Beam Test of the Microwave Ion Source for the 20-MeV Proton Linac

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1. Introduction

According to the operation scenario of the PEFP (Proton Engineering Frontier Project) 100-MeV machine, the required operation time of the ion source must be at least 100 hours without any maintenance. The required specification of ion source for 100-MeV proton linac is shown in Table 1 [1].

Table1. Specification of proton source for a long life time

Species	Proton
Beam energy	50keV
Operating current	20mA
Emittance (Normalized rms)	0.2π mm mrad
Proton fraction	>80%
Life time	> 100hr(weekly operation)
Operation mode	pulse beam extraction(2ms, 120Hz)

To meet the operation time requirement of the ion source, a microwave ion source was developed and tested at test stand installed at Korea Atomic Energy Research Institute (KAERI). We could confirm that it was possible to operate the ion source more than 100 hours through the long time operation test [2]. During the test, we operated the ion source in CW mode. After the long time operation test was finished, the microwave ion source was installed in the 20-MeV accelerator to supply beam to the linac. We did pulse beam test of the newly installed ion source in the 20-MeV accelerator to check its performance.

2. Installation

The microwave ion source for the 20-MeV proton linac includes the microwave components to generate and deliver the microwave power, a solenoid magnet and its power supply, a vacuum system, power supplies for beam extraction and bias electrode, a cooling system [3].

The isolation transformer provides the electrical isolation between the high voltage side and the ground level. The power supplies for the solenoid and the magnetron reside in high voltage side, whereas those for the extraction and bias reside in ground level. The system block diagram is shown in the Fig. 1 [3].

To install the microwave ion source in the 20-MeV proton linac, we manufactured an adapter which included a feedthru for the bias voltage and the fiducial point for the alignment of the ion source by using a Laser Tracker. The microwave ion source installed in 20-MeV proton linac is shown in the Fig. 2.

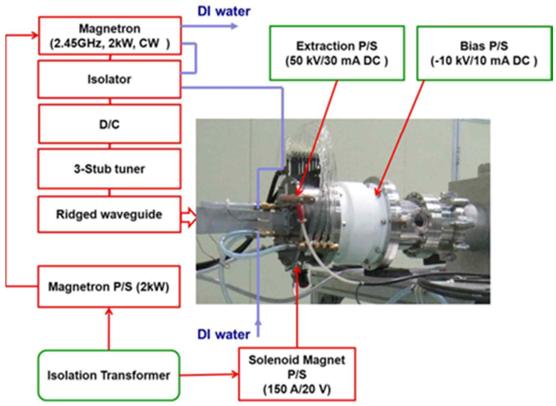

Fig. 1. System block diagram

Fig. 2. Microwave ion source installed in 20-MeV proton linac

3. Beam Test

The proton injector of the 20-MeV proton accelerator consists of a newly installed microwave ion source and low energy beam transport (LEBT) system which includes two solenoid magnets for beam focusing, two steering magnets, vacuum box located at the center of the solenoid magnets, AC current transformer installed at the downstream of the 2^{nd} solenoid magnet. During beam test, we did not operate the steering magnets and also fixed the operation current of the solenoid magnets, which were 155A for 1^{st} solenoid magnet and 190A for 2^{nd} solenoid magnet.

Before the beam extraction, we measured the reflected microwave power from the plasma chamber and the result is shown in Fig. 3. The vacuum pressure is gas pressure at the vacuum box. Below 1.0×10^-5 Torr, the plasma could not sustained at the magnet current of 80.5A and the reflected power could be reduced by using microwave 3-stue tuner.

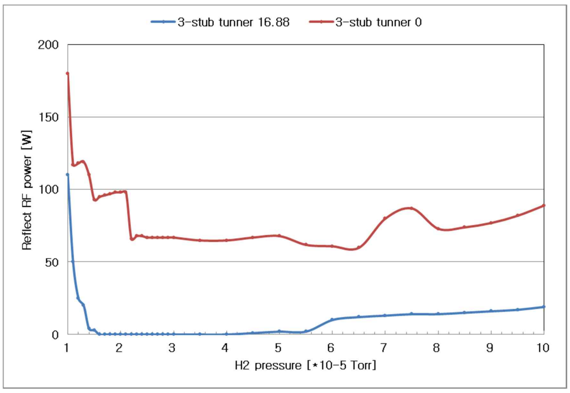

Fig. 3. Microwave reflected power from the plasma chamber depending on the vacuum pressure at the vacuum box

The beam current was measured depending on the microwave power and solenoid magnet current and the results are shown in Fig. 4. During the measurement, the gas pressure at the vacuum box was maintained at 1.7×10^-5 Torr. The beam current behaviors depending on the solenoid magnet current were similar except the beam current increase with the microwave power. Also the reflected microwave power patterns were similar as shown in Fig. 5. The beam pulse signal shape was very stable when the reflected power was minimum value. The beam current depending on the microwave power is shown in Fig. 5. The current is increasing with driving microwave power. In this measurement, we fixed the tuner position at 16.8mm.

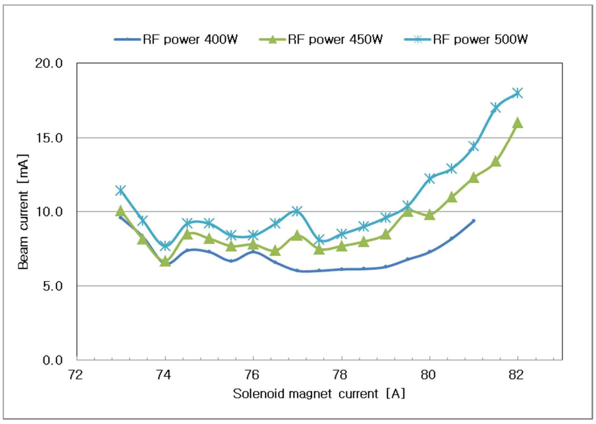

Fig. 4. Beam current depending on the solenoid current and microwave power

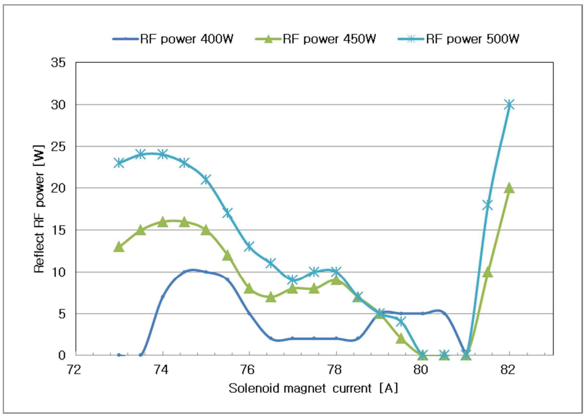

Fig. 5. Reflected microwave power depending on the solenoid current and microwave power

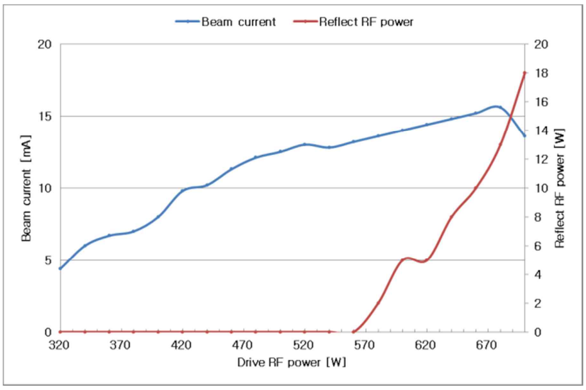

Fig. 6. Beam current and reflect power depending on the microwave power

4. Conclusions

The microwave ion source was installed and tested at 20MeV proton accelerator. Beam currents were measured depending on the microwave power, solenoid current and gas pressure. Because the beam current depends not only on the ion source operating parameters but also the LEBT solenoid current, we need to measure the beam data depending on the LEBT solenoid operating parameters.

ACKNOWLEDGMENT

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