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Test of the PEFP 3MeV RFQ Upgrade

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1. Introduction

A 3MeV RFQ upgrade has been newly designed, fabricated to solve the problems in existing RFQ such as sharp edge, reverse curvature radius at radial matching section, inadequate RF seal in addition to the tuning problem [1]. It consists of four sections with the almost same physical dimensions compared to existing ones. In order to solve the problem related to the improper cavity tuning, pre-brazing tunings of each section to translate minor vanes were carried out. After brazing, tunings of a segment that consists of two sections, and two segments were carried out step by step. The tuning requirements are like bellows.

- resonant frequency : design value ± 5kHz
- quadrupole field : < 2 % of design value
- dipole field : < 5% of quadrupole one

After tuning, high power RF test was carried out up to the design field level. It took about 8 hours to reach the design field level with stable cavity field and no serious vacuum degradation both in window and cavity.

2. Tuning

2.1 Vane adjustment before brazing

The minor vane adjustments before brazing were carried out to adjust the frequency and quadrupole field profile. To do this, the brazing surface was changed from step one to flat for admitting the minor vanes translation. The requirements were that the quadrupole and dipole field were within 10%, 20% of design values at the frequency within 200kHz error. The frequency was measured with a vector network analyzer (Agilent 8753ES) and the field profile was measured using the bead perturbation method. The initial resonant frequencies of the quadrupole mode were 3~4MHz higher than the design one in each section. After the translation of the minor vanes to the cavity inside about 300um, the design frequencies could be obtained. The initial frequency and vane translation distance of each section were summarized in Table 1.

2.2 Segment Tuning

After brazing, two sections were joined to form a segment. In this configuration, a segment is a complete cavity. The initial frequency of segment 1 was 348.033 MHz, and the quadrupole, dipole field profile errors were about 4 % and 10% respectively, As for segment 2, the initial resonant frequency was 348.132MHz, and quadrupole and dipole field profile errors were about 4% and 5% respectively. After tuning with movable tuners, the resonant frequency and quadrupole, dipole field profile of both segment 1 and segment 2 were 349.944MHz, within 2 % and 5%, respectively. The setup for segment tuning is shown in Figure 1.

Table 1. Results of pre brazing vane adjustments

Section No.	Initial Freq. (MHz)	Final Freq. (MHz)	Q1, Q4 Vane (um)	Q2, Q3 Vane (um)
1	353.524	349.314	+130	+220
2	353.538	349.485	+300	+360
3	352.558	349.360	+300	+300
4	352.319	349.155	+300	+300

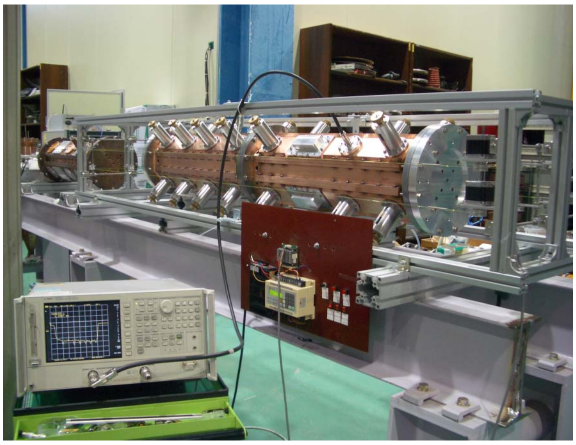

Figure 1. Setup for segment tuning

2.3 Two Segments Tuning

In PEFP 3MeV RFQ upgrade, two segments were joined together via coupling plate to constitute a complete 3MeV RFQ cavity.

Before frequency and field tuning, the diameter of the coupling plate hole and lengths of the dipole stabilizer rod should be determined. A coupling plate and dipole stabilizer rods were used to stabilize the field against perturbation, and the parameters could be determined by equalizing the mode spacing between nearby quadrupole modes and dipole modes respectively. The final hole diameter of the coupling plate was 118mm, and the lengths of the dipole stabilizer rod at low energy side was 145mm, high energy side 105 mm.

The RFQ was tuned at 349.931MHz with the quadrupole field error was less than 2% that of design one and dipole field error within 5% which satisfied the

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requirements. The final field profile for quadrupole and dipole are shown in Figure 2 and Figure 3 respectively.

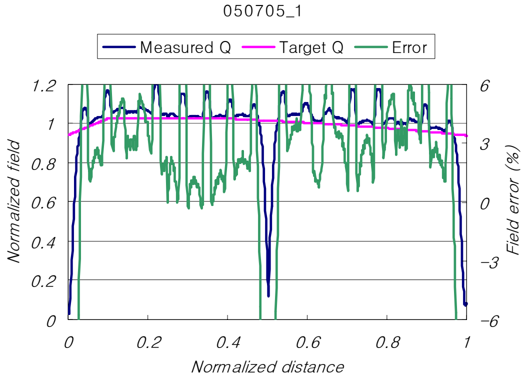

Figure 2. Tuned quadrupole field profile

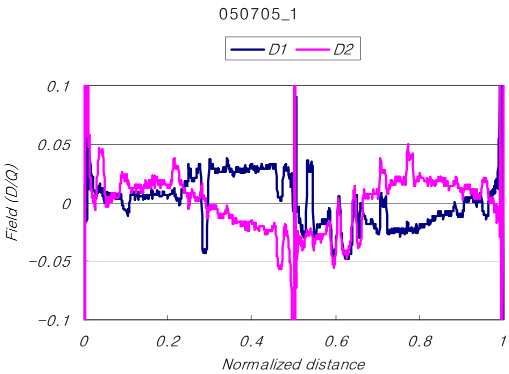

Figure 3. Tuned dipole field profile

3. High Power RF Test

The RFQ upgrade after installation is shown in Figure 4. The resonant frequency was 350.00MHz at 45C wall temperature maintained by heater. The vacuum levels at cavity, window 1, window 2 were about 2E-7 torr, 4E-7 torr and 2E-7 torr, respectively. The high power RF test has been carried out. At first, the RFQ upgrade was driven with 50us, 5Hz and the RF reflection power level was high and those phenomena might come from electron loading at window because the vacuum at window also became degradation. Above 80kW forward power level, the RF power signal and vacuum level at windows became stabilized. And the unstable reflected power and vacuum degradation were observed again beyond 270kW forward power. From this power level, the RF power was increased very slowly step by step to keep the stabilization of the vacuum level. After about 8 hours from RF turn on, the design field level, 1.8 Kirlpatrick, was reached without degradation of vacuum level. After that, the pulse length was increased up to 80 us with 1Hz that could be used for preliminary beam test, and the resulting RF power signal is shown in Figure 5. At this power level the vacuum conditions were maintained below 5E-7 torr.

Figure 4. Installed RFQ upgrade

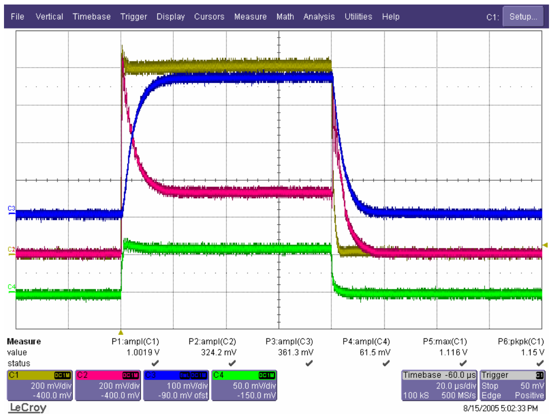

Figure 5. RF signal at 450kW forward power
(Ch 1 : forward power, Ch 2 : reverse power
Ch 3 : cavity power, Ch 4 : klystron reverse power)

4. Conclusion

A PEFP 3MeV RFQ upgrade has been developed at PEFP. To satisfy the requirements of RF parameters such as frequency and field profiles, vane adjustments before brazing, one segment tuning and two segments tuning were carried out. After low power tuning, high power RF test has been conducted up to the design field level. It took about 8 hours to reach the design value with stable conditions. Based on these results, preliminary beam tests will be carried out.

5. Acknowledgement

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6. REFERENCES

[1] H.J.Kwon, et al., “Design and Fabrication of PEFP 3MeV RFQ upgrade”, in these proceedings.