Ansys Fluent Thermal Analysis of the EIC Beampipe

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December 14, 2023

This note presents the Ansys Fluent thermal simulation results for the EIC beampipe with multilayer insulation and constant inlet airflow velocity and air temperature.

A beampipe model [1] [2] that consists of truncated Al cone sections (blue) and a central Be section (yellow) was generated with Ansys SpaceClaim, Fig.1a. Because the multilayer insulation of the beampipe has a wall thickness of 160.1 µm, it was not implemented as a physical part to avoid complicated meshing. The Conduction Shell option of Ansys Fluent was used to add, over the outer surface of the entire beampipe, the thickness of each layer of the multilayer insulation (polyimide 80 µm, Al 0.1 µm, and aerogel 80 µm). Table I lists beampipe dimensions and materials.

Part/ material	Length [mm]	ID/ OD [mm]	ID/ OD [mm]	OD [mm]	ID [mm]	Wall thickness [mm]
Beampipe inlet/Al	3700	202/ 208	58/ 64	N/A	N/A	3
Beampipe central section/Be	1485	N/A	N/A	64	62	1
Beampipe outlet/Al	3815	224/ 230	58/ 64	N/A	N/A	3

TABLE I. Model dimensions.

The mesh, generated with Ansys Fluent Meshing, had a cell size of 0.5 mm for the Be section, 1.5 mm for the Al sections, and variable cell sizes for the three mesh layers between the solid and fluid domains; in all ~29 million cells.

Simulation conditions were as follows: inlet airflow velocity v_{af} = 5 m·s^{-1}, inlet air temperature 100°C, convection coefficient h_c = 5 Wm^{-2}K^{-1}, and ambient air temperature T_{aa} = 20°C. The number of iterations was limited to 300; however, convergence of the solution required only 142 iterations.

To conclude, Figs. 1b–e show beampipe temperature, airflow velocity, and pressure. Analysis of the plots shows that the Be wall temperature = 93°C, v_{af} increases in the Be section from 5 m·s^{-1} to 62.7 m·s^{-1}, and the air pressure in the Be section is ~1.7 Pa.

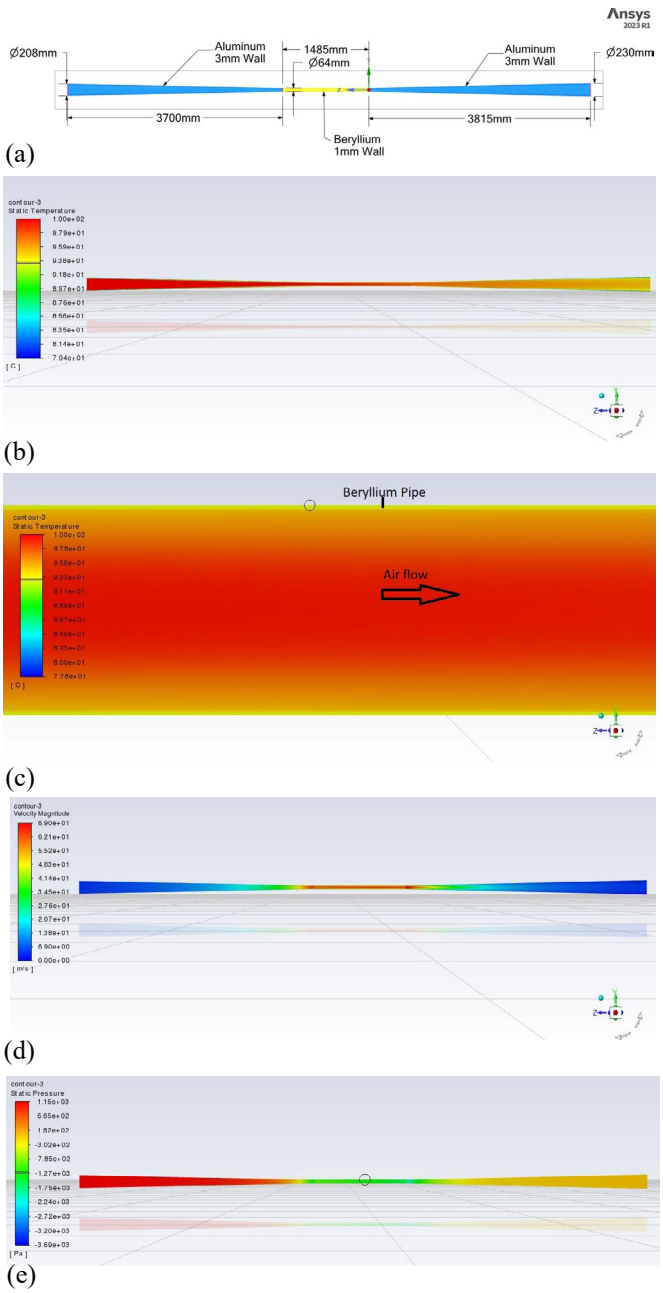

FIG.1. (a) Beampipe, (b) temperature (air temperature in beampipe and Be section. Temperature of wall is 93°C.) (d) air velocity in beampipe, (e) cross-sectional view of the air pressure in beampipe.

[1] P. Campero, et al., *Thermal Analysis of the Beryllium Beampipe at Interaction Point 6 of the Electron Ion Collider*, DSG-Note 2022-09, 2022.
[2] P. Campero, et al., *Thermal Analysis of the Electron Ion Collider's Beryllium Beampipe Section*, DSG-Note 2023-09, 2023.