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Low Temperature RF Test of Two-cell SRF Prototype Cavity for PEFP

Han-Sung Kim*, Hyeok-Jung Kwon, Yong-Sub Cho
PEFP KAERI, Daejeon, Korea
**Corresponding author:kimhs@kaeri.re.kr*

1. Introduction

To confirm the design and fabrication procedures and to check the RF and mechanical properties of a low-beta elliptical SRF (Superconducting Radio-Frequency) cavity, a niobium cavity with two cells has been designed and fabricated as a prototype PEFP SRF cavity. For the test at low temperature of 4.2 K, a cryostat was designed and fabricated. The cryostat was thermally insulated with 40 layers of super-insulations and the vacuum jacket and equipped with temperature monitors and liquid level meters. The RF system for driving the cavity is based on PLL (phase locked loop) to main the resonance condition. The cavity was cooled to 4.2 K with liquid helium to make cavity superconducting state. Total liquid helium consumption was about 620 liters during the experiment.

2. Experimental Setup

2.1 Two-cell SRF Cavity

The major parameters of the two-cell SRF cavity are like followings [1].

- Frequency: 700 MHz
- Operating mode: TM010 pi mode
- Cavity type: Elliptical
- Geometrical beta: 0.42
- Number of cells: 2
- Accelerating gradient: 8 MV/m
- Epeak/Eacc: 4.106
- Bpeak/Eacc: 8.28 mT/(MV/m)
- R/Q: 32.57 ohm
- Epeak: 32.85 MV/m (1.34 Kilp.)
- Geometrical factor: 124.58 ohm
- Cavity wall thickness: 4.3 mm
- Stiffening structure: Double ring
- Effective length: 0.18 m

The cavity is fabricated through various processing stages such as machining, deep drawing and the electron beam welding. Inner surface of the fabricated cavity was cleaned through the chemical etching with removal of roughly 100 um and high pressure rinsing with ultra-pure water. The fabricated cavity installed in the insert of the cryostat is shown in Fig. 1.

2.2 Cryostat

The cryostat includes the vacuum jacket with 40 layers of the superinsulation and 10 layers of thermal reflectors at the upper part of the cryostat [2]. It is equipped with liquid helium and liquid nitrogen level meters and the temperature sensors. The static heat loss is estimated to be about 5.4 W. The height is about 2400 mm and the inner diameter is about 685 mm. Fig. 2 shows the drawing and photograph of the fabricated cryostat.

Figure 1. Two-cell SRF cavity installed in the insert.

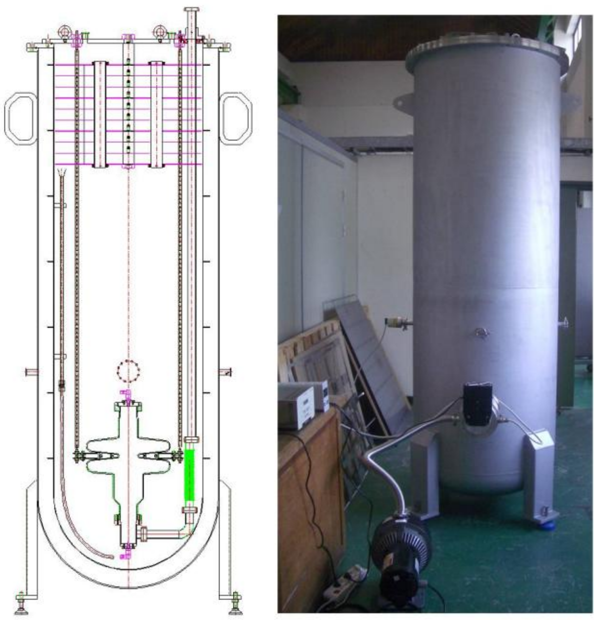

Figure 2. Drawing and photo of the cryostat.

2.3 RF System

The RF system is based on the PLL to main the cavity on resonance and to minimize the reflected RF power [2]. The schematic diagram of the RF system is shown in Fig. 3. The vector signal generator is used as VCO (voltage controlled oscillator) and phase comparator which generates voltage signal proportional to the phase difference between the forward RF power and cavity RF power is used to drive the signal generator FM function.

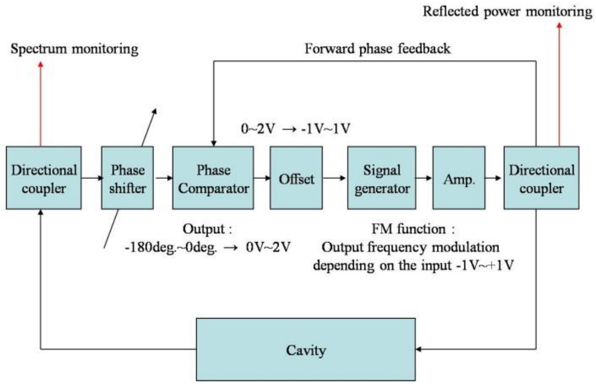

Figure 3. RF system for the low temperature RF test.

3. Results and Conclusions

RF power of about 90 W is applied to the SRF cavity with pulsed mode. Pulse length was 50 ms. We measured the forward, reflected and transmitted RF power, respectively as shown in Figure 4. The cavity is equipped with two couplers; one is over-coupled and the other is under coupled. The loaded Q and the coupling coefficient were obtained from the fitting of the reflected power waveform as shown in Fig. 5. From the measurement, the estimated unloaded Q was about 3.7E+7 and accelerating gradient was about 1.8 MV/m, which was limited by the RF amplifier.

The BCS resistance at 700 MHz, 4.2 K is about 155 nΩ. If we assume that the residual resistance is about 250 nΩ including magnetic resistance, total surface resistance is about 405 nΩ, which results in unloaded Q of about 3.1E+8. The reasons for such low measured Q are not fully explained yet and under investigation.

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[1] Sun An, Y. S. Cho and B. H. Choi, "PEFP Low-beta SRF Cavity Design", Proc. of PAC07, p2164, Albuquerque, 2007.
[2] Han-Sung Kim, Hyeok-Jung Kwon, Yong-Sub Cho and Sun An, "Prototyping and Vertical Test for PEFP Low-beta Elliptical Cavity", Proc. of SRF2009, p854, Berlin, 2009.

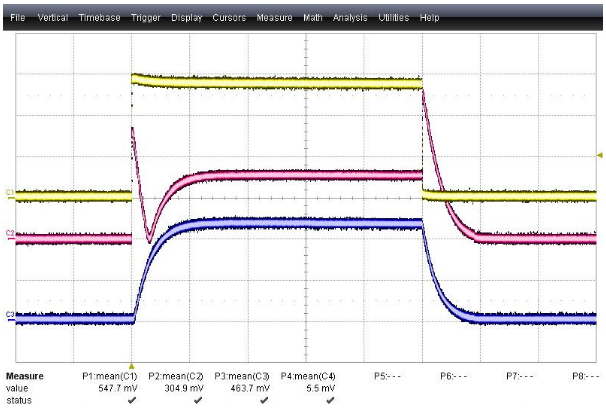

Figure 4 (a). Over-coupled case
(yellow: forward, red: reflected, blue: cavity)

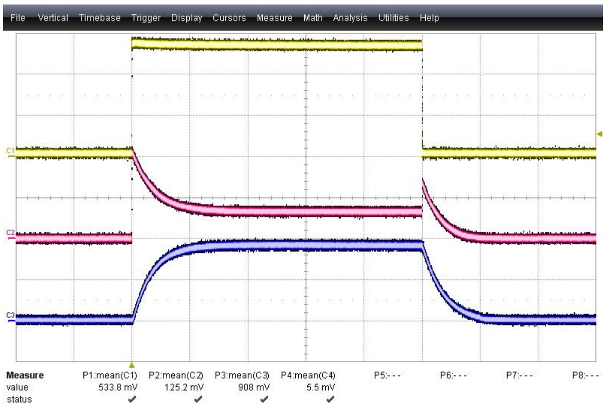

Figure 4(b). Under-coupled case
(yellow: forward, red: reflected, blue: cavity)

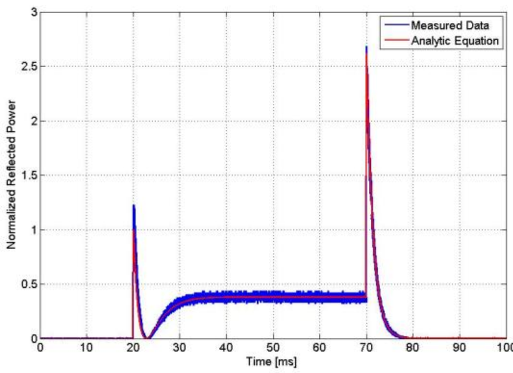

Figure 5(a). Over-coupled case (beta: 3.65, Ql: 6.2E+6)

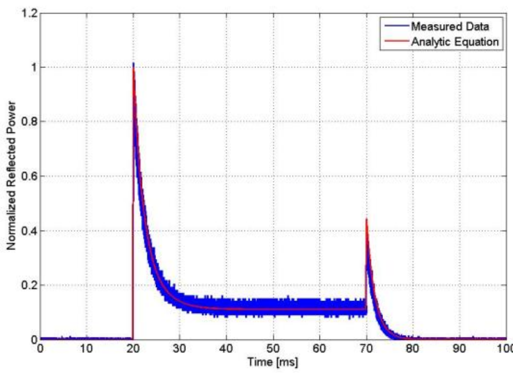

Figure 5(b). Under-coupled case (beta: 0.49, Ql: 7.0E+6)