THE CAVITY TEST FACILITY "CRYHOLAB" AS A TEST STAND FOR HIGH POWER COUPLERS AT CRYOGENIC TEMPERATURE

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Abstract

A collaboration between the IPN-Orsay and the CEA-Saclay groups involved in Superconducting RF Cavities (SCRF) activities are working on 700 MHz elliptical cavities for the high energy part of a high intensity proton accelerator. The study of the fundamental power coupler (FPC) for these cavities has just started. The coupler should deliver 150 kW in CW mode (this is the maximum power needed for the $\beta = 0.85$ five-cell elliptical cavities foreseen for the proton linac in the XADS and EURISOL projects).

The FPC design is based on the SNS power coupler (based on the KEK design). While the scaling from 805 MHz to 704 MHz is being performed, and the FCP thermal behaviour and cooling calculated, we are studying the possibility to use the "CryHoLab" facility (the horizontal test stand for multi-cells superconducting cavities) as a power coupler test stand at cryogenic temperature.

INTRODUCTION

The horizontal test stand “CryHoLab” was initially designed [1] to test various type of superconducting radio frequency cavities fully equipped (Helium Tank, Cold Tuning System, fundamental coupler...). The test stand was then orientated to test mainly $\beta = 0.85$ & 0.65 700 MHz cavities for XADS and EURISOL projects. At that time, two types of couplers were foreseen to be installed in CryHoLab: the TESLA and the APT couplers respectively for 1.3 GHz and 700 MHz cavities. These couplers were mounted horizontally on the side of the cryostat. They also have sufficient compliance in the transverse direction allowing the cavity to be simply put on epoxy-glass posts.

An additional 4,2 K at 1 atm. loop in the CryHoLab feed box was also designed to perform a heat sink on the coupler outer conductor.

The FPC integration in CryHoLab is based on a geometrical scaling of the SNS FPC from 805 MHz to 704 MHz. The FPC structural and thermal studies are on progress

Preliminary conceptual designs of the FCP insertion in either the horizontal or vertical positions are described in this paper.

CRYOGENIC INSTALLATION

CryHoLab is fed either from 500 litres LHé dewars or from a 2000 litres vessel (7) filled by a 120 l/h liquefier. The radiative shielded parts are cooled with liquid nitrogen boil off. The cryostat feed box [2] features a buffer vessel (6) of about 80 litres capacity from which the cryostat loops are supplied: Cavity cool-down (2), cavity feeding in 2 K operations (1), cavity support table cooling (3) and an additional loop dedicated to FPC outer conductors cooling (4).

The complete installation, working in liquefier mode, is able to handle an overall helium boil off of 4.2 g/s. With around 3.5 g/s for dynamic operation @ 2K and additional power measured at 0.5 g/s for static losses [3] (including feeding losses) the remaining helium flow rate (0.2 g/s) will be sufficient to cool the FPC outer conductor.

No supercritical helium at 3 atm. is available on the test stand. A simplified flow scheme of the CryHoLab cooling loops is shown below.

Figure 1: CryHoLab cooling loops

The buffer vessel (6) may be pressurised, using the outlet valve (5), at around 100 mbar. It would lead to a maximum helium flow (1 atm., 150 K) of 0.08 g/s flowing, for instance, into a 14 m long 4 mm diameter tube. The available cooling from 4.2 K to 290 K would then be about 120 W. The regulation valve (4) may also
be used to adjust the helium flow rate into the outer conductor heat exchanger to the nominal value. The coupler cooling loop in CryHoLab should be sufficient to remove the heat loads on the FPC cold part with an 1 atm. helium flow.

**FPC MOUNTING SCENARII INSIDE CRYHOLAB**

Two ways of mounting the FPC, horizontally or vertically (like SNS, KEK), are studied. The choice will be made after the FPC mechanical calculations.

The first scaling of the FPC to our frequency led to the global dimensions given on the figure 2. Only the quoted dimensions result from the scaling, all others are only schematics.

![Figure 2: FPC schematic](image)

The length of the outer conductor was taken arbitrarily and some variations resulting on the thermal calculation should not affect the general principle of the mounting into CryHoLab. The diameter of the compensation bellow was taken identical to the SNS FPC.

**Vertical mounting**

It is possible to mount the FPC in vertical direction like KEK or SNS, giving the advantage to have less induced transverse stresses on the window. The drawings below show the different steps of the cavity/FPC insertion into CryHoLab.

The outer and inner conductors and the window assembly (1) are mounted on the cavity in clean room. The set is installed, outside the clean room, on two rolling boards (2) put on rails (3) fixed on a transport table.

![Figure 3: cavity on transport table](image)

Then, the cold tuning system (4), the compensation bellow of the FPC (5, 7) and a support structure (6), fastening the FPC during the transport from the clean room to the CryHoLab site are assembled.

In CryHoLab, the rails of the transport table are fitted to the rails of the cryostat and the whole assembly is introduced inside the cryostat.

![Figure 4: Cavity introduction into CryHoLab](image)

The support structure (6) is removed, allowing the FPC Bellow (5) to be moved down giving accessibility to screw the internal part and the external part of the FPC (8) together. The connecting flange of the FPC bellow (7) is then screwed to the vacuum vessel inner extension (9).

The compensation bellow (5) is mounted to the vacuum vessel inner extension (9) and to the FPC (10).

![Figure 5: External and internal FPC parts mounting](image)

At least, cryogenic pipes (12), cavity pumping tube (11), and 80 K thermal shield around the vacuum vessel inner extension (13) are mounted.

![Figure 6: thermal shield mounting](image)

**Horizontal mounting**

To be tested in CryHoLab cavities are put on a table cooled at 20 K and attached to the 300 K vacuum vessel with two epoxy-glass posts. In the horizontal mounting
case, the small thermal contraction of epoxy – glass posts will cause a displacement able to over stress the window in the transverse direction.

The aim of the study was to define the general features of the mounting in CryHoLab but further mechanical simulations on the FPC itself have to be performed in order to evaluate the window resistance to transverse loads.

![Figure 7: Horizontal FPC mounting into CryHoLab](image)

The fixed point of the cavity is at the coupler position where the rolling board (1) is fixed to the rails. The opposite rolling board (2) is free allowing the cavity to shrink (during cool down) in the longitudinal direction.

Due to the pressure difference on the 300 mm diameter FPC connecting flange an important load (~7000 N) will be applied to the cavity. An epoxy glass tube (3) connected to the vacuum vessel through a bellow (4) of same dimensions as the FPC bellow (5) will be mounted at the opposite side to equilibrate the load on the cavity.

CONCLUSIONS & FUTURE WORKS

CryHoLab, in a first approach, will be able to test the FPC of KEK/SNS type at cold temperature, assuming that no major dimensional changes will occur after the final scaling from 805 to 704 MHz.

The complete design of the CryHoLab site, concerning the wave guides mounting for FPC tests is to be finished.

A more precise HF scaling is to be achieved for the end of November. From this, the thermal calculations and the design of the outer conductor and inner extension heat exchangers and also the way to cool the inner conductor will start and will lead to the complete design of the FPC.

The ceramic windows supplier will be chosen according to the SNS FPC study feedback. A room temperature conditioning bench is also under study. Two FPC will be ordered in 2003 and conditioned at 80 kW (travelling wave), the presently available power at 704 MHz. FPC cold tests in CryHoLab are scheduled for early 2004.

REFERENCES

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