

The research of spherical door shroud in huge space environmental simulator

Tong hua¹, Liu ran², Chen jin ming³

1,2,3 Bei Jing institute of spacecraft environment Engineering

Background

Liquid nitrogen shroud is an important device of simulating space cold and black environment. Meanwhile, since the low temperature of the liquid nitrogen makes the gas molecules falling on the shroud's surface, thus, the shroud is also an important part of vacuum vessel pumping system. The door shroud in huge space environmental simulator which is change from flat plate to spherical shape can effectively enlarge the environmental capacity. The spherical door shroud has become new tendency recently.

Design

- The effective diameter of lateral shroud in huge space environmental simulator is 7500mm, with the effective length of 10000mm.
- The shroud is divided into 4 parts: door shroud, back shroud, left lateral shroud and right lateral shroud. Each part is supplied with LN2 independently.

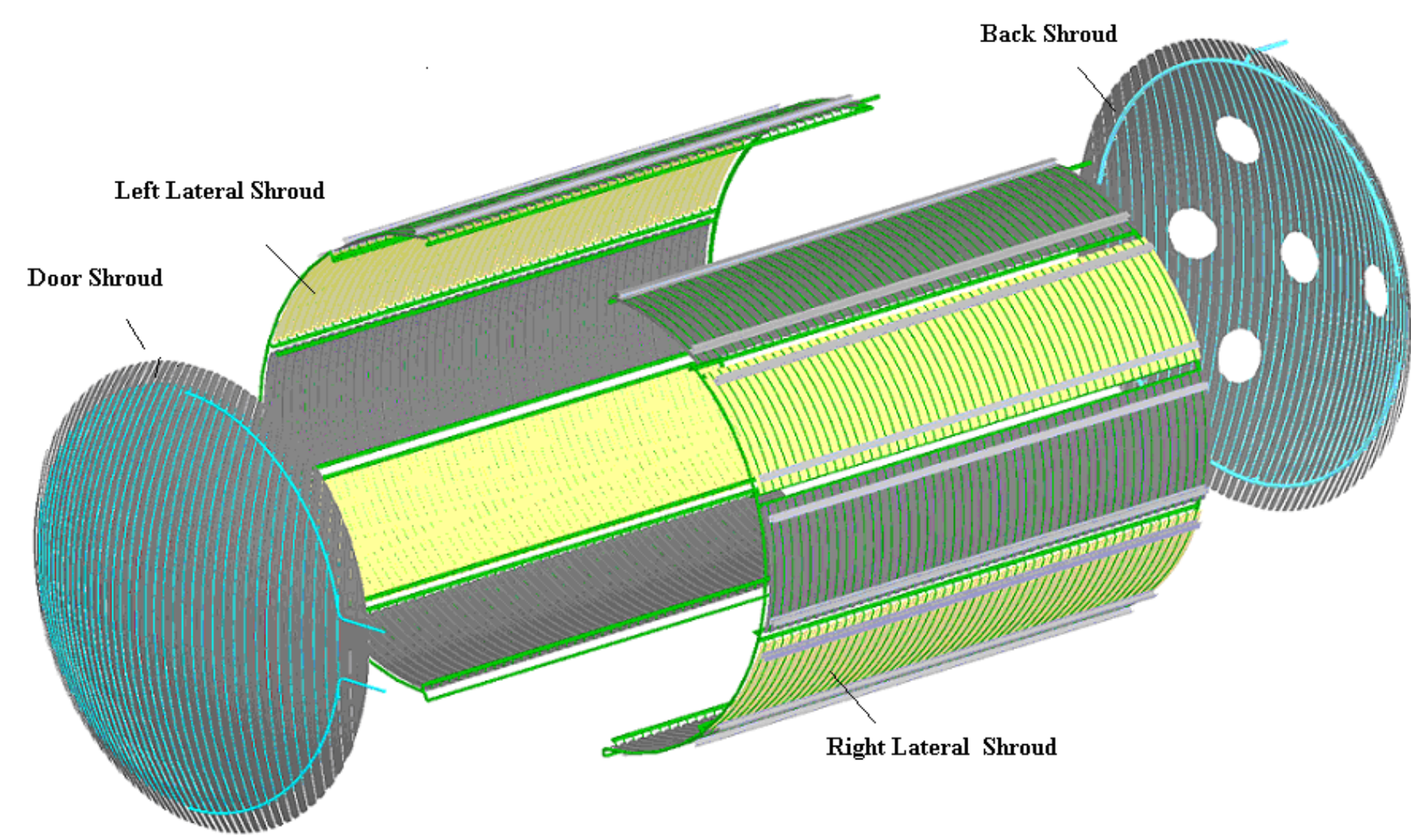
Conclusion

- The key technology of door shroud's design、emulator、manufacture represents first class level in world.
- Shroud reform on site enlarge the environmental capacity.
- The shroud opening pores change the flow massage, the temperature of sub-pipes is also disturbed , the profile of temperature also fluctuate. The emulator indicates, the highest temperature of door shroud surface is still near -188.7°C, the temperature rise of liquid nitrogen 、 flow pressure loss and the temperature of door shroud surface are all met the performance index of shroud.
- The door shroud passed the verification, the performance index of shroud all achieved the demand of contract, which mean the technology of shroud emulator is successful.

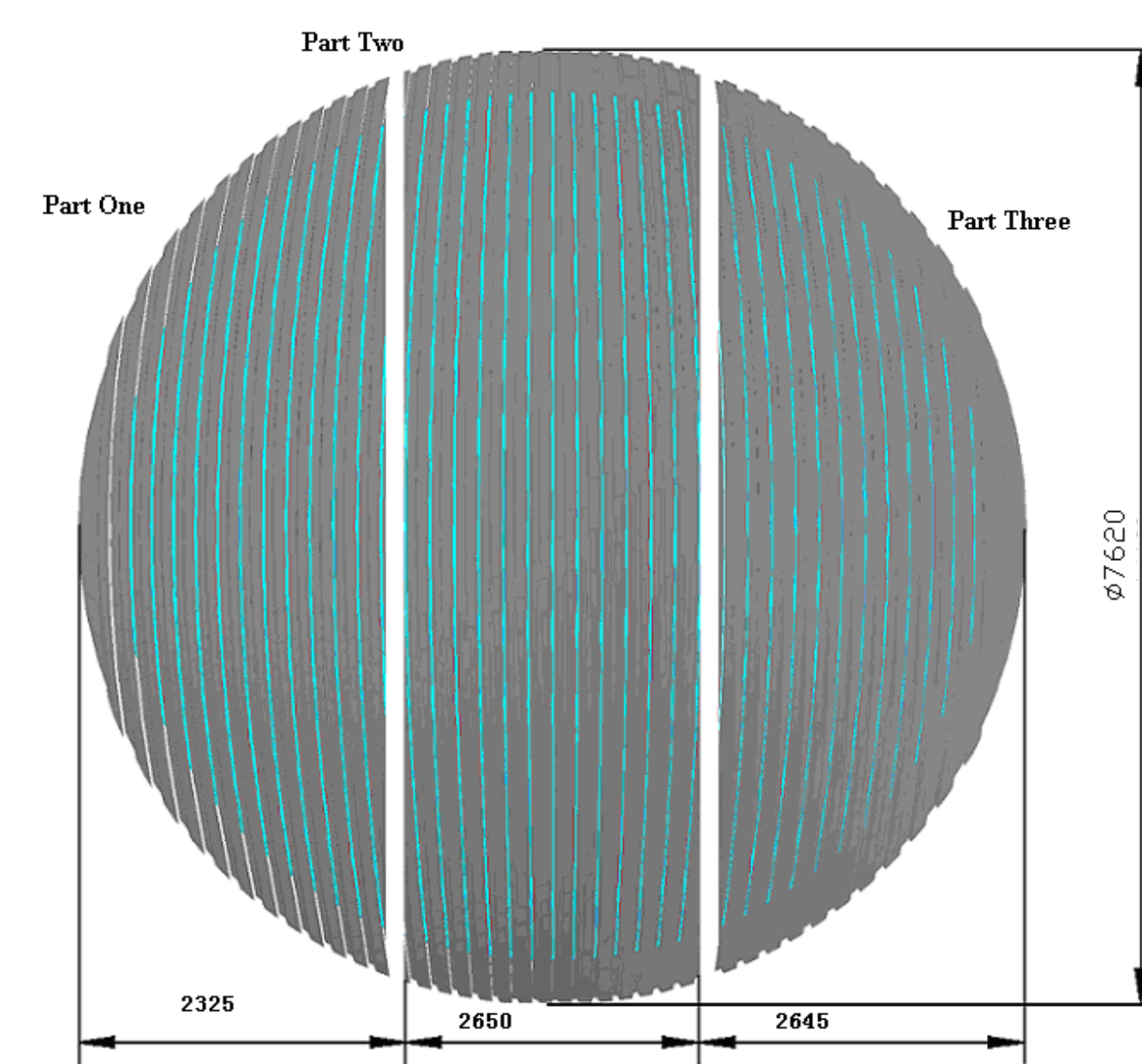
Methods

Structure of shroud

The shroud is pipe sheet structure of stainless pipe welding copper fin.



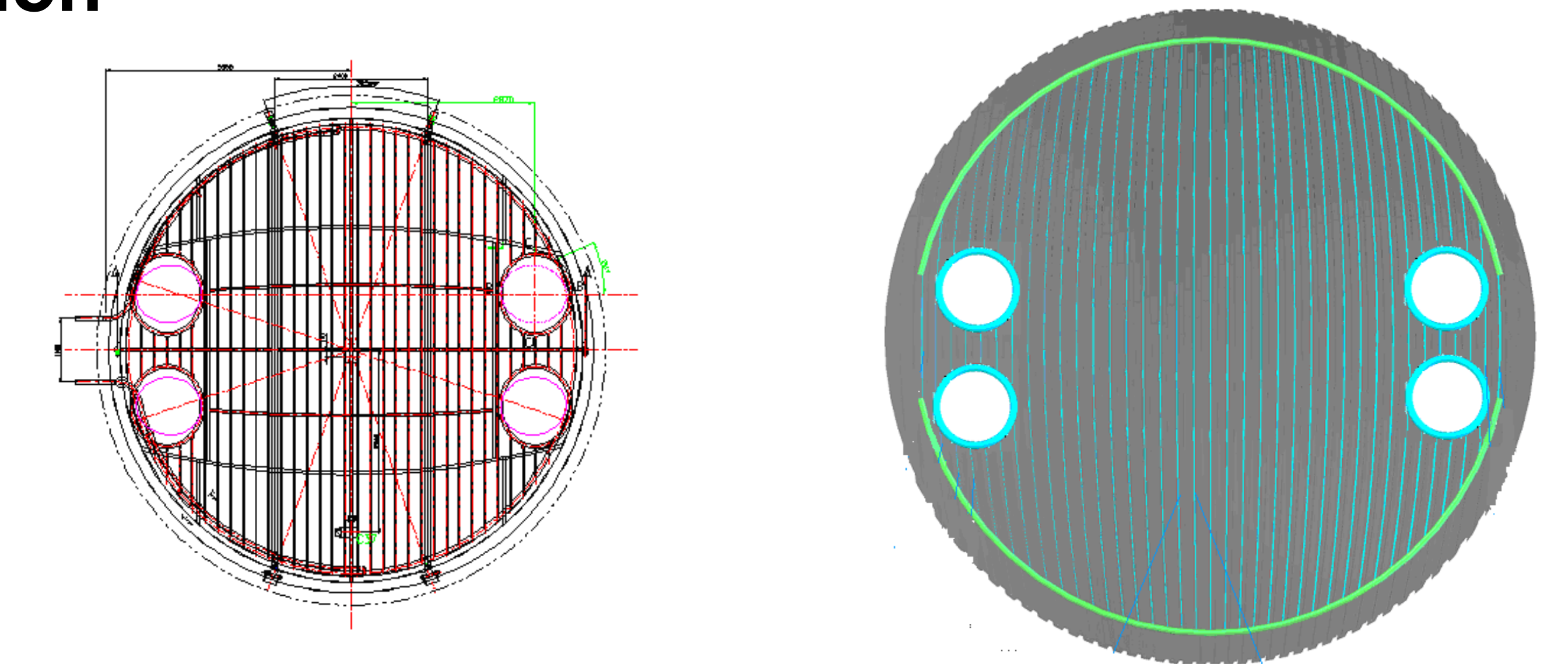
Door Shroud



The door shroud is the structure of sphericity with the diameter of $\phi 7620\text{mm}$ and the distance between two pipes of 200mm. In terms of transportation, the door shroud is divided into 3 pieces, with one in the middle, and each in left and right. The one in the middle is the biggest, with the size of $7620\text{mm} \times 2610\text{mm} \times 1520\text{mm}$ (L \times W \times H) . The door shroud has the entrance for liquid nitrogen at the bottom and exit on the top. The door shroud's entrance and exit for liquid nitrogen are set on the side of the door, for the convenience of dismantling and installing door. With the entrance at the bottom and the exit on the top, metal soft tube is installed close to the entrance and the exit, for the convenience of the installment of door shroud.

Door shroud modification

There are three problems in door shroud opening pores reform:
 a. define the position of door shroud opening pores
 b. clear the element copper which infiltrates in sub-pipe
 c. cancel local stress
 The position of door opening pores is defined by solidwork three-dimensional drawing. Clear the element copper thoroughly by sander. Then weld the summary ring pipe ,repair frame A special method is used in the welding form of summary ring pipe and sub-pipe, which can cancel local stress. After repairing, the door shroud can be assembled .

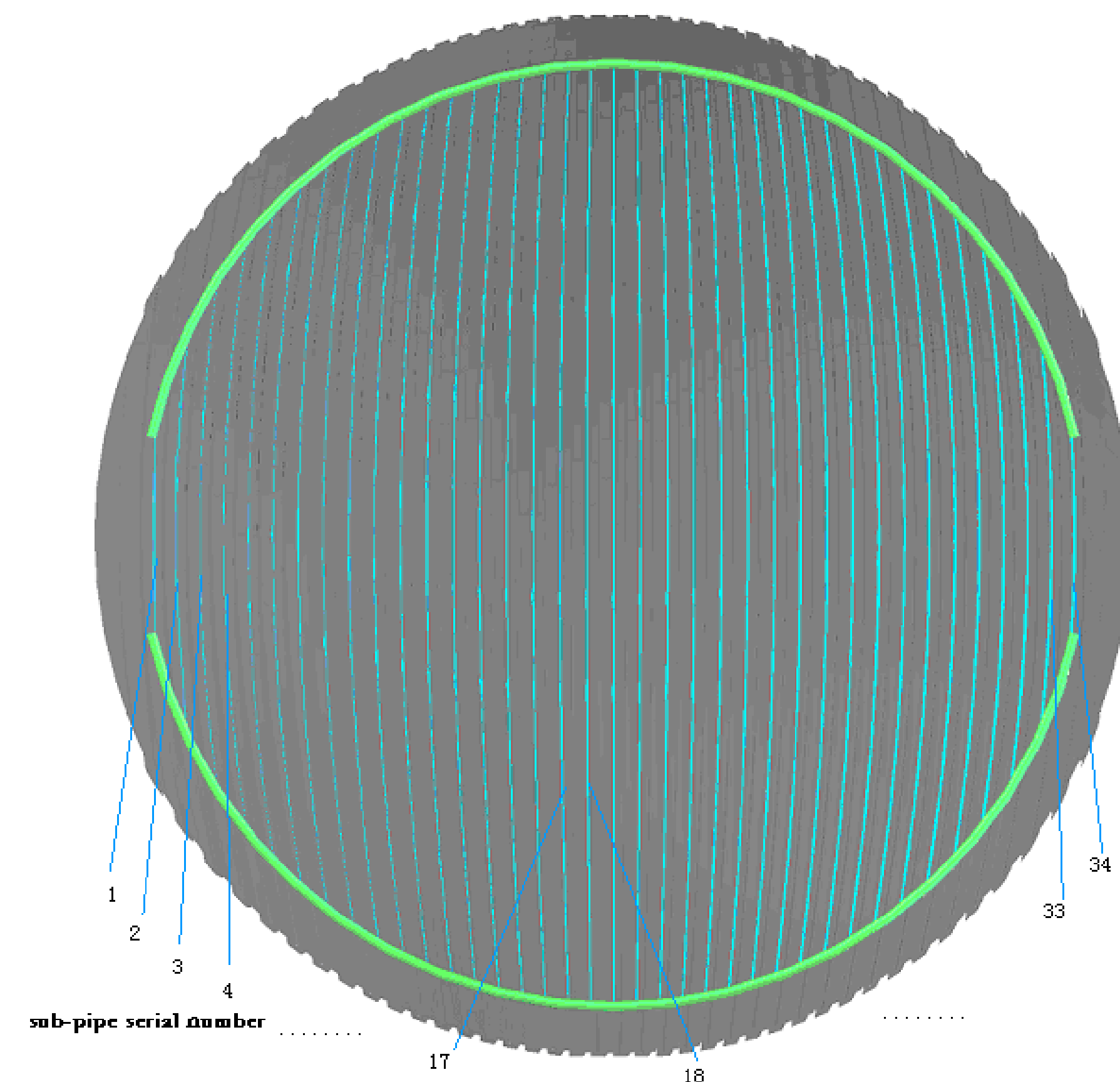


The drawing of opening pores in shroud

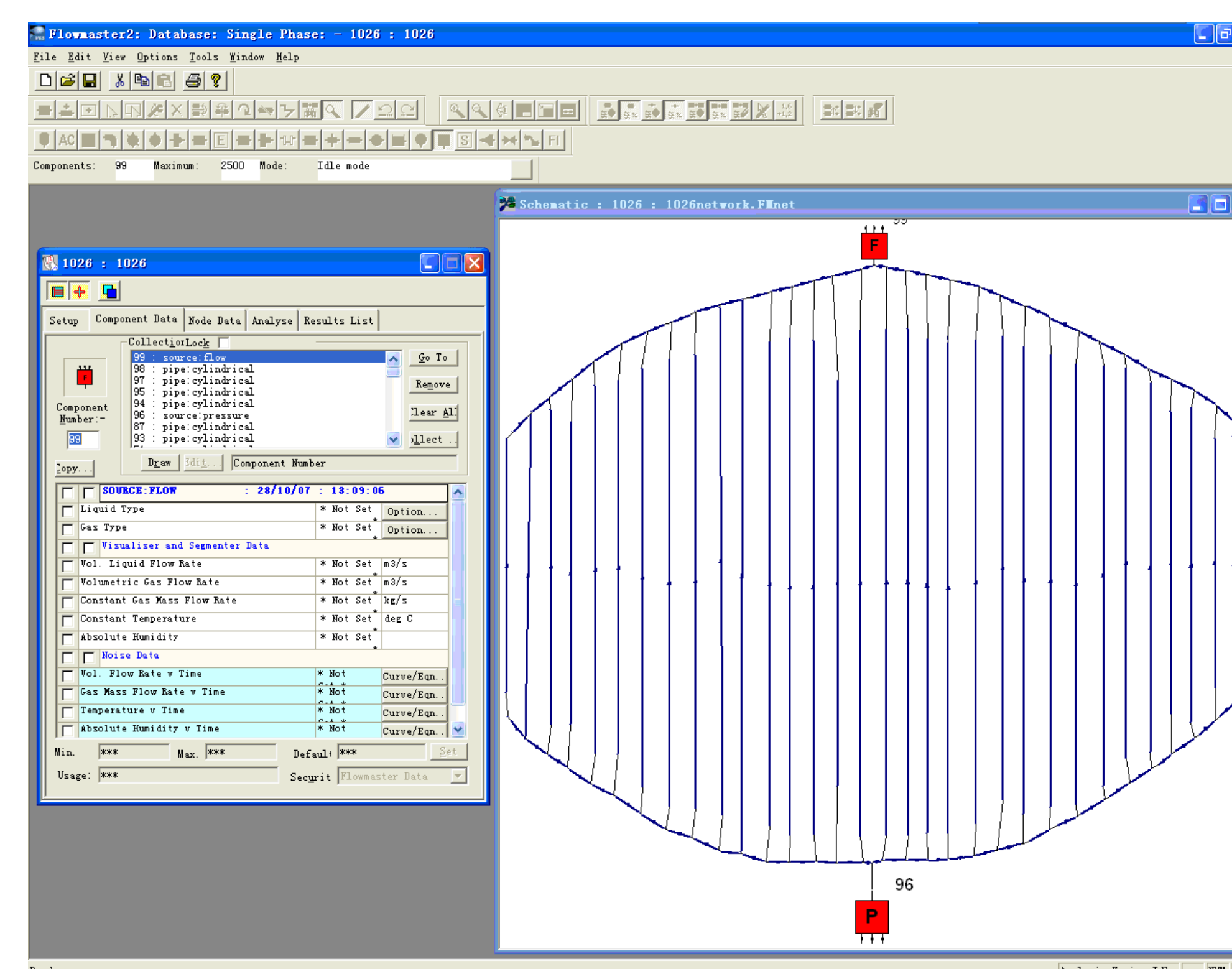
Shroud emulator

the software of flowmaster is used to build model to emulate the flow of liquid nitrogen in shroud's sub-pipe. According to the calculation of steady state heat transfer in single phase closed-cycle system ,the temperature of shroud's sub-pipe curve can be obtained.

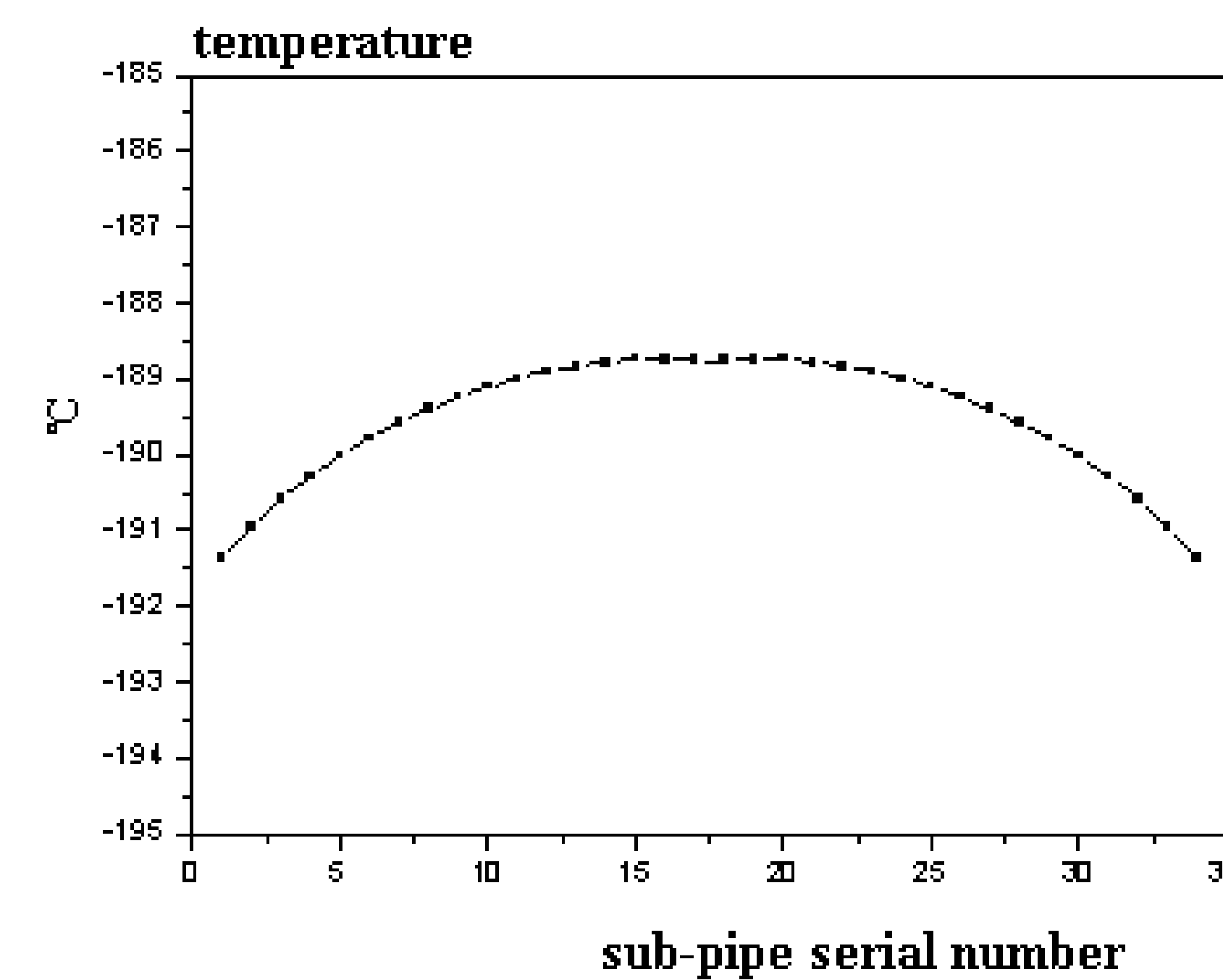
Door shroud build model ,the model's boundary input condition is as follow:
 The working substance in shroud is liquid nitrogen:
 Door shroud liquid nitrogen's volume flow is 8m³ per hour,
 temperature in entrance is -191°C, liquid nitrogen pump's outlet pressure is 0.45MPa.
 The average heat load works on door shroud is 230W/m².



The serial number of door shroud sub-pipe is as shown

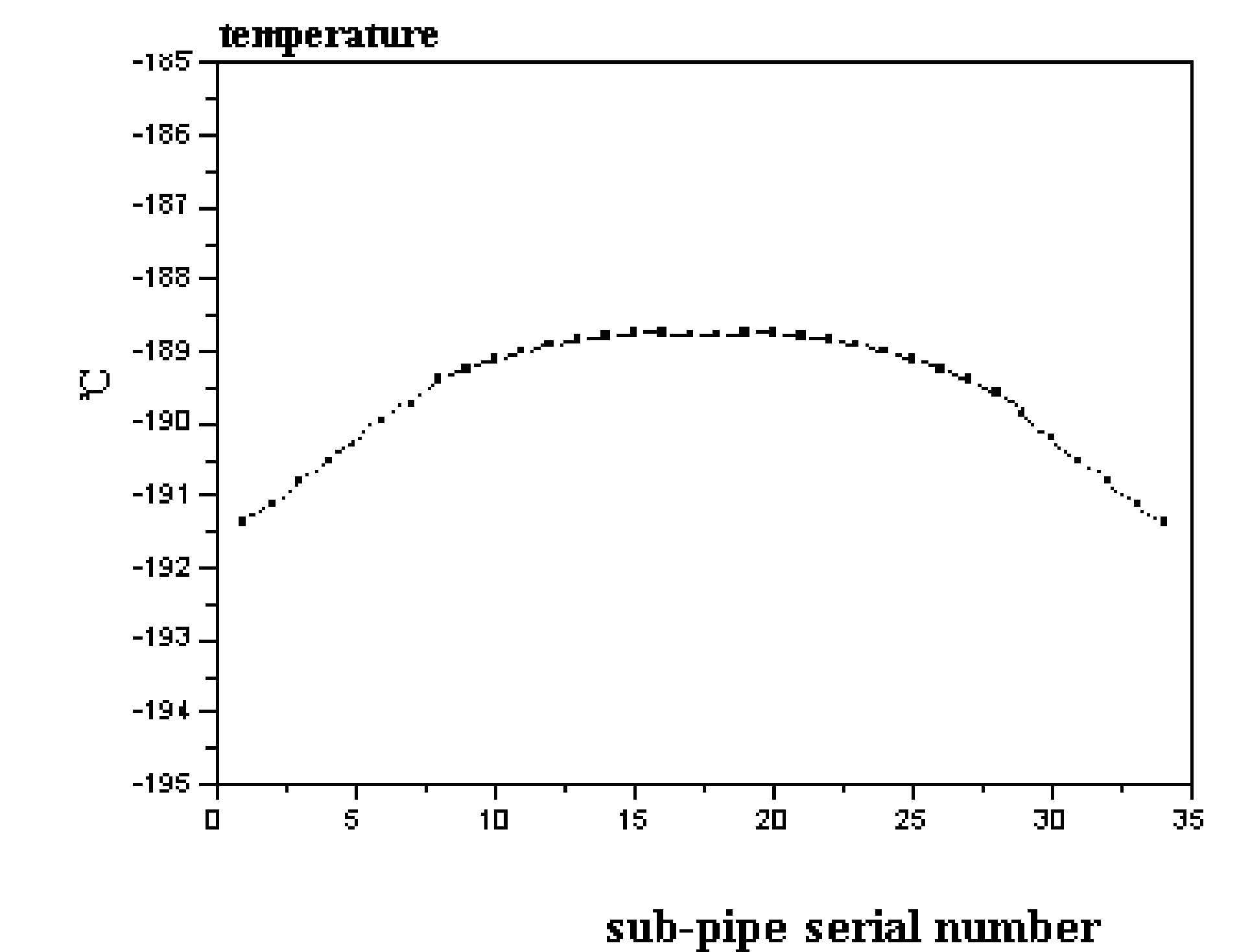


the drawing of door shroud model building
 The liquid nitrogen outlet pressure of door shroud is 0.397 MPa.



the highest temperature of door shroud surface is -188.7°C. The temperature rise of liquid nitrogen 、 flow pressure loss and the temperature of door shroud surface are all met the performance index of shroud.

Door shroud model building after opening pores



The curve shows: as the opening pores change the flow massage, sub-pipe 2 to sub-pipe 7 and sub-pipe 28 to sub-pipe 33 resistance also changes too, thus the temperature of sub-pipes is also disturbed , the profile of temperature also fluctuate. But the highest temperature of door shroud surface is still near -188.7°C.