

Fabrication Status of 3-MeV RFQ Cavity for KOMAC Accelerator

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1. Introduction

Since its commissioning in 2013, the 100-MeV proton linear accelerator (linac) at the Korea Multi-purpose Accelerator Complex (KOMAC) has been providing user beam services for a wide range of applications. With over 11 years of continuous operation and more than 35,000 accumulated beam hours, the accelerator has reached a stage where long-term strategies for aging management are required. The radio-frequency quadrupole (RFQ), which has served as the injector since its initial commissioning in 2004, has shown gradual performance degradation. Endoscopic inspection of the vane surfaces revealed extensive arcing spots and surface erosion, strongly suggesting that the deterioration originates from accumulated surface damage (Fig. 1). In response, a new RFQ has been designed to replace the existing structure, incorporating several design modifications aimed at enhancing both reliability and beam transmission efficiency.

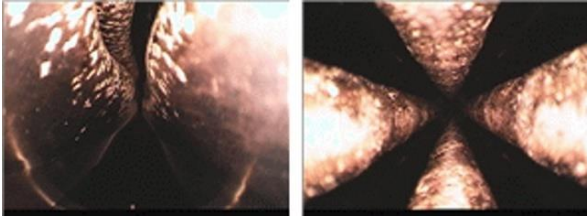


Fig. 1. Damaged RFQ vanes.

2. Design Highlights of New RFQ

In the new design, the resonant coupling structure previously located at the RFQ midsection was eliminated to simplify the mechanical configuration and facilitate field tuning. The overall length was increased from 3,266 mm to 3,537 mm to improve high-current transmission performance. A major design modification was made in the gentle buncher section, where the output energy was extended from 550 keV to 580 keV while maintaining the same input energy of 86.5 keV. Simulation studies demonstrated that this adjustment significantly improves beam transmission, especially under high-current operation, while maintaining tolerance to various error sources. Additionally, the focusing strength was carefully optimized to ensure smooth phase advance matching between the RFQ exit and the entrance of the downstream drift tube linac (DTL) [1].

Table 1: Design parameters of the new RFQ

Parameter	Value
Input beam energy	50 keV
Output beam energy	3 MeV
Operating frequency	350 MHz
Transverse emittance	0.2 π . mm. mrad
Longitudinal emittance	0.107 deg.MeV
RFQ type	4 - vane
Vane voltage	85 kV
ρ/r_0	0.87
Length	353 cm

Expanding the energy range of the gentle buncher necessitated changes to the total length and geometry of the RFQ. Figure 2 compares the old and new RFQs in terms of the modulation parameter (m) and the minimum aperture (a).

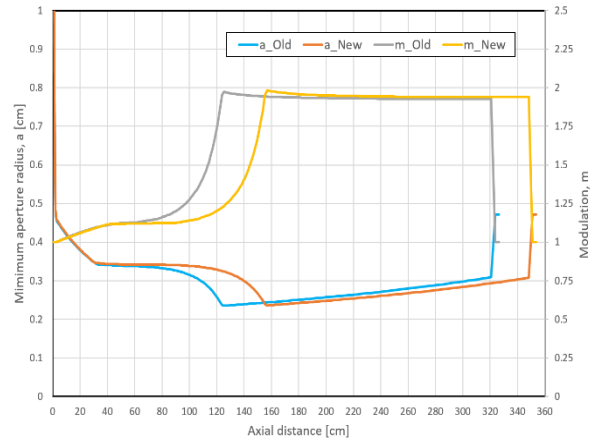


Fig. 2. Comparison between old and new RFQs in terms of modulation and minimum aperture.

3. Fabrication Status

Fabrication of the new RFQ is currently in progress. Major and minor vanes have undergone rough machining and drilling of the cooling channels. To ensure mechanical stability and sealing of the channels, plug brazing was performed using a gold-copper alloy (AuCu, 5:5), which also served as an annealing step to relieve residual stress generated during machining. This

process minimizes deformation in subsequent assembly brazing. Final machining and dimensional verification using a 3D scanner are underway, after which the vanes will be assembled through precision brazing.

Figure 3 shows the 3D CAD model of the new RFQ, including auxiliary system interfaces such as vacuum pumping ports, cooling pipes, and a granite-based supporting structure. Figure 4 shows the vacuum leak check after plug brazing. One of minor vane under final machining and one of major vane after final machining are shown in Fig. 5 and Fig. 6, respectively. Subsequent steps include resonant frequency adjustment, field tuning, and full-power RF testing, which are scheduled for completion within the year.

The development of this upgraded RFQ is expected to restore and improve the injector performance of the 100-MeV linac, ensuring stable long-term operation of the facility. The design and fabrication strategies reported here may also provide useful references for future RFQ upgrades in other accelerator facilities facing similar aging issues.

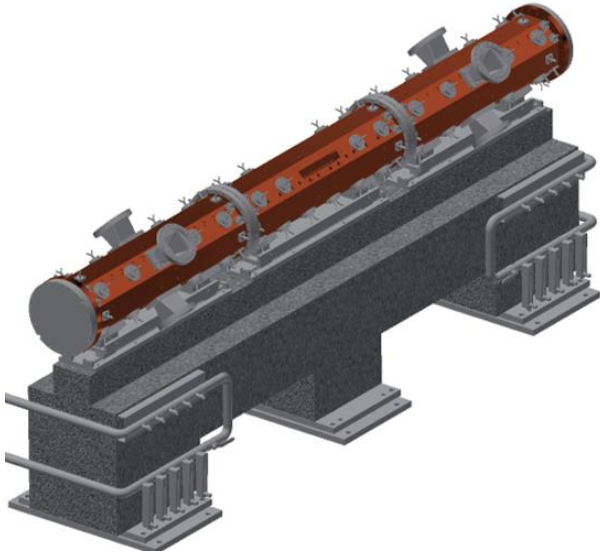


Fig. 3. 3D CAD model of the designed new RFQ.



Fig. 4. Vacuum leak check after plug brazing.



Fig. 5. RFQ minor vane under final machining.

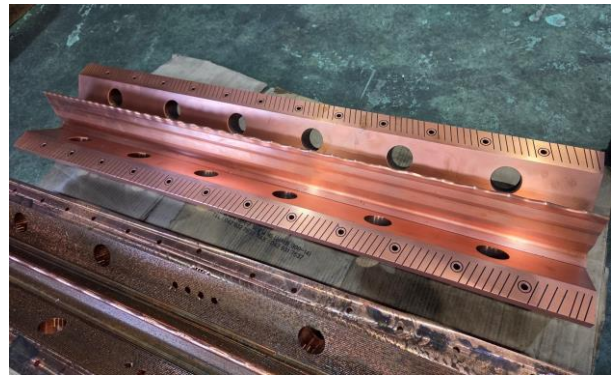


Fig. 6. Major vane after final machining.

ACKNOWLEDGMENTS

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REFERENCE

- [1] H. S. Kim, S. H. Moon, D. H. Kim, S. H. Lee, H. J. Kwon, New 3-MeV RFQ Design and Fabrication for KOMAC, LINAC2024 proceedings.