IMPROVEMENTS OF CLEANING METHODS FOR HIGH Q-SLOPE PROBLEM IN FULL END SINGLE CELL CAVITY

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Abstract

We are developing LL high gradient SRF cavity for ILC. Recently we have observed a Q-slope problem at higher gradient over 35-40MV/m on the full end single cell cavities, which have a HOM coupler and an input coupler on a beam tube. This problem might be due to poor rinsing in such a complicate structure. We have studied new post EP cleaning methods: inner ultrasonic cleaning, steam cleaning, and so on. In this paper we will report these results.

INTRODUCTION

KEK WG5 group is developing an ACD high gradient SRF cavity applied low loss (LL) shape, so called Ichiro cavity as an ILC R&D. Ichiro cavity can produce a gradient higher than 50MV/m, of which principle proof has been done on the single cell cavities with center cell shape of Ichiro 9-cell cavity but not yet on the 9-cell cavity. We are still fighting on the 9-cell demonstration.

To find out the reason of the difficulty, we are investigating the end cell cavity. Recently we have confirmed that its RF design has no problem to produce 50MV/m (Fig.1 left) and problem is in the beam pipe with a HOM coupler and an input coupler port (Fig.1 right). Q-slope happens at higher than 35MV/m in such a cavity configuration.

Motivation of the study

One of the reasons might be in difficulty of cleaning after electropolishing. So we have studied to see it and searched more efficient cleaning methods for such a complicated end group.

PRIMITIVE EXPERIMENTS

We have made primitive experiments to visually observe the difficulty in the cleaning. We made a 1.3GHz demountable acryl model cavity (Fig.2, left). We sprayed MOLYKOTE, which is usually used as lubricant, on the inner surface and dried. Thus the contaminated surfaces was rinsing tested by various methods.

Remained contamination by HPR

Fig.3 shows the remained contamination by our regular HPR rinsing condition (6MPa, 15min. from Top to Bottom one pass at 22mm/min at down speed, 11 rpm). One can easily understand that HPR jets cannot shot fully inside of the input coupler port (Fig.3 left). HOM coupler is more difficult to be cleaned up due to the complicated structure (Fig.3, right).

Rinsing difficulty even by Ultrasonic rinsing

Fig.4 shows results of the ultrasonic rinsing subsequently done after the HPR mentioned above. The rinsing was done in an ultrasonic bath with 600W at

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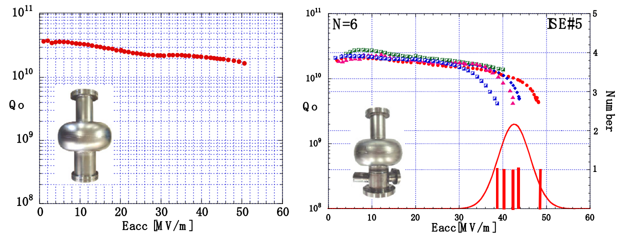


Fig.1: Ichiro end cell cavity performances without (left) and with (right) full end group.

28kHz for 30 minutes. The contaminations are still remained. The real contamination with SRF cavity might be different from such the MOLYKOTE spraying. However, it has to be noticed that the real remained contamination would be difficult to be removed even by Ultrasonic rinsing.

Thus, we have visually confirmed where contaminations remain on the HPR and seen how difficult to remove them by Ultrasonic rinsing.

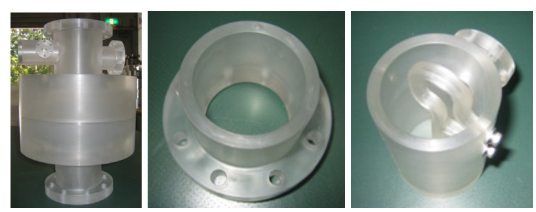


Fig.2: 1.3GHz demountable acryl model cavity.

Fig.3: Remained contamination in the input coupler port (left) and HOM coupler (right) after a regular HPR (6MPa, 15min) with SRF single cell cavity at WG5-KEK.

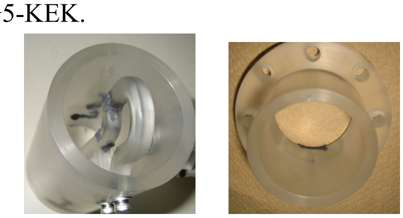


Fig.4: Ultrasonic rinsing after HPR.

INVESTIGATION OF NEW POST EP CLEANING METHODS

We have investigated several new methods in order to improve the cleaning.

*Optimization of HPR parameters*First, our regular HPR parameter was more optimized; especially the up/down speed of the cavity was investigated. Our HPR nozzle has totally 8 holes: 4 horizontally and 2 upper 45^{O} and 2 down 45^{O}. As shown in Fig.5 (4 photos from the left), the speed was changed from 22mm/min. (regular) to 2mm/min.at the fixed rotation speed of 11rpm. Input port was much cleaned at the slowest speed because the horizontal jet can stay much longer in the input port. The right photo in the Fig.5 shows the rinsing situation in the HOM coupler at up/down speed of 2mm/min. Still contaminations remain on the HOM antenna.

Magasonic rinsing with water

22mm/min 11mm/min. 5.5mm/min. 2mm/min. 2mm/min

Fig.5: Optimisation of the up/down speed of HPR.

The better HPR parameter cannot remove off the contamination in the HOM coupler. We investigated Megasonic rinsing. Again, the objects were sprayed MOLYKOTE and rinsed with water in a Megasonic bath at 950kHz, 600W for 30 minutes. Elimination of the contaminations was perfect for both in this case, however bubbles were created in the acryl bulk as seen in Fig.6 middle. The erosion might be an issue with Megasonic rinsing.

Ultrasonic rinsing with degreaser

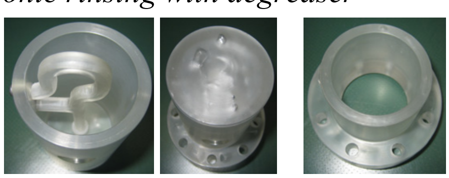


Fig.6: Megasonic rinsing (950kHz, 600W, 30min.) effect.

We tested Ultrasonic rinsing with degreaser instead of water for more mild rinsing method. As similar to the Megasonic rinsing experiment, the objects were rinsed in an Ultrasonic bath with 2% MICRO-90 degreaser for 20 minutes at 28kHz @ 600W. The result is shown in Fig.7. A remarkable rinsing effect was observed for both. No remained contamination was found on both. One has to consider that in the actual cavity post EP cleaning the Ultrasonic rinsing power might become small due to the longer distance from the oscillator.

Fig.7: Rinsing effect by Ultrasonic rinsing with degreaser.

Inner Ultrasonic rinsing

Inner Ultrasonic rinsing could be much effective and more reliable than Ultrasonic bath rinsing. To date, our available inner Ultrasonic equipment was on 56kHz and 200W as seen in Fig.9. We have tested it with 2% MICRO-90. The result is shown in Fig.8. The objects were sprayed MOLYKOTE and dried. The objects were Ultrasonic rinsed in a big Poly bucket with 2% MICRO-90 for 50 minutes. The rinsing effect was not enough for HOM coupler. Contaminations remained at the bottom of the HOM cylinder.

Fig.8: Experiment of the inner Ultrasonic. rinsing.

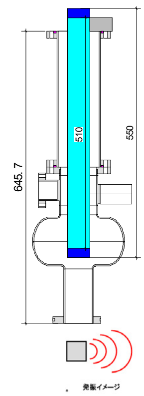


Fig.9: Inner Ultrasonic.

Horn Ultrasonic rinsing with degreaser

A maker of Ultrasonic suggested us to use their Horn Ultrasonic as shown in Fig.10. Difference from the inner Ultrasonic in Fig.9 is the direction of radiation. The radiation of the Horn Ultrasonic is axially symmetric. The available equipment was on 28kHz @ 500-1000W and duty factor 50-100%.

We have tested this with 2% MICRO-90 detergent as the same rinsing configuration in Fig.8. The results are seen in Fig 11. After 10min. rinsing at 1kW, 100% the objects were once taken out from the bucket and water rinsed. The rinsing situations are shown in the left two photos in Fig 11. Contamination was removed off in the input coupler but still not yet in the HOM coupler.

We took additional 5min. Horn Ultrasonic rinsing. The result is the right photo in Fig.11. Contamination in the HOM coupler was also perfectly eliminated. Some part of this effect might be in contribution by the water rinsing on the way. Liquid agitation during the rinsing or water rinsing on the way might be an important effect to eliminate contaminations.

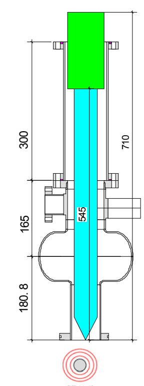
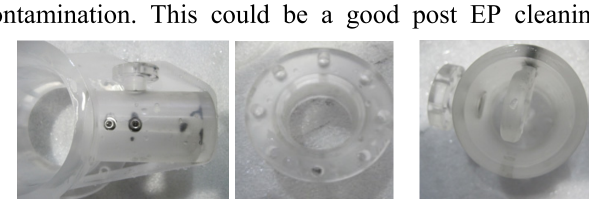


Fig.10: Horn Ultrasonic.

Steam Cleaning

To date, we can commercially buy steam cleaner with a low price, which is designed for floor cleaning or oily kitchen range cleaning. Steam can easily get into such a complicated structure. Steam cleaning would be effective to remove chemical residues, oily contamination or sulfur contamination. This could be a good post EP cleaning



Horn 10min. Horn 10 min. Horn totally 15 min

Fig.11: Effect of the Horn Ultrasonic rinsing.

method.

We have tested it with single cell cavity as shown in Fig.12. The visual effect was in shedding water. After the steam cleaning SRF surface is uniformly wet and does not shed water.

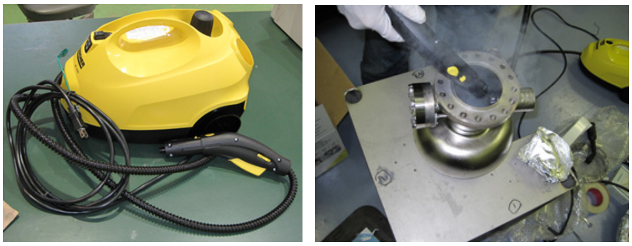


Fig.12: Steam cleaner (left) and Steam cleaning with a cavity (right).

RESULTS OF THE NEW POST EP CLEANING WITH SRF CAVITIES

Among the various cleaning methods tested above, steam cleaning is most easy. We have tested it first with single cell cavities. The detail will be reported in the reference [1] in this conference.

Steam Cleaning and regular HPR

A typical result is reported with ISE#7(Ichiro single end cell cavity) with the same shape in Fig.1 (right). The reference performance is shown in Fig.13 (blue squares). The performance was limited by 31.4MV/m by field emission. This cavity was left exposing air in the class 10 clean-room for longer than a half of year after the VT. After that, it was steam cleaning rinsed in the class 100 clean-room with DI water for 10 minutes and subsequently made HPR with the our regular condition. The result was excellent. Maximum gradient was improved to 47MV/m with Q-slope and the X-ray onset was also pushed up 32MV/m. We have several results on the steam cleaning. The trend is maximum gradient is improved in almost case and the X-ray onset is pushed up over 30MV/m or eliminated.

Steam cleaning and optimized HPR

Steam cleaning is promising but the gradient is still limited by the Q-slope. So we tested the combination of the steam cleaning and the optimized HPR rinsing condition, of which parameters are: 22rpm, 5mm/min at the end group area for 15 min. x 2 times and Top to Bottom on whole cavity at 22rpm, 11mm/min for 15min x 2 times. In these tests, cavities have no chemistry and only repeated rinsing by this new method. The result can be discussed with statistics. As seen in Fig.14, gradient and Qo were systematically pushed up.

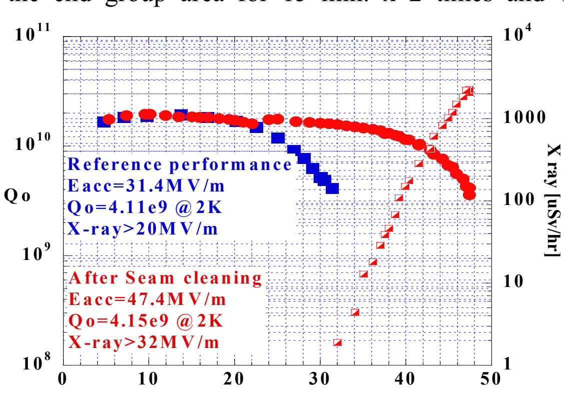


Fig.13: An example of Steam cleaning effect.

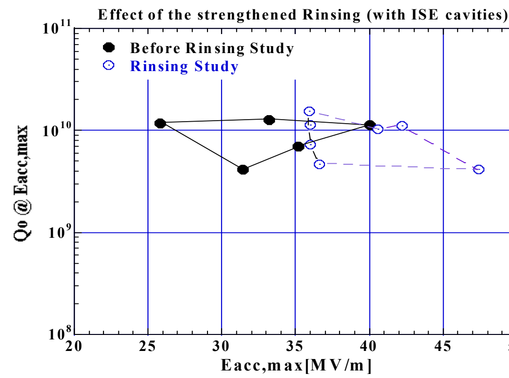


Fig.14: Effect of steam cleaning and optimised HPR.

Horn Ultrasonic rinsing

Horn ultrasonic is the under way now. At first we tested on 28kHz 1kW for 5 minutes however, field emission or Q-slope at the gradient lower than 30MV/m happened. We suspected the erosion by the Horn Ultrasonic rinsing. We took EP(20μm) and applied this rinsing as post EP rinsing at lower power level of 500W x 50% duty factor. The result is presented in Fig.15. In this case gradient was once pushed up to 43.5MV/m without serious Q-slope but cold leak happened at the highest gradient. It seems to be effective. We will take more data soon.

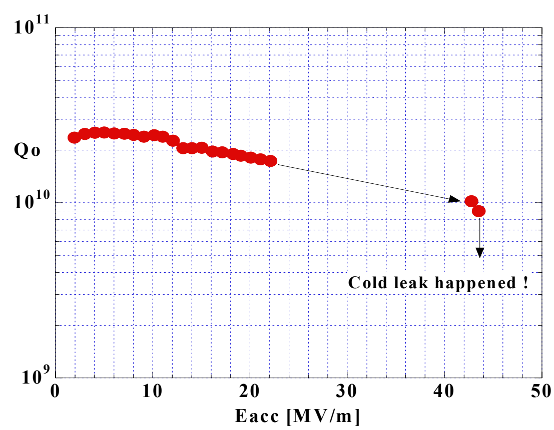


Fig.15: A suggesting the good effect on the Horn ultrasonic.

SUMMARY

We have investigated new rinsing method to solve the high field Q-slope in the ISE series cavities. The study is still under way. Steam cleaning and Horn Ultrasonic rinsing look very promising. We will take more data soon.

REFERENCES

[1] F.Furuta et al., in this conference. WEPE005.