EIC Beampipe Test Stand with Aerogel Thermal Simulation

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A new 3D model for the EIC Test Stand Beampipe setup by DSG group was developed to include components of the actual test stand and allow a simulation with results that can be used as a reference to compare with the actual measurements. The new developed 3D model includes the heater elements (x2), heater pipe, the beampipe, 1 mm aerogel insulator, inlet pipe with ¼ inch connectors, and the silicon pipe. See fig.1.

To ensure the contact region between the heater pipe and the beampipe just as the actual setup a thin slide was creater between them along the entire length.

The surface and volume mesh of the model was completed, I had to use local size options to provide a high quality of mesh for the inner volume of the heater pipe and the inner volume of the beampipe since these two regions presented a thin regions.

Thermal properties each material associated with the solid component is show in table 1. for the fluid domains, I configured air for the beampipe inner volume and mineral oil for the heater pipe inner volume. For the mineral oil thermal properties were set by introducing the coefficient for the polynomial curves associated since its thermal properties varied as function of the temperature (based on specifications)

Component	Material	density [Kg/m3]	specific heat [J/Kg°C]	Thermal Cond. [W/m*K]
Heater Pipe, Heater Elements	Steel	7850	420	45
Beampipe, Silicon Pipe, Inlet Pipe, ¼'air connectors (x4)	Aluminum	2719	871	202.4
Insulator layer	Aerogel	150	948	0.04
O-Ring	Rubber	1150	1050	0.2

Table I. Materials used per component

- **Generated a model of the EIC test stand model with critical components for thermal simulation**
- **Meshed model, set boundary and cell zone conditions based on the actual conditions for the test stand**
- **Ran multiple simulations and generated velocity and temperature contour plots with the results**

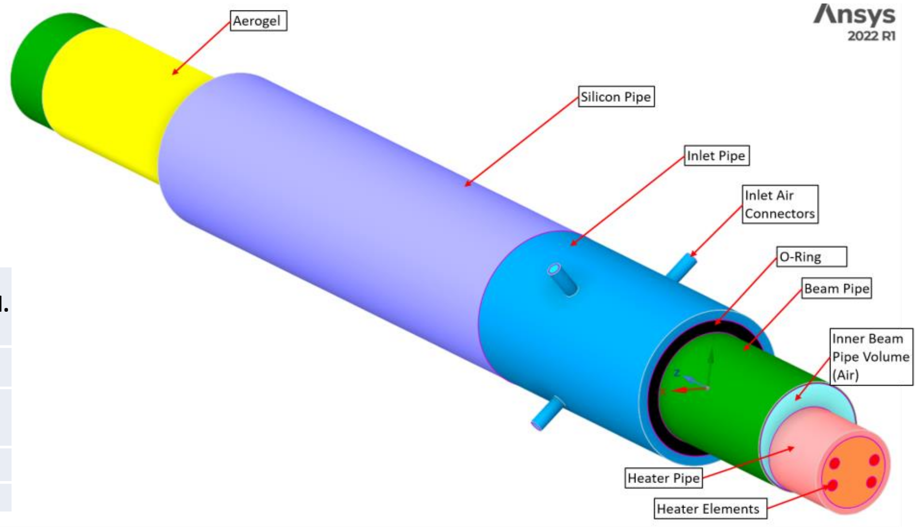

Fig. 1 EIC Test Stand model with critical components for the thermal interaction

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I setup the cell zone and boundary conditions, some of them are shown in table II below. For the simulations two approaches to configure the source of heat for the model were set. One was by setting the heater elements with a fixed temperature and another by setting the heater elements with power based on its volume (Watts per cubic meter).

Solver	Fluid Flow Fluent , pressure-based
Model	k-omega, Shear Stress Transport (SST)
Heat Transfer	Natural and forced convection
Precision	Double
Simulation Iterations	2500
Heat of source	1,365,516 W/m3
Air temperature	22 °C
Air flow velocity (per connector)	27.63 m/s or total 210 L/min

Table II. Cell Zone and Boundary Conditions

During the initial attempt to run the thermal simulation I face floating point errors due to the improper way of implementing the variable thermal properties for the mineral oil, I resolved the issues by using piece polynomial with range parameters.

From the results noted that the setting the heat of source with ~1,365,516 W/m3 to achieve a temperature of 100°C in the beampipe; the maximum velocity at the outlet of the annulus space formed between the inlet face of the silicon pipe and the outer face of the aerogel insulator was 3.4 m/s; the silicon temperature 30.22 °C, Beampipe temperature 100.13 °C, and heater pipe upstream temperature was 112.4 °C

The Ansys-Fluent simulation results and the measured RTD values (test stand) are close, except for the heater pipe temperatures, which are considerably low in the simulation since the heater elements heat of source settings were decreased to achieve the required 100 °C at the beampipe. I forced a lower temperature in the simulated heater pipe compared to the actual tests stand heater pipe since it has a greater contact surface area with the beampipe.

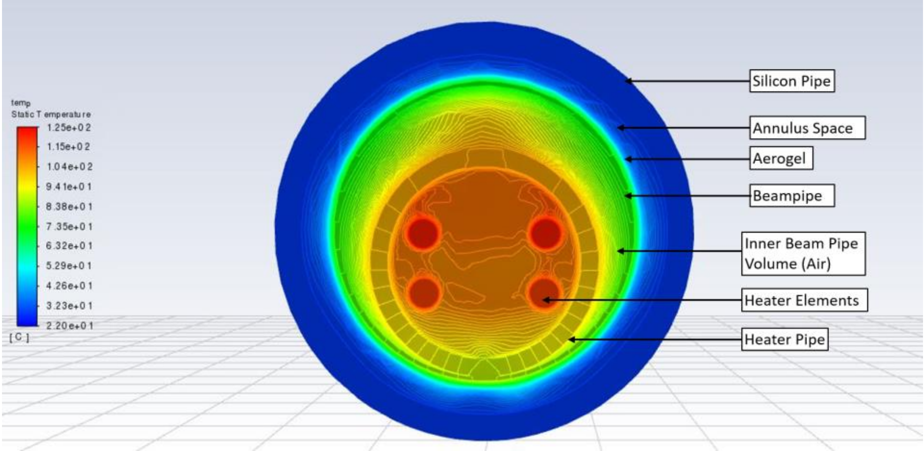

Fig.2. front/upstream view of the temperature contour plot for the central section of the model

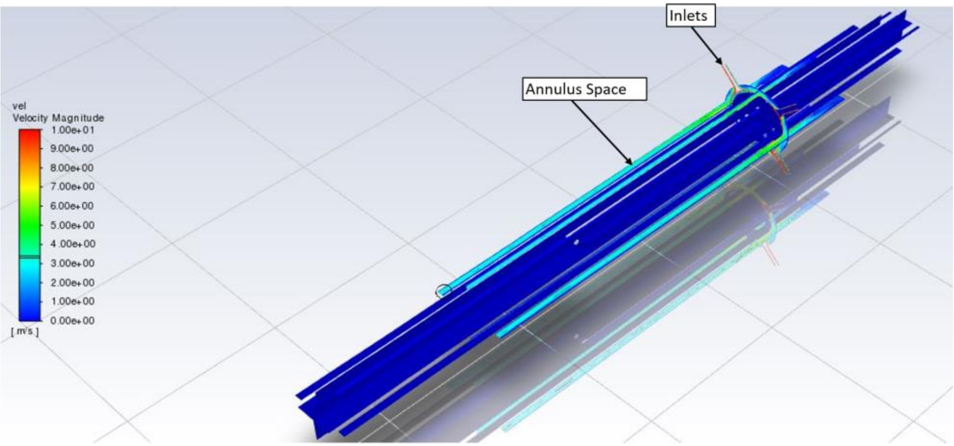

Fig.3. Velocity contour plot – isometric view shows the velocity variation in the annulus space with a total air flow inlet of 210 L/min. Velocity contour plot in a range of 0 -10 m/s