STATUS OF KEKB SUPERCONDUCTING CAVITIES

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Abstract

KEKB HER(high Energy ring) operating stably by using 8 superconducting cavities. The Maximum current is more than 1.4 A, so the HOM(higher order mode) power of each cavity is as high as 16 kW, and the beam power of 400kW is handled by each cavity. To increase beam current more than 2 A and future Super KEKB project, HOM dampers of 3 mm thick ferrite have been constructed to test higher absorbing power of more than 40 kW. The construction of input coupler for 500 kW operation power is also starting with new industry TiNOx coating.

INTRODUCTION

KEKB, an asymmetric energy double-ring electron-positron collider for B-physics, was commissioned in December 1998. Two types of heavily-damped cavities are used in KEKB. A normal conducting cavity system (ARES) is used in both the low energy ring (LER) and the high energy ring (HER); 8 superconducting cavities were installed in the HER. This increased the beam current of the HER up to 1450 mA. The current was not limited by the superconducting cavities but rather by HOM heating of vacuum components such as masks. High current application of superconducting cavities needs high field damped structure type cavities, high power input couplers, HOM loads and powerful cryogenic systems. The cooling water system for each cavity HOM damper were increased from 20 kW to 40 kW at 2006 summer.

SUPERCONDUCTING CAVITY

The long-term operation of 8 superconducting cavities in KEKB successfully continued from 2000.The beam test of the prototype cavity at the TRISTAN Accumulation Ring (AR) reaching a maximum current of 0.57 A in 1996, we started construction of 8 superconducting cavity modules for the KEKB HER. Figure 1 shows the whole module. The superconducting cavity has a single cell structure with large aperture beam pipes on both ends so that higher order modes (HOM) can propagate out of the cavity and be damped by ferrite absorbers bonded on the inner surface of the beam pipe. During long-term operation the typical cavity maximum fields changing as Fig.2.

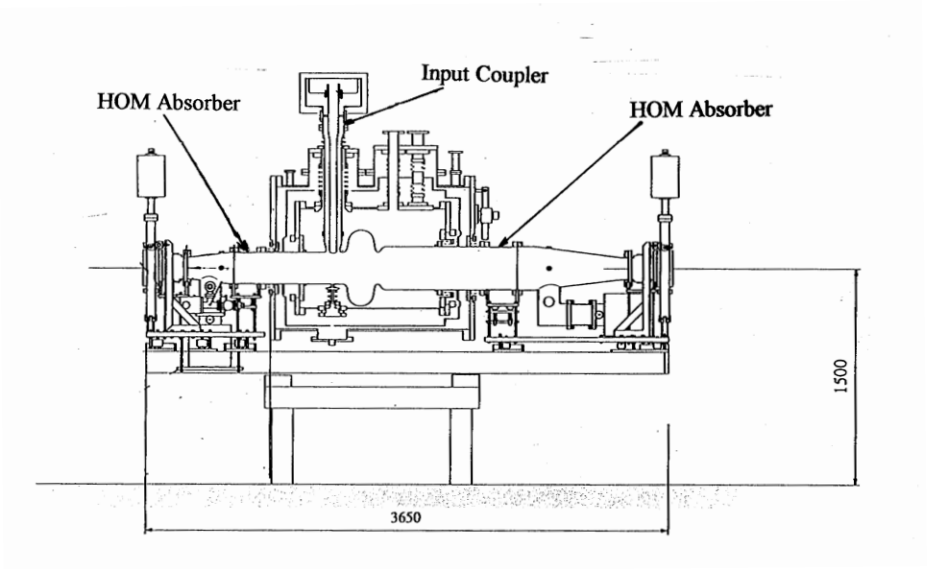

Figure 1: Superconducting cavity of KEKB.

D10A cavity 3 time open to air and D10B once time open to air during summer shutdown of 2005 to change input coupler coupling for strong beam loading.

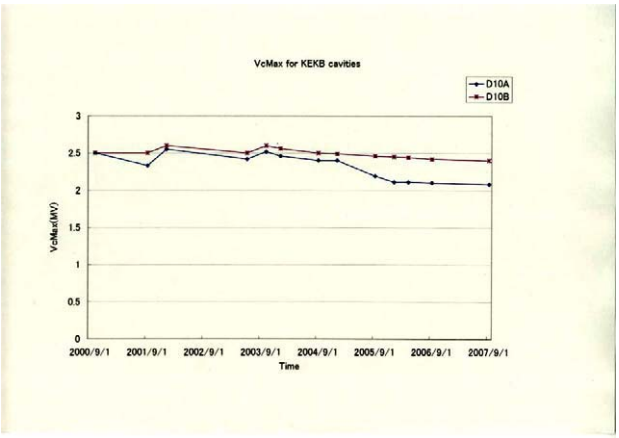

Figure 2: Performance for KEKB SC cavity.

Fig.3 shows Q0 value degradation for long-term operation. D10A 3 times opened to air due to indium joint failure and the Q0 value obviously degraded.

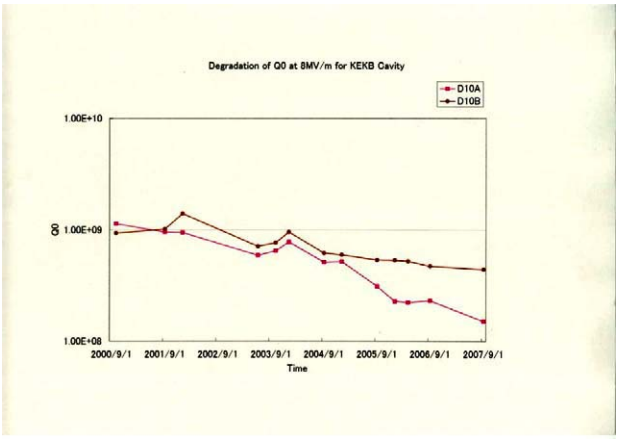

Figure 3: Q0 degradation of typical KEKB cavities during long-term.

KEKB INPUT COUPLER

KEKB input coupler use water cooling for the inner conductor. The calculated heat transfer by radiation is about 0.6 W for the electro-polished Cu inner conductor. This heat transfer is small and is expected to have almost no effect on cavity performance in the case of high fields of more than 10 MV/m for KEKB. The water cooling has enough cooling capacity for up to 1 MW power transmission. The window of the coupler is almost same as those in the 1MW klystrons used at TRISTAN, which have a long lifetime of more than 50000 hours. The KEKB couplers can be operated at 1 MW in principle . For stable higher power operation, the KEKB couplers have diagnostics of vacuum, electron and arc detector for precise RF processing and interlock operation. All coupler window ceramic coated with TiNOx and the surface were rinsing with ozonized water about 10 minutes for reducing the secondly electron yield coefficient.

Before cooling down the cavities, we condition the input couplers up to 300 kW with perfect reflection condition, and up to 300 kW with dc bias voltages applied on the inner conductor up to +- 2kV. The developed high power doorknob transition with capacitor for applying bias voltage works well up to 300 kW perfect reflection condition (corresponding to 1.2 MW of forward power). The insulating material is two layers of 0.125 mm thick polyimide films. The doorknob transition with air cooling duct for insulating capacitor is shown in Fig 4.

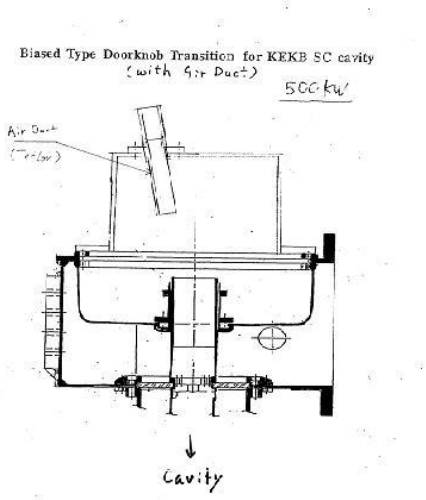

Figure 4: Bias type doorknob transition with air cooling duct for insulating capacitor.

The spare coupler tested up to 500 kW and the processed coupler keep in few Pa vacuum in 4 month and tested up to 800kW in short time as Fig. 5.

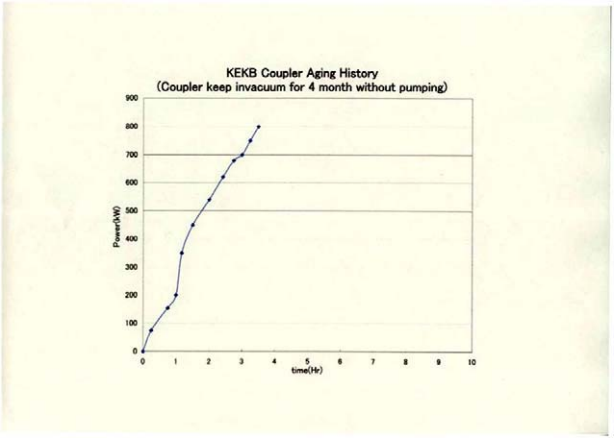

Figure 5: High power test of input coupler after 4 month .

Recently, the company of TiNOx coating for ceramic window changed and inner conductor cooling pass of the input coupler is changed to increase cooling and to reduce construction cost. So we are constructing a new coupler for 600 kW power test.

HOM DAMPERS

HOM dampers are made of 4mm ferrite and tested up to 18 kW and 25 kW for the SBP and LBP, respectively, as shown in Fig.6. The surface temperatures were almost 200 deg. C for maximum power.

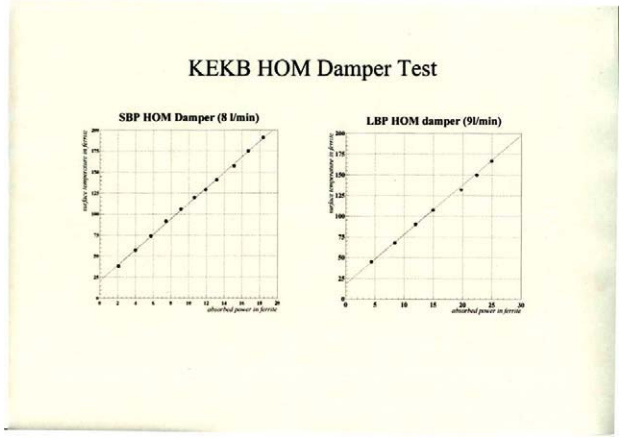

Figure 6: high power test for HOM damper of 4mm ferrite.

More high power HOM is demanded for planed project of Super KEKB, we construct 3mm thick ferrite dampers to decrease surface temperature. Low power RF measurements show good absorbing performance as 4 mm thick ferrite dampers as Fig.7. These will be tested more than 40 kW soon.

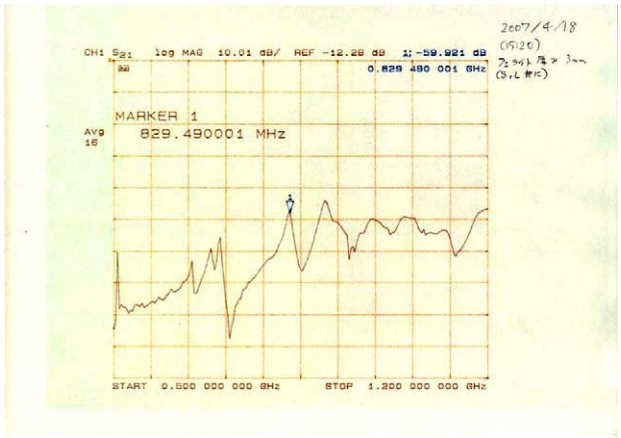

Figure 7: RF measurement of 3 mm thick ferrite HOM damper.

SUMMARY

Long term operation of KEKB superconducting cavity for more than 7 years are successfully continued without serious performance degradation. But some cavities have to open to air due to indium joint failure and have degradation of Q0 values at 2 MV.

HOM damper tested up to 40 kW absorbing power for one cavity at test bench. And new 3mm thick damper have been constructed.