NE 533 Moose Project Report

By Patrick Hartwell

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Section 1:

Material properties justification:

For the uranium and zirconium material properties, the values used are directly taken from the lecture materials. The helium thermal conductivity is the same, but the specific heat and density values are commonly available online. All values were then adjusted to the correct order of magnitude to match those used with the heat source kernel.

Brief Discussion of the Input File:

There are two input files for part 1. The first is the steady state while the second is the transient. They do not vary significantly from one another beside their executioners and heat source kernels. The mesh segment is made of an original GeneratedMeshGenerator type, with two subdomains added to allow for individualized material properties.

In addition to the mesh there is a right sided boundary condition of temp=500 which was made based on the provided uniform cladding surface temperature from the statement "Outer cladding temperature: 500 K".

Summary of Results

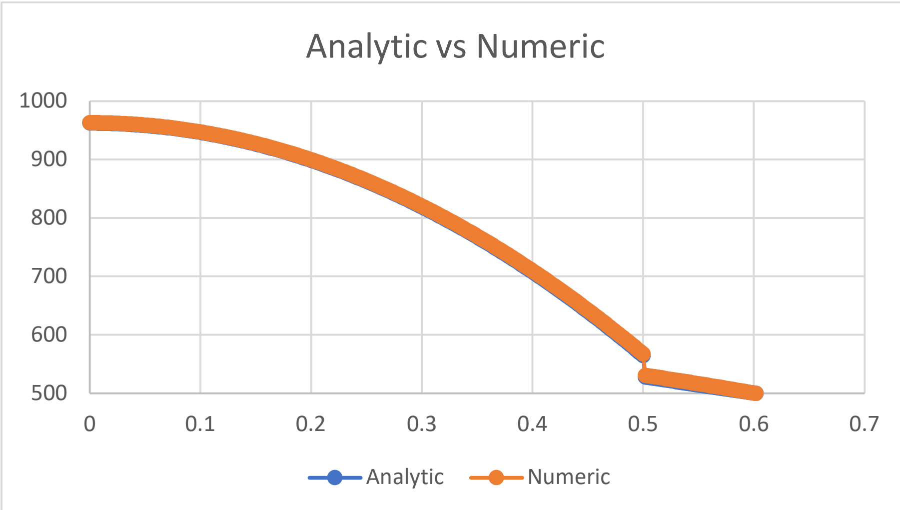

Figure 1: The numerical and Analytic solutions, although they match well enough that it appears there is only one.

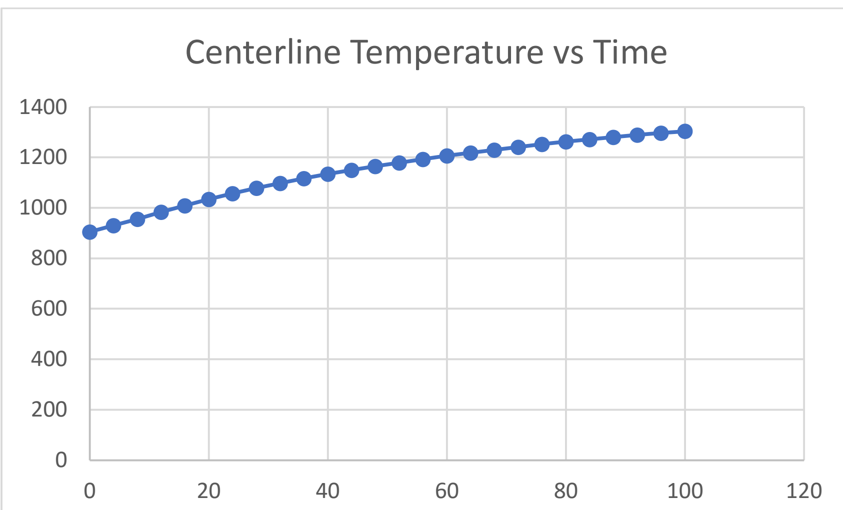

Figure 2: Shown above is the transient centerline temperature from t=1 to t=100.

Both figures display predictable values without any noteworthy deviation.

Comparison and Analysis of Results:

The numeric solution found in the steady state perfectly matches the Analytic solution predicted. The centerline temperature transient shown in figure 2 is approximately 1300 at the t=100 mark. This combined with the tapered off rate of change indicates that the change in centerline temperature from steady state is roughly equal to the difference from cladding surface to steady state centerline temperature. Given that the transient function indicates an eventual doubling of the linear heat rate, the centerline temperature to cladding surface temperature difference doubling is precisely as expected.

Section 2:

Material properties justification:

The previously mentioned materials are once again drawn mostly from the lectures, but in the case of the water specific heat and flow rates, those values were combined into a scaling constant so that they could be more easily controlled to ensure that the water temperature stayed at a reasonable level.

Brief Discussion of the Input File.

From the previous parts input files this part has few differences. The largest is the addition of a coolant channel which prompts adding a parsed function to the boundary condition. This adds a height dependent function for the first stage, and a time dependent function for the transient stage. Beyond that is converting the heat source to a function of time and height.

Summary of results:

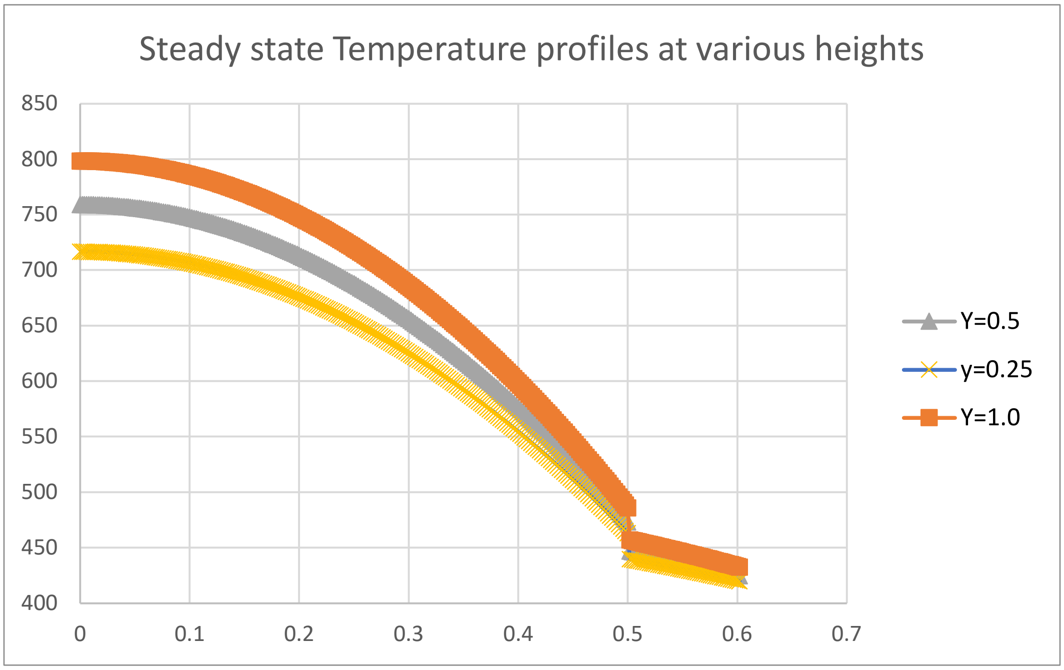

Figure 3: Shown above are the three temperature profiles at the initial steady state without the position or time dependent heat flux.

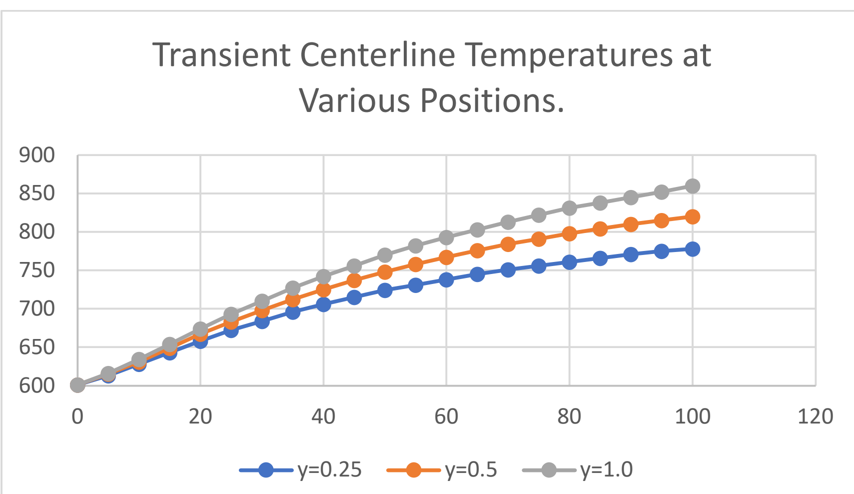

Figure 4: This figure shows the requested comparison between three points along the fuel center line from t=0 to t=100.

Peak centerline temperature occurs at y=100 in both the transient and the Steady state cases. This is because the heat production and the change in the coolant temperature are both creating a higher baseline temperature for the highest point in the system.

Comparison and Analysis of Results:

In both figures the trend is that the higher the point in the fuel the higher the temperature. This is true initially and then even more so once the height dependent linear heat flux function is added. This is contrary to typical real fuel because the inlet and outlet coolant temperatures are both below the points where departure from nucleate boiling can interfere with the removal of heat from the fuel.

Section 3:

Material properties justification:

Given that the main objectives of this project are gaining competency with the code and making proper use of it, it isn't surprising that most of the material properties are found inside the lecture materials. In this section the Poisson's ratio, Youngs Modulus, and the linear thermal expansion coefficient are all readily available in the lecture notes, but in the case of the Temperature Dependent Thermal Conductivity it was best to create a simplified polynomial expression which remains accurate.

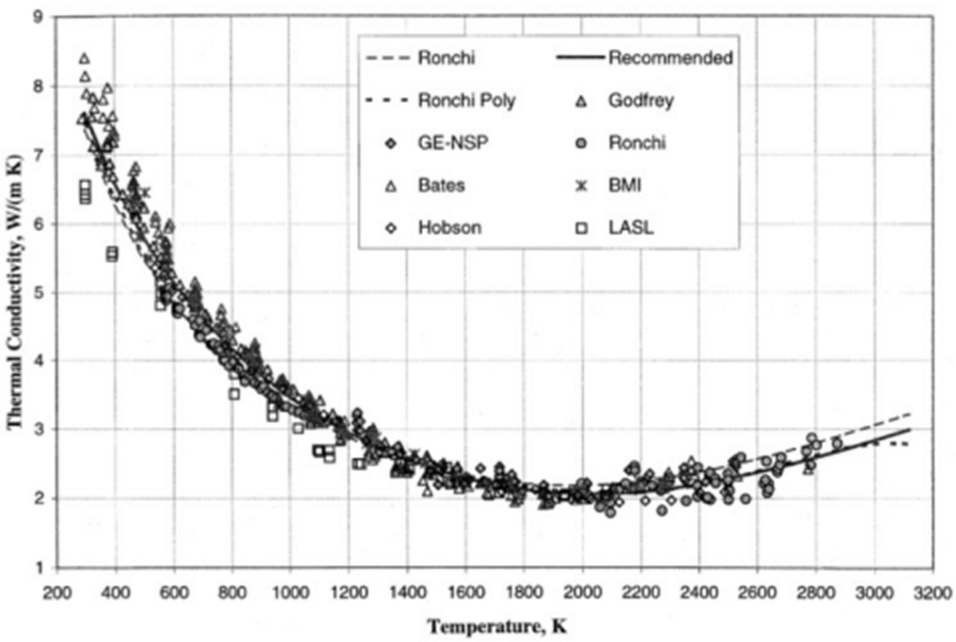

Figure 5: Lecture material sourced graph of the Uranium Dioxide thermal conductivity plot.

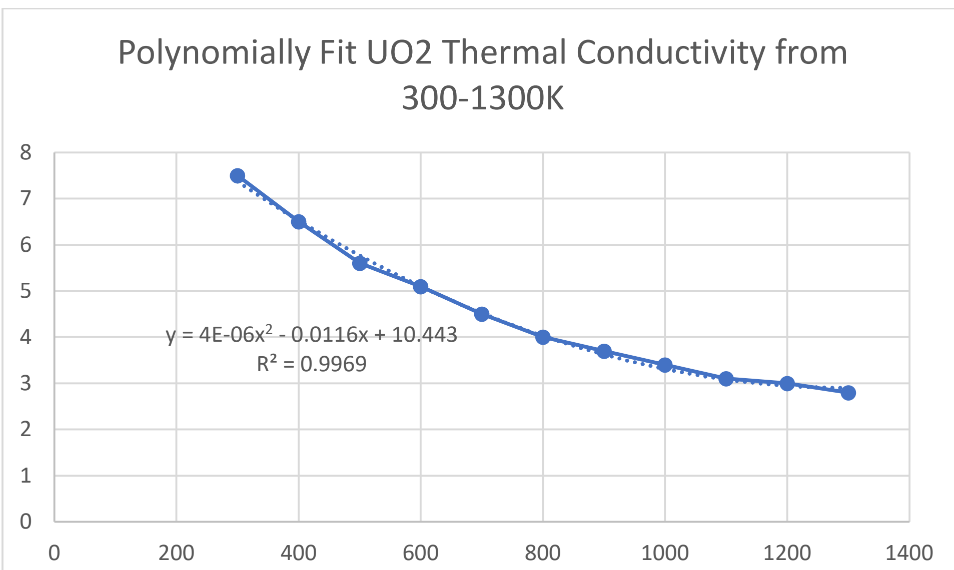

Figure 6: Simplified Polynomial equation and graph of the Uranium Dioxide thermal conductivity plot.

Brief Discussion of the Input File.

As per the pattern part 3 is also split between two inputs with the first being substantially different from the previous codes. There is a single material and no subdomains used since it is a homogenous material. The second code is more like the parts 1 and 2 with a variety of subdomains for the varied thermal conductivities.

Summary of results

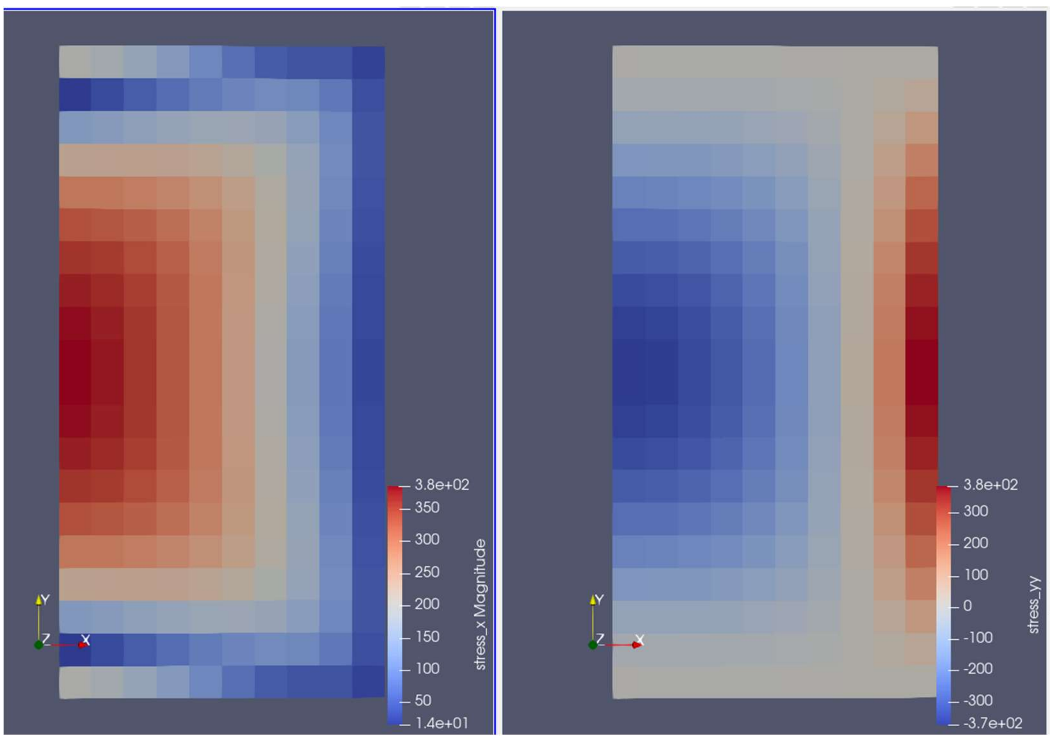

Figure 7: Part 3 Stress plots for constant thermal conductivity.

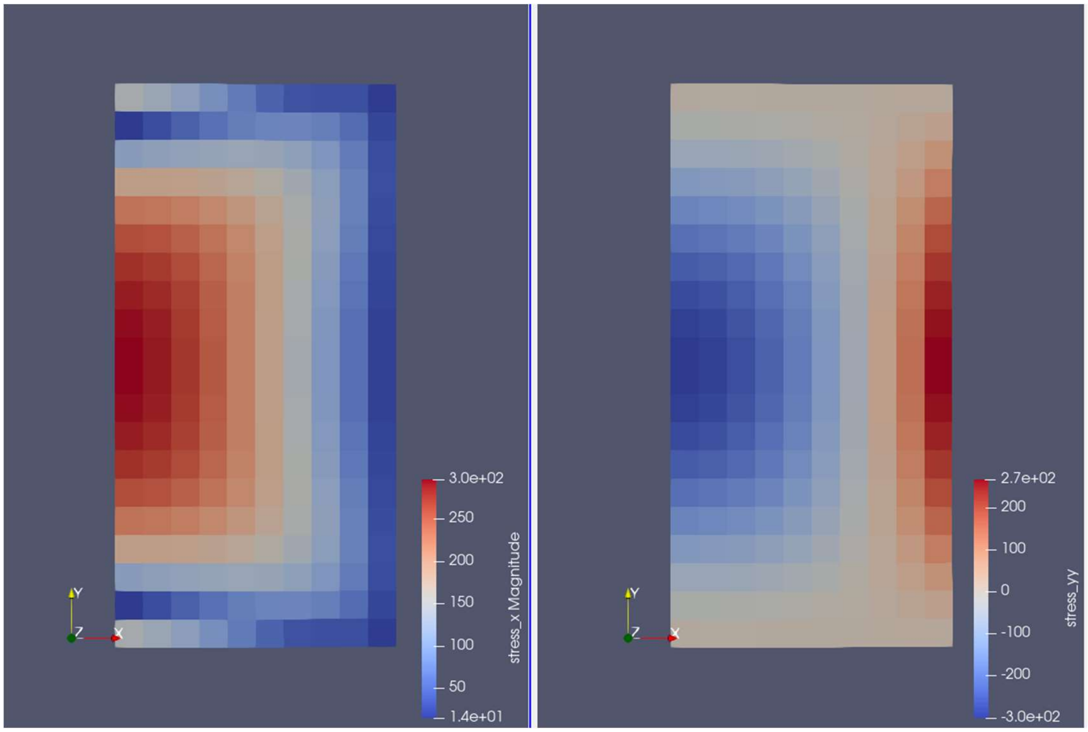

Figure 8: Part 3 Stress plots for temperature varied thermal conductivity.

Comparison and Analysis of Results:

While the distribution of stress is nearly identical between those shown on Figures 7 and 8, the peak stresses of the constant conductivity are equal while same is not true for the temperature dependent thermal conductivity. Additionally, the stress magnitudes shown on figure 8 are substantially lower than those of figure 7. This is the result of the Constant thermal conductivity I chose being higher than was accurate. The value used correspond with a temperature of 950 K which is substantially higher than several regions on the plots, so this makes sense.