Design and Fabrication of the KOMAC RFQ

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Abstract

A RFQ linac (3MeV, 350MHz, 20mA, CW and 324cm in length) is being built for the Korea Multipurpose Accelerator Complex (KOMAC). The physical and engineering design of the H^+/H^- RFQ linac are described. The fabrication process for the cold model and structure support is described. The current status of the RFQ is reported.

1 INTRODUCTION

The Radio-Frequency Quadrupole (RFQ) linac, which will produce a 20mA beam of H^+/H^- with the energy of 3MeV, was proposed for the Korea Multipurpose Accelerator Complex (KOMAC) [1-4]. This paper presents the physics and engineering design plus the fabrication status of the KOMAC RFQ. The RFQ concept is shown in Fig. 1 with the parameter values given in Table 1.

The main focuses of this physics and engineering design in the RFQ are as follows:

- To understand the transmission of the mixing H^+/H^- beam into the RFQ.
- To obtain the tuning frequency by undercutting the end regions of the vane.
- To determine the locations and shapes of the coolant passages.
- To determine the shape of the brazing surface.

The physics and engineering design study is presented in section 2. Section 3 describes the fabrication status of the KOMAC RFQ.

Table 1. RFQ Linac Parameters.

PARAMETER	VALUE
Operating frequency	350 MHz
Particles	H^+ / H^-
Input / Output Current	21 / 20 mA
Input / Output Energy	0.05 / 3.0 MeV
Input / Output Emittance, Transverse/norm.	0.02 /0.023 π-cm-mrad rms
Output Emittance, Longitudinal	0.246 MeV-deg
Transmission	95 %
RFQ Structure Type	4-vanes
Duty Factor	100 %
Peak Surface Field	1.8 Kilpatrick
Structure Power	350.0 kW
Beam Power	67.9 kW
Total Power	417.9 kw
Length	324.0 cm

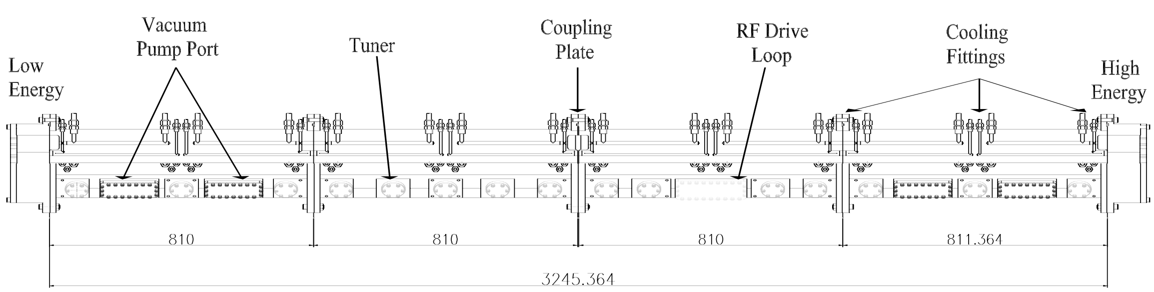

Figure 1. 3MeV, cw KOMAC RFQ Drawing.

0-7803-5573-3/99/$10.00@1999 IEEE.

2 PHYSICS AND ENGINEERING DESIGN

The motion of the mixing H^+/H^- beam into the RFQ has beeb studied by using a time marching beam dynamics code QLASSI [5]. Fig. 2 shows the dependence of the beam transmission rate and the H^- mixing ratio. The longitudinal beam loss increases with the concentration of negative ions by the bunching process which is distributed by attractive forces. Because of the space charge compensation in the low energy sections, the transverse beam loss decreases with the mixing ratio of H^-. In the KOMAC RFQ, the mixing ratio of H^- is less than 10%.

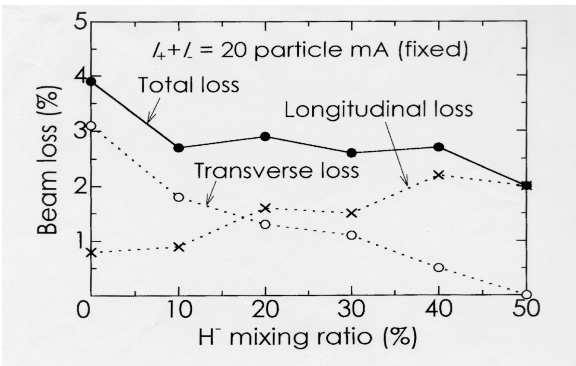

Figure 2. Dependence of Beam Transmission Rate and H^- Mixing Ratio.

In general, most of the RFQ structure can be understood in a two-dimension model. However, the end regions and the joints need full three-dimensional modelling. These regions have been investigated with the three-dimensional electromagnetic code, MAFIA [6]. Fig. 3 shows a three-dimensional simulation model of the end region of the RFQ. The end-gap distance and undercutting depth were varied until the quadrupole mode frequency of the model was tuned to 350.3MHz. In this case, the end-gap distance and undercutting depth are 7.5cm and 2.7cm, respectively. Fig. 4 shows the

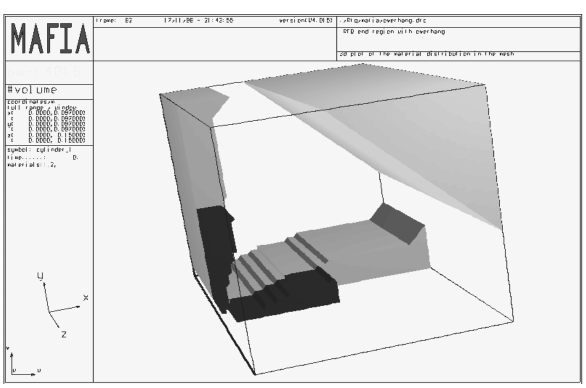

Figure 3. 3D Simulation Model of the End Region.

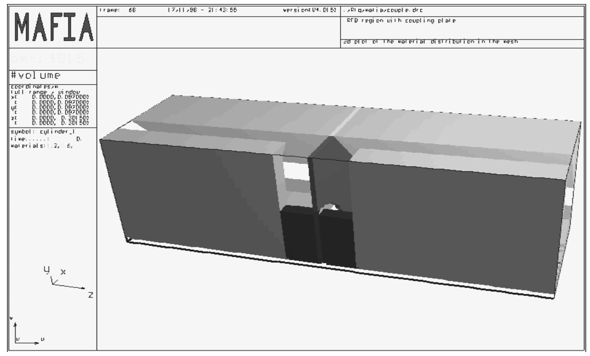

Figure 4. 3D Simulation Model of a Two-Section Coupled RFQ

MAFIA model of a two-section coupled RFQ. The simulation result has shown that a 0.205cm coupling gap-distance, a 2.5cm undercutting depth and 5.2cm coupling plates inner radius results in a near optimum separation between the quadrupole modes. Results simulated by the MAFIA models will be tested on a cold model which has been fabricated with Al6063.

In the design of the coolant passages, we considered the thermal behaviour of the vane during CW operation and manufacturing costs. The thermal and structure analysis is studied with SUPERFISH [7] and ANSYS codes. The average structure power by rf thermal loads is 0.35 MW and the peak surface heat flux on the cavity wall is 0.13 MW/m^2 at the high energy end. In order to remove this heat, we consider 48 longitudinal coolant passages in each of the sections, as shown in Figs. 1 and 5. Fig. 5 shows a thermal distribution of the cavity at the high energy end. The material is oxygen-free high-conductivity copper (OFHC). The thermal loads were given by SUPERFISH analysis. The heat transfer coefficients are between 11kW/m^2-C to 15 kW/m^2-C.

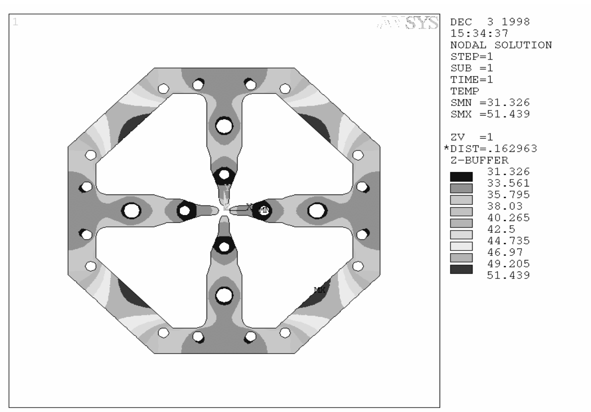

Figure 5. Temperature Distribution of the Cavity at the High Energy End of the KOMAC RFQ.

Because of the flow erosion of the coolant passages, we consider the maximum allowable bulk velocity of the coolant as 4.5m/sec. From the thermal-structural analysis of ANSYS, the peak temperature on the cavity wall is 51.4 °C, the maximum displacement is 42μm and the intensity stress .is 13MPa. We use the cooling tower on the cavity walls and the refrigeration system on the vane area. For rf tuning, the coolant passages on the vane area are operated with 10 °C coolant. However the temperature of the coolant of the passages on the cavity wall is varied to maintain the cavity on resonance frequency. The coolant passages in the cavity wall and vane area are the deep-hole drilled. The entrances of deep holes at the vane end are brazed.

3 FABRICATION STATUS

The RFQ cold model was fabricated with Al6063, as shown in Fig. 6, and the field test with the beadpull perturbation technique will begin next week. A bead is metal and is drawn through the four quadrants of the RFQ near the outer wall.

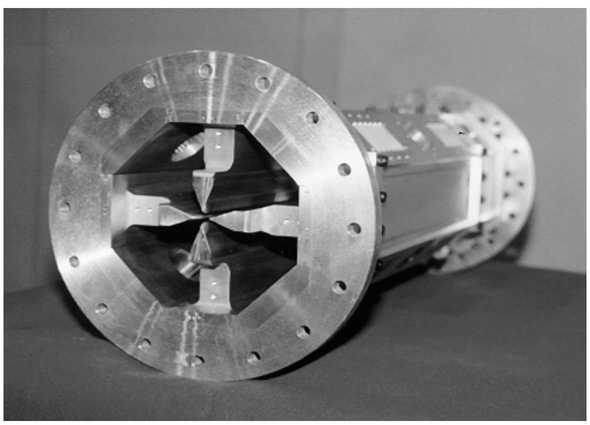

Figure 6. A Section of the KOMAC RFQ Cold Model.

The four quadrants of the RFQ are fabricated separately and brazed. Because of the leak of the brazing surface and the strain of the RFQ structure by furnace heat, it is important to determine the exact shape of brazing area[8]. Fig. 7 shows an 81cm long brazing test unit. The test unit was brazed in a vertical orientation with LUCAS Bag-8, a AgCu alloy with a liquids temperature of 780 °C.

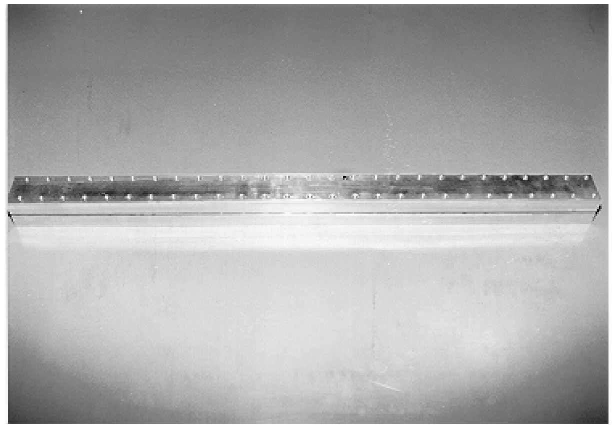

Figure 7. Brazing Test Unit.

At the present time, new brazing test unit is being brazed and one of the four sections is being fabricated.

4 ACKNOWLEDGMENT

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