DESIGN OF A 9-CELL CAVITY ILC TEST CRYOMODULE IN CHINA*

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Abstract

Technical design of a 9-cell cavity cryomodule has been finished by a collaboration group between IHEP (Institute of High Energy Physics) and TIPC (Technical Institute of Physics and Chemistry), which was set up in last October for the ILC cryomodule related R&D work in China. The designed Cryomodule is a "test model" for the ILC cryomodule, and as a component of a superconducting accelerator test unit which will be built in the near future. It also can be used for the horizontal test of a 9-cell cavity. This paper presents the detail structure, cryogenic flow diagram, thermal and mechanical simulation of the cryomodule.

INTRODUCTION

The International Linear Collider (ILC) is a proposed linear particle accelerator, which will be the world largest research center in the high energy physics field in the future [1]. The superconducting RF technology was chosen for the main linac of the ILC in 2004. As a part of the R&D activities for ILC in China, A SRF Cryomodule collaboration group between IHEP (Institute of High Energy Physics, Chinese Academy of Sciences) and TIPC (Technical Institute of Physics and Chemistry, Chinese Academy of Sciences) was set up in last October. A technical design of a 9-cell cavity cryomodule is their first task. The Cryomodule is a "test model" for the ILC cryomodule[2-4], and as a component of a superconducting accelerator test unit which will be built in the near future. The 3D modelling, thermal and mechanical simulations, cryogenic flow diagram, manufacturing process and the cost estimation were carried out for this cryomodule.

STRUCTURE OF THE TEST CRYOMODULE

As a “test model” for the ILC cryomodule, the main structure of the cryomodule is similar with the ILC cryomodule[2-4], as shown in Figure 1. The gas helium return pipe (GRP) is the backbone of the module. Two epoxy posts support the GRP; the cavity and the superfluid helium vessel suspend under the GRP through the sliding supports. At one end of the two-phase helium pipe, a helium vessel is added, so as the liquid surface of the 2K helium is easy to be controlled; at the other end, the two-phase helium pipe is connected to GRP. The gas helium in the two-phase helium pipe is pumped to GRP and the liquid helium flows to the 2K vessel.

CRYOGENIC FLOW DIAGRAM

The cryomodule provides static 2K operation environment for the SRF cavity. The 2K heat load of the module is absorbed by the superfluid helium flow. The 5K shield is cooled by helium. The 80K shield is cooled by Nitrogen.

At the static condition, the estimated 80K, 5K and 2K heat loads of the cryomodule are 16.7W, 2.55W and 0.6W respectively. At the dynamic condition, the input coupler and the cavity will cause a little more heat load. The detail is shown in Table 1. Figure 2 shows the cryogenic flow diagram. The cryogenic system provides 4.5K liquid helium to the helium dewar. The pressure in the dewar is 1.2bar. From the 4.5K dewar, the liquid helium is pre-

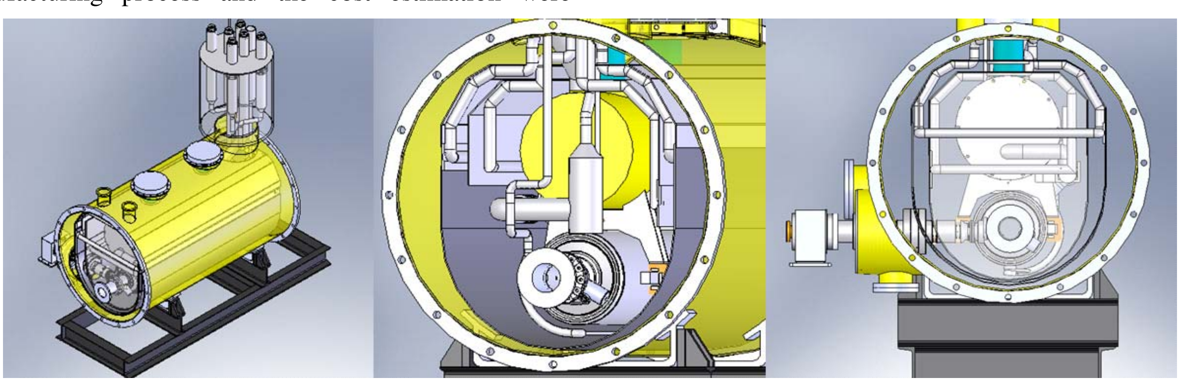

Figure 1. Structure of the ILC test cryomodule

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cooled and throttled to 2K. The 2K two-phase helium flows to a phase-separate vessel, in this vessel the gas helium is pumped to GRP and the liquid helium flows to the 2K vessel to cool the cavity. The pressure in the phase-separate vessel is 16 mbar. The liquid surface of the helium in the vessel is controlled to a stable value by adjusting the power of a heater. The T-S diagram is shown in Figure 3.

Table 1. Estimated heat load of the test cryomodule

Heat source	Static (W)			Dynamic (W)		
	80K	5K	2K	80K	5K	2K
Radiation	4	0.15	/	/	/	/
Supports	3	0.4	0.05	/	/	/
Input coupler	7.2	1.2	0.04	3	0.2	0.03
Cavity	0.5	0.2	0.1	/	/	0.8
Instrumentation cable	1	0.3	0.2	/	/	/
other	1	0.3	0.2	/	/	0.2
Summary	16.7	2.55	0.6	3	0.2	1.03

The mixture of the 300K and 80K helium gas precool the cryomodule to 80K, and then the liquid helium is used to cool the module to 4.5K. After the precooling finished, the 4.5K liquid helium dewar provides the helium to 2K system.

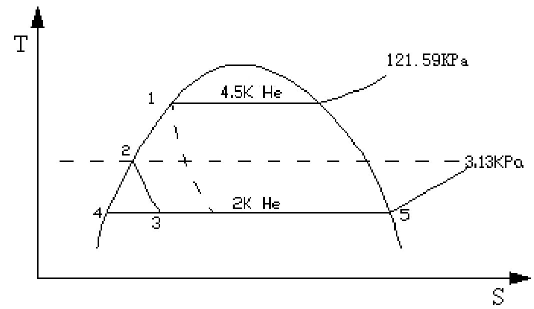

Figure 3: S-T diagram of the test Cryomodule

THERMAL AND MECHANICAL SIMULATION

Thermal and mechanical behaviors of the test cryomodule were simulated with the FEM software ANSYS, include the temperature distributions of the 5K and 80K shields with the varied mass flow of the cooling gas, the stress distributions and deformation of the 5K shield, 80K shield, 2K system and the support posts at the room temperature and the cryogenic temperature, and etc. The maximum temperature difference of the 80K shield is limited within 10K, and the 5K shield is limited within 5K. The maximum deformation of the two shields is limited within 5mm. Figure 4 shows the temperature distribution and deformation of the 5K shield with the helium mass flow 0.08g/s. Figure 5 shows the vertical deformation of the 2K system at the room temperature. Figure 6 shows the stress distribution of the support posts after cool-down.

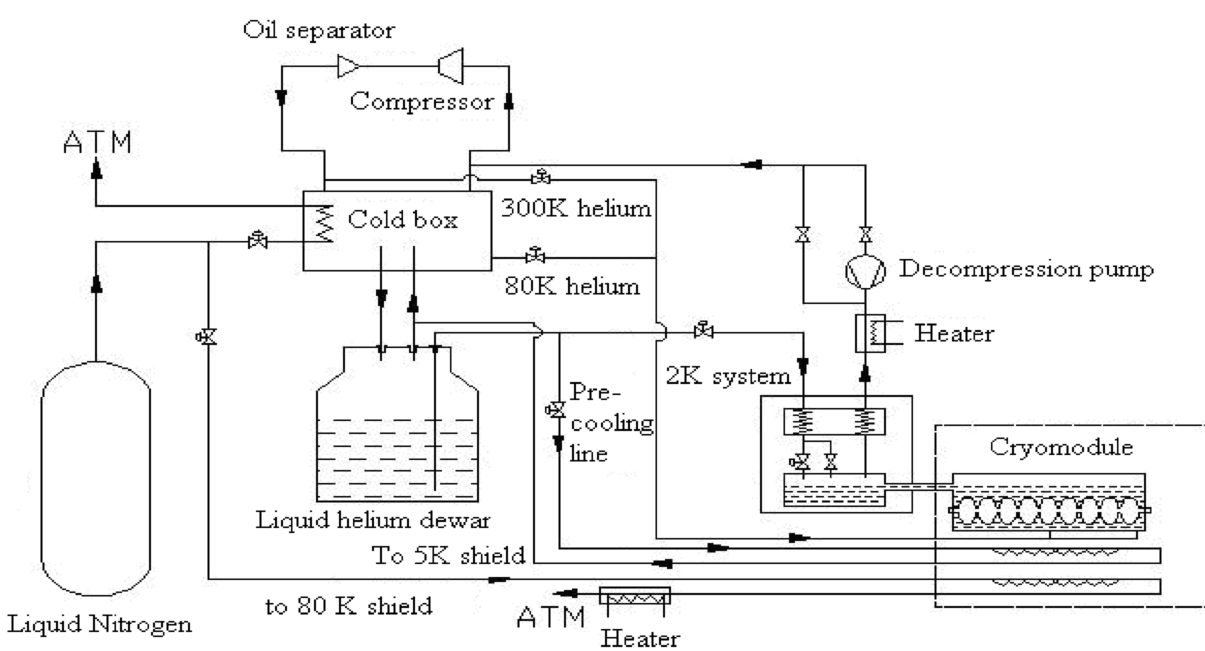

Figure 2: Cryogenic flow diagram of the test Cryomodule

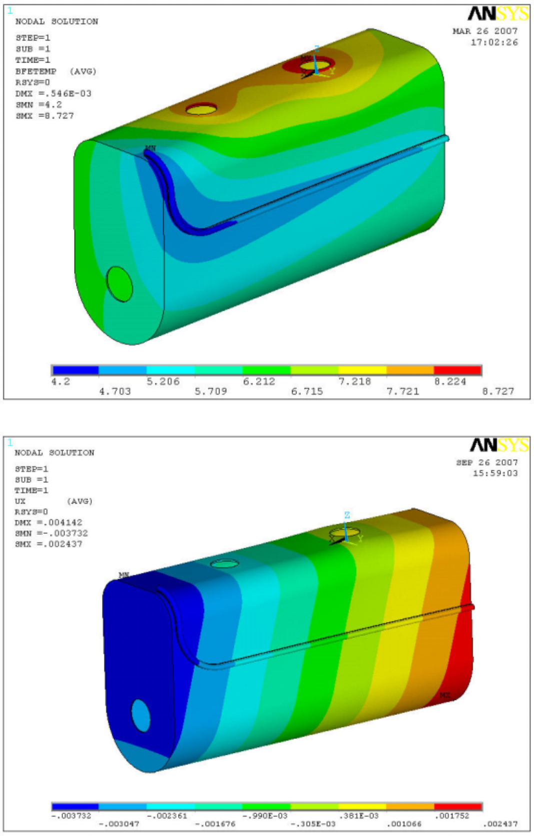

Figure 4. Temperature distribution and deformation of the 5K shield with the helium mass flow 0.08g/s.

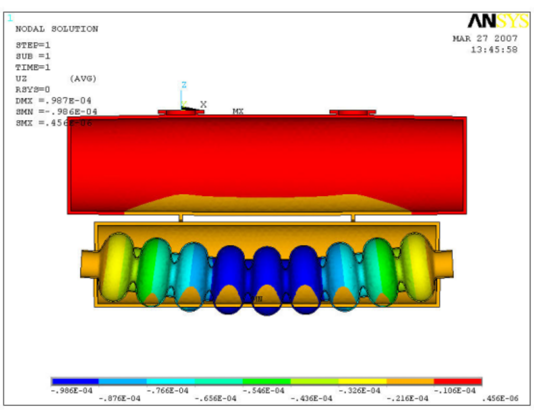

Figure 5. Vertical deformation of the 2K system at the room temperature

SUMMARY

As a part of R&D work for ILC in China, a test model for the ILC cryomodule was designed. The 3D modeling, thermal and mechanical simulation, cryogenic flow diagram, fabrication process and the cost estimation were carried out for this test cryomodule. The cryomodule will be fabricated in the near future as a part of the superconducting accelerator test unit.

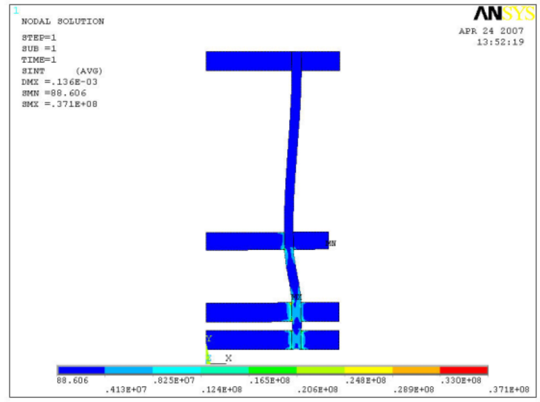

Figure 6. Stress distribution of the support post after cool-down

ACKNOWLEDGEMENT

This work is supported by National Natural Science Foundation of China (NSFC, 10525525).

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