Development of new type “Ninja” cathode for Nb 9-cell cavity and experiment of vertical electro-polishing

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MOPLR039

Marui Galvanizing Co., Ltd. has been improving Vertical Electro-Polishing (VEP) technologies and facilities for Nb 9-cell superconducting accelerator cavities for International Linear Collider (ILC) in collaboration with KEK. This time, we developed new type Ninja cathode in order to improve VEP uniformity of Nb 9-cell cavity inner surface based on the results of 1-cell cavity VEP experiments. In this article, we will report construction of new type "Ninja" cathode for a Nb 9-cell cavity and the experiment of VEP using this.

Introduction

In the previous work, we have developed a 9-cell cavity VEP facility which includes:
- EP solution cooling system
- Cooling of outer surface of cavity with water spray

Using the above facility, cavity temperature during VEP could be controlled well at ~25 ° C.

Recently, we have developed a new type of Ninja cathode for VEP of 9-cell cavities to improve surface state and polishing uniformity. We have performed a VEP experiment for 9-cell coupon cavity using this Ninja cathode.

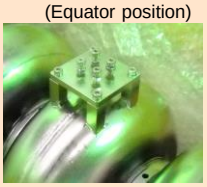
9-cell VEP facility

9-cell coupon cavity

9-cell coupon cavity

Coupon holders and view ports (Near iris position)

Coupon holder (Equator position)



In order to optimize VEP parameters, a 9-cell coupon cavity was fabricated (Ref S. Kato et al. MOPLR038).
- Nb coupons are set on equator positions of 1st, 5th and 9th cell.
- View ports with Nb coupons are set near irises of 1st, 5th and 9th cell.
- An EP current can be measured for individual coupon.
- Coupons are removed for surface analysis.

New Ninja cathode for 9-cell cavity VEP

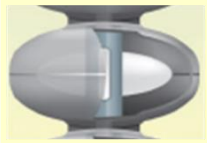
(1) Bubble diffusion prevention
- The Ninja cathode was covered with mesh sheet.
- Wings were made with insulating material.

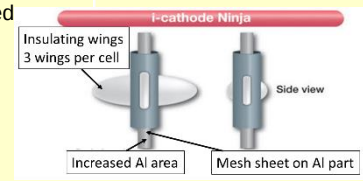
(2) To improve surface smoothness
- Cathode surface area was enhanced

(3) Easy fabrication and use in VEP
- The number of wings per cell was decreased from 4 to 3.

(1) and (2) have been optimized with a 1-cell Ninja cathode.
(Ref. V. Chouhan et al. MOPLR037)

Schematic view of Ninja cathode





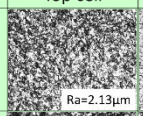
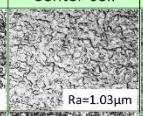
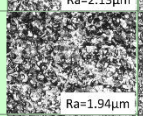
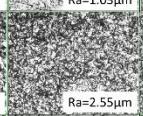
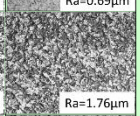
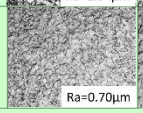
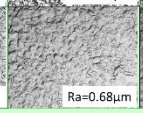
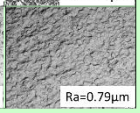
VEP experiment

VEP setup

View port observation

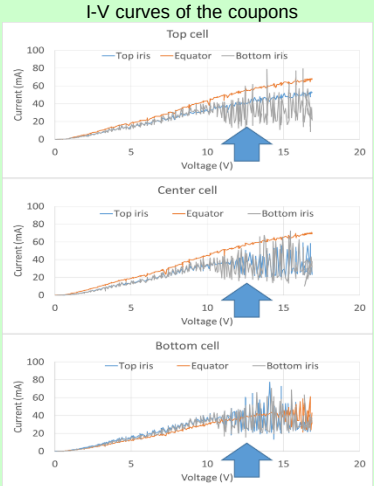
	Top iris	Bottom iris
Top cell		
Center cell		No photo
Bottom cell		

Microscope images and Ra values of the coupons

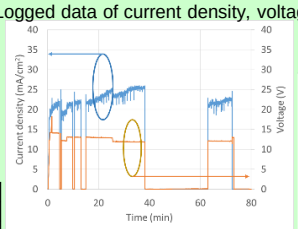
	Top cell	Center cell	Bottom cell
Top iris	 Ra=2.13μm	 Ra=1.03μm	 Ra=0.69μm
Equator	 Ra=1.94μm	 Ra=2.55μm	 Ra=1.76μm
Bottom iris	 Ra=0.70μm	 Ra=0.68μm	 Ra=0.79μm

200μm

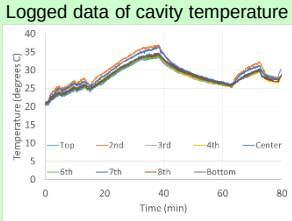
I-V curves of the coupons



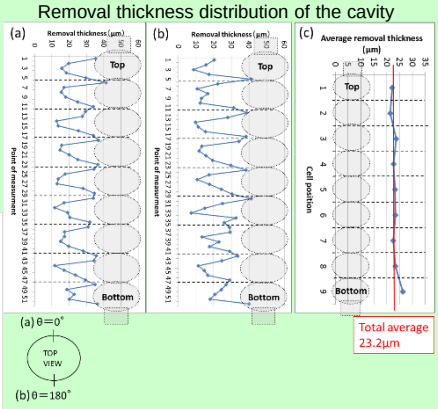
Logged data of current density, voltage



Logged data of cavity temperature



Removal thickness distribution of the cavity



VEP condition (Follow the 1-cell VEP best condition)

Parameter	Condition
EP solution(H_2SO_4:HF)	9:1 (used)
EP solution flow direction	Bottom to top
EP solution flow rate	5 - 10 L/min
Cathode rotation speed	50 rpm
Cathode	New Ninja
Voltage (target)	Around 13 V
Current density (target)	Around 30 mA/cm²
Cavity temperature (target)	20 – 25 ° C
EP duration	Around 50 min
Cooling method	Cavity water cooling + EP solution cooling
Chiller temperature	Around 15 ° C
Coolant flow rate	~8 L/min

Applied voltage of this VEP

From this VEP condition, good uniformity can’t be achieved. The main reasons may be,
(1) High cavity temperature during EP
(2) Not enough voltage for polishing region
(3) Bubble diffusion happen in the cavity
(4) Screening of the cathode surface due bubbles

As countermeasures of these point, we think
(1) Use higher power chiller
(2) Apply higher voltage
(3) Revise mesh sheet setting, bubble removal
(4) Pumping of bubbles should be improved

After improving these points, we will try 9-cell cavity VEP experiments again.

Summary

To obtain uniform polishing in VEP of a 9-cell cavity, a new type of Ninja cathode was developed. VEP of 9-cell coupon cavity was performed to understand problems appear in VEP.

A Smooth surface and uniform removal were not obtain with the VEP as performed only once. However, we obtain a lot of information to improve VEP conditions and our VEP facility.
After improving the facilities, VEP of the 9-cell coupon cavity will be performed again to optimize VEP conditions.