INSULATION - FLOW BALANCING

This case study investigates the balancing of forced flow through a perforated flow distribution manifold situated between the thermal insulation and the bottom of a cylindrical test cavity that forms part of a highly specialized experimental facility. The purpose of the insulation and manifold is to adequately insulate the very high temperatures within the test section while still allowing forced flow of gas to enter at the bottom of the test cavity.

NUCLEAR INDUSTRY

CUSTOMER PROFILE:

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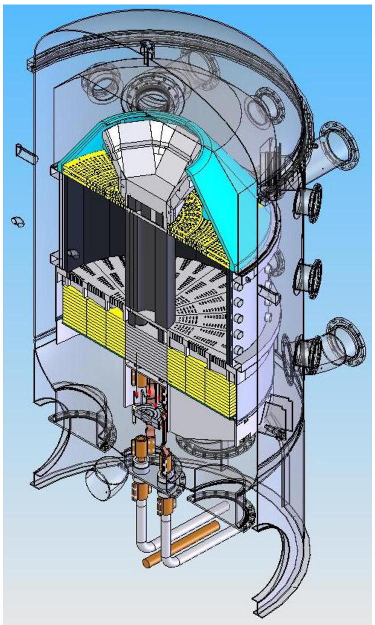
CHALLENGE:

The objective of the simulation is to model the flow rates through the respective flow channels and perforations of the inlet manifold. This was required to initially determine the appropriate sizes of the channels in order to achieve the most uniform distribution of gas flow into the bottom of the test cavity.

SOLUTION:

The results show that the flow distribution conforms well with the desired values in all cases.



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FLOW BALANCING THROUGH INSULATION

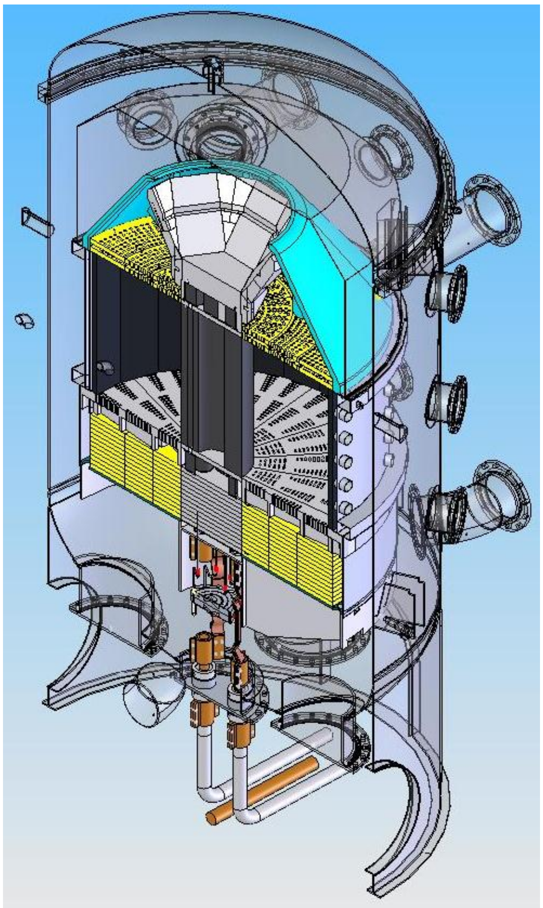
INTRODUCTION

This case study investigates the balancing of forced flow through a perforated flow distribution manifold situated between the thermal insulation and the bottom of a cylindrical test cavity that forms part of a highly specialized experimental facility. The purpose of the insulation and manifold is to adequately insulate the very high temperatures within the test section while still allowing forced flow of gas to enter at the bottom of the test cavity.

SYSTEM DESCRIPTION

Figure 1 shows a section through the test facility under investigation. Note the insulation layers (yellow) below the test cavity together with the perforated flow distribution manifold directly between the insulation and the test cavity.

Figure 1: Section through the test section.



The purpose of the insulation and manifold is to adequately insulate the very high temperatures within the test section while still allowing forced flow of gas to enter at the bottom of the test cavity.

Figure 2 shows a section through the insulation and flow distribution manifold while Figure 3 shows more detail of the manifold itself. As shown in the figures, the flow enters from the bottom through numerous vertical circular channels positioned around the perimeter. From there it is fed towards the centerline via five horizontal rectangular channels into different cavities, from where it enters the test cavity through numerous slotted perforations.

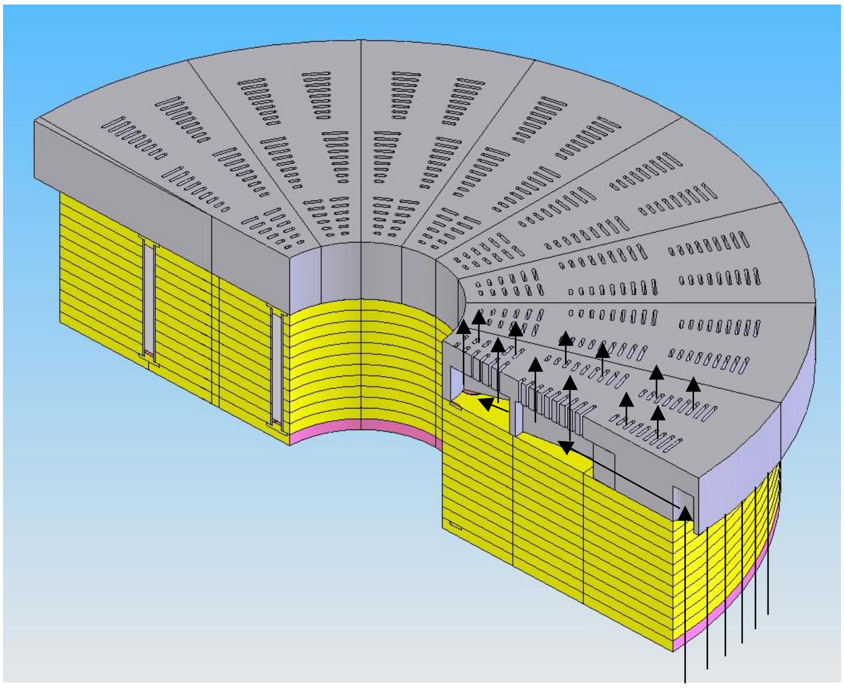


Figure 2: Section through the insulation layers and perforated flow distribution manifold.

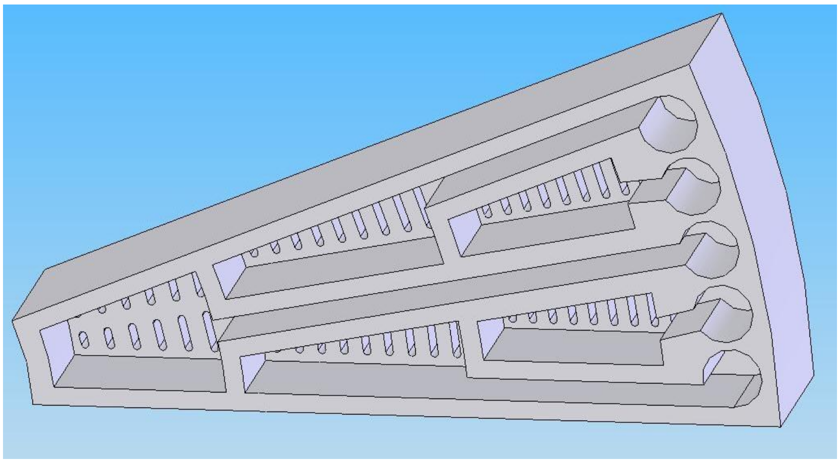


Figure 3: Detail of the perforated flow distribution manifold.

The flow enters from the bottom through numerous vertical circular channels positioned around the perimeter. From there it is fed towards the centerline via five horizontal rectangular channels into different cavities.

The purpose of the manifold is to achieve the most uniform flow distribution possible at the inlet to the test cavity. This will of course be a function of the geometries of the flow paths within the flow distribution manifold. The manifold can be divided into three regions namely the inner, middle and outer regions. The inner region is fed from only one cavity and must supply 20% of the total flow rate. The two middle cavities must supply 38% and the two outer cavities must supply the other 42% of the total flow rate.

Determine the appropriate sizes of the channels in order to achieve the most uniform distribution of gas flow into the bottom of the test cavity.

OBJECTIVE OF SIMULATION

The objective of the simulation is to model the flow rates through the respective flow channels and perforations of the inlet manifold. This was required to initially determine the appropriate sizes of the channels in order to achieve the most uniform distribution of gas flow into the bottom of the test cavity.

FLOWNEX MODEL

The Flownex model for a single flow distribution manifold block is shown in Figure 4.

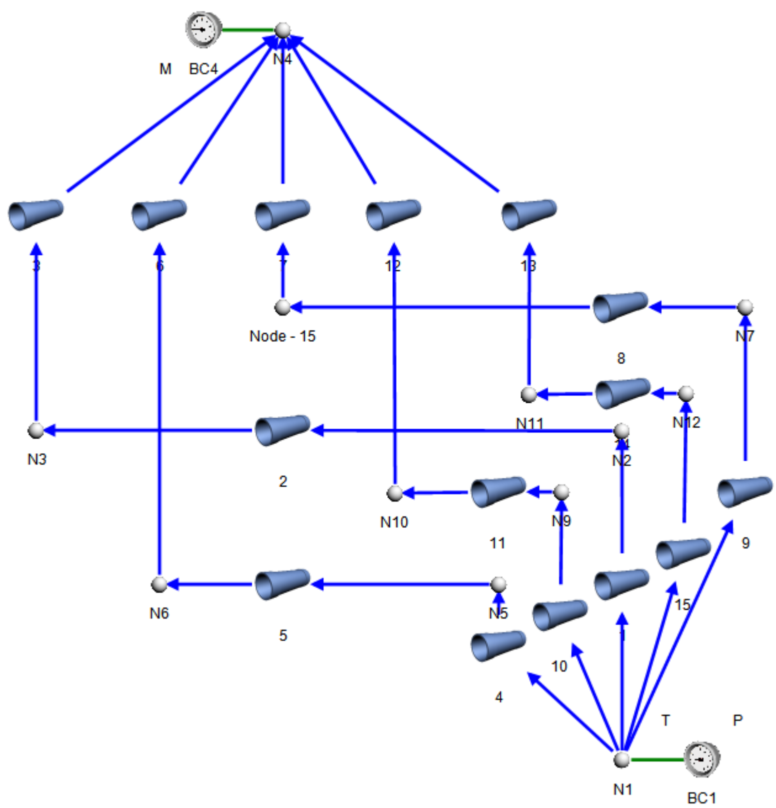


Figure 4: Flownex network of a single flow distribution manifold block.

Node 1 represents the cavity below the insulation layers from which the gas is fed while node 4 represents the test cavity. Pipe elements 4, 10, 1, 15 and 9 represent the vertical circular inlet channels in the order shown in Figure 3. Node 3 represents the single cavity inner region, nodes 6 and 8 the two cavities in the middle region and nodes 10 and 11 the two cavities in the outer region. Pipe elements 3, 6, 7, 12, 13 represent the respective sets of perforated slots that feed the gas into the bottom of the test cavity. Pipe elements 2, 5, 8, 11 and 14 represent the horizontal channels.

DESCRIPTION OF SIMULATION

The pressure and temperature boundary values of 100 kPa and 35°C are specified at node 1 while the appropriate flow rate is specified as a mass sink at node 4. The simulation was done for various different flow rates through the bed since it may vary during the operation of the test facility. The impact of the flow channel geometry is represented by suitable areas, lengths and pressure loss factors.

RESULTS

The desired versus obtained flow rate distributions are shown in the table below.

Region	Required	4kg/s	3kg/s	2kg/s	1kg/s	0.5kg/s
Inner	20.0%	19.3%	19.3%	19.2%	19.1%	19.2%
Middle	38.0%	39.0%	39.0%	39.0%	39.1%	39.1%
Outer	42.0%	41.7%	41.7%	41.7%	41.8%	41.8%

CONCLUSION

The results show that the flow distribution conforms well with the desired values in all cases.

The impact of the flow channel geometry is represented by suitable areas, lengths and pressure loss factors.

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