HIGH POWER CONDITIONING OF THE INPUT COUPLER FOR BEPCII SUPERCONDUCTOR CAVITY

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Abstract

High power conditioning and RF processing of the input coupler for BEPCII superconductor cavity (SCC) has been performed. Gas desorption is very important for a new input coupler; and high power conditioning and electron bombardment is quite effective for outgasing. For this reason, the DC bias voltage is applied to the conductors of coupler in the room temperature conditioning. RF power with full reflection of 150kW has been arrived under±2000V DC bias voltage during the room temperature conditioning. At the same time, other methods have also been studied to improve the performance of input coupler during the beam operation. Up to now, the input coupler works well under the beam current of 250mA and beam energy is 2.5Gev, which means the input coupler can feed 100kW RF power to beam in continuous wave in normal operation. The details about the high power conditioning and RF processing of the input coupler will be given in the paper.

INTRODUCTION

BEPCII is a double ring collider of positron-electron. The luminance of BEPCII will be increased to $10^{33}cm^{-2}s^{-1}$, which is 100 times of BEPC. In order to compress beam length well, two 500 MHz superconductor cavities (SCC) have been used to replace the 200 MHz normal conducting cavities used in BEPC. The input coupler for BEPCII SCC is desired to feed 150kW RF power under continuous wave (CW) to meet high beam current of 910 mA in colliding operation mode.

The BEPCII SCC input coupler is based on the KEKB SCC coupler. A coaxial planar Tristan chock window is adopted. However, the BEPCII SCC coupler operates at 499.8 MHz and KEKB SCC coupler operates at 508 MHz. So there are some slight modifications in structure compared with KEKB SCC coupler. The height of the upper doorknob h is increased to 97.35mm to keep the central frequency 499.8MHz [1].

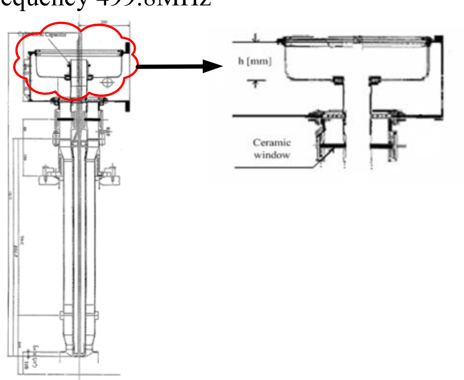

Fig.1 High power input coupler for BEPCII SCC is based on the KEKB SCC coupler [2].

INITIAL RF PROCESSING AT HIGH POWER TEST STAND

The initial high power RF processing has been performed by means of KEK high power test stand, starting with CW RF power up to 300kW in traveling wave mode, and then with partial reflected power. Fig.2 shows the trip times as a function of the power level during the initial test.

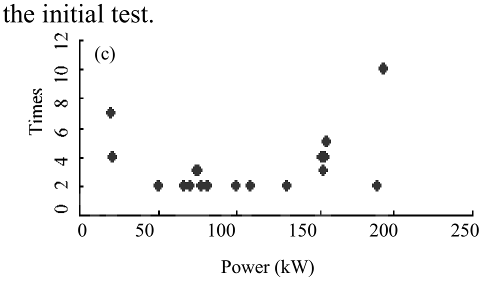

Fig.2 Trip times as a function of the power level during the initial test

CONDITIONING AT ROOM TEMPERATURE

The coupler was exposed to air when assembled into the cryo-module, so conditioning to high power again for the coupler is necessary before the SCC horizontal test, and toom temperature conditioning is more effective than the case of cooling-down. During coupler room temperature conditioning, the cavity should be off-resonant to keep the power in full reflection. The cavity frequency is detuned 1 MHz, deviated from of the central frequency 499.8MHz. The measurement result shows that the power leakage into the cavity is about 22.5W when the RF power reaching 150kW, which is safe for the SCC.

During the high power conditioning, the arc, electron current, vacuum and temperature should be monitored closely. Three monitor ports nearby the ceramic window are prepared for monitoring electron current, vacuum and discharge light. Moreover, several thermocouples are put on the doorknob and outer conductor. Fig.3 shows the distribution of various monitor sensors.

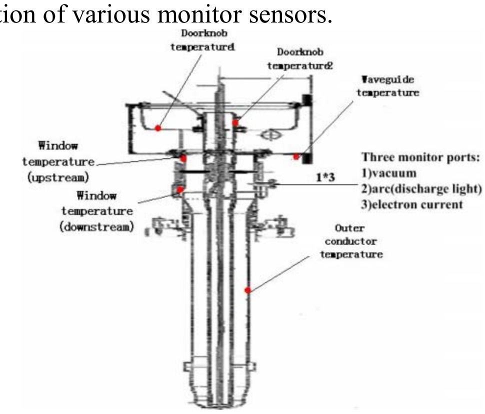

Fig.3 The distribution of various monitor sensors

Each signal monitored has a limitation value, which is listed in table1.

Table 1: The threshold values of various monitor signals

Monitor signal	Threshold value
Electron current	$< 5\mu A$
Window vacuum	$< 3\times10^{-5} Pa$ *
Cavity vacuum	$< 3\times10^{-5} Pa$ *
Doorknob temperature 1	$< 80^{o}C$
Doorknob temperature 2	$< 80^{o}C$
Waveguide temperature	$< 60^{o}C$
Window temperature (upstream)	$< 60^{o}C$
Window temperature (downstream)	$< 60^{o}C$
Outer conductor temperature	$< 62^{o}C$

(*Interlock value for the window and cavity vacuum is $5\times10^{-6} Pa$ in the case without DC bias voltage conditioning. When the DC bias voltage applying coupler, this value will be reset as $3\times10^{-5} Pa$ due to a large amount of gas desorption.)

We conditioned the coupler up to 150kW with full reflection. Fig.4 gives the history of the conditioning. It can be found that the processing was very difficult below 40 kW, there were a lot of outgasing points. A result can be concluded that the Multipacting effect and outgasing activities mainly occurred in these lower power levels.

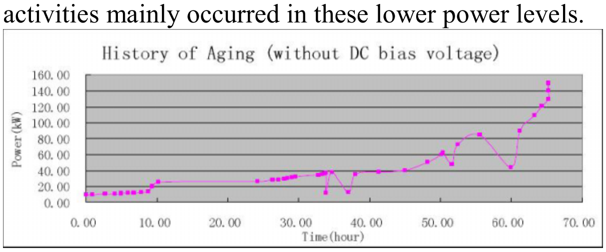

Fig.4: The history of conditioning without DC bias voltage

Fig.5 and Fig.6 show the trip times as a function of the power level and the interlock record, respectively. The e-current and vacuum increasing interlocks are dominating between 30kW and 50kW. It can be found that multipacting mainly occurred between 30kW and 50kW. It also can be seen that the electron current and vacuum increasing appeared almost simultaneously, which indicated that the electron bombardment was effective for gas desorption. In addition, arc trips happened at the lower power level, and the arc is mainly produced by the multipacting near the ceramic window [3], so, it can be concluded that the multipacting near the ceramic window occurs mainly at the lower power levels.

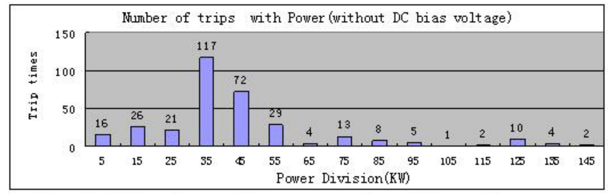

Fig.5: The trips times as a function of power

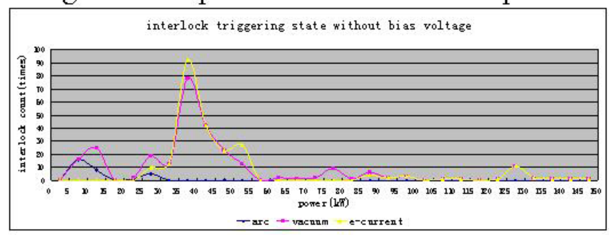

Fig.6: The interlock state record

After finishing conditioning with full reflection of 150kW, a DC bias voltage with max $\pm 2000V$ was applied to the inner conductor, continue conditioning with power up to 150kW, which is necessary and effective. As we know, the conditioning area along coupler coaxial line is not full parts due to the pattern of bias voltage applied can expand the processing area., and DC bias voltage can excite a new type of one-point one order multipacting on the inner conductor [4]. During conditioning with bias voltage, discharge light, electron current and the vacuume increasing activities reappeared at several power levels (Fig.7). Since the first order multipacting effect is very stable and stubborn, and its MP power band is the broadest [5], there was a lot of the condensed gas desorbed from the coupler surface through the electron bombardment.

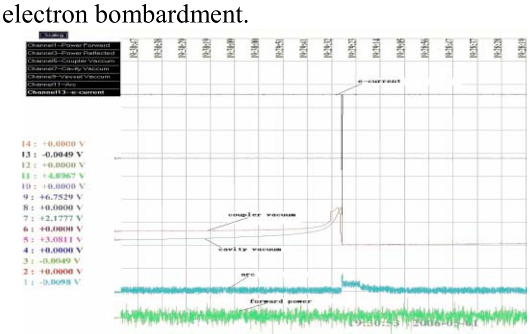

Fig.7: Inspection screen during the DC bias voltage conditioning

The Fig.8 shows the vacuum variation during the DC bias voltage aging. In the beginning, with a positive bias voltage between +200V and +800V, a lot of vacuum interlocks were triggered, especially at lower power levels. As the positive bias voltage increased more than +1000V, nearly no gas desorption appeared. However, as the negative bias voltage applied to -2000V, the vacuum became bad and electron current was observed again. Especially, as the bias voltage arriving to -1600V, the electron current was so high that the conditioning needed much longer time. Finally, after long time bias voltage conditioning, RF power arrived to 150kW in standing wave without vacuum trip.

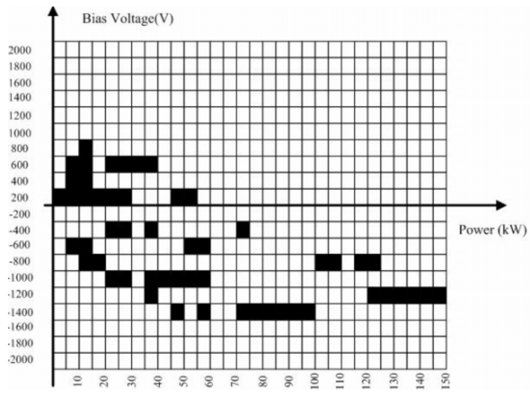

Fig.8: The vacuum variation during the DC bias voltage conditioning, the filled blanks indicate vacuum pressure increasing

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RF PROCESSING WITH BEAM OPERATION

In operation, with beam increasing, the distribution of the RF field in coupler will change from standing wave to partial reflection, even traveling wave. Further more, when beam operation through cavity, there are a lot of gas getting into the coupler. As a result, multipacting effect in the coupler might occur again, even more frequently. Specially, for the beam current over 200mA/2.5GeV in BEPCII case. A series of methods have been used to improve the vacuum performance of coupler, such as conditioning coupler under DC bias voltage applied. Fig9 is the inspection of DC bias voltage RF processing with beam operation.

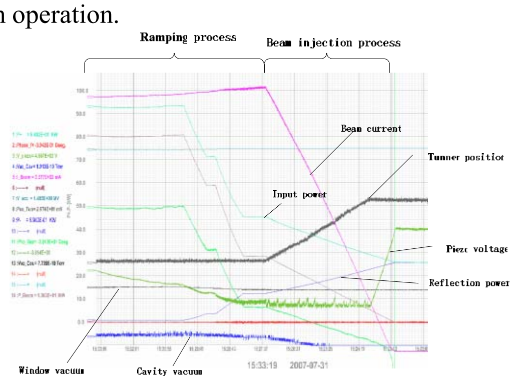

Fig9: Inspection result of DC bias voltage processing with beam operation

SUMMARY

The room temperature conditioning for BEPCII SCC input coupler has been performed. Through the different conditioning at room temperature, most of MP points in input coupler in the range up to 150kW in standing wave mode have been eliminated, and distribution areas of MP points have been found. Applying DC bias voltage during room temperature conditioning is effective for gas desorption. In addition, we also took a try to apply DC bias voltage to coupler during beam operation, which seems to be helpful to improve the coupler performance by suppressing the multipacting in coupler, but some simulations and more elaborate experiment should still be done for the possibility verification of this processing.

REFERENCES

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