DEVELOPMENT OF SUPERCONDUCTING QWR AT MHI-MS

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Abstract

Mitsubishi Heavy Industries Mechatronics Systems, Ltd. (MHI-MS), a subsidiary company of MHI, took over MHI's accelerator business on October 1, 2015, and has been developing the business since that time.

MHI-MS is manufacturing the prototype super-conducting quarter-wave resonator (QWR) for RIKEN superconducting linac project. MHI-MS has dedicated surface treatment facilities for superconducting cavities, the prototype QWR will be treated using these facilities. 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] since 1977. Moreover, MHI-MS is developing a 73MHz prototype superconducting quarter-wavelength resonator (QWR) for superconducting linear ion accelerator project for RIKEN Nishina Center [2]. In addition, we installed new facilities to perform surface preparation for SRF cavity in our factory. A trial run of the new facilities was finished successfully [3]. A surface preparation of prototype QWR will be carried out using these facilities. The development of QWR is supported by RIKEN.

FABRICATION OF 73MHZ PROTOTYPE QWR FOR RIKEN

MHI-MS has developed some fabrication method for superconducting cavities, for example forming, burring and EBW during development of many superconducting cavities for electron accelerator. 73MHz prototype QWR is developed using these methods. The shape and structure of 73MHz QWR for RIKEN is shown in Fig.1.

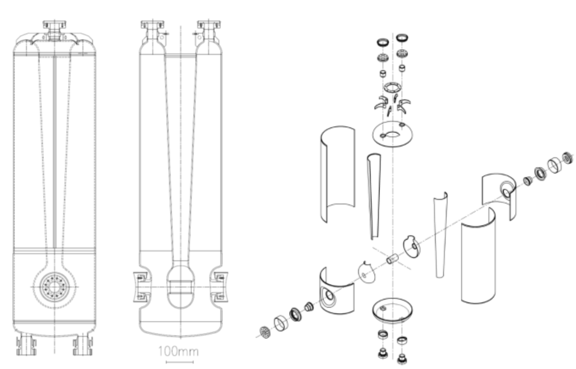

Figure 1: 73MHz prototype QWR for RIKEN.

Drift tube and Stem

Drift tube and stem are composed of two half parts made by forming from niobium sheet. Two half parts are assembled by EBW using special jigs. MHI-MS has the technique of making smooth welding bead and special jigs. Drift tube part is divided from stem part because of consideration of mass production. Drift tube, stem and sub-assy are shown in Fig. 2.

Figure 2: drift tube (top), stem (middle) and sub-assy (bottom).

Body

Body part (see Fig. 3) around beam port is dented. This part is made by forming. The forming jig was designed based on the forming simulation.

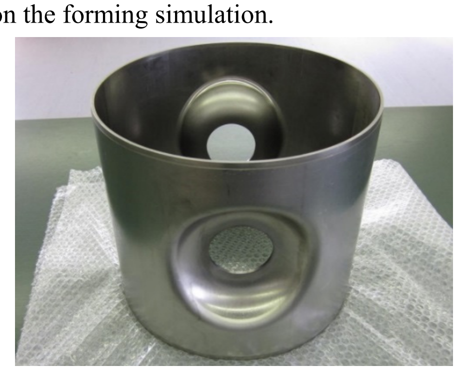

Figure 3: Body part.

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Top and Bottom

Top and Bottom parts are made by deep drawing method from niobium disk. (See Fig. 4) Forming of top part needs six or more steps. Nozzle part is made by burring because the shape of a connecting port part can became simple and the total cost can be reduced.

Figure 4: Top and bottom.

Assembly of QWR

After the sub-assembly by EBW, these parts will be temporarily assembled and resonance frequency of the QWR will be measured. Then the length of these parts will be adjusted by machining. The frequency measurement of QWR is shown in Fig 5.

Figure 5: Frequency measurement of QWR.

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. MHI-MS became able to carry out the surface preparation of superconducting cavity by adding the existent vacuum heat treatment furnace.

As a trial run of the 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. Q-value after surface preparation was good enough for SRF cavity, so the trial run of the new facilities succeeded.

BCP

Table 1 shows specifications of the BCP facility.

Table 1: Specifications of the BCP Facility

Item	Value
Acid	Mixture of HF, HNO_3 and H_3PO_4
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 the ultrasonic bath. Table 2 shows specifications of our Ultrasonic bath.

Table 2: Specifications of the 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

HPR

Superconducting RF cavity is high pressure rinsed with ultra-pure water. Outline and specification are shown in Fig. 6 and Table 3. This facility has 4 axes movements.

Figure 6: High pressure rinse facility.

Table 3: Specifications of the 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, and 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 [4][5]. Figure 7 is the picture of clean area with KOACH. Figures 8 and 9 are the picture of cryo-module assembly at this clean room. And Table 4 is specifications of the clean area.

Figure 7: Clean area with KOACH by KOKEN Ltd.

Figure 8: Heavy parts are brought into clean room using crane. Workers are wearing ISO7 clean ware.

Figure 9: Workers change their cloths and start the clean work.

Table 4: Specifications of the Clean Area

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

Heat treatment

MHI-MS has a vacuum heat treatment furnace. This furnace is enough to treat multiple QWR cavities in one batch. Figure 7 shows pictures of the furnace, and Table 5 shows specifications.

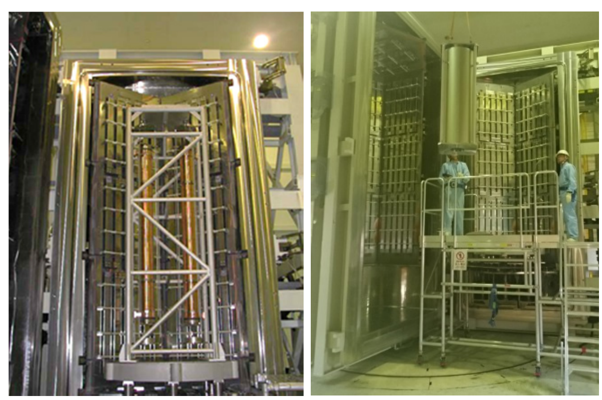

Figure 10: Heat treatment furnace.

Table 5: Specifications of the Heat Treatment Furnace

Item	Value
Temperature	Max 1200deg.C
Processing vacuum	$> 1\times10^{-4}$ Pa
Size	Φ1.3m × 3.5m

Surface preparation of prototype QWR

After fabrication, the surface preparation of the 73MHz prototype QWR for RIKEN will be done using these facilities in autumn 2017.

MASS PRODUCTION OF QWR

MHI-MS and RIKEN started to manufacture the mass production model of QWR for heavy ion accelerator project at RIKEN. The number of cavity is ten (10). Mass production model of QWR is based on the design and experience of prototype QWR.

CONCLUSION

Our recent activities about fabrication of the superconducting QWR are reported in this paper.

- MHI-MS and RIKEN are developing the prototype superconducting QWR for RIKEN superconducting linac project.
- Parts of QWR were fabricated using manufacturing method which is developed during development of many superconducting cavities.
- MHI-MS has installed the new facilities for surface preparation of SRF cavity such as BCP, Ultrasonic cleaning, HPR and Class 10 clean room.
- A trial run of the new facilities succeeded and the 73MHz prototype QWR will be treated using them.
- MHI-MS and RIKEN stared to manufacture the mass production model of QWR for RIKEN project.

ACKNOWLEDGMENT

We acknowledge the support of High-Gradient Cavity R&D team in RIKEN Nishina Center for the development of superconducting QWR.

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