A 350MHz CW RFQ LINAC FOR THE KOMAC/KTF

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Abstract

A 350MHz cw Radio-Frequency Quadrupole (RFQ) linac has been designed to accelerate 20mA proton beam from 50keV to 3MeV and a test 450keV RFQ has been fabricated to understand physical and engineering design, construction, cooling, control, rf system, and beam diagnostics techniques for a 3MeV, 350MHz, cw RFQ linac which is the major component for the Korea Multipurpose Accelerator Complex (KOMAC) Test Facility (KTF) project. Electricl test results and the current status are presented.

1 INTRODUCTION

The linear accelerator for the KOMAC Project [1-3] will include a 3 MeV RFQ linac. The KOMAC/KTF RFQ [4-6] concept is shown in Fig. 1 with the technical specifications given in table 1. RFQ is a 4-vane type and consists of 56 tuners, 16 vacuum ports, 1 coupling plate, 4 rf drive loops, 96 cooling passages, and 8 stabilizer rods. RFQ is constructed as an all-brazed OFHC structure, integrated from separate 81cm long sections. One section will be used for rf power feed via two 250kW or four 125kW coupling irises. When in operation, its active resonance control is mainly by modulation of cooling system.

The 450keV RFQ is a test stand for the development of the 3MeV, 350MHz, cw KTF RFQ linac. The physics, engineering design study, and the fabrication is presented in section 2. Section 3 describes a present status of the KTF RFQ.

Table 1. The KOMAC/KTF 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

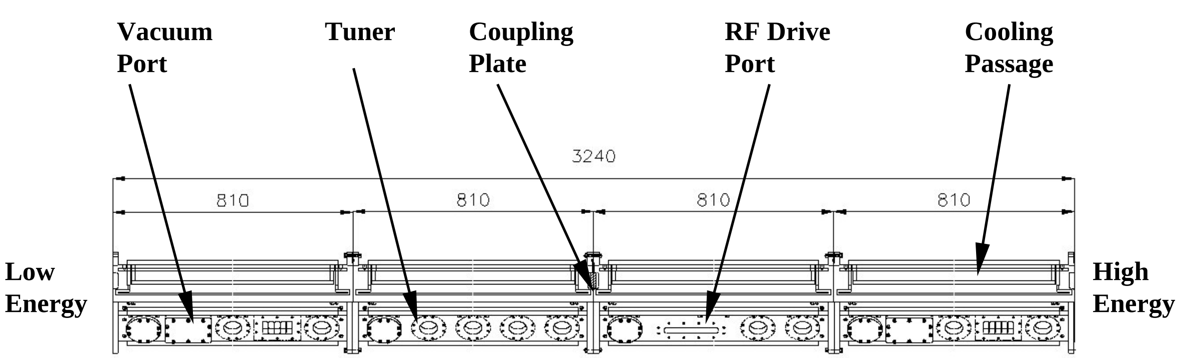

Figure 1. 3MeV, 350MHz, cw KOMAC/KTF RFQ

2 0.45MeV RFQ LINAC

2.1 Physics and Engineering Design

A test 450keV RFQ has been designed and fabricated to understand construction process, cooling, control, rf drive system, and beam diagnostics techniques. Figure 2 shows the various parameters defining the 0.45MeV RFQ design versus position. In this design, the peak electric field was limited to 1.8 times the Kilpatrick criterion [7]. These parameters were obtained by CURLI, RFQUICK, PARI, and PARMTEQM [8]. The curves labeled "V", "Phase", "B", "A", "r", " a", "m", "E_z" and "W" show the voltage difference adjacent vane-tips, synchronous phase, focusing strength, accelerating efficiency, average radius, aperture radius, modulation factor, average axial electric field and beam energy along the RFQ, respectively.

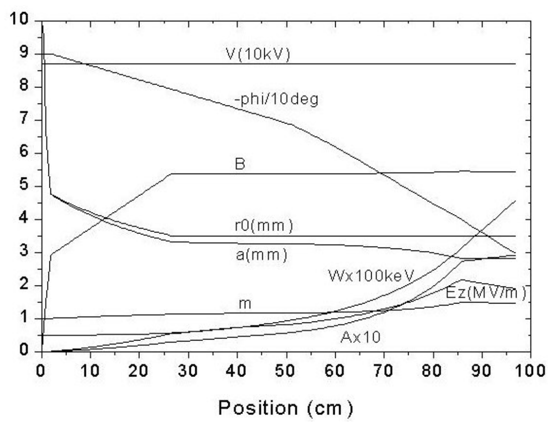

Figure 2. 0.45MeV Design Parameters.

To obtain the focusing required to match the beam from LEBT to the RFQ requires a weaker focusing and a larger aperture at the entrance of the RFQ. Another important factor in the RFQ design is to maintain a constant capacitance per unit length along the axis of the RFQ. In order to maintain a constant capacitance, the average radius from the vane tip to the axis of the RFQ is changed.

A problem in the design of the 3MeV KTF RFQ with cw operation result from the rf thermal loads on the cavity walls. In order to solve this, we are going to test a cooling in the 0.45MeV RFQ. 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 [9] and ANSYS codes. The peak surface heat flux on the cavity wall is 0.102 MW/m^2 at the high energy end. In order to remove this heat, we consider 24 longitudinal coolant passages in vanes and cavity, as shown in Figs. 3. Fig. 3 shows a thermal distribution of the cavity at the high energy end. The material is oxygen-free high-conductivity copper (OFHC). The thermal loads was given by SUPERFISH analysis. The heat transfer coefficients are between 11kW/m^2-C to 15 kW/m^2-C. 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 Code, the peak temperature on the cavity wall is 60.9 ^oC, the maximum displacement is 58μm and the intensity stress is 15MPa. For rf tuning, the coolant passages on the vane area are operated with 10 ^oC coolants. However the temperature of the coolant of the passages on the cavity wall is about 20 ^oC and is varied to maintain the cavity on resonance frequency. The coolant passages in the cavity wall and vane area was the deep-hole drilled. The entrances of deep holes at the vane end have been brazed.

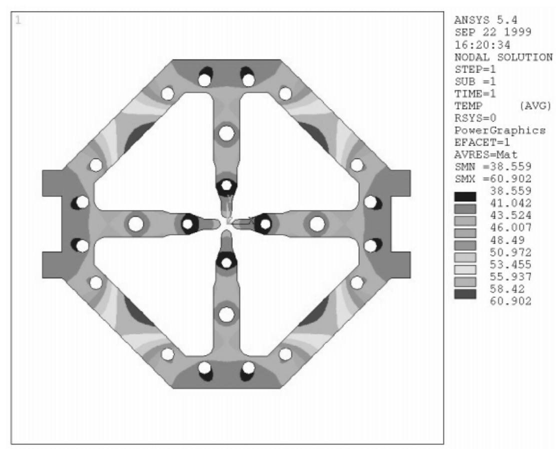

Figure 3. Temperature distribution of the cavity at the high energy end of the 0.45MeV RFQ.

2.2 Fabrication

There is the rectangular undercut of the vanes. The exact dimension of the undercut has been determined empirically by cutting vane of hot model which was fabricated into the OFHC. Fig. 4 shows a variation of a resonant frequency versus a depth of undercut.

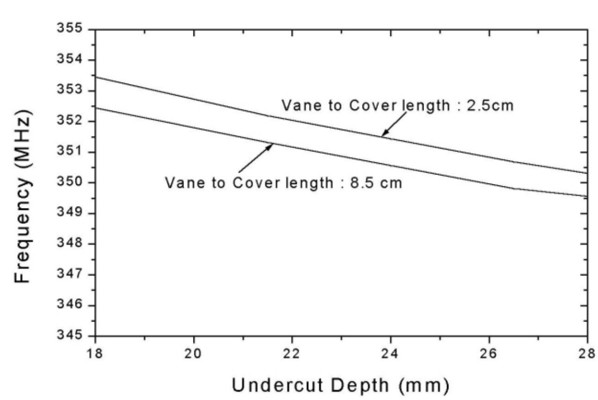

Figure 4. Plot of resonant frequency versus a depth of undercut.

The resonant frequency of RFQ cavity inversely decreases with undercut depth. To maximise an effect of a stabilizer rod, we determined that the undercut depth and vane to end-cover length for the 0.45MeV RFQ are 28mm and 35mm, respectively. Fig. 5 shows a shift of dipole mode by inserting a stabilizer rod. The shifted frequency is 4MHz.

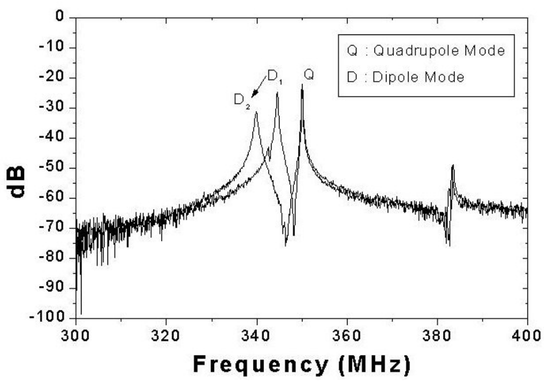

Figure 5. A shift of a dipole mode by a stabilizer rod:
D_1 : stabilizer rod depth into vane end = 0 cm ;
D_2 : stabilizer rod depth into vane end = 23 cm ;
A diameter of stabilizer rod = 1cm.

The four quadrants of the RFQ have been fabricated separately and brazed. Thus the RFQ is the completed monolithic structure and the vanes are permanently aligned. This structure serves to mitigate the cost and to simplify the mechanical support system. Because of the leak of the brazing surface and the strain of the RFQ structure by the furnace heat, it is important to determine the exact shape of brazing area. To determine the exact shape, we have been performed two brazing test. Fig. 6 shows 96.4cm long 0.45MeV RFQ which was brazed in vacuum furnace. The RFQ was brazed in a vertical orientation with LUCAS BVag-8, AgCu alloy with a liquids temperature of 780 °C.

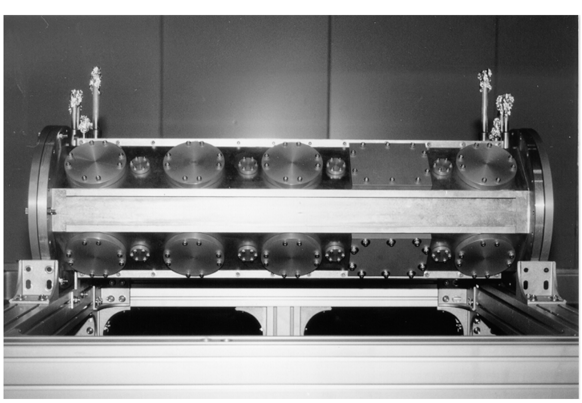

Figure 6. A brazed 0.45MeV RFQ.

3 PRESENT STATUS

The design of 3MeV RFQ has been completed. The cold model with Al6063 has been fabricated and tested. The hot model is being fabricated. As a test bed for 3MeV RFQ, the design, construction, electrical test, and vacuum test of the 0.45MeV RFQ have been finished. A cold models of a tuner and rf loop coupler have been fabricated and is being tested. A low-level RF control system is being designed. A design of a low energy beam transport (LEBT) system has been finished and two solenoids is being fabricated.

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REFERENCES

[1] T.Y. Eom et al., "A Study on the Development Plan and Preliminary Design of Proton Accelerator for Nuclear Application", KAERI/RR-1769/96.

[2] C.K. Park et al., "The KOMAC Project: Accelerator and Transmutation Project in Korea", Proceeding of APAC98, Tsukuba, (1998).

[3] B.H. Choi, "KOMAC", OECD NEA Workshop, (1998).

[4] J.M. Han et al., "Design of a 350MHz, CW RFQ for the KOMAC project", Proceeding of APAC98, Tsukuba, March 23-27 (1998) .

[5] J.M. Han et al, "Design of the KOMAC H^+/H^- RFQ Linac", Proceeding of LINAC98, Chicago, (1998)

[6] J.M. Han et al., "Design and Fabrication of the KOMAC RFQ", Proceeding of PAC99, New York, (1999).

[7] W.D. Kilpatric, "Criterion for Vacuum Sparking Designed to Include Both rf and dc", Rev. Sci. Instr. 28, 824 (1957).

[8] K.R. Crandall et al., "RFQ Design Codes", LA-UR-96-1836, (Revised February, 1997).

[9] J.H. Billen and L.M. Young, "POISSON SUPERFISH", LA-UR-96-1834 (Revised December, 1997).