CRYOGENIC TEST OF A COAXIAL COUPLING SCHEME FOR FUNDAMENTAL AND HIGHER ORDER MODES IN SUPERCONDUCTING CAVITIES

J. Sekutowicz, DESY, Hamburg, Germany
P. Kneisel, TJNAF, Newport News, USA

Abstract

A coaxial coupling device located in the beam pipe of the TESLA type superconducting cavities provides for better propagation of Higher Order Modes (HOMs) and their strong damping in appropriate HOM couplers. Additionally, it also provides efficient coupling for fundamental mode RF power into the superconducting cavity. The whole coupling device can be designed as a detachable system. If appropriately dimensioned, the magnetic field can be minimized to a negligible level at the flange position. This scheme, presented previously in [1], provides for several advantages: strong HOM damping, flangeable solution, exchangeability of the HOM damping device on a cavity, less complexity of the superconducting cavity, possible cost advantages. This contribution describes the results of the first cryogenic test.

INTRODUCTION

Motivation

In the coaxial coupling (CC) scheme, shown in Fig. 1, all couplers are shielded by the inner tube, which is supported by the Nb disk welded to it and to the beam tube. The disk is an electric short in the coaxial line, which is formed by the inner and outer tubes, and thus separates electrically two mirrored coupling devices and neighboring cavities. The pair of mirrored coupling devices can be flanged between two cavities. The flanges are located ~35 mm apart from the end irises, at the positions where the standing wave of the magnetic field has its notch.

Our motivation to develop the CC scheme has been discussed comprehensively in [1]. Here, we recall some arguments. The CC scheme has the following advantages as compares to the standard TESLA scheme:

- Field asymmetries and kicks from all couplers are small.
- The distance between two cavities is shorter.
- The body of the cavity stays cylindrically symmetric, which enables its fabrication by hydro-forming as a seamless device.
- The interior of the coupling device and the cavities can be better cleaned before the final assembly.

The CC scheme provides for good damping of HOMs and for easy matching of the fundamental mode coupler.

A potential disadvantage in the present design could be insufficient cooling for the inner tube. This may cause a temperature rise above Tc and may require an additional devoted cooling at that location for the final design.

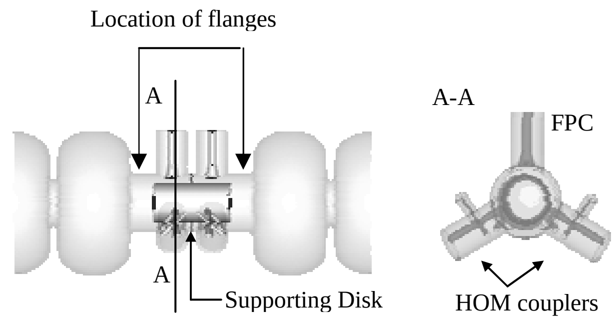

Figure 1: FPC and HOM couplers in two mirrored CC devices placed between two cavities (left) and cross-section of the coupling device (right).

PREPARATION OF THE CRYOGENIC TEST

The Nb prototype of the CC device was built at TJNAF in 2008. The prototype is simplified since it is equipped with two HOM couplers and has no input coupler port. We chose a 1.6-cell SRF gun cavity, built in the frame of another superconducting R&D project, for the cold tests of the CC device. The cavity and CC device are shown in Figure 2. Both the CC device and cavity had EB welded conflate flanges, made of the NbZr alloy, for the superconducting connection. The cavity itself is made from large grain niobium. The ring gasket for the connection was made of polycrystalline niobium and it was heat treated at 600°C. After the 1:1:1 BCP chemical treatment and high pressure water rinsing (only the cavity), parts were assembled and pumped down for several days to the vacuum level of 8.0E-8 mbar. We noted that there was a small leak at the Nb gasket location

Figure 2: 1.6-cell SRF gun cavity and coaxial coupling device before the assembly.

The Nb gasket is both a vacuum gasket and provides the superconducting connection.

There are three objectives for the cold tests.

- The first objective is to investigate multipacting (MP), which has been found in the coaxial part of the beam tube by means of the MP simulation. This resonant phenomenon should take place at two field levels of the accelerating gradient E_{acc}=2 MV/m and 26 MV/m. The predicted MP is of 4-th order two-side and thus it should be possible to process. The MP levels at gradients from 10÷45 MV/m are displayed in Figure 3.
- The second objective is to look at possible heating of the inner tube, which can be expected for cw operation
- The third objective is verification of the performance limitation of the superconducting gasket in pulse and cw operation.

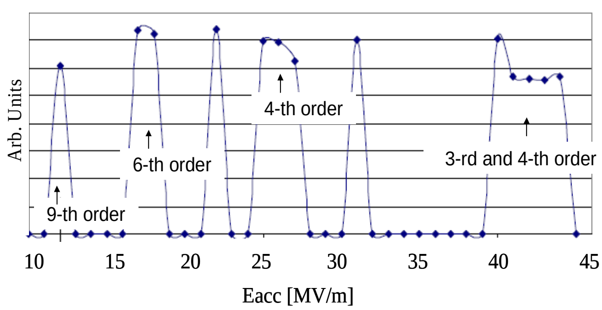

Figure 3: MP levels at higher accelerating gradients. Simulations were performed by L. Xiao, ACD, SLAC.

RESULT OF THE FIRST COLD TEST

After the cool down the vacuum improved to 4.0E-9 mbar when the Dewar was full with superfluid helium. In addition, we noticed that Qext of the input antenna was rather high 5E10, which made the measurements in the low gradient region, <1 MV/m, very inaccurate. Figure 4 shows the measured performance of the assembly.

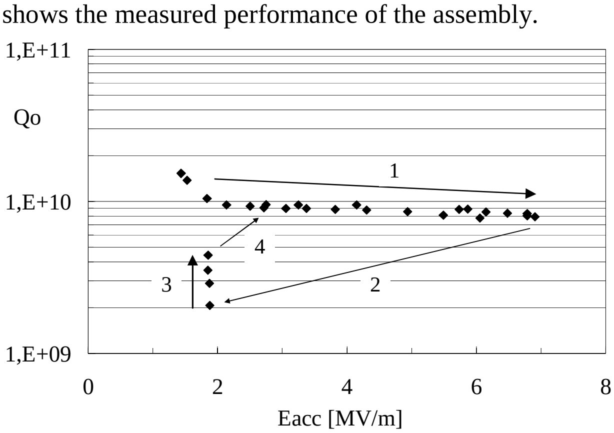

Figure 4: The very first measured result for the CC device attached to the 1.6-cell SRF injector cavity. The arrows show sequence of measured points.

The superconducting connection and result of the test are not satisfactory yet, but gave us some valuable information for the next test.

CONCLUSIONS FROM THE COLD TEST

Multipacting

The lower multipacting level, at ~2 MV/m, was observed. It took almost 2 hours to process that level, but finally it was overcome and it did not show up again. It looked like the surface was sufficiently cleaned and the secondary electron yield was kept below one. Unfortunately, due to the poor performance, we could not reach the higher MP level to check how fast it can be processed.

Heating and Q-switch

The intrinsic Q of the assembly was at "usual" level for the first cycle (see Fig. 4), when the input power was ramped up for the first time successively. At the maximum achievable gradient of E_{acc} = 7 MV/m, we observed a Q-switch, which caused a drop of E_{acc} to 1.9 MV/m. The Q-switch phenomenon indicated that some part(s) of the assembly were heated but could recover (pass 3) when E_{acc} stays < 2 MV/m. The relatively small Q change at pass 1 means that the heated part is located in rather low magnetic field. On the other hand, it took some time to cool down that part, which signifies that it had no direct contact to the superfluid helium. Our hypothesis is that heating was somewhere at the inner beam tube. In the coming test we will additionally to the cw measurements conduct pulse measurements to learn more about the heating location.

Mechanical Properties of the Superconducting connection

After the test the components have been disassembled for inspection. The edges of the NbZr flanges were strongly deformed, which indicated that the hardness of the material we used was below the expected value reported by the vendor. This value should be about 10% lower than the hardness of the NbTi alloy. The NbTi flanges with AlMg gaskets are widely used for all TESLA type cavities causing no vacuum problems even after several cool down - warm up cycles. We will need to re-work the NbZr flanges or use indium gasket for the next test.

ACKNOWLEDGMENT

We would like to thank our colleagues G. Slack and L. Turlington from TJNAF for their support of this work

REFERENCES

[1] J. Sekutowicz et al., "Coaxial coupling scheme for fundamental and higher order modes in superconducting cavities", Proceedings Linac08, Vancouver, Canada, 2008