ACTIVITIES ON SURFACE TREATMENT FOR SC CAVITIES IN NOMURA PLATING CO., LTD.

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Abstract

Since the early beginning of the TRISTAN project at KEK, Nomura Plating has been carrying out the surface treatment of SC cavities for KEK. In order to upgrade our activities and technology, we have made two L-band single-cell niobium cavities (Fig. 1, 2. [1]) and tested.

Two new surface treatments; a swing-barrel polishing and a chemical barrel polishing were started. First, we developed the swing-barrel polishing to increase mechanical polishing speed especially in the iris part. The cavity is rotated on a swinging bed during the barrel polishing. With the swinging, the polishing speed was increased in the iris area and the averaged increase in the whole cavity was about 10 % by two times 3 days continuous polishing. Next, we tried the chemical barrel polishing to shorten the polishing time much more. The cavity is chemically polished and tumbled simultaneously. The polishing speed was about 150 times faster, however, no good result has been achieved in the cold test at present. The development of this treatment is still in progress.

Fig. 1: Trimming of a half cell (Nomura Plating Co., Ltd.)

Fig. 2: Two niobium cavities of Nomura Plating Co., Ltd.

1. Introduction

In 1994, an investigation of the barrel polishing was started in order to replace a buffing in KEK [2]. Barrel polishing has some good points compared with buffing; 1) it can be used for the completed cavity (while the buffing is only for half cells so that another grinding is needed for EBW seams), 2) an automation and a quality control is easy, 3) it is low-priced (with the buffing, the labor costs are high) and in addition 4) high gradient can be achieved with less total removal of surface. In KEK, high accelerator field gradient of more than 25 MV/m have been achieved very reliably with the cavities that were barrel polished before electropolishing or chemical polishing. For the big projects like TESLA, a mass production of cavities under a high quality control is needed and the barrel polishing seems to be suitable for that purpose. However, it takes more than 2 weeks to get smooth enough surface.

In order to shorten the polishing time, we started the experiments of the swing-barrel polishing and the chemical barrel polishing in collaboration with KEK.

2. Swing-barrel polishing

In order to achieve high gradients, not only the defective surface layer (Estimated thickness of the defective layer is about 30 μm and mechanical polishing seems suitable to remove that [3]) but also defects on the EBW seam have to be removed. The barrel polishing is very effective method to remove these defects. But as mentioned already, the polishing speed is very slow, especially at the iris part where Esp is high and another EBW seam exists.

In 1996, to improve the situation and to apply to medium β cavities, for which the situation seems to be much worse, we have started the experiments of the swing-barrel polishing. It means the barrel polishing added a swinging of the whole barrel polishing system (Fig. 3).

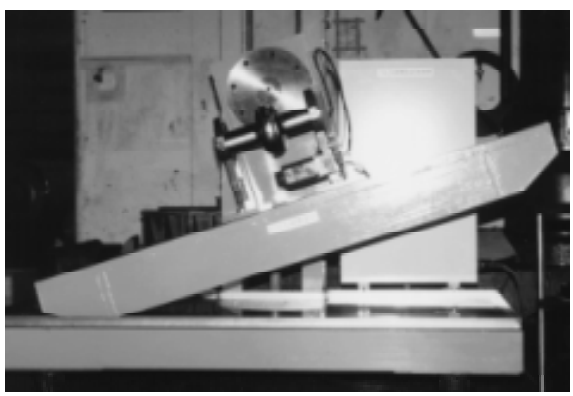

Fig. 3: Swing-barrel polishing (Nomura plating Co., Ltd.)

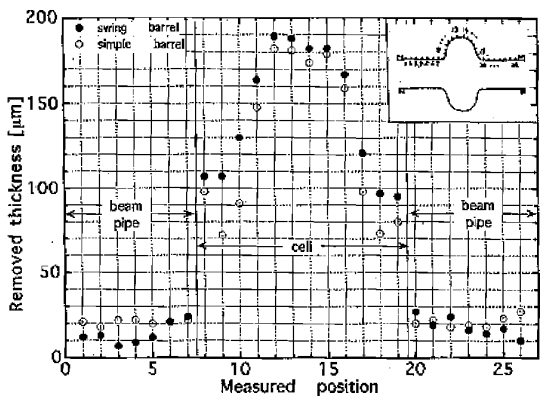

Fig. 4: Distribution of removal thickness with swing and usual barrel polishing (L-band, β = 1)

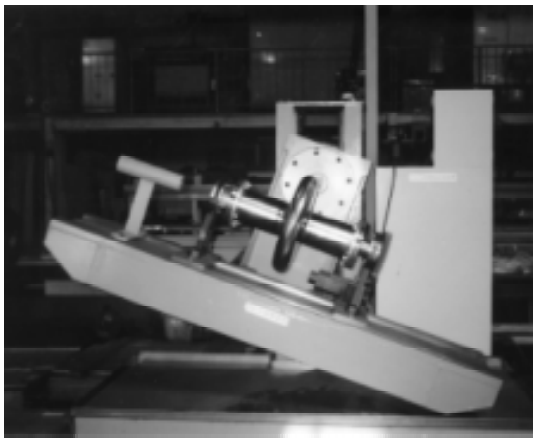

Fig. 5: Swing-barrel polishing of 600 MHz, β = 0.5 JAERI cavity (Nomura plating Co., Ltd.)

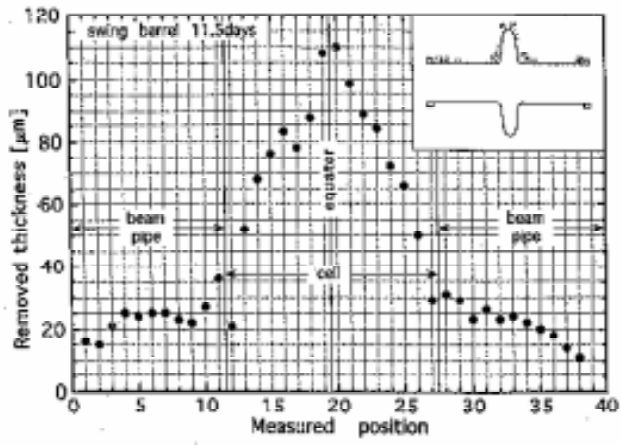

Fig. 6: Distribution of removal thickness with swing-barrel polishing (600 MHz, β = 0.5 JAERI cavity)

To check the effect of the swinging, we did 3 days continuous barrel polishing of a L-band, β = 1 cavity two times and measured the weight and thickness. With the swinging, the polishing speed increased (Table. 1). By measurement of the thickness, it seems that the swinging is effective for the iris part of the cavity (Fig. 4. swing-barrel; 121 g removed in Nomura plating Co., Ltd./ usual barrel; 108.2 g removed in KEK).

Table. 1: Removal weight of 3 days continuous polishing

	usual barrel polishing	swing-barrel polishing
removal thickness [g]	13.0	14.0
		15.3

Swing-barrel polishing was also applied to medium-β (β = 0.5) cavity of JAERI (Fig. 5). It took 12 days to remove 30 μm of the iris part of the cavity. The distribution of the removal thickness is similar to that of the L-band cavity (Fig. 6).

With the L-band cavity for which the swing-barrel polishing was applied, high accelerating gradient of 26.5 MV/m was achieved (Fig. 7). Before the swing-barrel polishing, there were dozens of spatter-balls (about 0.5 mm) on the iris EBW seams because of the unsuitable condition of the EBW. They were removed with the swing-barrel polishing of 23 g (~16 μm).

While with the medium-β cavity, more than the specified Epeak was achieved in JAERI.

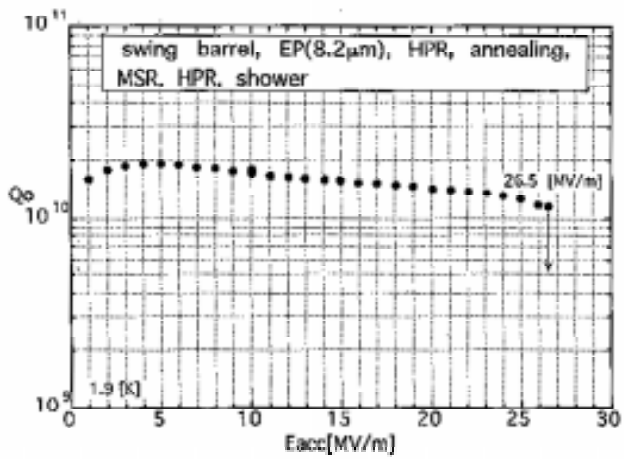

Fig. 7: Qo vs. Eacc of the swing-barrel polished cavity (L-band, β = 1 cavity)

3. Chemical barrel polishing

To remove the surface defect of the cavity much faster, we started the investigation of the chemical barrel polishing. It is the barrel polishing with the chemical polishing solution inside the cavity (Fig. 8).

With the chemical barrel polishing, a distribution of the removal thickness was changed from usual barrel polishing (Fig. 9).

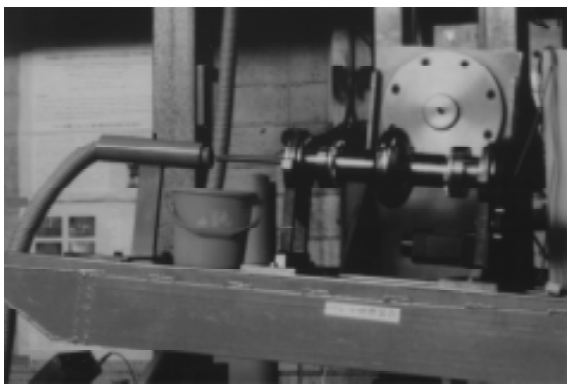

Fig. 8: Chemical barrel polishing of L-band, b = 1 cavity (Nomura Plating Co., Ltd.)

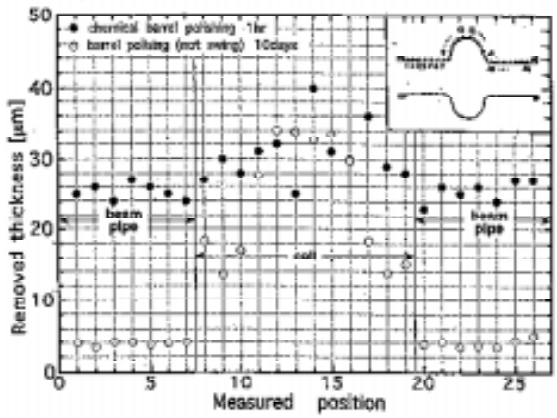

Fig. 9: Distribution of removal thickness with chemical and usual barrel polishing (L-band, b = 1 cavity)

As a polishing solution, we used the solution; water : hydrofluoric acid : nitric acid : phosphoric acid = 1:1:1:1 v/v. Though the polishing time was shortened from 3 weeks to 3 hours, the Eacc was only 16.6 MV/m (Fig. 10). After the measurement, 8 pits were found at the equator. So we ground away them and measured the cavity performance again. The Eacc was 17.1 MV/m (Fig. 11). At these measurement, the pressure of the final high pressure rinsing was only 56 kgf/cm^2 because of the pump trouble. So we measured the cavity again after the rinsing at 80 kgf/cm^2 . But the Eacc went down.

The effect of the chemical barrel polishing is not yet clear. The investigation will be continued and the optimization for the condition, such as composition and amount of solution might be required.

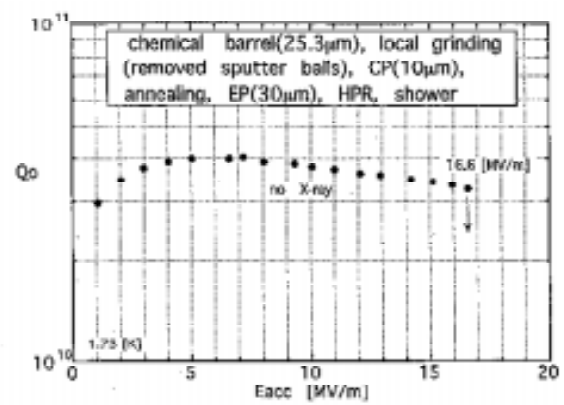

Fig. 10: Qo vs. Eacc of the chemical barrel polished cavity (L-band, b = 1 cavity)

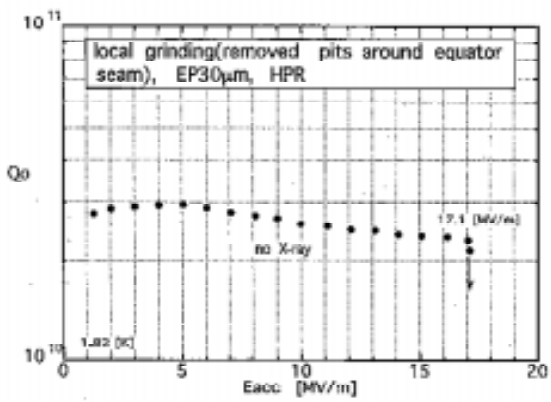

Fig. 11: Qo vs. Eacc after grinding (L-band, b = 1 cavity)

4. Conclusion

Swing-barrel polishing

1. Swinging increased the polishing speed by 10% on the average, especially the speed around the iris was improved.
2. It was applied to two single-cell JAERI cavities of $\beta = 0.5$. It took 12 days to remove 42μm on the average.
3. By the swing-barrel polishing as a pre-treatment, and the final electro-polishing of 10 μm, high accelerating gradient of 26.5 MV/m was achieved in our L-band single-cell cavity.

Chemical barrel polishing

1. The chemical barrel polishing could reduce the polishing time very much.
2. The effectiveness is not yet clear, especially for the defects on EBW seams. Further tests and the optimization is in progress.

5. Acknowledgment

The authors thank to Mr. Shuhei Nomura (president of Nomura Plating Co., Ltd.) for his support to our study. And we thank to Dr. N. Ouchi (JAERI) for his permission to publish data about the swing-barrel polishing of the medium-β cavity.

6. Reference

[1] T. Suzuki et al., “In-house Fabrication and Performance of L-band SC Cavities”, Proc. of the 22nd Linear accelerator meeting in Japan, Sendai, September 9 - 11, 1997, p.116 - 118 (Japanese)

[2] T. Higuchi et al., “Investigation on Barrel Polishing for Superconducting Niobium Cavities”, Proc. of the 7th workshop on RF superconductivity, Saclay, France, October 17 - 20, 1995, p.723 - 727

[3] K.Saito et al., “A Roll of the Mechanical Polishing in the Surface Treatment of Superconducting Niobium RF Cavities”, Proc. of the 21st Linear accelerator meeting in Japan, Tokai-mura, September 30 - October 2, 1996, p.225 - 227 (Japanese)