DESIGN OF THE COLD MASS SUPPORT ASSEMBLY OF TEST CRYOMODULE FOR IMP ADS-INJECTOR II

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Abstract

In order to test the performance of the HWR cavities and verify the related technique for cooling the cavities and the solenoids together, a test cryomodule (TCM1) containing one superconducting cavity followed by two superconducting solenoids was developed for the Injector II of the Accelerator Driven Sub-critical System (ADS). The TCM1 consists of cryostat and cold mass assembly. The cryostat is composed of vacuum chamber, thermal shields, cooling circuit, cold mass support assembly, and instrumentations. The cold mass assembly includes one cavity and two solenoids. A set of cold mass support assembly was developed for supporting the cold mass working at 4.4 K. The support assembly mainly consists of Ti support frame, stainless steel rods, three-dimensional position adjuster and LHe cooling passage. It was designed to minimize the heat loads introduced by stainless steel rod. It can support the weight of the cold mass and stand the thermal stress after the cool down. In order not to affect the performance of the cavity, it will not impose any force on the cavity. It can be adjustable for alignment of the cold mass both at room temperature and 4.4 K. This paper provides the detailed design of the TCM1 cold mass support assembly.

INTRODUCTION

In 2012, The Institute of Applied Physics(SINAP), Chinese Academy of Science(CAS) designed a cryomodule of TCM1 for ADS. The main components of TCM1 include vacuum chamber, cavity, solenoids, tuner, coupler, cold mass support assembly and so on. Stainless steel support rods, Ti support frame and position adjusters compose the cold mass support assembly. Main components of TCM1 is shown in Fig 1.

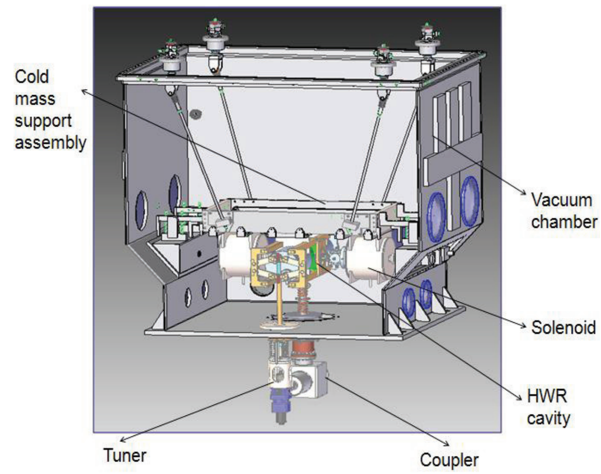

Figure 1: Main components of TCM1.

TECHNICAL REQUIREMENTS FOR COLD MASS SUPPORTS

Technical requirements for cold mass support assembly are summarized as follows:

- To support the weight of the cold mass.
- To adjust the deformation and position changing of the cold mass caused by cold shrinkage.
- To lower the force imposed on the cavity.
- To minimize head loads introduced by the stainless steel rod.
- To minimize the thermal stress in the cold mass supports.

MAIN POINTS FOR DESIGN

Several measures are taken to achieve the technical requirements, and they are summarised as follows:

- Three-dimensional position adjuster is designed to keep the position precision of the cavity and solenoids.
- Spherical washer are used to make the stainless steel rods can rotate around one point within a certain angle.
- Rod end bearings are used to minimize the stress caused by cold shrinkage.
- Special screw hole is designed to keep the position precision of the cavity and the solenoids

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Three-Dimensional Position Adjuster

The three-dimensional position adjuster is composed of three swallow-tailed guide rails, bellows, flanges and a guide rod. The details of the three-dimensional position adjuster are shown in Fig. 2. The third guide rail in the bottom is fixed to the flange, the upper two guide rails can move along x and y orientation respectively. Moreover, the guide rod can move up-and-down along z orientation. In this way, we can compensate the position changing in three directions because of thermal contraction. The available compensation value of the adjuster is summarized in Table 1.

Table 1: Available Compensation Value

Orientation	X	Y	Z
Value(mm)	±7	±7	±15

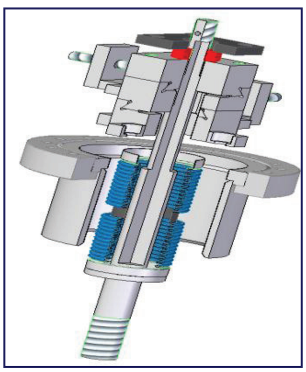

Figure 2: The structure of three-dimensional position adjuster.

Spherical Washer and Rod End Bearings

In order to minimize the thermal stress in the stainless steel support rods, we use spherical washer and rod end bearings at the two ends of the stainless steel support rods (Fig. 3). In this way, the rod can rotate around one point within a certain angle and it would release the thermal stress caused by the cold shrinkage of the cold mass support assembly.

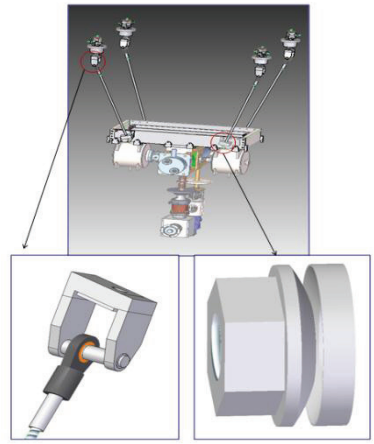

Figure 3: Rod end bearings and spherical washer used at the ends of the stainless steel rod.

Ti Support Frame

There are two solenoids fixed on the Ti support frame. In order to minimize the position changing of the solenoids after cool down, hexagon fit bolts and relevant screw hole are used on the cross beams, which are used to connect solenoids and Ti support frame. There are two cross beams for each solenoid, one can control the shift of X orientation and the other one control the shift of Y orientation (Fig. 4).

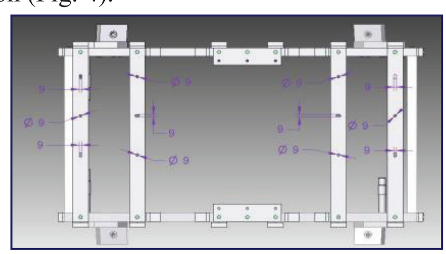

Figure 4: Hexagon fit bolts hole on the Ti support frame.

Cooling down the Ti support frame is important, two cooling passages are designed on the Ti support frame plate to cool the whole Ti frame (Fig. 5).

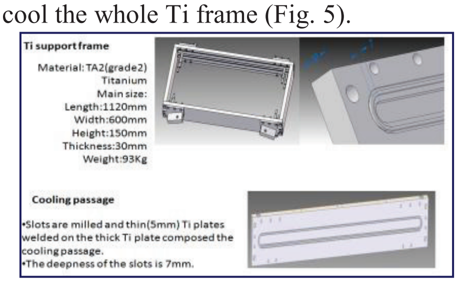

Figure 5: Cooling passage on the Ti support frame.

TEMPERATURE AND DEFORMATION SIMULATION RESULTS

Temperature Distribution

The temperature distribution of TCM1 is simulated. The result indicates that the cold mass (solenoids, cavity and cold BPM) can get down to 4.4K, and the maximum temperature of the Ti support frame is 11.5K (Fig.6), the difference in temperature between cold mass and Ti support frame is not so much that the heat load to cold mass is suitable.

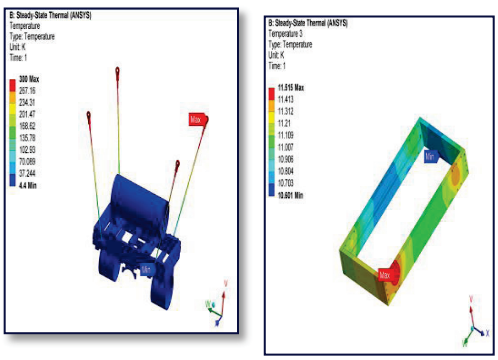

Figure. 6: Temperature distribution for Cold mass and Ti support frame.

Thermal Contraction

Thermal contraction of TCM1 is also simulated. The maximum deformation value along beam orientation(Y) is 1.4mm, and the value in X orientation is 2.92mm, in Z orientation it is 1.57mm (Fig. 7) .We can compensate the deformation by three-dimensional adjusters properly to control the position precision of the cold mass.

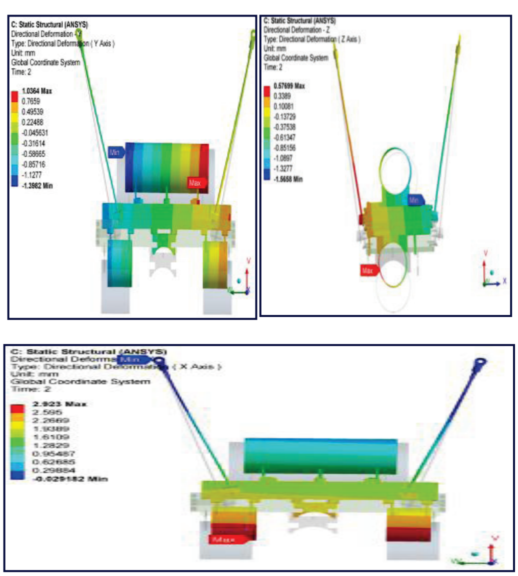

Figure 7: Simulated results of thermal contraction in three directions.

FUTURE DEVELOPMENT

The cold mass support assembly is just for only one HWR cavity and two solenoids. Next step more than three cavities and four solenoids would be supported properly, and the support assembly would be more complicated. The relative position between cavities should be take into account.

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