MHI-MS'S PRODUCTION ACTIVITIES OF SUPERCONDUCTING CAVITY

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Abstract

Mitsubishi Heavy Industries Mechatronics Systems, Ltd. (MHI-MS), a subsidiary of MHI, took over MHI's accelerator business on October 1, 2015, and has been developing the business since that time. MHI-MS has developed manufacturing process of superconducting cavities continuously. In this presentation, recent progress will be reported.

INTRODUCTION

MHI-MS has supplied the superconducting RF cavities and the cryomodules for various electron accelerator projects, such as a STF and c-ERL project at KEK [1]. Moreover, MHI-MS is developing the superconducting low beta cavities and superconducting RF electron gun cavity. In addition, we installed the new facilities to perform surface preparation for SRF cavity in our factory. The trial run of these new facilities was performed in collaboration with KEK.

NEW FACILITIES FOR SURFACE PREPARATION OF SRF CAVITY

MHI-MS has installed the new facilities for surface preparation of SRF cavity such as Buffered Chemical Polish (BCP), Ultrasonic cleaning, High pressure rinse (HPR) and Class 10 clean room.

BCP

Schematic diagram of BCP facility is shown in Figure 1. Apparatus consists of acid tank with heat exchanger, water tank, water chiller, scrubber, acid pump, water pump and piping. Table 1 is specification of BCP facility.

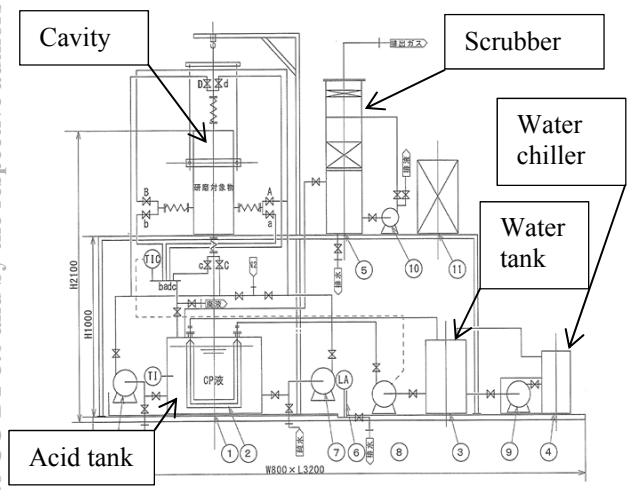

Figure 1: Schematic diagram of BCP facility.

Table 1: Specification of BCP Facility

Item	Value
Acid	Mixture of HF, HNO3 and H3PO4
Temperature control of acid	14-20deg.C
Acid flow	1-30L/min
Volume of cavity	100L
Rinsing	Pure water

Ultrasonic Bath

Superconducting RF cavity is cleaned after BCP process using this ultrasonic bath. Outline of ultrasonic bath is shown in Figure 2. And specification is in Table 2.

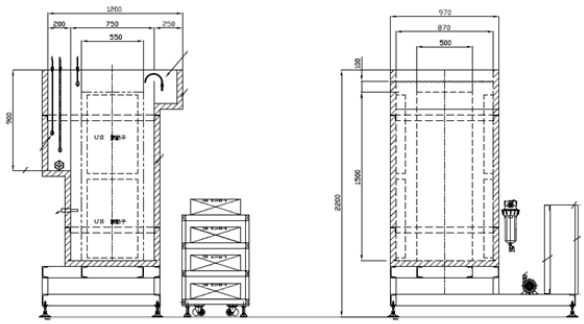

Figure 2: Outline of ultrasonic bath.

Table 2: Specification of Ultrasonic Bath

Item	Value
Material of tank	Stainless steel
Maximum size of object	L500 x W550 x H1500mm
Cleaning medium	Pure water + detergent
Ultrasonic	40kHz, max 8000W
Temperature	Max 50 deg.C
Circulation	Max. 40L/min
Rinsing	Pure water

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HPR

Superconducting RF cavity is high pressure rinsed with ultra-pure water. Outline and specification are shown in Figure 3 and Table 3. This facility has 4 axes movements.

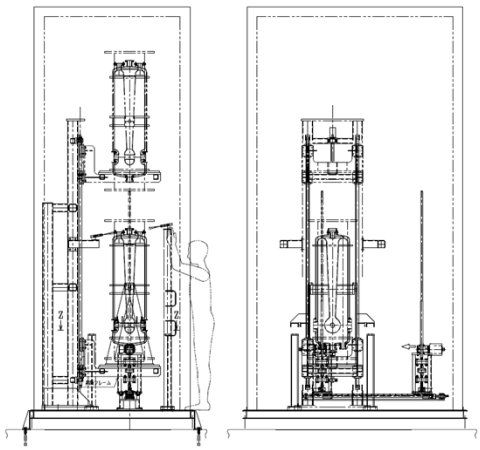

Figure 3: Outline of high pressure rinse facility.

Table 3: Specification of High Pressure Rinse Facility

Item	Value
Specific resistance of Ultra-pure water	> 18MOhm cm
Water Pressure	Max 10MPa
Water Flow	Max 10L/min
Movement	4 axes (Vertical movement of cavity, Cavity rotation around vertical axis, Rotation of cane, Horizontal movement of cane)

Clean Area

We have introduced KOACH by KOKEN Ltd. This advanced apparatus for clean room technology enables to keep clean area even if area is not covered by closed clean room. Coherent flow of filtered air, generated from apparatus, makes area clean enough to assemble superconducting RF cavity [2]. Figure 4 is the picture of clean area with KOACH. And Table 4 is specification of clean area.

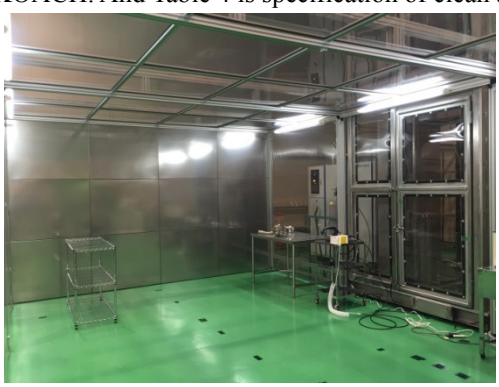

Figure 4: Clean area with KOACH by KOKEN Ltd.

Table 4: Specification of Clean Area

Item	Value
Cleanliness	Class 10
Type	Horizontal coherent flow from side wall
Location	Inside of Class 10000 clean room

A TRIAL RUN OF NEW FACILITIES

As a trial run of new facilities for surface preparation, we tried surface preparation and final assembly of 1.3GHz niobium single-cell elliptical cavity and measured RF performance in collaboration with KEK. The cavity surface was polished by electro polishing before trial run.

Heat Treatment

The cavity which was put in a Titanium box was put in a vacuum heat treatment furnace, as shown in Figure 5. The cavity had been heat-treated at 750 deg C for 3 hours.

Figure 5: Heat treatment setup.

BCP

The cavity was polished with the mixture of HF, HNO3 and H3PO4 which circulated. The polishing amount was 20μm. BCP setup is shown on the left side of Figure 6.

Ultrasonic Cleaning

The cavity was cleaned after BCP process using ultrasonic bath. A detergent was poured in the cavity. Pure water filled the ultrasonic bath. Ultrasonic cleaning setup is shown on the right side of Figure 6.

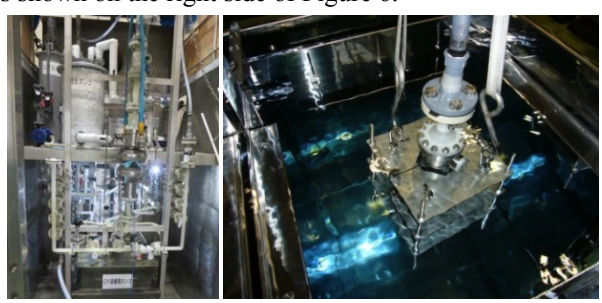

Figure 6: (left) BCP setup (right) Ultrasonic cleaning setup.

HPR

The cavity was high pressure rinsed with ultra-pure water. The cavity was dried by lightly baking. HPR and final

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assembly were performed in Class 10 clean room, as shown in Figure 7.

Figure 7: (left) HPR setup (right) Final assembly of the cavity.

Vertical Test

The RF performance of the cavity was measured in collaboration with KEK. V.T. result is shown in Figure 8. Q-value after surface preparation was good enough for SRF cavity.

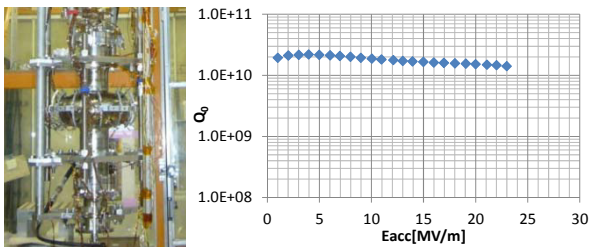

Figure 8: (left) V.T. setup (right) Q-E curve of the cavity that was made surface preparation

SUPERCONDUCTING RF ELECTRON GUN CAVITY

MHI-MS has developed SRF electron gun cavity in collaboration with KEK. Specification of the cavity is shown in Table 5. We manufactured first prototype cavity in 2014 [3], and manufactured choke structure in 2016. Choke structure was welded to the cavity recently, as shown in Figure 9. This cavity is under vertical test.

Table 5: Specification of SRF electron gun cavity

Item	Value
RF frequency	1.3GHz
Beam energy	2MeV
Average beam current	100mA
Initial beam diameter	2mm
Emittance	< 1mm mrad
Bunch length	10ps
Beam energy spread	< 2keV (<0.1%)

Figure 9: (upper left) First prototype cavity (upper right) Coke structure (bottom) Modification cavity.

CONCLUSION

Our recent activities about development of SRF accelerator are reported in this paper.

- MHI-MS has installed the new facilities for surface preparation of SRF cavity such as BCP, Ultrasonic cleaning, HPR and Class 10 clean room.
- As a trial run of these new facilities, we tried surface preparation and final assembly of 1.3GHz niobium single-cell elliptical cavity and measured RF performance in collaboration with KEK.
- A trial run of new facilities succeeded and we are ready to do all manufacturing process of SRF cavity before cooling RF test.
- We are developing SRF electron gun cavity in collaboration with KEK.

ACKNOWLEDGMENT

We acknowledge the support of SRF group in KEK for our usual activities of development of SRF accelerator.

REFERENCES

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