BEAM TEST RESULTS ON HOM ABSORBER OF SUPERCONDUCTING CAVITY FOR KEKB

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Abstract

A series of beam tests using TRISTAN Accumulation Ring (AR) was dedicated to verify the feasibility of RF system and other components planned for KEKB, B Factory project at KEK. In this paper, we describe the results on Higher Order Mode (HOM) absorbers used for Superconducting Cavities (SCC). The absorber was manufactured by HIPping of ferrite powder onto copper tube. The SCC system was operated stably with HOM's being damped, and up to total of 4.2 kW was absorbed through the absorber without any problem.

1 INTRODUCTION

HOM absorbers made of ferrite have been developed for SCC's to be used for KEKB High Energy Ring (HER) [1,2]. To check the validity of our manufacturing technique using Hot Isostatic Press (HIP) of pre-sintered ferrite powder, a full-size absorber alone was beam tested in TRISTAN MR [3]. Finally, a SCC with two absorbers was beam tested three times in 1996 in TRISTAN Accumulation Ring (AR). This paper presents a summary of these tests mainly concerning HOM absorbers.

2 INSTRUMENTATION

Installation process of the absorbers and preparation for the tests will be described below in terms of hardware and software.

2.1 Hardware

Figure 1 shows the full set up of the system with detailed dimensions of absorbers on each side. Hardware consists of a SCC, a cryostat, an input coupler, two HOM absorbers, two tapers with ducts and ports for gauges, two 270 L/s ion pumps and two gate valves.

2.1.1 Assembly of absorbers

Absorbers were degreased and rinsed with ethanol using a closed system with ultrasonic agitation. Then they were assembled with tapers, bellows and gate valves. Before installing to SCC, up-stream and down-stream sets were connected together and baked at about 120 ˚C for a few days. Finally, after venting with filtered pure nitrogen gas, they were attached to SCC in a clean hut of class ~1000.

2.1.2 Installation of sensors

Two cold cathode gauges were set on both up-stream and down-stream tapers. To analyze gas species, a Quadrupole mass analyzer was set on the duct attached to up-stream taper. 2 rows of 8 azimuthally distributed thermo-couples were taped on the outer surface of absorbers. Moreover, two sets of Pt thermometers were inserted in the inlet and outlet of the copper cooling pipes as well as a digital flow rate meter for precise calorimetric measurements of absorbed power. Also, 3 RF pick up antennas were set at 0, 45 and 90 degrees from top of each taper.

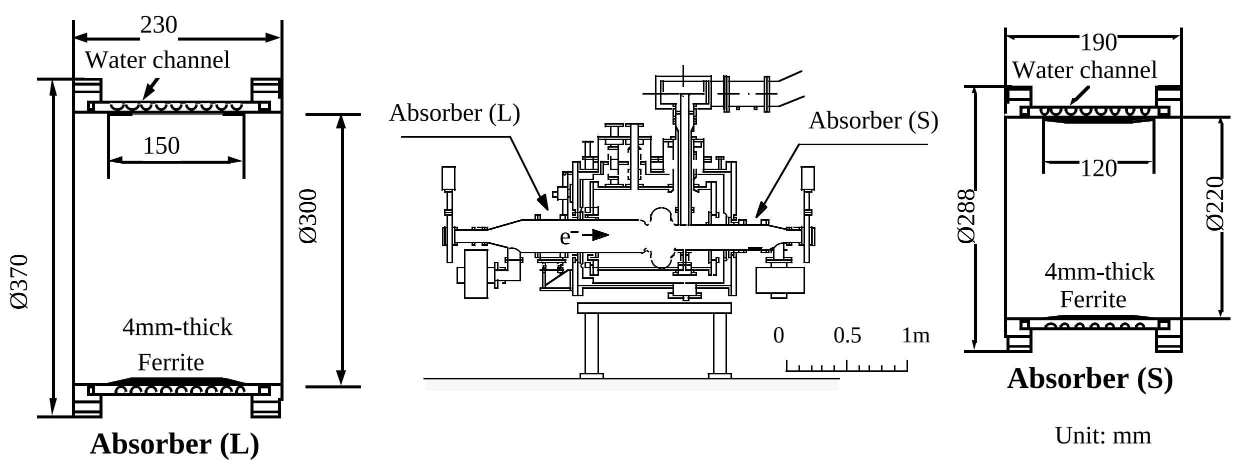

Figure: 1 Superconducting Cavity (SCC) with HOM absorbers and detailed dimension of each absorber.

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2.2 Software

Software consists of GP-IB based data acquisition system operated with a software named Labview. Total of about 130 data were taken and stored in a MO disk every 30 sec. These data were retrieved with another application software named Kaleida Graph for further analyses.

3 RESULTS

The beam tests ended with successful results after strengthening the pumping power of the neighboring ducts [4,5]. The pumping power and the amount of the gas entering the SCC are estimated to be 3 times stronger and 1/10, respectively [6]. This fact reconfirmed the importance of keeping the SCC clean against gases. The number of trips decreased drastically and stable operation was possible. Below are the summary of HOM absorbers.

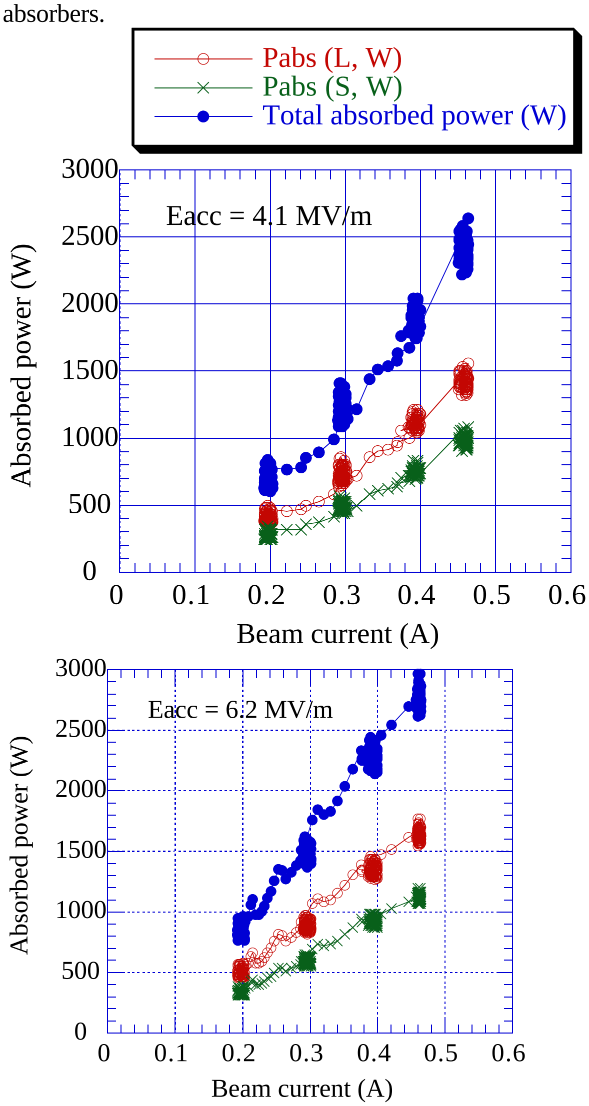

Figure: 2 Absorbed power as a function of beam current at different cavity accelerating fields. “L” and “S” denote Large and Small absorber, respectively.

3.1 HOM Damping

HOM’s were searched with a spectrum analyzer. With our tuner, up to 400 kHz of fundamental mode could be searched and no significant increase of HOM were found, confirming the capability of damping.

3.2 Power Handling

The maximum power absorbed went up to 4.2 kW in total. Figure 2 shows a typical absorbed power as a function of beam current at Eacc = 4.1 and 6.2 MV/m. The cavity voltage can be obtained by multiplying the gap length of 0.243 m with Eacc. As one can see, the absorbed power did not increase quadratically because the bunch length got elongated with higher currents, resulting in the decrease of loss factor as shown below. The uncertainty of the absorbed power was mainly due to the fluctuation of inlet water temperature caused by regulated cooling system.

No symptom of degradation on the absorbers were observed during the tests.

3.3 Loss Factor

As mentioned above, bunch length changed with beam current and cavity voltage. Figure 3 shows the bunch length measured with a streak camera. As one can see, increasing cavity voltage could make the bunch length shorter, but not much. Also, the bunch length became

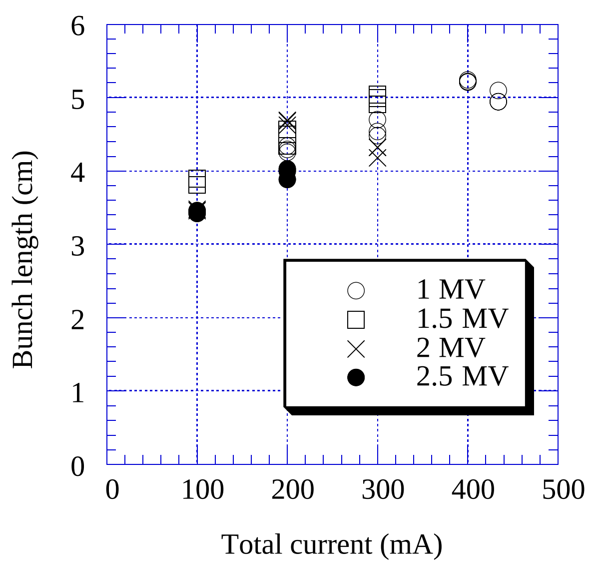

Figure: 3 Bunch length as a function of total current at various cavity voltages. 4x4 bunches. Data were taken with a streak camera.

longer with beam current.

To obtain the bunch lengths as short as possible with absorbed power large enough to measure loss factor precisely, we used 50 bunches with feedback on [7]. As shown in Fig. 4, we could get as short as 1.5 cm, which is still far from KEKB design value, 0.4 cm, though. The calculation in Fig. 4 is the sum of ABCI calculations without absorbers and analytic calculations of absorber themselves. Neither entering nor outgoing power from SCC were considered. The measured data were close to the calculation at shorter bunches and lower at longer bunches as shown in Fig. 4.

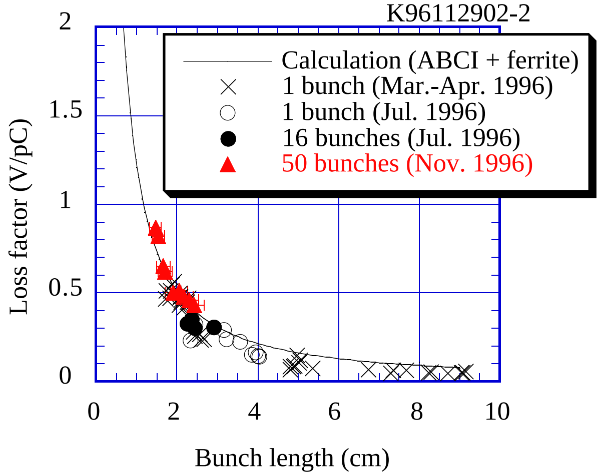

Figure: 4 Comparison of the measured loss factor with calculation.

3.4 Outgas

As mentioned earlier, drastic decrease of trip rate of SCC after strengthening the pumping power of the neighboring ducts made it clear that the entering gas from outside had caused most trips. Also, it suggests that, if the integration of outgas from absorbers at high losses exceeds a certain amount, it might cause trips in the future. The threshold roughly estimated from obtained data is about 1 Torr liter, though we could not reach this level at the last test in which the amount of gas from absorbers seems to have been comparable or larger than the gas entering from outside.

3.4.1 Gas species detected with a mass analyzer

As shown in Fig. 1, quadrupole mass analyzer was set on a duct at up-stream taper. The most gas detected was hydrogen. A summary of the analyses is as follows.

- For some reason, back ground level of mass analyzer increases with cavity fields higher than ~6 MV/m.
- The amount of hydrogen increases with beam currents.
- It also increases during aging of the input coupler.
- At 8.3 MV/m and 400 mA with SCC on, the amount of hydrogen is much higher (~x3<), compared to the operation (450-500 mA) with SCC off.
- Apart from hydrogen, the observed mass numbers during warm-up are 18, 16, 12, 28, although they were much less than hydrogen.

4 DISCUSSION

On the mass analyses, though the detected gas was chiefly hydrogen, we are not 100 % sure that the contamination or condensation on SCC that cause the trips can be attributed to hydrogen alone because the other gases condense on the surface of SCC more easily than hydrogen and they might not have been detected well with the mass analyzer.

On the loss factor, it seems to get higher than present prediction at 4 mm. It will be important to clarify the sources for additional losses and estimate the loss factor at KEKB HER more accurately.

5 CONCLUSION

Beam tests of SCC with HOM absorbers made of HIPped ferrite were performed using TRISTAN AR. The SCC was operated stably with HOM's being damped especially after the reduction of gas condensation on its surface.

The power absorbed through absorbers went up to 4.2 kW at maximum and 2 to 3 kW for more than 120 hours. No symptom of degradation was observed on the absorbers. Loss factor at 1.5 to 2.5 cm agreed well with calculation but was lower than calculation at longer bunches.

Since we did not face many trips at the last beam test in which we could estimate the amount of the condensed gas more accurately than the previous tests, we cannot conclude on the threshold level of the amount of condensed gases at which trips start occuring. However, from previous tests our rough estimate is about 1 Torr liter. To avoid this problem in the future, the outgas rate of absorbers should be reduced further along with the efforts to minimize the amount of gases that enter from outside.

6 ACKNOWLEDGEMENTS

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REFERENCES

[1] T. Tajima et al.: Proc. 1995 PAC, p. 1620.
[2] T. Tajima et al.: Proc. 1996 EPAC, p. 2127.
[3] T. Tajima et al.: KEK Report 96-7 (1996).
[4] S. Mitsunobu et al: in this conference.
[5] T. Furuya et al.: in this conference.
[6] Y. Suetsugu: private communication
[7] M. Tobiyama: private communication