INPUT COUPLER OF SUPERCONDUCTING CAVITY FOR KEKB

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Abstract

The high power coupler is one of the key components of the superconducting cavity for high current operation. The input coupler for the KEKB superconducting cavity is of coaxial type. It has been operated on a beam exceeding 380 kW. We conditioned the input coupler for the next four cavities up to 300kW of input power, while applying a DC bias voltage of up to ±2kV on the inner conductor. This RF processing with bias voltage was found to be effective in suppressing multipacting.

1 INTRODUCTION

KEKB is an asymmetric electron-positron collider for B-meson physics, consists of two rings, an 8 GeV high energy ring (HER) and a 3.5 GeV low energy ring (LER). Four superconducting cavities have been operated under a beam of 500mA in the HER. The cavity is supplied with a power of 270kW. During this summer, additional four cavities will be installed in the HER to increase the beam current to 1.1 A. The conditioning procedure of the coupler was studied at the HER and also at the AR-ring in 1995. This paper describes the preparation and aging process of the couplers used on the four additional superconducting cavities.

2 INPUT COUPLER FOR KEKB

The RF system at the KEKB is required to accelerate the large beam current stably. The input coupler needs to feed a power exceeding 270kW. Table 1 gives the parameter of the SCC coupler. Figure 1 shows the structure.

Table 1. Parameters of the SCC coupler

SC cavity parameter		
Frequency	508.887	MHz
Voltage	1.5	MV/cell
R/Q	93	
Number of cells	8	
Coupler		
Loaded Q	$7 * 10^4$	
Power to beam	270 kW	

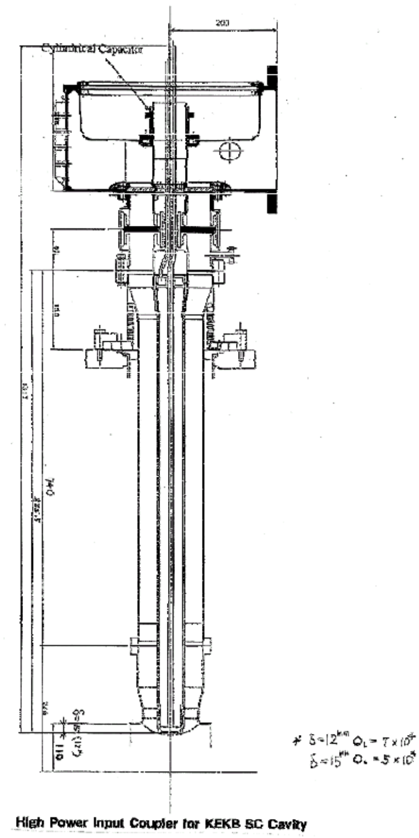


Figure 1. Input coupler for the KEKB

The window of the input coupler has a choke structure to decrease the electric field at the gold braze of the ceramic. This is almost the same as in the 1MW klystrons used at TRISTAN, which have demonstrated long-life operation at high power. The gap of 3 mm of the choke was changed to 4 mm to reduce the field strength around the ceramic window by a 20%. The ceramic window is a 10mm thick coaxial disk made of 95% purity alumina. The surface of the window on the vacuum side is coated with TiNxOy to reduce the coefficient of the secondary electron emission. The inner conductor side of the window is cooled by water and the outside conductor is cooled by air .

The impedance of the coaxial parts is 50 ohms. The inner conductor is made of electropolished copper, and the outer conductor is made of stainless-steel plated copper by pyrophosphoric acid. The coaxial pipe has fins outside, cooled by 8 l/min He gas flow at 4 K operation.

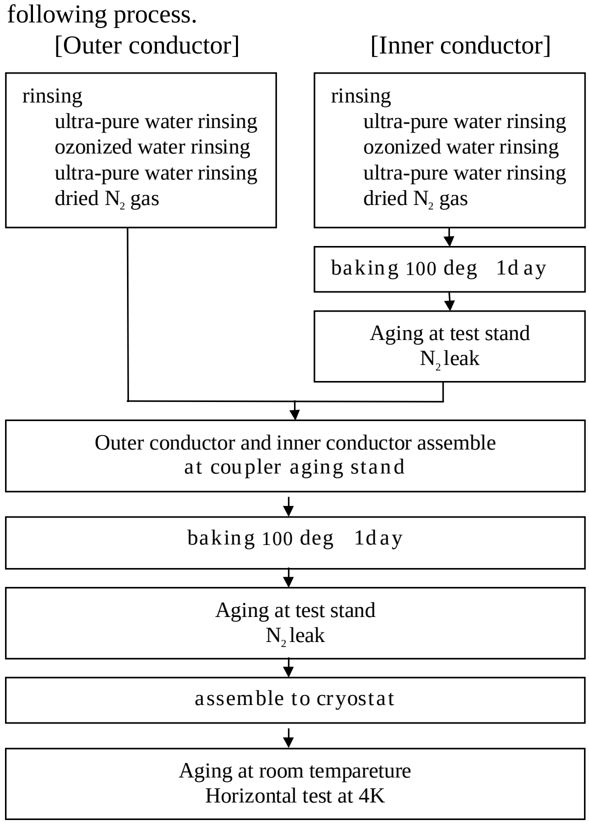
To suppress multipacting and make the aging process effective, doorknob transition sections are used to supply a bias voltage of±2kV to the inner conductor. An electric insulator made of two layers of 0.125 mm thick polyimide films is inserted between the inner conductor and the doorknob. To reduce the RF leakage from isolated parts, the doorknob are capped with an aluminum RF shield.

For a high power operation, the diagnostic and interlock system is important. The port near the window has been increased from one to three. The discharge light (arc) sensor and vacuum gauge are set for interlock protection and electron pick up to monitor the aging process.

For the KEKB we conditioned the input coupler up to 300kW of full reflected power.

3 PROCESS

The next four couplers have been prepared by the following process.



We have tested the aging effect for 2 types of treatment, ultra-pure water rinsing and ozonized ultra-pure water rinsing. For the coupler rinsed by ozonized ultra-pure water, an increase in vacuum pressure was observed over a broad range of power. However, arc break down around the 100kW is decreased. The total aging time is similar for two kinds of treatment. The result is shown in figures 2 and 3.

We use ozonized ultra-pure water rinsing for the couplers to reduce the breakdown around 100kW. The inner conductor and outer conductor was filled with 3 ppm ozonized ultra-pure water for 5 or 10 minutes.

The coupler has to be opened to air for assembly into the cryostat. Therefore it is important to establish the procedures of the coupler treatment after the aging. We studied the treatment in the following cases.

1st step: Aging after ultra-pure water rinsing.
2nd step: Aging after leaking N_2 gas for 3 hours.
3rd step: Aging after leaking N_2 gas for 1min and air for 3 hours.
4th step : Aging after leaking air for 3 hours.
5th step : Aging after keeping in vacuum.

The aging time of each step is shown in figure 4. The result is that the aging history is remembered by the coupler, and the treatment of the coupler is effective against exposure to air after a slow N_2 leak.

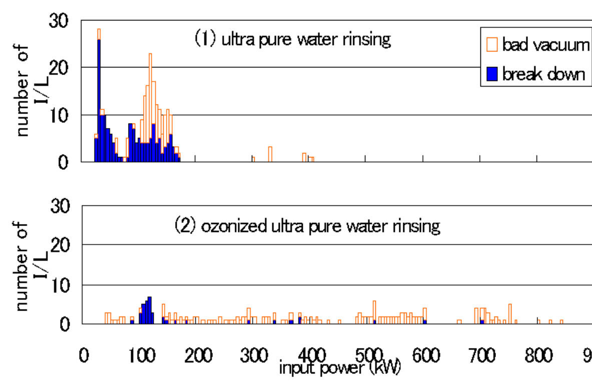


Figure 2. Frequency of interlock activation

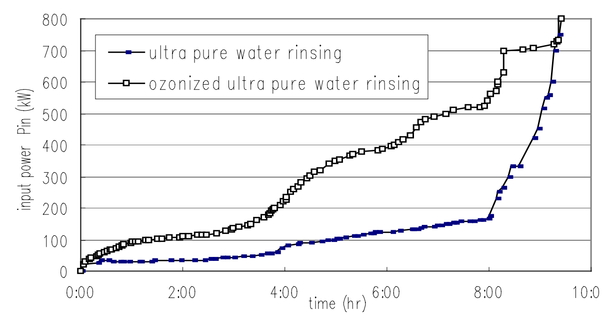


Figure 3. Aging history

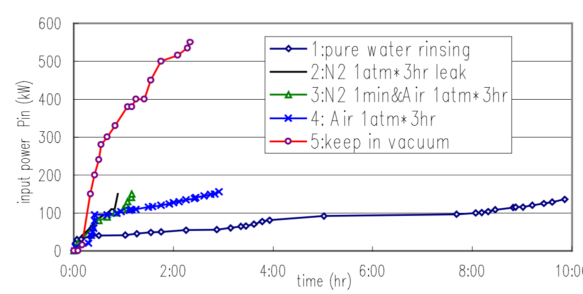


Figure 4. Treatment after aging

4 BIAS AGING

During the beam study on November 1996, bias voltage was applied for the first time with beam. When a bias voltage of -700V was applied, a large increase in vacuum pressure was observed as well as a temperature rise in the coupler. After that process, cavity breakdown decreased and the operation became stable. Therefore aging by bias voltage is thought to be effective on coupler conditioning.

At the test stand, we conditioned the new input couplers up to 400kW with 30% reflected power, and up to 300kV in field, with a DC bias voltage of ±2kV. In the horizontal test, the input power of the couplers reached 300kW with full reflected power.

The total amount of desorbed gases is estimated by multiplying the pressure integrated over the time period and the effective pumping speed. Table 2 shows the result for the sixth and eighth couplers.

Table 2. Amount of desorbed gas [unit:Torr*l]

	#6	#8
At coupler aging stand		
Baking	4.4	3.4
Aging without bias	2.2	2.1
Bias aging	0.5	0.4
After assembly into cryostat		
Baking around window	no bake	2.7
Aging without bias	1.9	1.2
Bias aging	1.2	0.9

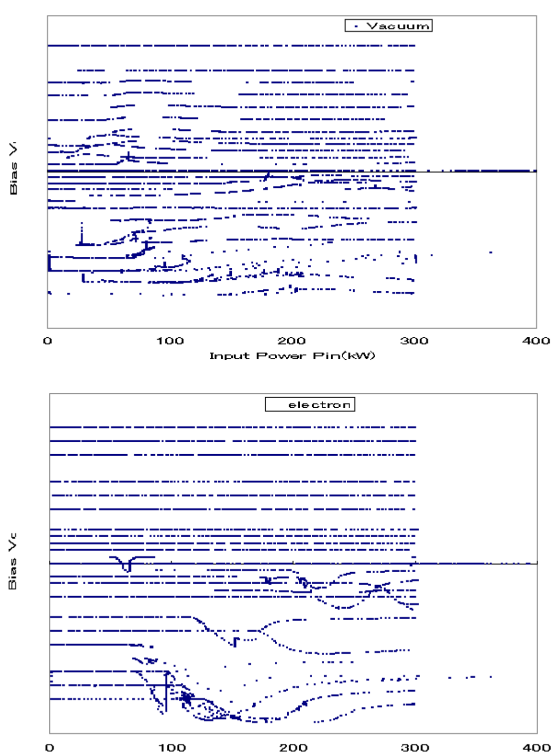


Figure 5 Surge in vacuum and electron mission -to bias voltage from +2kV to –2kV

The main desorbed gas from the coupler during baking is H_2O, its amount changing with the temperature. As the aging proceeds, the pressure of H_2O decreases. H_2 and CO/N_2 are the main components desorbed during bias aging. From the AR test, it seems that the desorbed gas H_2 or CO/N_2 is likely to be responsible for the cavity trips. Therefore we applied bias aging on the coupler at room temperature before cooling down the cavities. During this room temperature conditioning, the desorbed gas was evacuated by ion pumps.

As the bias was increased throughout the range, there was a surge in vacuum pressure and electron emission was observed, as shown in Figure 5. After the bias aging, there were few pressure surges. This conditioning decreased the coefficient of secondary electron emission of the inner and outer conductors as well as the ceramic window.

5 SUMMARY

The high power input couplers for KEKB have been operated stably with high current beam without beam processing. The couplers could handle up to 380kW of RF power with a beam current of 0.5A. This is the highest power of continuous operation in the world to date.

Next four couplers have finished the first conditioning on the coupler test stand. In the horizontal test, they have been supplied up to 300kW power at full reflected power.

The RF processing with bias voltage was found to be effective in reducing multipacting.

The study to understand this mechanism is being continued.

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