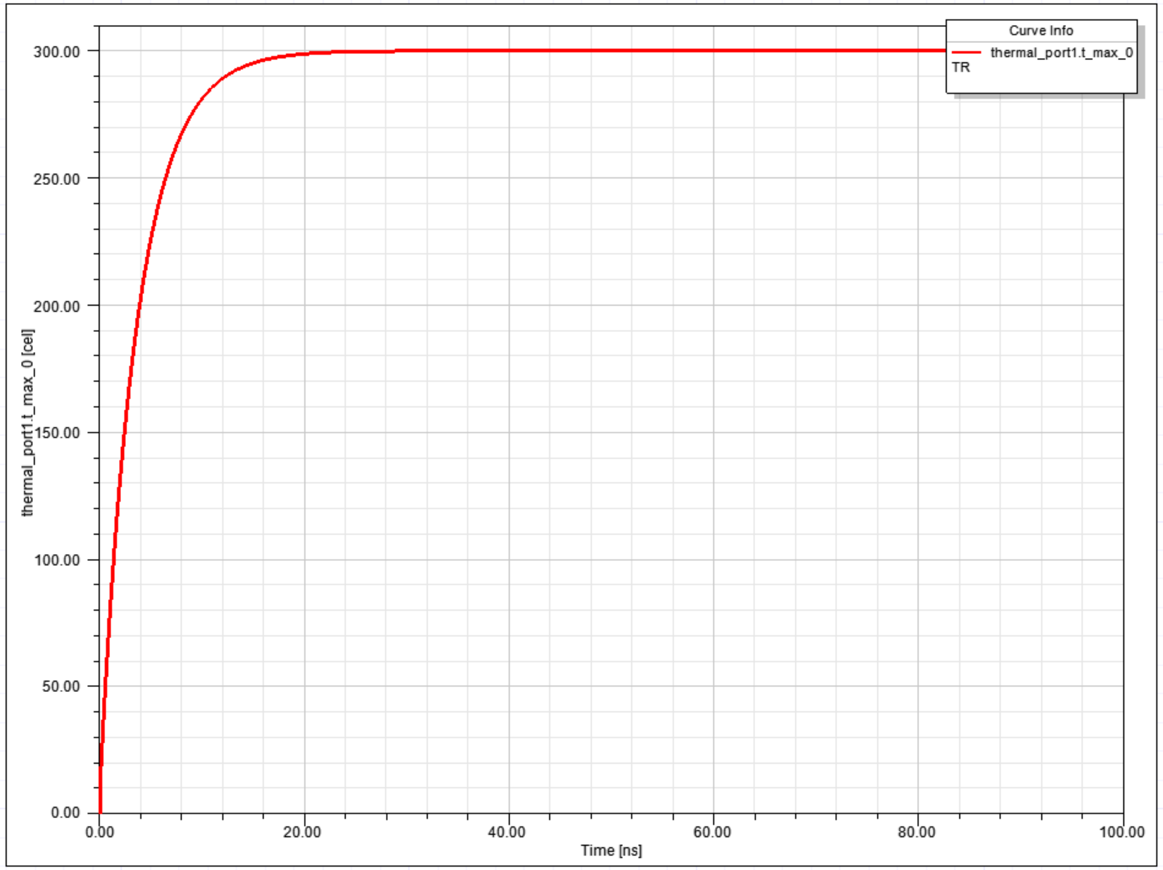


Fig.8: Temperature Distribution limiting at $300^{O}C$

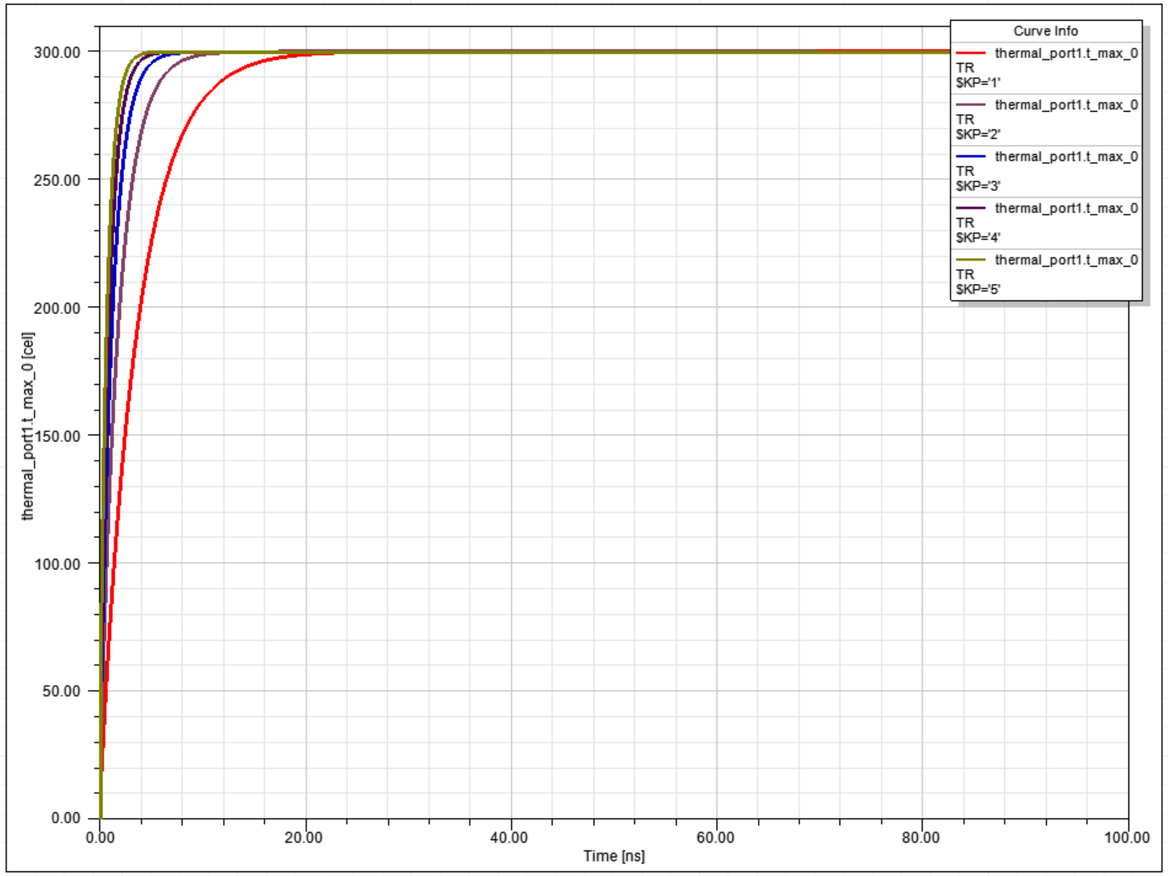


Fig.9: Optimized curves

Result Comparison

Result Comparison between the Reduced model-expanded result from the Simplorer and ANSYS Full model result.

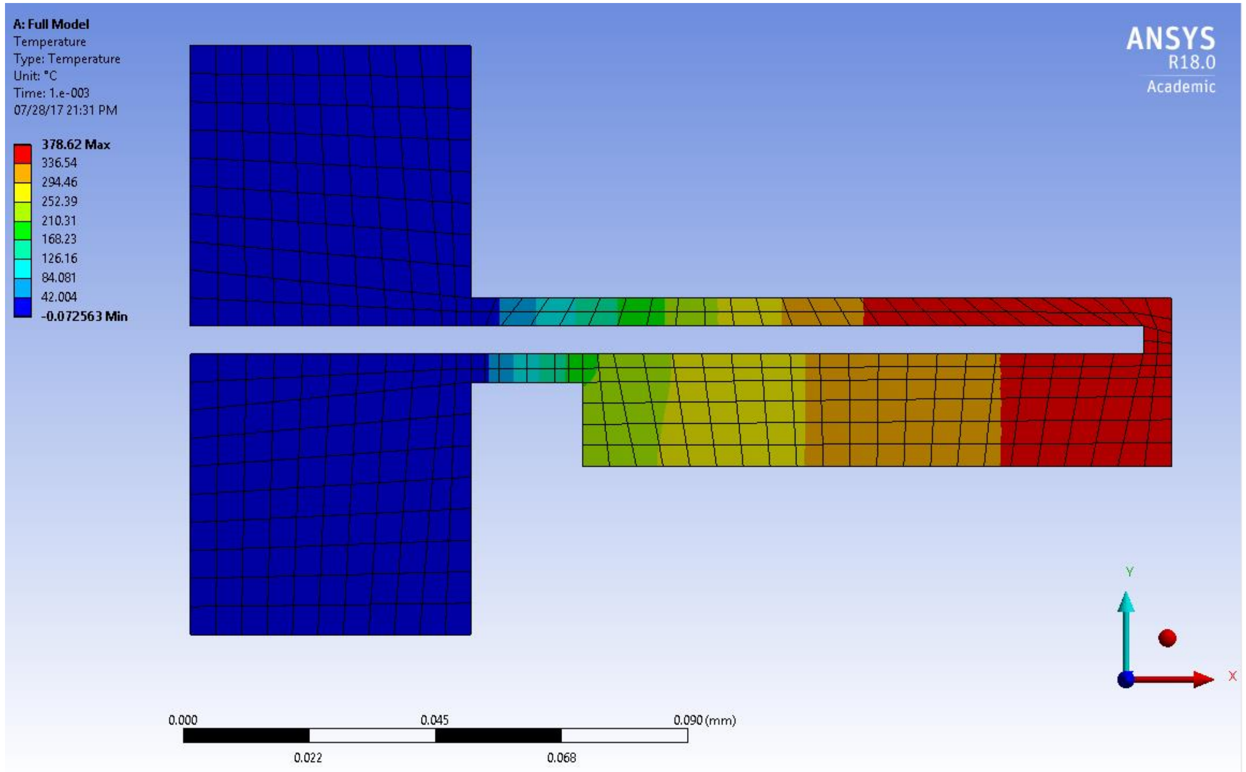


Fig.10: Full Model Results

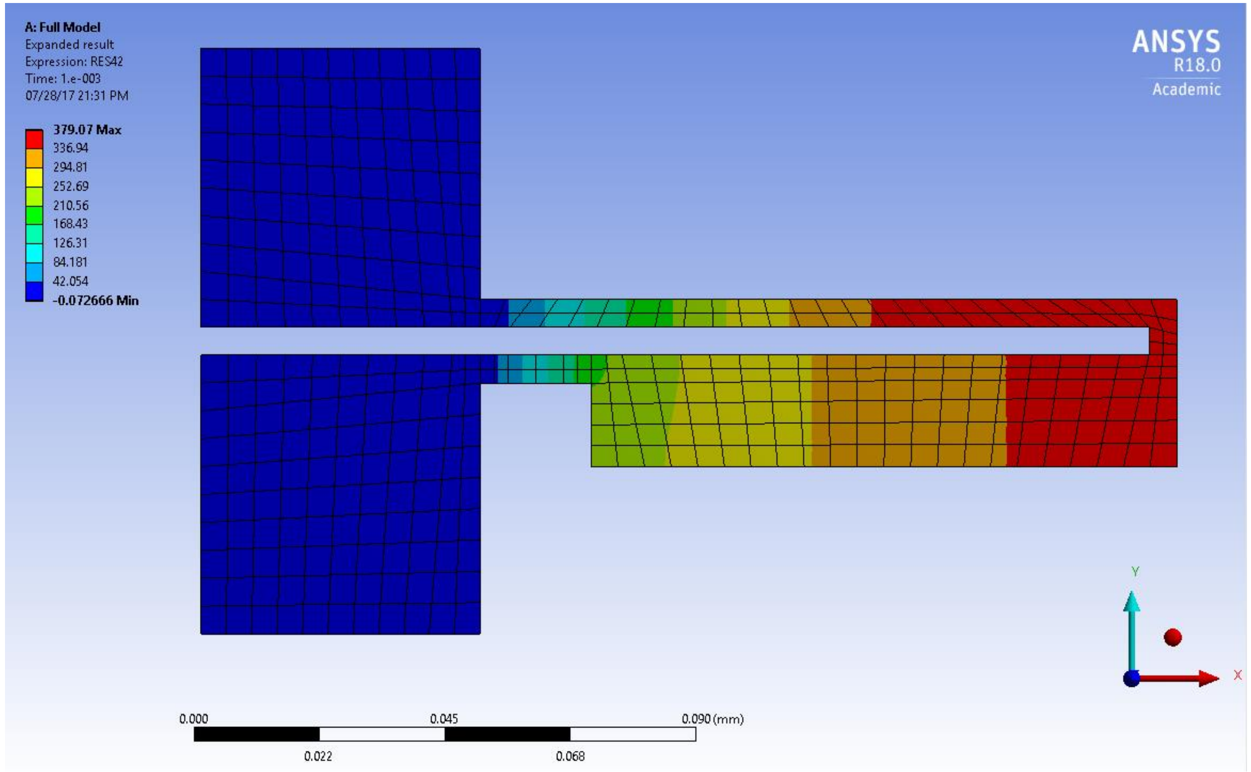


Fig.10: Reduced Model-Expanded Results

Result Comparison

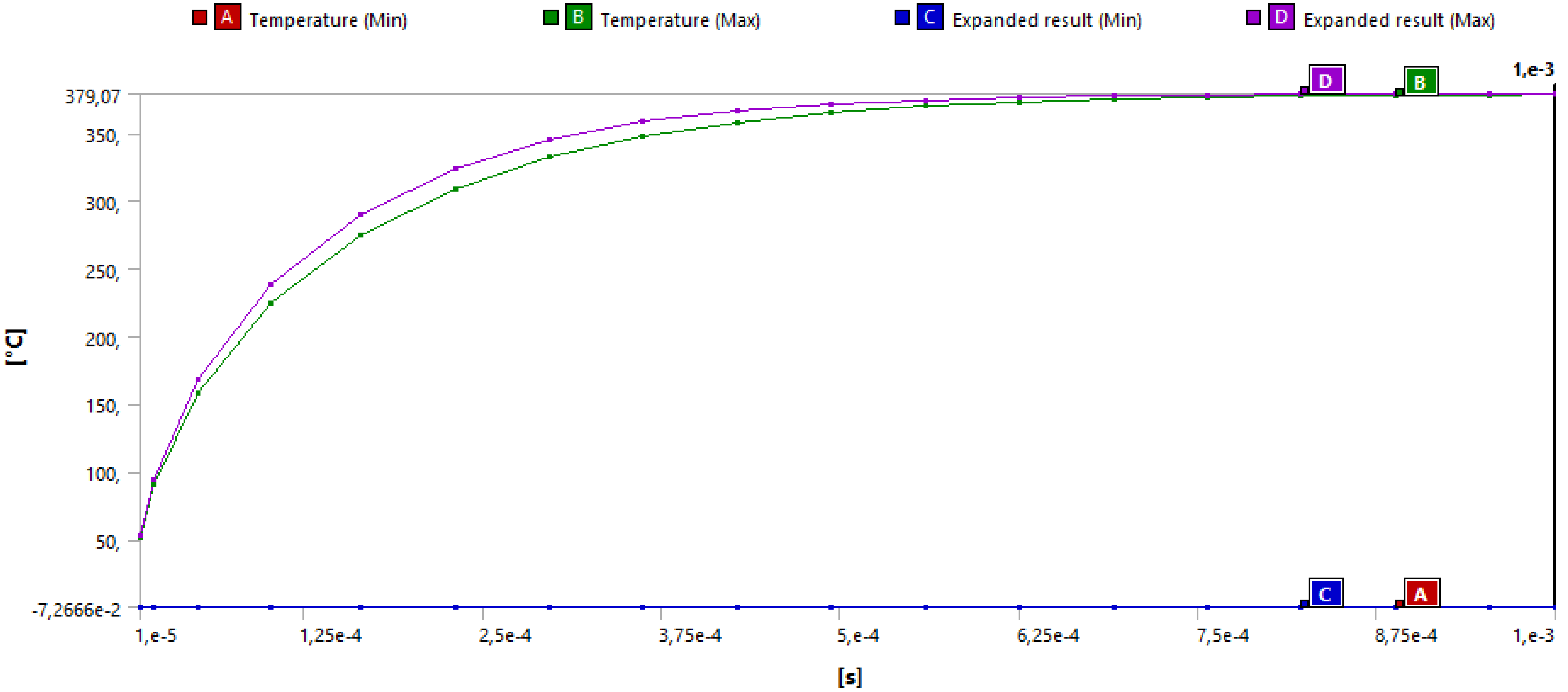


Fig.10: Comparing Expanded Results

Conclusion

- The results from both appear to follow same Temperature distribution and values.
- This means that the Reduced model can also be used in place of the Full model, thus reducing the computation effort.
- Maximum actuator temperature increases quickly to 300°C using PI controller optimization.

Reference

[1] E.S. Kolesar, P.B. Allen, J.T. Howard and J.M. Wilken, J. Vac. Sci. Technol. A, 17 (1999) 2257-2263.

[2] Kaur, Sandeep, Sukhdeep Kaur, and Subhash Poonia. "APPLICATION OF THERMAL ACTUATOR". *International Journal of Advanced Research in Computer and Communication Engineering* 2.10 (2013): 3. Print.