VERTICAL ELECTRO-POLISHING OF NB SINGLE-CELL CAVITY USING CATHODE WITH VARIABLE-GEOMETRY WINGS AND ITS RESULTS OF VERTICAL TEST

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Abstract

Marui Galvanizing Co. Ltd. has been studying Vertical Electro-Polishing (VEP) on Nb single-cell superconducting accelerator cavity with the goal of mass-production and cost-reduction of Electro-Polishing (EP) process in collaboration with KEK and CEA saclay. And we invented our original cathode named "i-cathode Ninja"® which has four Al wing-shape parts for single-cell cavity VEP. We thought that these parts can realize uniform distributions of both electric current and EP solution flow at inner surface of cavity. Using this cathode, we performed various tests of VEP with Nb single-cell cavities. In this article, we will report results of VEP using "i-cathode Ninja"® and 1AC3 Nb single-cell cavity form CEA Saclay for vertical test.

INTRODUCTION

Electro-polishing (EP) has been used for the final surface treatment to improve acceleration gradient of Superconducting Radio-Frequency (SRF) cavity. So far, horizontal electro-polishing (HEP) have been adopted mainly for cavity EP [1-2]. In addition to this, vertical electro-polishing (VEP) is studied actively [3-4]. Marui Galvanizing Co. Ltd., decided to focus on the VEP because of the benefit for mass production (for example space-saving, no cavity rotation), and we started the study on the VEP process in the collaboration with KEK and CEA Saclay. For cavity EP, we thought that uniform anode-cathode distance and diffusion of flesh electrolyte in the whole cavity are most important factor. To realize these, we invented the VEP using cathode with variable-geometry wings named "i-cathode Ninja"®. [5]. Once, we have performed the 1st-3rd VEP of single-cell cavity using this cathode and reported these results [5]. Now, coupon cavity VEP has been performed for parameter investigation and surface analysis [6]. And 9-cell VEP setup preparation and VEP study have been performed [7]. In this article, we report the results of VEP using "i-cathode Ninja"® and 1AC3 single-cell cavity from CEA Saclay for vertical test.

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I-CATHODE "NINJA" ®

The schematic view of the "i-cathode Ninja"® which we invented is shown in Fig.1.

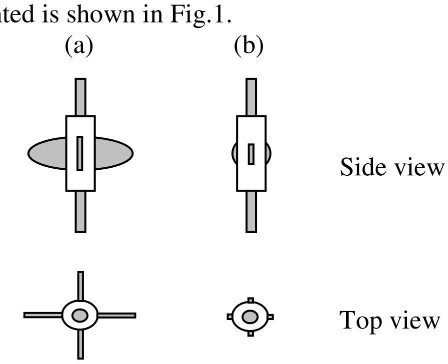

Figure 1: Schematic view of "i-cathode Ninja"®. (a) unfolded status. (b) retracted/folded status.

The most important feature is that it has four wing-like shaped aluminum cathodes at the center of cavity cell. Compared with rod type cathode,

(1) The wings agitate electrolyte in the cell of cavity and flesh electrolyte goes around the equator.
(2) The wings make the distance between the cathode and the equator shorter in the cell and realize the uniform distance distribution between cathode and anode.

There are two benefits to use "i-cathode Ninja"®. Then this cathode has a retractable structure of flexible wings and can be folded and unfolded by simple action.

1ST 1AC3 SINGLE-CELL CAVITY VEP

Fig.2 shows pictures of VEP setup and single-cell cavity of this experiment.

Figure 2: (Left) Picture of single-cell VEP system. (Right) Picture of single-cell cavity.

The setup is basically the same as previous single-cell cavity VEP [5], following points are modified.

(A) Temperature measurement points were increased to get temperature distribution in detail.

(B) To improve temperature distribution, cavity was air-cooled using two ducts which have some holes and spot cooler.

(C) Continuous voltage was supplied and OFF time was removed

The "i-cathode Ninja"® was used for this VEP. The VEP conditions are shown at Table 1, and Fig.3 shows the bubbles at upper side during VEP.

Table 1: Conditions of this VEP Experiment

Items	Conditions
Electrolyte composition	H_2SO_4(98%):HF(55%) =9:1(V/V)(Flesh)
Electrolyte flow direction	Bottom to top
Electrolyte flow rate	5 L/min
Cathode rotation speed	1 rpm
Voltage	5-6 V
Target current density	20-30 mA/cm^2
EP time	150 min
Target cavity temperature	Around 25 °C

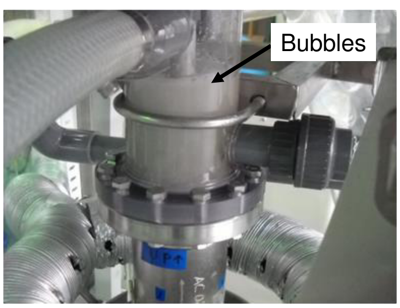

Figure 3: Picture of bubbles at upper side during VEP.

Fig.4 shows the logged data of temperature, current density, voltage during VEP. The cavity temperature was successfully reduced under 25°C and uniform on the whole. At the same time, the electrolyte temperature was kept around 25°C in water bath. The current density ranged around 25 mA/cm^2 and it could be controlled close to the target.

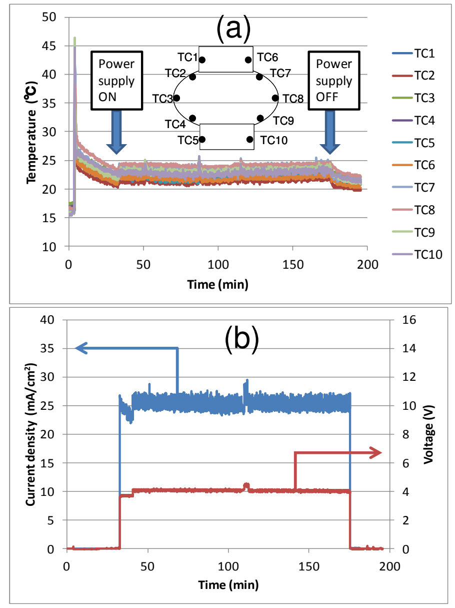

Figure 4: (a) Logged data of temperature of cavity. (b) Logged data of current density and voltage.

Fig.5 shows the images of inner surface of cavity before and after VEP observed with a digital camera.

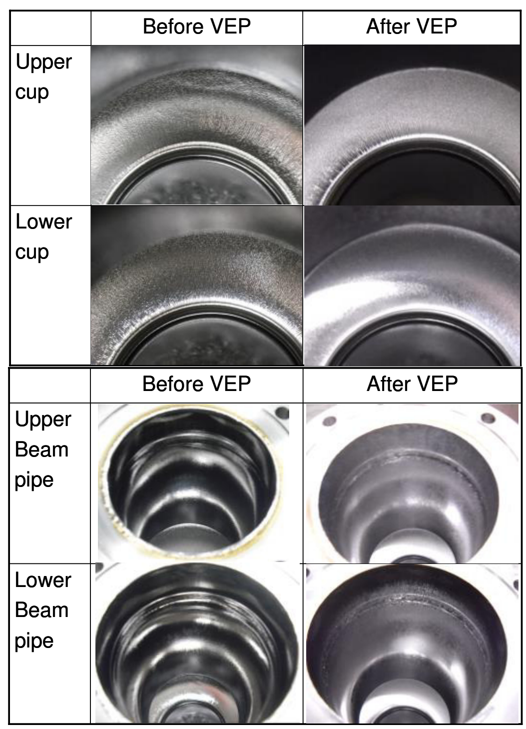

Figure 5: Images of inner surface of cavity (upper and lower cup, upper and lower beam pipe) before and after VEP observed with a digital camera.

At macroscopic surface, bubble trace lines were disappeared and surface roughness was improved, but metallic luster was reduced and crystal grain like pattern was able to be seen at microscopic surface. Fig.6 shows the images of inner surface of cavity before and after VEP observed with an endoscope.

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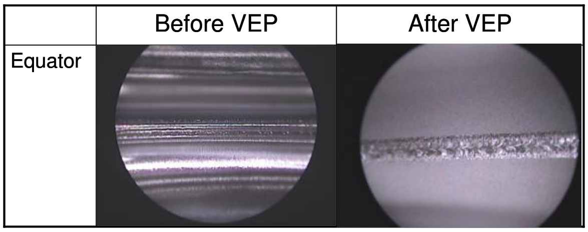

Figure 6: Images of inner surface of cavity (equator) before and after VEP observed with an endoscope.

The surface of beam pipe and equator welding area became rough and large crystal grain like pattern appeared. Fig.7 shows the removal thickness distribution after VEP. We use ultrasonic thickness gauge (GE sensing & inspection technology, CL-5). To determine the removal thickness, we measured the thickness three times per one point and took average before and after VEP.

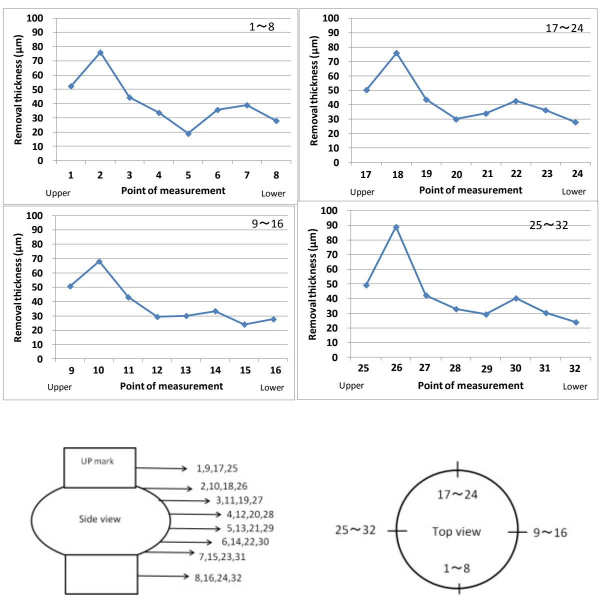

Figure 7: Removal thickness of the cavity measured at four lines.

On the whole, we can see that the removal thickness of upper iris is the largest. This is similar tendency as previous VEP [5]. Fig.8 shows the relationship between temperature and removal thickness. The temperature data is at 120 min after starting VEP. At horizontal direction, there was little difference both temperature and removal thickness. On the other hand, at vertical direction, there was large difference of removal thickness in spite of little difference of temperature. It is thought that the bubbles which appear during VEP hit on the surface of upper area directly and removal thickness become large by the effect of agitation [8].

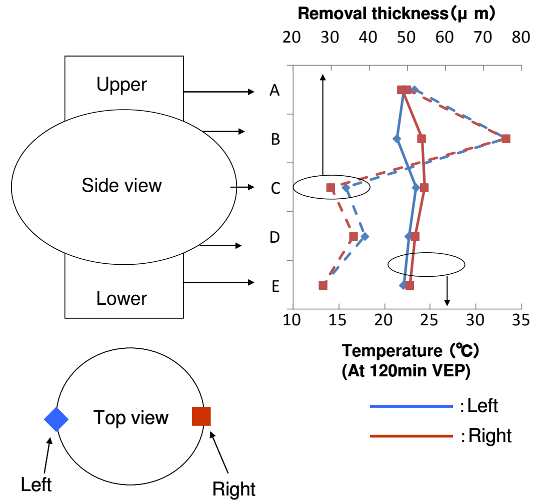

Figure 8: Relationship between temperature and removal thickness.

This time, the vertical test was planned after our VEP. But, the contamination problem of our VEP facility was found by coupon cavity VEP and surface analysis [6]. So now, the vertical test is suspended. After solving this problem, we will perform vertical test to evaluate accelerating gradient.

SUMMARY

We performed the VEP of 1AC3 single-cell cavity from CEA Saclay using "i-cathode Ninja"® for vertical test. At macroscopic surface, bubble trace lines were disappeared and surface roughness was improved, but metallic luster was reduced and crystal grain like pattern was able to be seen at microscopic surface. At vertical direction, there was large difference of removal thickness in spite of little difference of temperature. The vertical test is suspended because of contamination problem. After solving this problem, we will perform vertical test to evaluate accelerating gradient.

REFERENCES

[1] M.Rizzi et al., SRF2013, Paris, France 2013, MOP045
[2] R.L.Geng et al., SRF2011 Chicago, IL USA 2013, TUPO015
[3] F.Eozenou et al., SRF2013, Paris, France 2013, TUP046
[4] F.Furuta et al., SRF2013, Paris, France 2013, TUP049
[5] Y.Ida et al., SRF2013, Paris, France 2013, TUP052
[6] V.Chouhan et.al.,Proceedings of LINAC14,THPP098
[7] K.Nii et.al., Proceedings of LINAC14, MOPP108
[8] S.Kato et.al. TTC Meeting 2014, Desy,Hamburg, Germany