Developing Progress of Critical Equipments in CSNS Cryogenic Hydrogen System

Guoping Wang[1], Yu Zhang[1], Zhangzhan Chen[2], Chongchao He[1], Meiying Ding[1], Yaqiong Wang[1], Na Li[1], Daming Sun[2], Kun He[1]

1. Institute of High Energy Physics, Chinese Academy of Sciences, 19B YuquanLu, Beijing, P.R.China
2. Institute of Refrigeration and Cryogenics, Zhejiang University, 38 Zheda road, Hangzhou, P.R.China

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Introduction

Neutron scattering technique is one of the ideal methods to study the material structural and dynamics, and now is widely used in scientific research and industry areas. Spallation neutron source is designed to accelerate proton beam pulses, and striking a solid metal target to produce fast neutrons, and then, these fast neutrons become slow neutrons with lower energy by colliding with moderators. China spallation neutron source started construction in October 2011, and this project will last for 6.5 years.

Overall progress of CSNS cryogenic system

Highlights of CSNS cryogenic system are the special design for the accumulator. The accumulator was positioned in a separately cold box, in order to make it more accessible and to facilitate rapid replacement. In one case, the accumulator breaks out, it will be much more convenient to remove and replace by simply open the accumulator cold box.

Helium refrigerator has been finished designing, manufacturing and factory testing in Linde, and will be shipped to the project site in this July. Cryogenic hydrogen circulators and cryogenic valves were purchased from Barber-Nichols and STOHR separately, and have already arrived.

Emphasis is focused on the research and development of critical hydrogen equipments in this study.

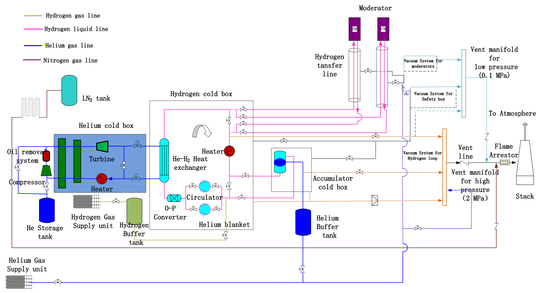

Figure 1 Schematic of CSNS cryogenic system

Developing progress of critical hydrogen equipments

CSNS cryogenic hydrogen system composed of several key equipments, including hydrogen-helium heat exchanger, moderators, heater, hydrogen circulators, ortho-para hydrogen convertor, cryogenic valves and pipelines. Most of these devices are independently developed, and the latest developing progress will be shown in this study.

Hydrogen-helium heat exchanger

CSNS cryogenic hydrogen-helium heat exchanger adopts aluminum plate-fin heat exchanger with counter flow. Serrated fins are used to enhance the heat transfer performance.

A prototype of hydrogen-helium heat exchanger was developed and finished manufacturing. Later, performance test for this heat exchanger will be conducted in a cold box that imitates the real working conditions.

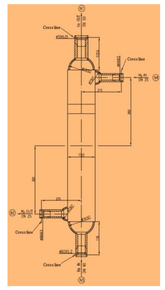

Figure 2 Design model of the hydrogen-helium heat exchanger

Table 2 Design parameters for CSNS cryogenic hydrogen-helium heat exchanger

Type	Aluminum plate-fin heat exchanger	
Medium	H_2	He
Mass flow rate / g/s	73.15	110
Design pressure / bar	25	25
Working pressure / bar	15	1.4
Allow pressure drop / bar	0.2	0.2
Inlet temperature / K	-	16.45
Outlet temperature / K	18	-
Heat exchanger power / W	2200	

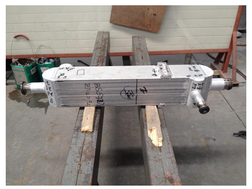

Figure 3 Physical model of the hydrogen-helium heat exchanger

Cryogenic hydrogen heater

The hydrogen heater is mainly composed of two parts, the vessel and the sheathed heaters. Baffle plates are longitudinally arranged inside the vessel, and orifices in the baffle plates are set to arrange the sheathed heater. A prototype of the cryogenic hydrogen heater has been design and manufactured. The height of the heat core is 940 mm, and the diameter of the heat vessel is 114 mm.

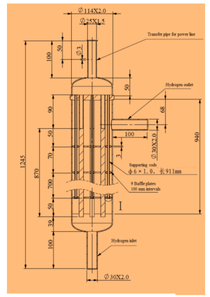

Figure 4 Design model of the cryogenic hydrogen heater

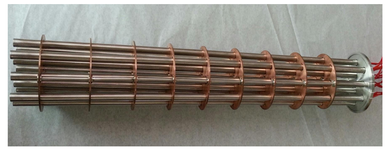

Figure 5 Physical model of the cryogenic hydrogen heater core

Ortho-para hydrogen convertor

Cylindrical vessel was adopted for CSNS ortho-para hydrogen convertor. Catalyst feeding port was also set at the convertor top. Orifice baffle plates were adopted and arranged at both the top and bottom of the convertor. Total height of the convertor is 1.2 m, and its diameter is 159 mm.

Manufacturing of a prototype of ortho-para hydrogen convertor has been finished. Sealing performance test was conducted at 2.5 MPa pressure, and helium leakage value was below 10^{-9} Pa•m^3/s. Next, the catalyst will be feed into the convertor vessel, and pressure drop will be measured to estimate the qualification of this prototype.

50 kg Ferric hydroxide have been purchased from Molecular Products, Inc.

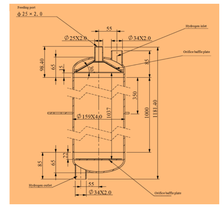

Figure 6 Design model of the ortho-para hydrogen convertor

Figure 7 Physical model of the ortho-para hydrogen convertor

Cryogenic hydrogen flow meter

Venturi flow meter was adopted and a prototype was developed. Structural design and manufacturing have been finished. Sealing performance test and accuracy test have been conducted. The outer leakage is less than 1×10^{-12} Pa•m^3/s, and the maximum deviation is less than 3.5%. Results show that the prototype of the Venturi flow meter can satisfy its requirement well.

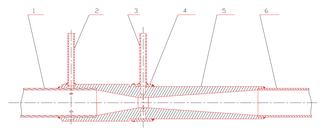

Figure 8 Schematic of Venturi flow meter structure
1-inlet pipe; 2-pressure sampling position at upstream; 3-pressure sampling position at the throat; 4-snap ring; 5-Venturi pipe; 6-outlet pipe

Hydrogen cold box

All the hydrogen devices will be integrated in two cold boxes, one is the hydrogen cold box, and the other is the accumulator cold box. All these devices will be installed on the top flange. The vessel of hydrogen cold box and its instrument bracket have been finished manufacturing. The accumulator cold box has been finished design recently.

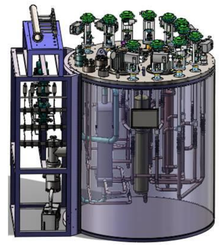

Figure 9 Schematic of the hydrogen cold box

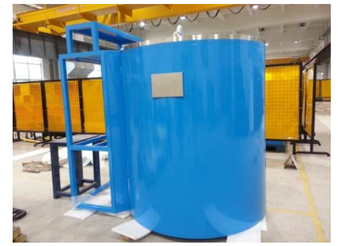

Figure 10 Physical model of the hydrogen cold box vessel

Conclusion

CSNS cryogenic system was under construction now. Cryogenic hydrogen circulators and cryogenic valves purchased from Barber-Nichols and STOHR have already arrived, and helium refrigerator will be arrived in late July. A prototype of accumulator has been manufactured in 2013, and performance test shown a good function of pressure fluctuation regulation by the motion of accumulator bellows. Hydrogen-helium heat exchanger prototype and cryogenic hydrogen flow meter prototype have been finished manufacturing, and the development of cryogenic hydrogen heater and ortho-para hydrogen convertor will be completed in July. Engineering design of hydrogen cold box has been finished, and the cold box vessel has been manufactured. Equipments in the hydrogen cold box will be installed and integrated later this year. According to the project schedule, CSNS cryogenic system will complete construction at the end of 2015, and started commissioning then.

Acknowledgements

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