Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 19-20, 2022

Fabrication of a Plasma Chamber with Water Cooling for a Microwave Ion Source at KOMAC

Dae-Il Kim [a) b) *], Mun-Ho Jo [a)], Sang-Hun Lee [a)],

Yu-Seok Kim [b)]

[a)] Korea Atomic Energy Research Institute, KOrea Multi-purpose Accelerator Complex,
181 Mirae-ro, Geoncheon-eup, Gyeongju-si, Gyeongsangbuk-do 38180

[b)] Division of Nuclear & Energy System Engineering, Dongguk University,
123 Dongdae-ro, Gyeongju-si, Gyeongsangbuk-do 38066

1. Introduction

The ion source for the 100 MeV proton accelerator is a 2.45 GHz microwave ion source [1]. The microwave ion source is a device that can operate for a long time of about 2,000 hours or more, and as a result of aging of the device, periodic replacement of consumables is required. And replacement of parts in microwave ion source may occur due to unexpected shutdown [2]. In recent years, there have been about 5 types of breakdown in the ion source, and the most frequent occurrence is high-voltage insulator breakage [3]. In this report, as a process to improve the cause of high-voltage insulator breakage, a plasma chamber that can be cooled by water is designed and the contents of changing the inner diameter of the solenoid electromagnet are described and presented.

2. Methods and Results

The high-voltage insulator is made of MC nylon and is located between the plasma chamber and the solenoid electromagnet, allowing the solenoid electromagnet to be driven at ground potential as shown in the Fig. 1.

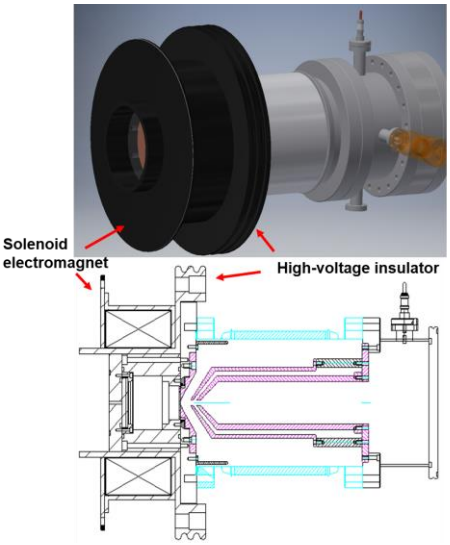

Fig. 1. Location of high-voltage insulator

2.1 Breakdown about high-voltage insulator

In the high-voltage insulator breakage, the heat generated in the plasma chamber was transferred to the high-voltage insulator, giving a change in physical properties and leading to breakage. Due to the structure of the ion source, the stress of thermal deformation is relieved at the edge while the plasma chamber, high-voltage flange, and solenoid electromagnet are confined, resulting in the breakdown of the high-voltage insulator [3].

2.2 Old solenoid electromagnet

Before the installation of the high-voltage insulator, there was a 7mm gap between the plasma chamber and the solenoid electromagnet, so there was space for air cooling. After the installation of the high-voltage insulator, the outer diameter of the plasma chamber is 116 mm, the thickness of the high-voltage insulator is 7 mm, and the inner diameter of the solenoid electromagnet is 130 mm. That is, it is a structure in which three parts are assembled without gaps [3][4]. In order to cool the plasma chamber, it is necessary to expand the inner diameter of the solenoid electromagnet.

2.3 New solenoid electromagnet

The new solenoid electromagnet has a diameter of 150 mm, increased by 20 mm. The Fig. 2. is a drawing of the manufactured solenoid electromagnet. And, the magnetic field as shown in the Fig. 3 was calculated using Poisson code at solenoid electromagnet current 70 A. The manufactured solenoid electromagnet was installed in the ion source and the magnetic field was measured using a gauss meter (FW BELL, model 8030). The Fig. 4 compares the simulated magnetic field value and the measured magnetic field value by gauss meter. Currently, the ion source of the 100 MeV proton accelerator is equipped with a manufactured solenoid electromagnet and is used. High-voltage insulator breakage has not occurred to date.

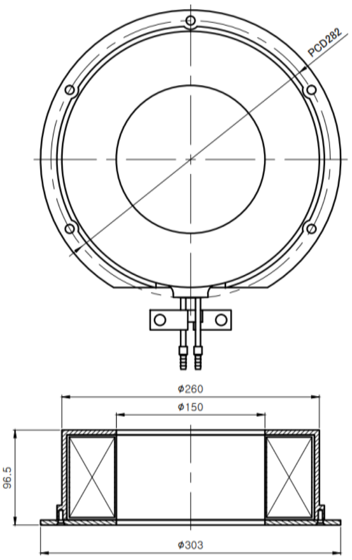

Fig. 2. Simulation by Poisson code

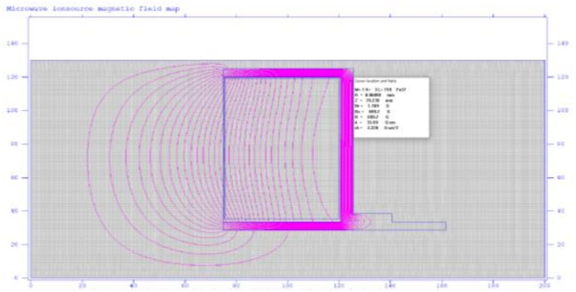

Fig. 3. Simulation by Poisson code

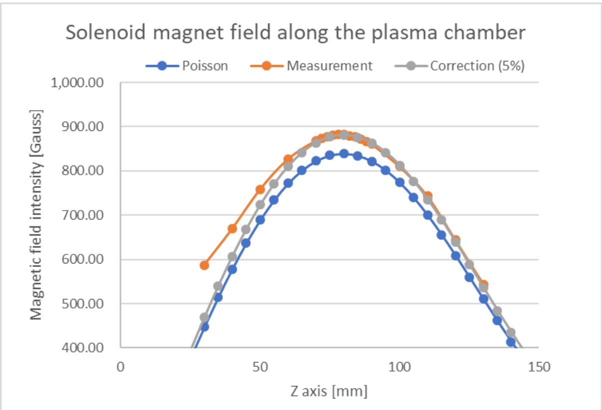

Fig. 4. Magnetic field profile

2.4 Fabrication of a plasma chamber with water cooling

The plasma chamber was designed as an integral part to enable water cooling in a space that was increased by 20 mm in diameter. The cooling water of the plasma chamber enters one inlet side and is bifurcated at the chamber side to cool the chamber surface. And, it is a structure that comes out toward one exit. The Fig. 5 shows the fabricated plasma chamber.

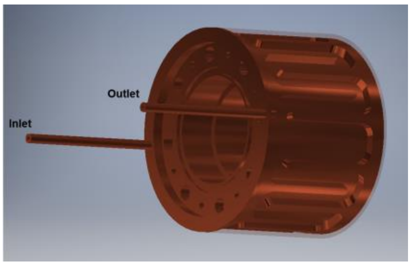

Fig. 5. Plasma chamber with water cooling

3. Conclusions

A main cause of microwave ion source breakdown is breakage of high-voltage insulators. Insulation breakdown due to changes in the physical properties of high-voltage insulators due to the high temperature in the plasma chamber. To improve main cause, a new solenoid electromagnet was fabricated and a water-cooled plasma chamber was fabricated. In the future, it will be installed on test-bench for a microwave ion source to perform plasma tests, high-voltage tests and beam extraction tests.

REFERENCES

[1] Hyeok-Jung Kwon, et al., “Study on the Microwave Ion Source of 100-MeV Linac” ICABU2015, Gyeongju, 2015.

[2] Dae-Il Kim, et al., “Installation of Test-stand for Conditioning of the Microwave Ion Source at KOMAC” Transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, 2021.

[3] Dae-Il Kim, et al., “Preliminary Test for Improving Plasma Chamber Cooling of Microwave Ion Sources at KOMAC” Transactions of the Korean Nuclear Society Autumn Meeting, Changwon, Korea, 2021

[4] Dae-Il Kim, et al., “Beam Test of the Microwave Ion Source for the 20-MeV Proton Linac” Transactions of the Korean Nuclear Society Spring Meeting, Taebaek, Korea, 2011