PROGRESS ON RFQ FABRICATION FOR RISP ACCELERATOR *

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Abstract

The 81.25MHz Radio Frequency Quadrupole (RFQ), which was designed to accelerate various ion beams from the energy of 10 keV/u to 500 keV/u, is under development for the Rare Isotope Science Project (RISP). The 5 meter long RFQ consists of 9 sections and the total weight is roughly 16 tons. Each sections of RFQ has octagonal cross-section and 8 pieces were brazed. RFQ will align and install by using a laser tracker on a supporter system. In this paper, the fabrication status of the RISP RFQ and the scheme of installation were described in detail.

INTRODUCTION

A heavy ion accelerator facility is under way for various science programs [1]. The uniqueness of the RISP facility is that it is composed with In-flight Fragment (IF) and Isotope Separation On-Line (ISOL) facilities to provide various rare isotope beams for users as shown in Fig. 1. The injector system was designed to accelerate high intensity stable ion beams from uranium to proton and deliver beams to In-flight Fragment (IF) facility. It consists of 28 GHz ECR ion source, LEBT, RFQ, and MEBT. The RFQ fabrication is under way. The design and manufacturing procedure was confirmed by prototyping the last unit module. In this paper, the progress report of the RFQ is presented.

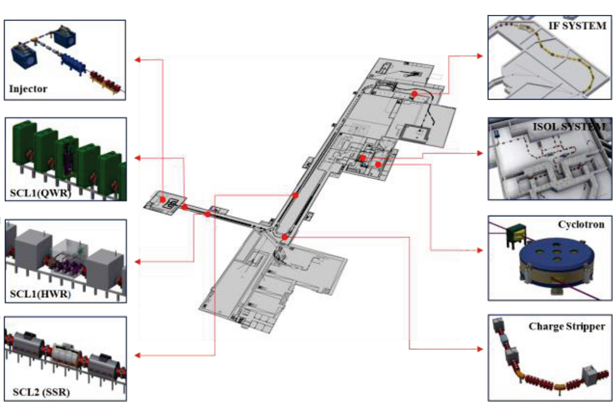

Figure 1: The layout of the RISP facilities.

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RFQ DESIGN

Table 1 shows design parameters for the RISP RFQ. The RFQ consists with nine modules and each one is separated to eight pieces. Figure 2 shows the cross sectional view. The RF resonator has an octagonal shape and the length is about 5 m.

Table 1: Parameters of the RISP RFQ

Parameters	Value
Frequency	81.25 MHz
Input Energy	10 keV/u
Output Energy	0.507 MeV/u
Duty Factor	100 %
Transmission	~ 98%
Peak Surface Field	1.7 Kilpatrick

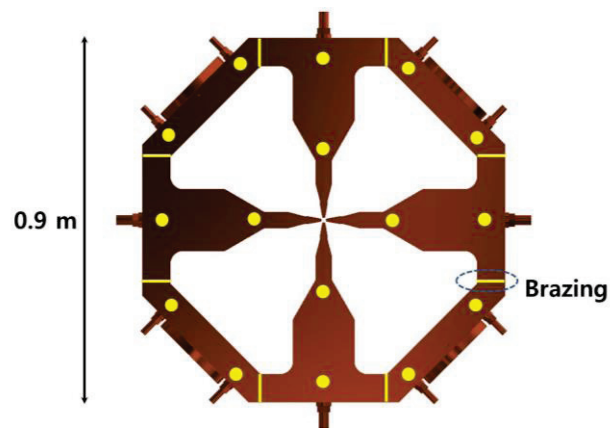

Figure 2: Cross sectional view of the cavity.

Three dimensional effects were calculated by using the code CST Microwave Studio. Especially the design of undercuts, the vacuum grids, and dipole stabilizer rods were performed. The RISP RFQ was designed to have a ramped field to reduce the cavity length [2-3]. So, the depth of undercut for high energy and low energy part were determined as 90 mm for the low energy end and 149 mm for high energy end through the simulation.

The frequency is tuned by the temperature of the cooling water during the operation. The cooling water is supplied by the resonance control cooling system which can control the temperature with +/- 0.1℃. RISP RFQ has twenty slug tuners for the static tuning, ten RF pickups, twelve vacuum ports, and two coupler ports. The diameter of tuners war 154 mm and movable tuners are designed to have operational flexibility.

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FABRICATION

The schedule for RFQ fabrication was planned to finish within 16 months. Due to the tight schedule, three machine shops were operated simultaneously during the RFQ segments machining. Consequently, all of cavities have been fabricated during 14 months.

The cavity is longitudinally separated by nine unit modules. The vacuum will be sealed by the viton O-rings at the connection of each unit modules. The unit module consists of four vanes and quadrants as shown in Fig. 2. The flanges for vacuum ports, pickups, tuners, and power couplers are located on the quadrants. The vanes and quadrants are jointed by the brazing. The fabrication procedure is listed as follows:

- Rough machining for vanes and quadrants.
- Drilling the coolant passage holes.
- Brazing the coolant passage plugs and various flanges (Annealing effect)
- Fine machining
- 1st assembling
- Machining for module flanges
- 2nd assembling and brazing
- Final machining

Machining

High-purity oxygen-free copper with hot isostatic pressing was used for vanes, quadrants, and flanges. At the first step, vanes and quadrants were roughly machined to have 2 mm residual dimensions of the final shape. The coolant passage was machined by using a gun-drill machine. The vane modulation was machined by using ball-end mills which was numerically controlled in the fine machining step. The distance from the beamline and the transverse radius of curvature were measured at each modulation by using a Coordinate Measurement Machine (CMM). The tolerance was less than ± 30 microns for all of peak and valley. At the fine machining step, the length of vanes and quadrants was left 5 mm on each end than the final dimensions considering the brazing of flanges and an assembled unit module. The cavity was machined to the final length after the final brazing.

Braze

There are three steps of brazing for the cavity. For plugging of coolant passages, BNi-2 alloy was used which melting temperature is 1010 ℃. Gold-copper alloy was used to braze various stainless steel flanges. The final brazing was accomplished by using BAg-8 which is an alloy of copper and silver. The liquidus temperatures of the gold-copper alloy and the BAg-8 are 970 ℃ and 780 ℃ respectively.

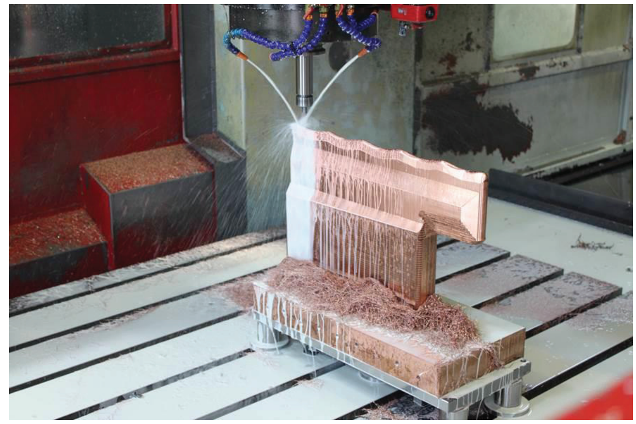

Figure 3: Modulation machining with the ball-end mill.

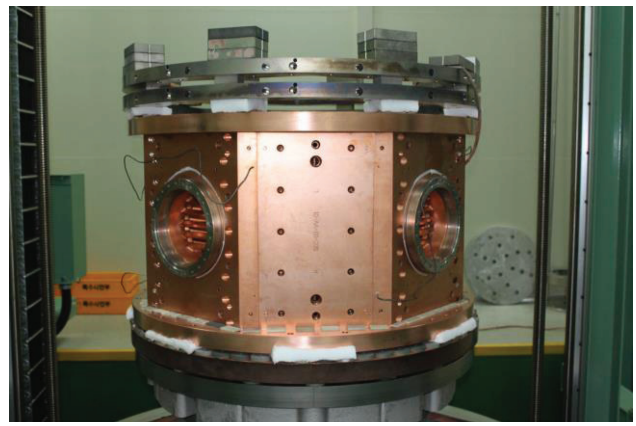

Figure 4: RFQ unit module just before the brazing.

Assembling and Alignment

After fine machining, eight segments was assembled and aligned by using adjustment plates. During the alignment of segments, the gaps between the modulations were monitored by using pin gauges as shown in Fig. 4. And the final results were measured by using the CMM. The tolerance of gaps between vanes is less than ± 50 microns after the final brazing.

Figure 5: Alignment of segments by using pin gauges.

Nine unit modules of RISP RFQ were finally fabricated as shown in Fig. 6.

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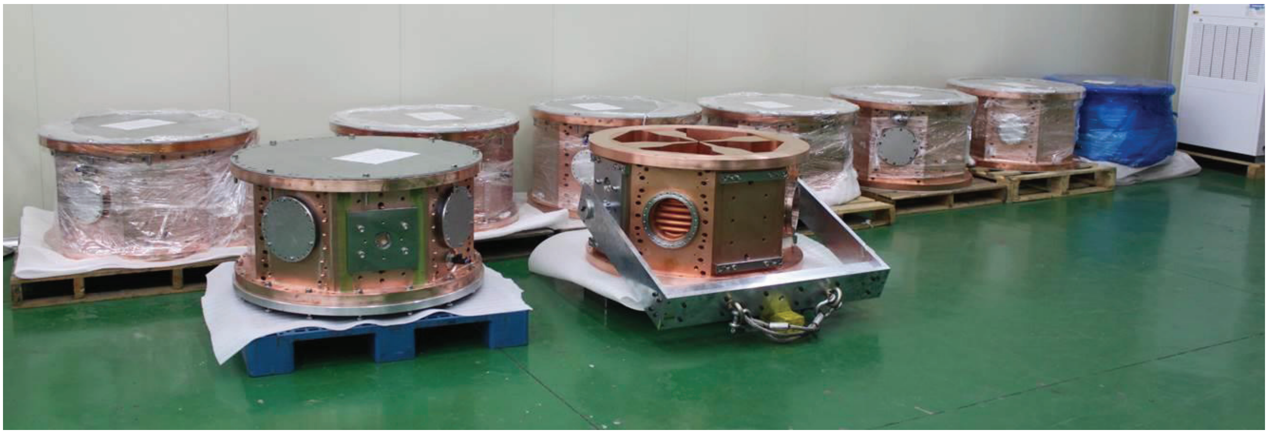

Figure 6: Fabricated nine unit modules of RISP RFQ.

INSTALLATION

Nine unit modules of RISP RFQ will be installed and assembled on the girder type support system as shown in Fig. 7. Each module will be assembled one by one by using a laser tracker and the vacuum test will be done after assembling a module respectively. The procedure of assemble and alignment is as follows;

- Install the RFQ support by using the laser tracker
- Fiducialize the module
- Assemble and check the vacuum tightness

The alignment of module connections will be guided with two pins of each plane and the position of modules will be monitored by using the laser tracker system.

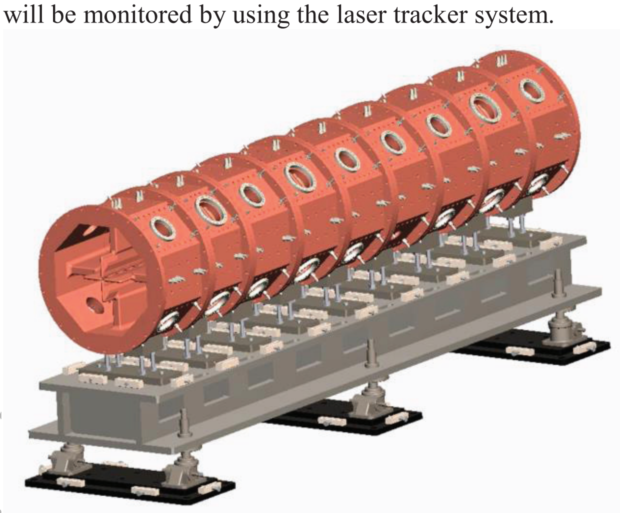

Figure 7: RFQ support system.

CONCLUSIONS

All of RFQ cavities have been fabricated which are consisted with nine unit modules. After the connection of unit cavities and the RF tuning, the high-power test will be performed at the end of 2016.

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