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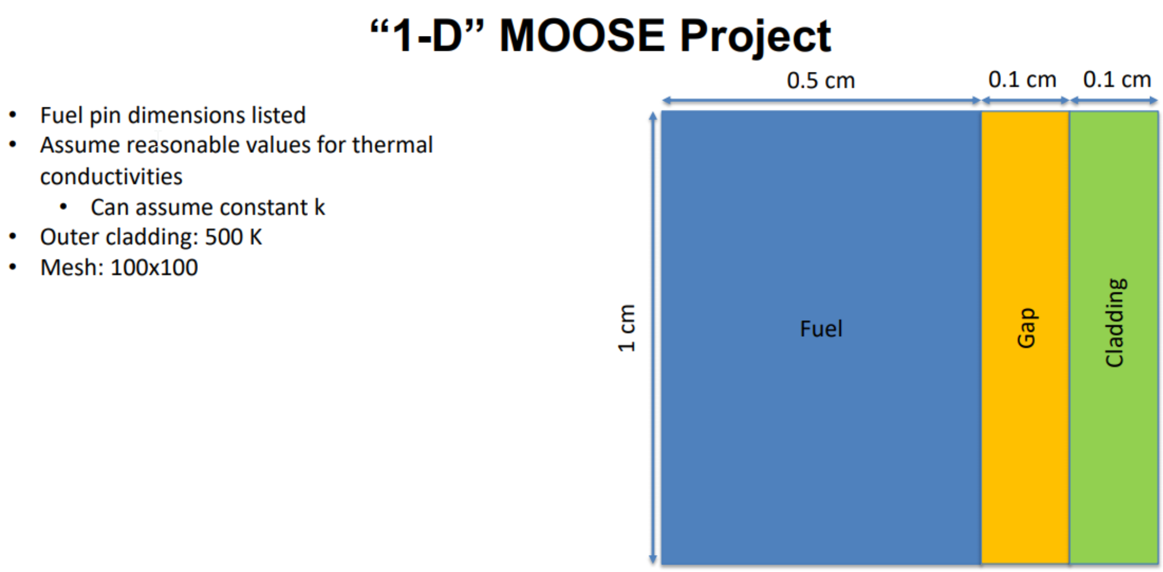
I.1. 1d Problem

I.1 steady state

Problem disscusion



Our problem is 1D by symmetry Y= cte to solve this problem with moose we first need to define our geometry in our input file with 100 elements in both directions then I divide the geometry into there blocks : first block for the fuel+gap and second for the fuel. Third block is the rest.

The problem is defined in the cartsian coordinates: The chosed thermal conductivities are as follows : k= 0.3 W/cm-K for the fuel k=0.1 W/cm-K for the gap K=0.17 W/cm-K for the cladding

Finally we defined our physics and finally our boundary conditions.

I.1.2 Result discussion

First lets try to solve this problem analytically since it's 1D amd it's for steday state

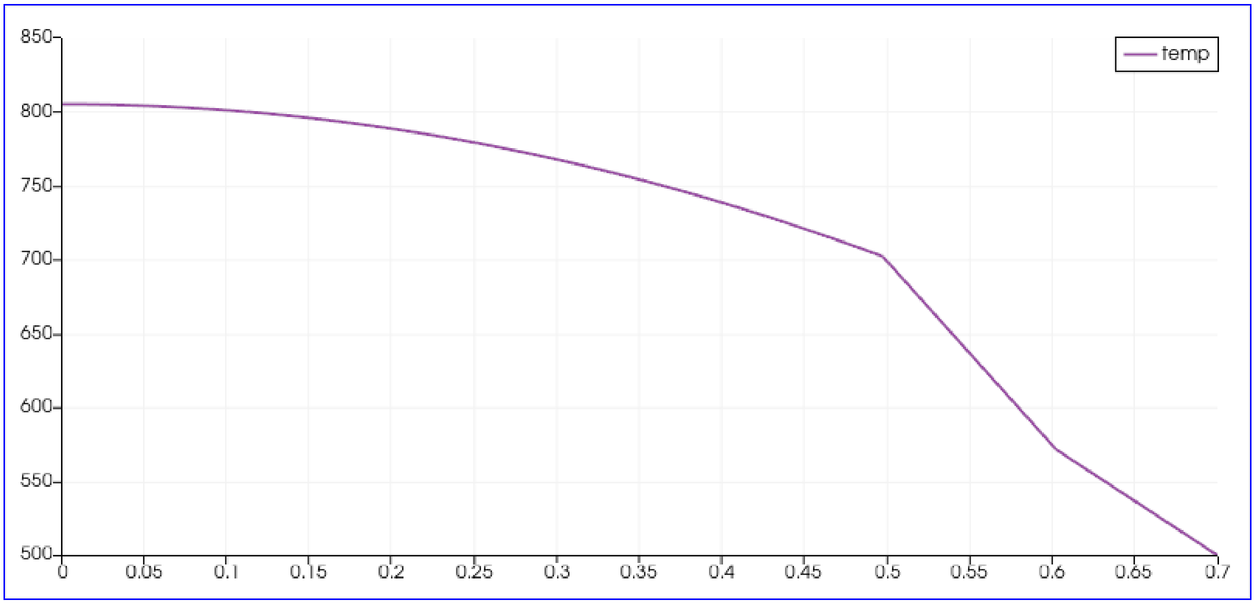


Figure 1 : Temparature profile T=f(X)

Figure 1: is a visualization of the output file using preview and it clearly shows our curve T as function of space in the X direction the curve is divided into three regions the cladding domain the gap domain and the fuel domain.

As we can see in Figure 1 the temperature profile is like the temperature profile discussed in the class which typical for 1D problem: the temperature profile is linear for cladding and the gap and parabolic inside the fuel our centerline temperature is equal to 805K which will be further investigated by the numerical resolution. The temperature of the cladding is 571K and we have a linear evolution of temperature inside the cladding. For the gap, the temperature in the fuel/gap boundary is 705K and the evolution is also linear which is an expected result.

To confirm our result for the centerline temperature, we can solve analytically the following equation:

$$T(x) - T(i) = \frac{Q}{2K}(X^2 - x^2) = \frac{250}{2 * 0.3}(0.7^2 - 0.5^2) = 100K\ for\ centerline$$

Then our centerline temperature is equal to 705+100= 805K then our analytical resolution confirms the result obtained from numerical resolution

I.2.transient centerline temperature

I.2.1 Problem discussion.

The difference in this case with the first case is that the heat flux is variable with time so the input file will be similar to the Input file of the steady state in the mesh part and the boundary condition the main diference is just the heat flux equation will be time depenedent so we will have a new variable which time instead of space $Q = 150 \times (1 - e^{-0.01t}) + 250$

The flow rate and the heat capacity and the density are defined as follows

For the fuel : 0.3 W/cm-K 0.33 J/g-K 10.980(g/cm3)

For the gap: 0.1 W/cm-K 5.19 J/g-K 0.00082(g/cm3)

For the clad: 0.17 W/cm-K 0.27 J/g-K 6.5(g/cm3)

So we need to find the cemterline temperature profile as function of time which :

I.2.2 Result discussion:

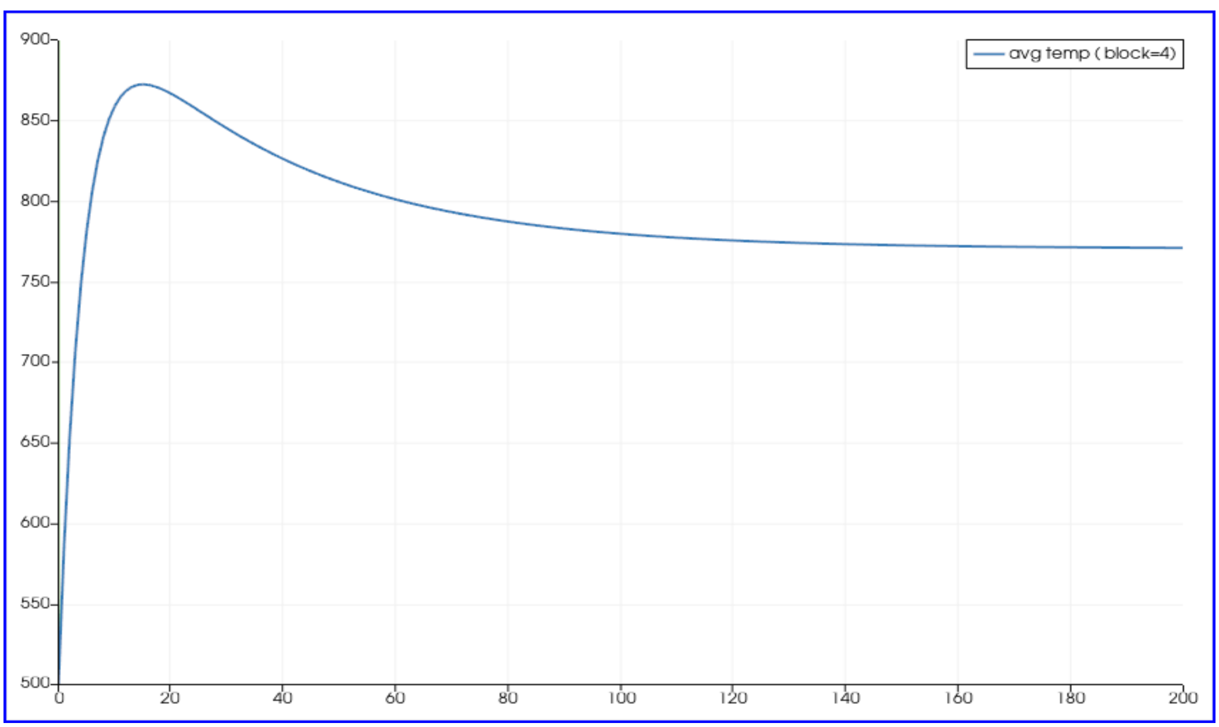


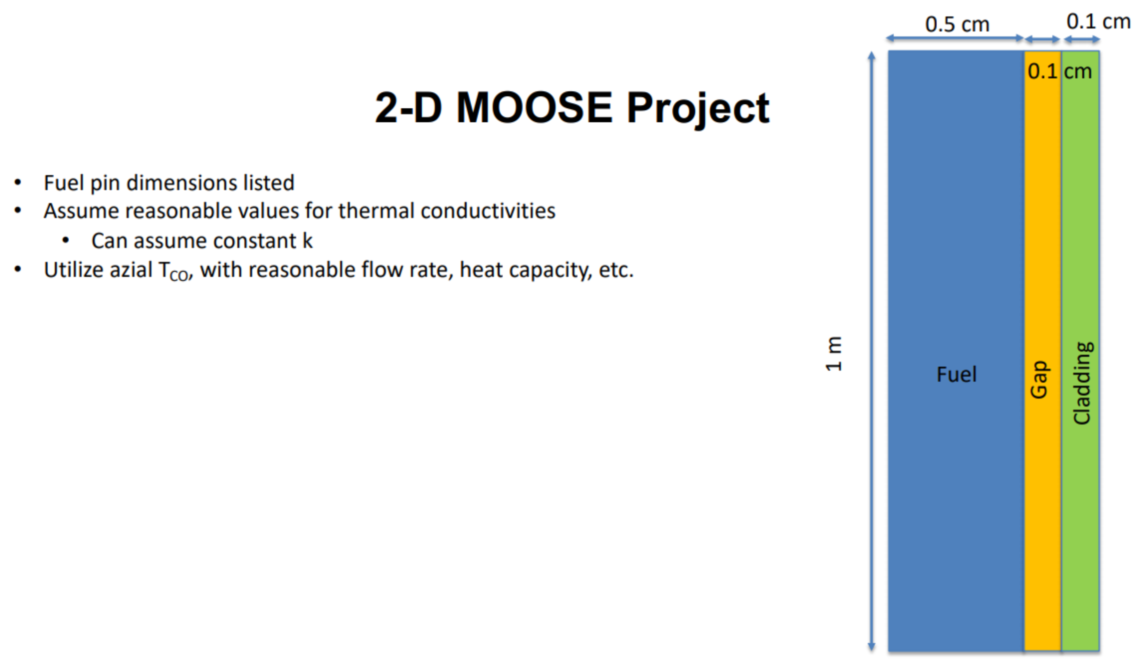
Figure 2: Centerline temperature as function of time in transient state case

As we can see for the centerline temperature profile as function of time, we can see that we have two regions we a transient state where the fuel temperature increases until it reach a value of 870K after 16seconds the it starts decreasing until it reach a value of 800K after 60 second then we have a steady state were our temperature start becoming constant at 770K. if we compare this case with steady state we can see that it's a fairly close result since at steady state the centerline temperature is 805K.

II.2D Problem

II.1. steady state

II.1.1. Problem discussion



our problem in this is 2D although it's 3D in geometry and it's 2D because of the symmetry Y=cte our mesh is defined as like the first problem as 100*100*100. The geometry is divided into different three different blocs as we can see in the problem overview. Our heat flux is constant Q= 250 W/cm^3

T_{CO} is calculated using the following equation:

$$T_{cool} - T_{cool}^{in} = \frac{1}{1.2}\frac{Z_o \times LHR^o}{\dot{m}C_{PW}}\left\{\sin(1.2) + \sin\left[1.2\left(\frac{z}{Z_o} - 1\right)\right]\right\}$$

The flow rate and the heat capacity are defined as follows

For the fuel : 0.05W/cm-K 0.30 J/g-K 10.20 (g/cm3) '

For the gap: 0.022 W/cm-K 5.200 J/g-K 0.0025(g/cm3)

For the clad: 0.18 W/cm-K 0.33 J/g-K 6.530(g/cm3)

II.1.2 Result discussion : Temperature Profile

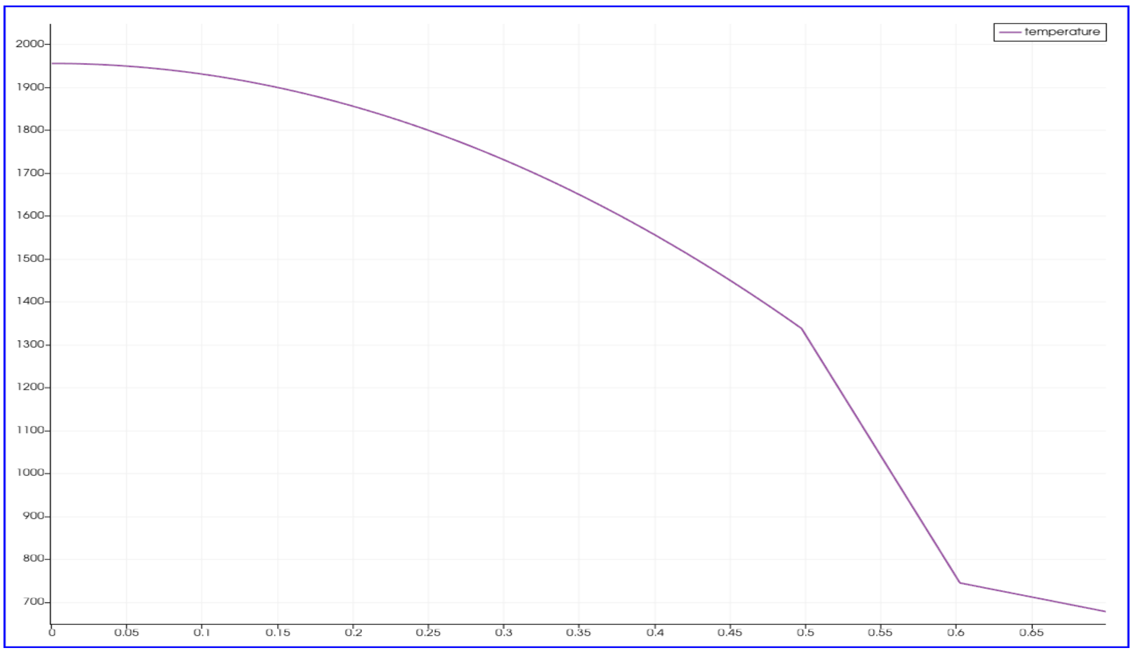


Figure 3 : Temperature Profile at Y= 0.25

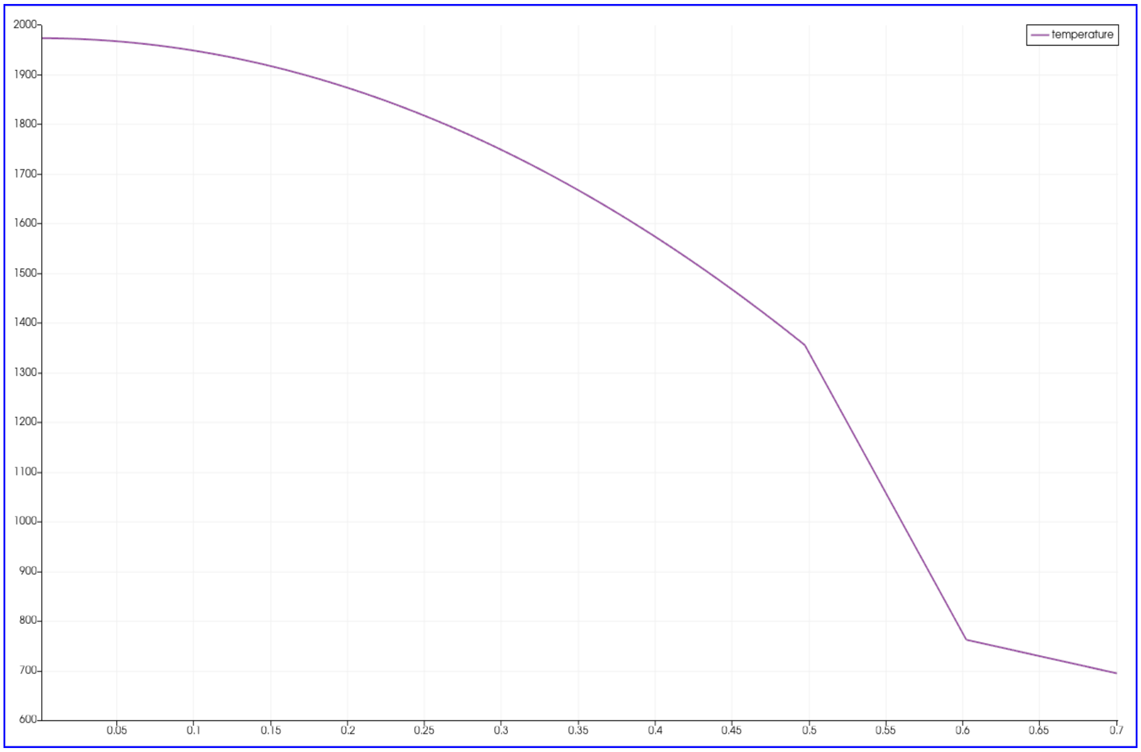


Figure 4: Temperature Profile at Y=0.5

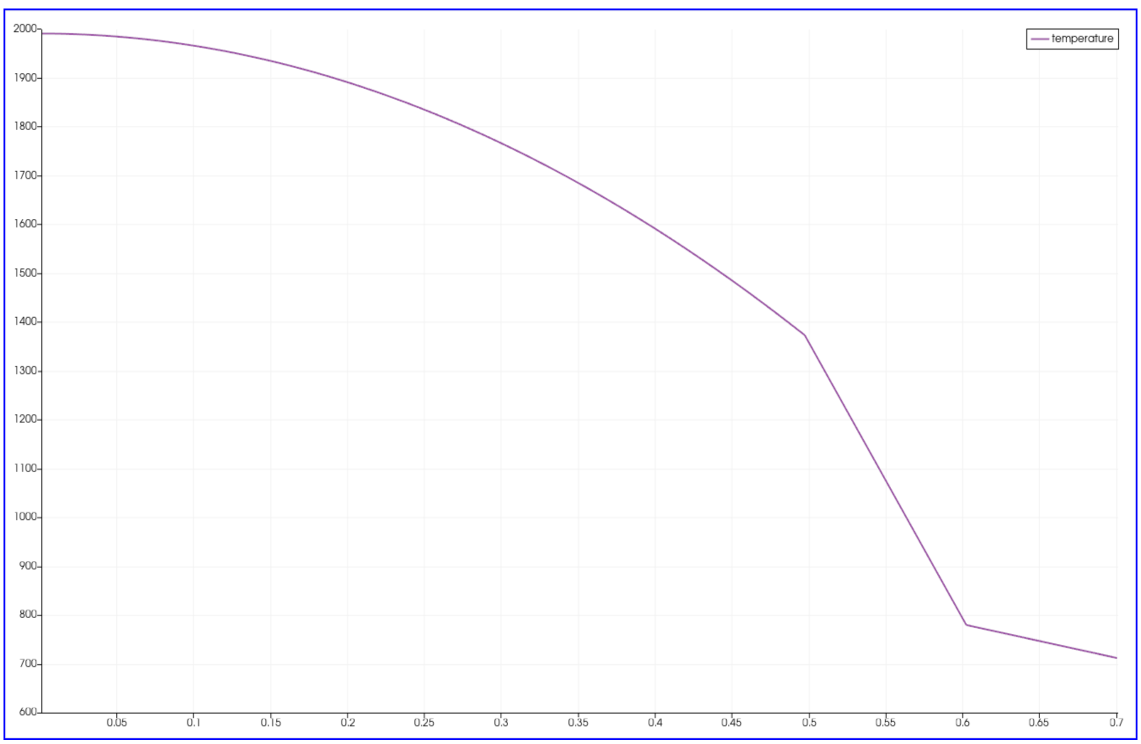


Figure 5 :Temperature Profile at Y=1

Figure 3 , 4 , and 5 represent the temperature profile at different locations in the Y axis at 0.25 0.5 and 1 m we can see that our results have similar behavior with the 1D problem the difference between the three cases is just a slight increase in the temperature with the same typical behavior we can conclude that temperature increase when Y increase because the highest temperature profile we have is at Y=1 and we can also know that the maximum temperature is located at (X=0,Y=1) point which the point located at the center of our system because this problem is simplifying geometry and the true geometry and temperature can be obtained with symmetry the geometry we have is ¼ of a plan which was cut from the fuel rod in the axial direction.

II.2. Transient state

II.2.1 Problem discussion:

In this case we have a 2D problem and it’s in transient state which means that the heat flux is varies with time the heat flux expression is the same as I.2.1 and it has the same flow heat, heat capcity and density as the steady state problem. So the boundary conditions and the physics are similar.

II.2.2 Result discussion:

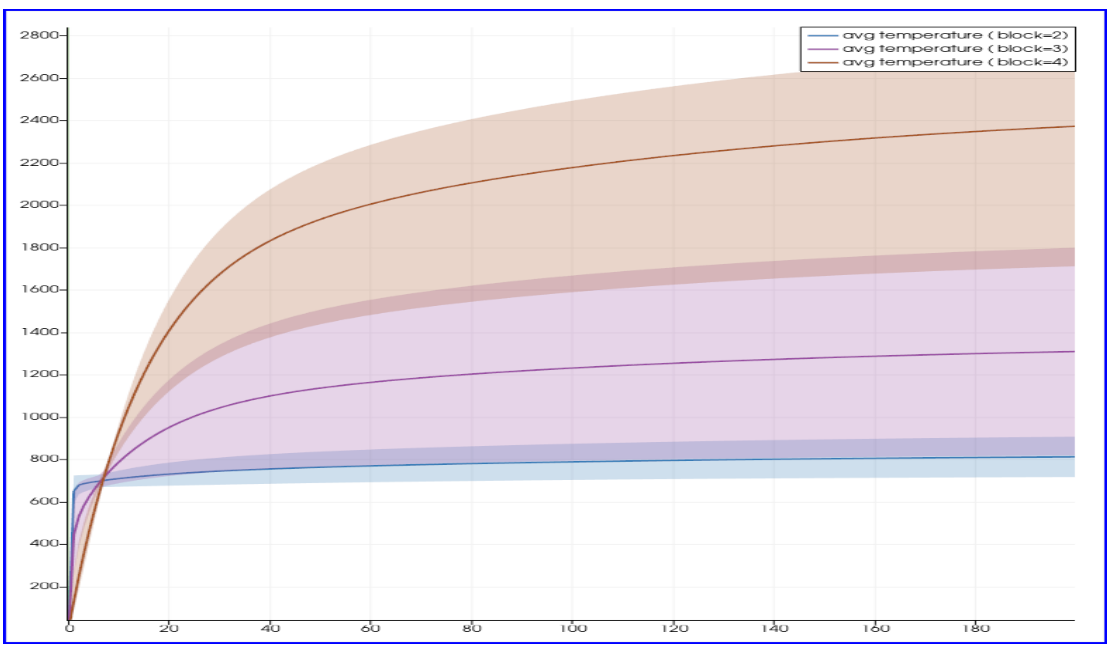


Figure 6: Temperature ranges for the fuel, gap cladding as function of time.

Figure 6 represent the ranges of the temperature from inside the to clad and gap as we can see the temperature range for the fuel is higher than the gap which is higher than the cladding. This not what was asked for but this the data that I could plot using paraview.

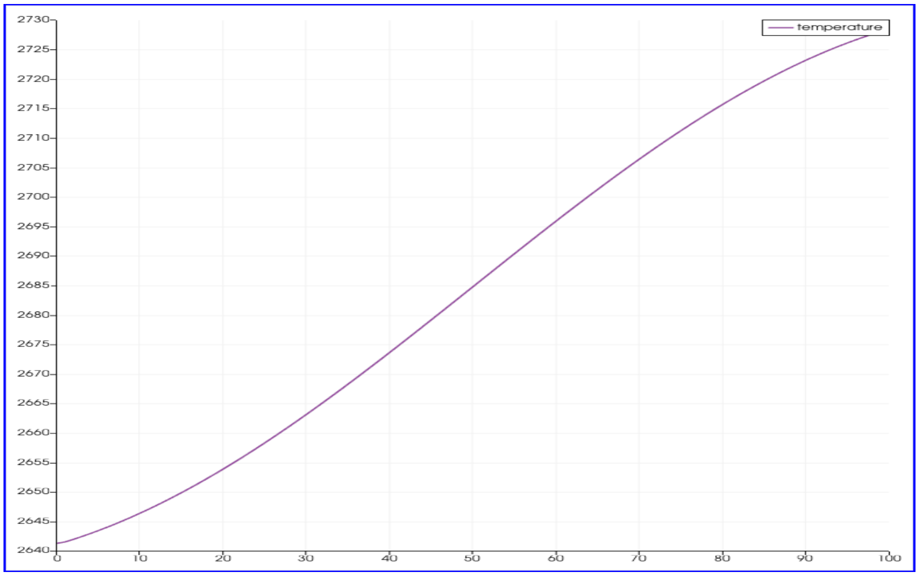


Figure 7: Centerline temperature profile as function of Y axis in cm

Figure 7 shows our centerline temperature as function of y and it shows that the highest, Is at 100cm so we can have the same conclusion as II.1.2