Ansys Fluent Thermal Simulation of the EIC Beampipe

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I developed a 3D model with the beampipe and insulator to study the thermal effect across the entire beampipe length, which was considered to be 9 m, when air is flow at the inlet at constant temperature and at various velocities.

Initially the model consisted on three parts: a body to represented the inner volume of the beampipe (fluid domain), the beryllium beampipe (solid domain), and the Kapton insulator (solid domain), but issues arose due to the addition of the thin layer of Kapton insulator (thickness of 0.39 mm) and the beampipe itself (thickness of 0.76 mm). To solve this issues I removed the physical parts of the beryllium pipe and the Kapton insulator layer form the model and only kept the inner volume of the beryllium pipe. To simulate the thermal effect of the beampipe and insulator parts without including them as physical parts of the model’s geometry, I used the Shell Conduction feature available in Ansys Fluent. Shell Conduction allows to simulate the material thermal properties and the thickness of the layers. For this case, I considered the beryllium pipe as the first layer and the Kapton as the second layer.

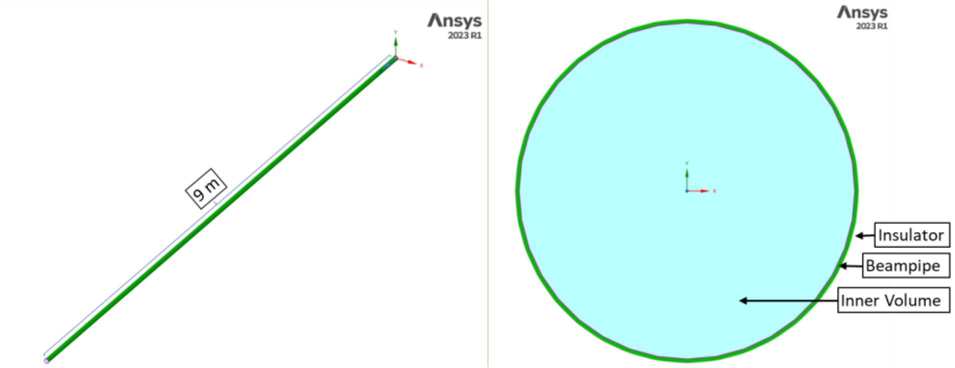

Fig.1. EIC beryllium beampipe model

- **Modeled and meshed beampipe considering its entire length**
- **Setup Fluent boundary conditions, cell zone conditions and conduction shell options for the insulator**
- **Generated contour plots for the velocity and temperature variables**
- **Generated plot to show the temperature convergence as function of the inlet velocity variations**

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Once the model consisted only on the inner volume of the beampipe part, I was able to mesh the model with no issues.
I introduced the material thermal properties for all solid and fluid domains such as beryllium, Kapton, and air.

For the boundary conditions, I set the left side cross section wall of the beampipe inner volume to be the inlet and the right side to be the outlet, for the inlet eight different velocities (1, 5, 10, 15, 20, 25, 40 and 50 m/s) were set at a constant temperature of 100 °C.

I set the simulation with 300 iteration but for each of them but the results were show with less than 150 iterations, meaning that the energy and velocity residuals were below the minimum set.

With the resulted data, I created velocity and temperature contour plots, See Fig.2., to analyze the temperature changes through the beampipe length, three temperature probes were placed, one at the inlet, one at the middle and one at the outlet section. I noted that Temperature between inlet and outlet sections starts to converge after airflow velocity increases to 40 m/s. See Fig.3.

In conclusion the simulation was completed and the temperature changes along the beampipe were analyzed and indicated that when that a high velocity would be required to keep a close temperature value between inlet and outlet sections of the beampipe, as expected. That high velocity might not be possible to run in the real scenario for the EIC beampipe. I plan to continue with this analysis to include a second layer of insulator.

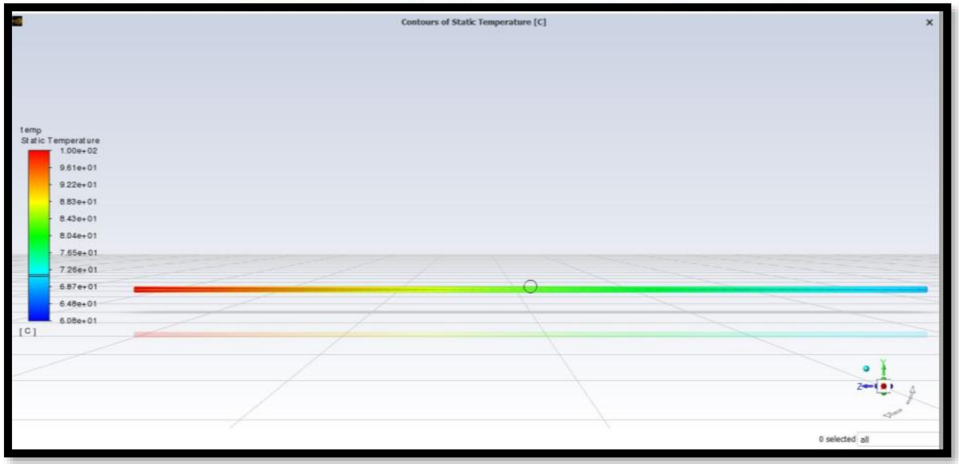

Fig.2. Right side view, cross section YZ plane shows the temperature variation along the length when inlet flow air was set at 100 °C with 5 m/s. Note that the temperature in the middle section (probe located at 4.5 m) was ~ 71°C

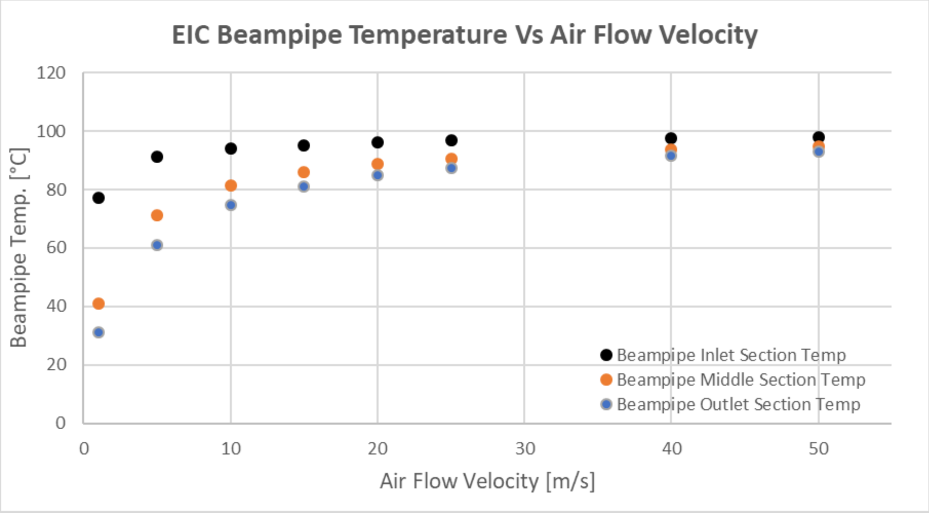

Fig.3. Plot shows the temperature at the inlet, middle, and outlet sections when air flows through its entire length at different inlet flow velocities from 1 to 50 m/s