# Vertical electropolishing of niobium nine-cell cavity with a cavity flipping system for uniform removal

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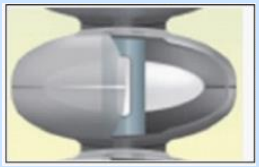
Marui Galvanizing Co., Ltd. has been developing vertical electropolishing (VEP) technology for single and nine-cell niobium superconducting radio frequency cavities using a unique cathode namely Ninja cathode in collaboration with KEK. The VEP process usually results in non-uniform removal with a large asymmetry along the cavity length. In order to suppress the asymmetry in removal, we are making different approaches. Flipping of the cavity during the VEP process is one of the approaches applied so far. A unique VEP setup, which allows the flipping of a multi-cell cavity, has been developed as reported earlier. Here, we report the improvement in the setup with automation for cavity flipping. VEP experiments were conducted with the improved system. VEP parameters were studied and the VEP results including the removal trend are discussed in detail.

## Introduction

In case of 9-cell cavity VEP, non-uniform removal of in-cell and inter-cell is major problem.

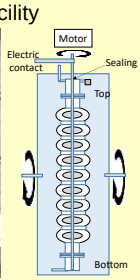
To solve this problem, we proposed two VEP methods.
(1) Separate (dual) flow VEP
(2) Cavity flipping VEP

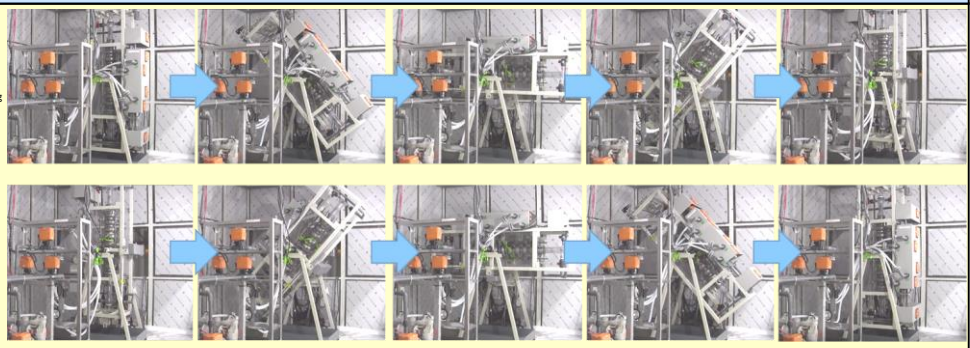
In this article, we show the results of cavity flipping VEP.
- Facility improvement
- VEP parameter
- Inner surface after VEP
- Removal trend



## Cavity flipping VEP

VEP facility

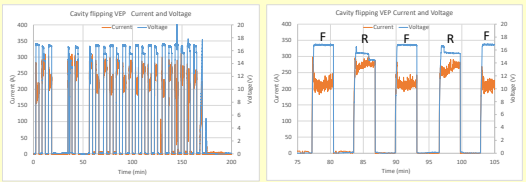


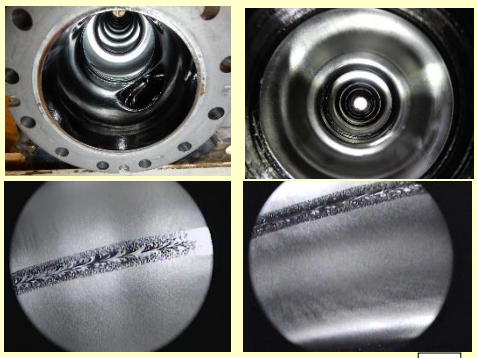
Automatic cavity flipping system (Upper : forward to reverse, lower : reverse to forward)

VEP condition

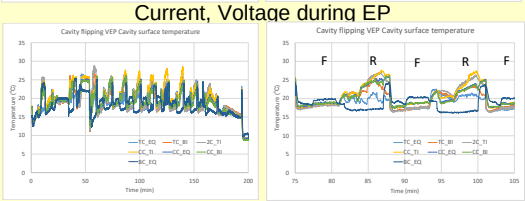
| Parameters | Cavity flip upside down VEP |
|---|---|
| Voltage | 17~18V |
| Current density | 20 – 30 mA/cm$^2$ |
| Cavity surface temperature | 20–25 ℃ |
| Cathode rotation speed | 20 rpm (both F and R) |
| Acid flow rate | ~5 L/min |
| EP time | 3min ON (F) – OFF, flipping – 3min ON (R) – OFF, flipping |
| Average removal thickness | ~30um |
| Cathode | Ninja-v6 (With metallic wings and mesh cover) |



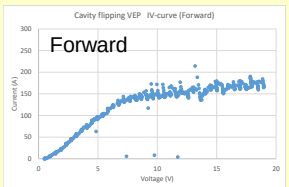

Current, Voltage during EP

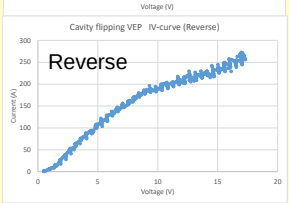


Inner surface after VEP

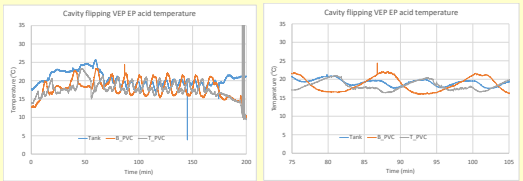



Cavity surface temperature during EP

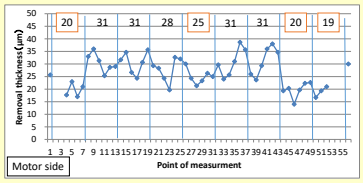


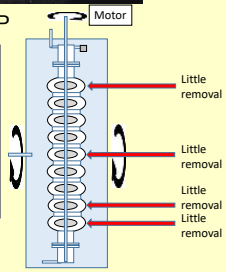

IV-curve




EP acid temperature during EP




Removal uniformity




## Experiment results

- The automatic cavity flipping system smooths the work and improves position reproducibility.
- IV-curve, current, cavity temperature were different between forward position and reverse position.

→There is a part that is asymmetrical in the forward position and the reverse position.

- Removal trend was relatively good, however the removal of 1$^{st}$, 5$^{th}$, 8$^{th}$ , 9$^{th}$ cell was smaller than other cells.

## Summary

- Cavity flipping VEP experiment was performed with improved VEP facility.

- Removal trend is relatively good.
- Current etc. is asymmetrical between forward and reverse.
- The removal of 1$^{st}$, 5$^{th}$, 8$^{th}$ , 9$^{th}$ cell was smaller

- Improve system symmetry
- VEP parameter optimization