

DESIGN OF HORIZONTAL TEST STAND (HTS-2) FOR SCRF CAVITIES AT RRCAT*

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Abstract

An upgraded horizontal test stand (HTS-2) is being designed at RRCAT to test fully dressed SCRF cavities of 1.3 GHz and 650MHz type. The HTS-2 is being designed in collaboration with Fermi Lab USA. Fermi Lab has a horizontal test facility (HTS) which can test one SCRF cavity at a time. HTS-2 will have the capacity for testing two SCRF cavities together. These could be 1.3GHz type or 650MHz type or a combination of the two. The mechanical arrangement comprising of cryogenic support post, frame bridge and the rolling cart, are described. Proposed cryogen flow scheme is also presented in the paper. The Finite Element analysis of 80K thermal shield is presented. The paper presents an overview of the design efforts made for HTS-2.

INTRODUCTION

All SCRF cavities have to be qualified in two test facilities before installation in a cryomodule. First the bare cavities are tested in a saturated bath of liquid helium, in vertical test stand (VTS) at a temperature of 2K. Cavities qualifying this test are dressed with their auxiliary equipment like helium vessel, HOM couplers, cold tuner and main coupler are tested in HTS [1]. This system will facilitate checking of cold leak tightness of the helium vessel, the tuning range, and performance of cold tuner. HTS facility is used for important cavity performance tests like establishment of Q v/s E_{acc} at 2K and for measuring cryogenic heat load [2]

The initial design of HTS at FNAL has been chosen as the basic configuration and modifications are being made to fulfill functional requirements expected from the new system. Modifications are also being made to incorporate changes based on operational experience of HTS at

FNAL. RRCAT is involved in design of HTS-2 in collaboration with Fermilab, USA under aegis of IIFC.

Functional Requirements

HTS-2 will be used for testing CW 650 MHz cavities for project-X as well as ILC type 1.3 GHz cavities. For the Project X cavities, the target is to reach an accelerating gradient of 19 MV/m and a Q (quality) factor of 2×10^{10} with expected dynamic heat load of 25 watt per cavity[3]. The design of HTS-2 will facilitate cavity testing both in pulsed and CW mode. This design will permit the testing of one 650 MHz and one 1.3 GHz cavity or two of the same type of cavities at a time. It will also allow accommodation of one cavity with a BPM and magnet package if required. The design of HTS-2 components, like vacuum vessel, cavity support system, thermal shield and 3D model are discussed in the paper. Preliminary static heat in-leak calculations through support post and a steady state finite element analysis for 80 K thermal shield are also presented in the paper. The paper presents an overview of design efforts made so far.

DESIGN OF COMPONENTS

Vacuum Vessel

Internal configuration of the HTS-2 was finalized to accommodate different cavities and their auxiliary systems. It was ascertained that a vacuum vessel of diameter 46 inch and 3.5 metre length will be needed. Vacuum vessel design calculations were done for vessel shell thickness and reinforcement of various openings in the vessel. It has been calculated that vessel shell thickness of 9.5 mm will be needed. Calculations have been verified according to section VIII, Div. I of ASME B&PV code.

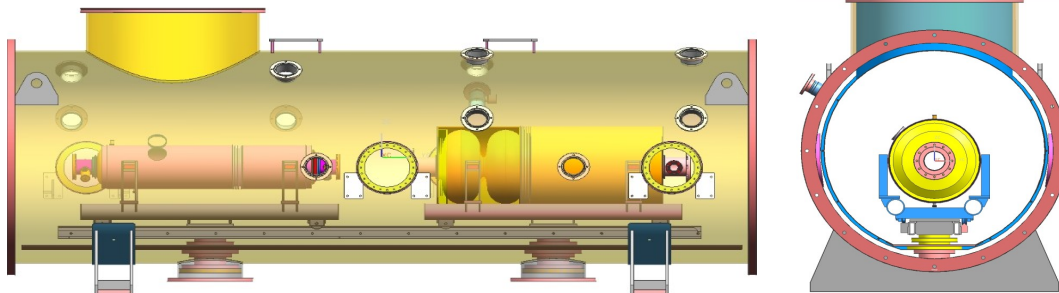


Figure 1: A 3D model of Second version of Horizontal Test Stand.

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Vessel has two ports at bottom for cryogenic support post of 300 mm diameter, one port on top for feed can of 800 mm diameter, twelve numbers of different

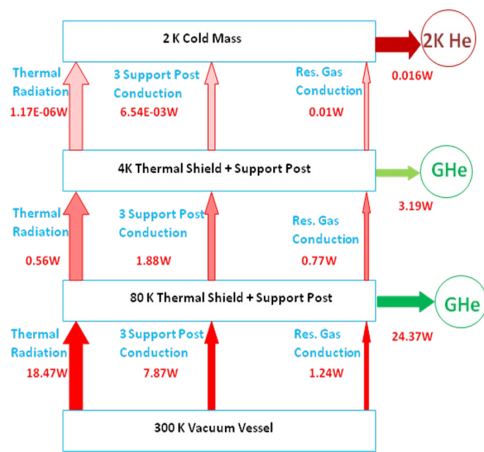


Figure 2 Schematic for static heat in-leak calculation.

instrumentation ports of 100 mm diameter, two ports for main coupler of 280 mm diameter. Coupler ports have been positioned at the ends for easy access to coupler parts during assembly

Cavity Support System

Dressed cavity with cold part of coupler is assembled outside the vessel on the rolling cart. Then it is moved inside the vessel and kept on the rail attached to the frame bridge that rests on two cryogenic support posts. The frame bridge and rolling cart have been modified so that irrespective of the type of cavity (650MHz or 1.3GHz cavity with different sizes) the same port on the Vacuum vessel can be used. Coupler port compatibility has been assured by introducing an adapter flange which will facilitate the use of both the types of power couplers which are contemplated for these cavities.

Cryogenic Support Post

Cryogenic support post transfers the load of cold mass to the vacuum vessel at room temperature with minimum conduction heat in-leak to 2 K. It is attached to two thermal intercept at 80 K and 4 K. It is a three component shrink fit assembly made of metal inner disc and outer ring with G11 tube in between. Applied tolerances between mating components decide the load bearing capacity of the support post while keeping stresses induced in components due to shrink fit within allowable limit. The cryogenic support post will consist of an inner disc (O.D.148mm) and outer ring (O.D.220mm and I.D. 152mm) made of SS304. The G-11 tube of thickness

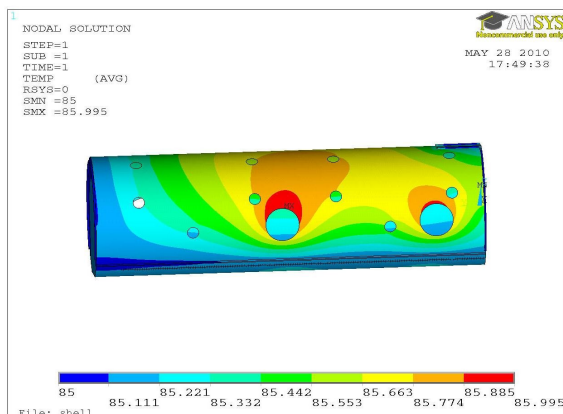


Figure 3: ANSYS model of 80 K thermal shield.

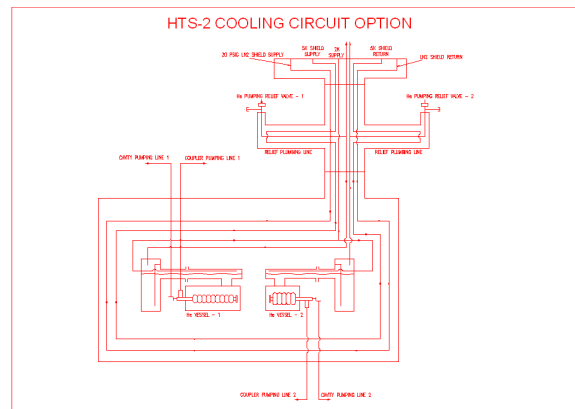


Figure 4: Cryogenic flow diagram.

2mm will be sandwiched between the disc and the ring. The interferences in ID have been kept at 0.2 mm and clearance in OD will be 0.05 before shrink fitting is done. This joint will be capable of carrying a load of around 7000 Kg which is much higher than load expected on each post. A scaled down prototype has been developed. Static heat in-leak through support post and thermal shield are calculated and shown in Fig.2.

Thermal Shield

Thermal shield analysis is being carried out for the thermal shields of HTS-2. Steady state thermal gradients are shown in figure 3. It is estimated that a maximum temperature gradient of 1K will be observed at 85K thermal shield. Work is in progress for simulating cool-down process to find out thermal distortion during cool-down to prevent thermal short.

Cryogenic Flow Circuit

Option under discussion for the cryogenic distribution to the cavities inside HTS-2 is shown in Fig. 4. Liquid He-II is supplied separately to the cavities to allow the testing of two cavities individually. Each cavity has separate liquid level dewar and heater to take care of transients. Each cavity has a separate 2K helium pumping line with its relief plumbing line to reduce cross talk. But these two helium pumping lines will be joined before J-T heat exchanger in a feed-can. Feed can (not shown in Fig. 4) contains J-T heat exchanger and J-T valve as well as other instrumentation and interface components.

Present Status

At present, fabrication drawing of various components is in progress. Load testing of cryogenic support post prototype is underway. Transient thermal analysis of 80K thermal shield by FEA is under progress with different tube layouts on shield.

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