Input Couplers for KEKB Crab Cavities

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Abstract

The RF input couplers for KEKB crab cavities were designed, fabricated and installed. The input coupler is shown in figure 1. The RF input coupler has a ceramic RF window and a T-stub structure. The shape of T-stub structure and length of the probe were decided using RF simulation program. The RF window and the doorknob translator may cause some reflection. The RF windows for superconducting accelerator cavities for KEKB (KEKB-SCC) and the doorknob translators for TRISTAN were used. According to the procedure of assembling the RF input coupler for KEKB-SCC, they were rinsed and assembled. Aging was done individually. After that, they were installed into cryostats for crab cavities. These cryostats were installed to KEKB and have been working. Three input couplers, which are included for prototype cryostat, were prepared.

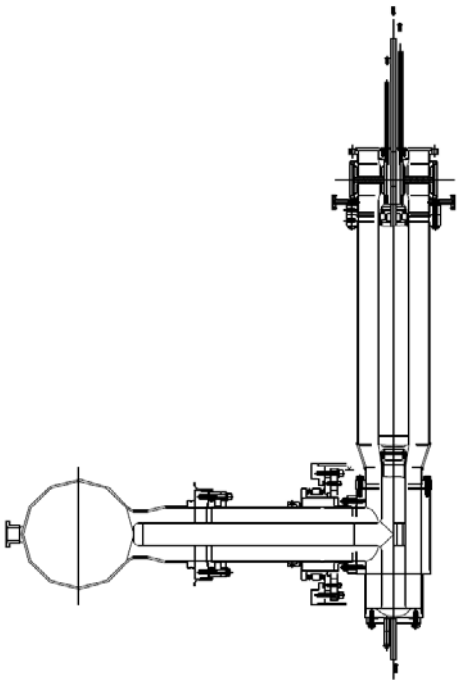

Figure 1: Schematic view of the RF input coupler

DESIGN

Since bunches are kicked horizontally in KEKB, the probe type RF couplers have to be attached horizontally. The RF power is supplied from above the cryostat. Thus, the couplers must have some structure to bend perpendicularly. And sufficient strength is required to support the horizontal part. To reduce development, the RF windows for KEKB-SCC and the doorknob translators for TRISTAN are used, too. If Doorknob translators for TRISTAN are used, DC bias can't be applied. But the input coupler for the crab cavity is shorten by the T-stub structure. So, that function can't be used. The Doorknob translators for TRISTAN are simpler than for KEKB-SCC.

Because the diameters of RF window and RF port of crab cavity are different, a section to reduce the diameter is required. These couplers have T-stub structure to provide sufficient strength.

The inner conductors between the RF window and the T-stub structure are separated to reduce the stress for RF window. And the diameters are changed at the connection part. The separated inner conductors are cooled by water respectively.

The couplers were designed to minimize the reflection coursed by T-stub structure and reducer of diameter. According to HFSS that is RF analysis code, the reflection caused by these structures is sufficiently small (VSWR < 1.15). Easy fabrication and low field enhancement were also considered. Three design candidates are shown in figure 2. Their transmit properties are shown in figure 3. In the case of (a) and (c) in figure 2, the maximum electric field appears on the surface of horizontal part of inner conductor. No field enhancement is occurred in case of (c) in figure 2. And the shape of figure 2 (b) is difficult to fabricate. The shape shown in figure 2(c) was adopted. It is assumed that 100kW of RF power will be fed from klystron in the practical operation. The inner conductors are made of copper. The outer conductor is made of stainless steel that plates copper.

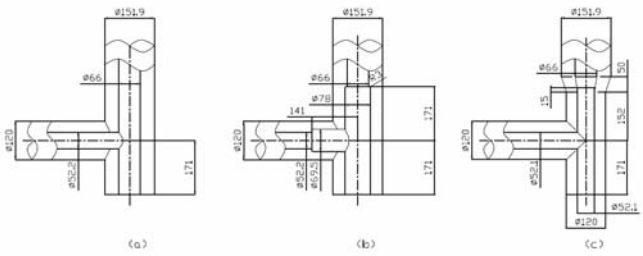

Figure 2: Schematic view of the candidates of the T-stub structures.(a)The simplest shape.(b)The diameters of inner conductor are changed at two points. (c)The diameter of inner conductor is changed using a taper.

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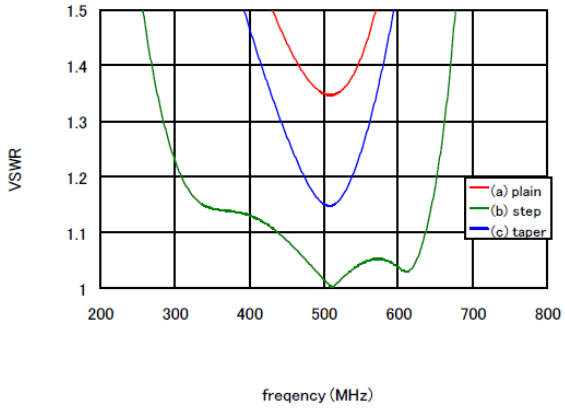

Figure 3: Transmit spectrum of T-stub structure.(a)The minimum value of the reflection is the highest in these models.(b)The reflection is the smallest. The bandwidth is very large.(c)The minimum value of the reflection and bandwidth are in middle of these models.

PREPARATION

Assembling

According to the procedure of assembling for KEKB-SCC, the RF input couplers were assembled and installed to aging stand [1]. The procedure is shown in figure 4. It was done in the clean room for KEKB-SCC (figure 5). At first, they was rinsed by pure water and O_3 water. It is thought that the O_3 water rinsing is effective to remove some organic contaminations [2]. To dry them, dry N_2 gas was blown. The dried coupler was assembled with an input coupler for KEKB-SCC. A waveguide part is between these couplers. The waveguide was designed to vanish the reflection at operation frequency. The inside of the waveguide and couplers were exhausted in the vacuum. The aging stand is shown in figure 6. After assembling, baking and He leak test were done. The baking temperature was set for 80℃, because some indium that melting point is about 156℃ was used as sealants.

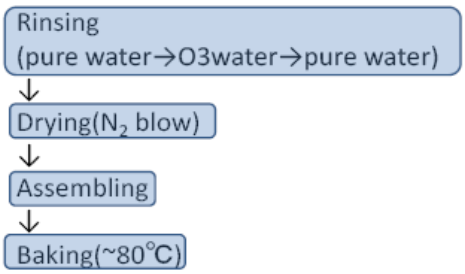

Figure 4: Prorocedure of The input coupler preparation.

Aging

The RF input couplers were conditioned before attached to crab cavity. At first, traveling wave was applied. It was spend 8 to 16 hours to overcome multipacting and to achieve 250kW of input RF power. The typical aging operation is shown in figure7. The interlock system sees the vacuum pressure and the light of arc. When interlock is worked, the RF power supply is stopped. The power level when the interlock is worked is defined as trip power.

Figure 5: The input couplers are assembled in the clean room. (left) O_3 water rinsing. (right) The input coupler was attached to the aging stand.

The progress of aging is shown in figure8. The aging time in figure8 shows just effective conditioning effort except some rest times that is lunchtime, night and weekend. Subsequently, standing wave was applied. The phase of standing wave, namely length of wave-guide is changed every 20˚(5cm). It is confirmed that the couplers can handle 200kW of standing wave RF power using prototype coupler. It was spend 4.5 hours to achieve 200kW of RF power. After finished the aging, the phase of standing wave was changed continuously as supplying 200kW of RF power. No trip was observed at that time.

To avoid the risk, the target of standing wave aging for the practical couplers was changed to 100kW. Trip was hardly observed below 100kW.

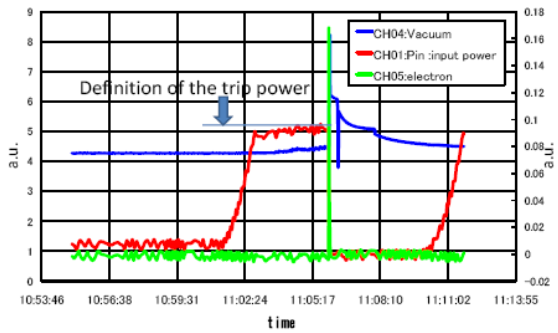

Figure 7: The element of typical aging operation

Installation on the cryostat

After aging, RF input couplers were inserted into cryostats. A special tool was produced, the input couplers slid on a plate of PTFE, and they were inserted. a portable clean booth was prepared. To prevent dust being involved, when the input coupler was installed, the crab cavity was opened in the clean booth, and clean N_2 gas was blown. To push the input coupler from outside of the clean booth,

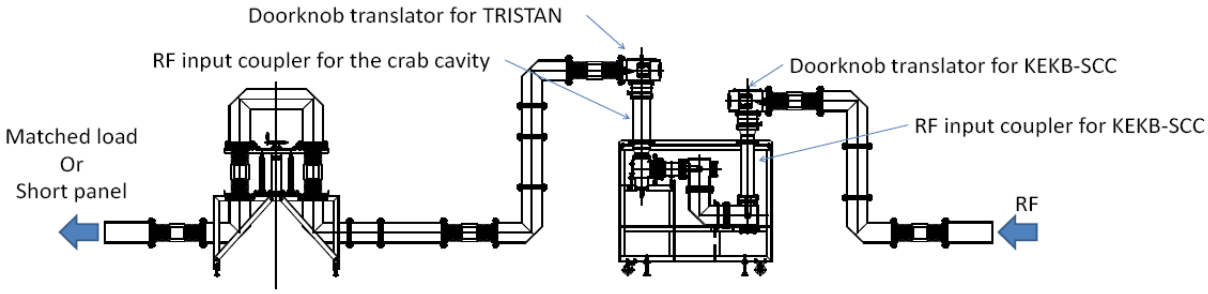

Figure 6: The Schematic view of the aging stand.

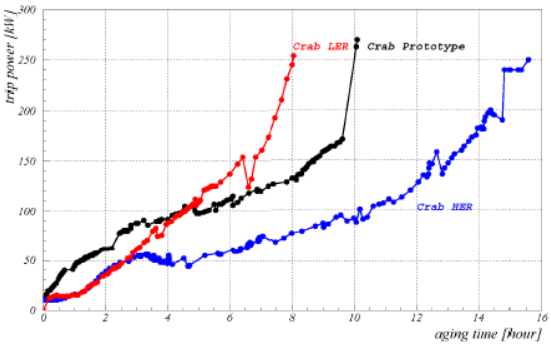

Figure 8: Progress of the traveling wave RF aging.

a long screw jack was attached behind the input coupler (Figure9).

STATUS

In practical operation, 25kW and 75kW of RF power are applied to LER and HER crab cavities respectively. Kick voltages are 0.9MV and 1.5MV at that time. At the operation in the spring 2007, total trip rates of crab cavities are 1.57times/day and 1.27times/day respectively.

SUMMARY

The RF input couplers for the crab cavities are designed, fabricated, conditioned, and installed. One of them has a ceramic RF window, T-stub structure, and separated inner conductors. Some aging was done at aging stand. At lease, 200kW of traveling wave RF power and 100kW of standing wave were applied. After aging operation, they were attached to crab cavities, and installed to KEKB. The crab cavities are working in KEKB.

At the operation in spring 2007, total trip rates of crab cavities are 1.57times/day and 1.27times/day respectively.

Figure 9: The input coupler is inserted into the cryostat.

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[2] T.Momose, Y.Maeda, K.Asano, H.Ishimaru, "Surface Analysis of Carbon on Ozone Treated Metals", J.Vac.Sci.Technol. A13,515(1995)