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Basic Design Study on 1-MV Electrostatic Accelerator for ion irradiation

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1. Introduction

The KOMAC (KOrea Multi-purpose Accelerator Complex) has electrostatic ion accelerators whose terminal voltages are less than 100kV. To extend ion beam irradiations with higher energy ions for industrial purposes, an electrostatic accelerator of 1-MV terminal voltage should have been studied. For industrial applications, the most important features of the accelerator are 1) high current and 2) high reliability for high irradiation dose and high through-put with high current and long irradiation time.

2. Basic Study

For the high current applications, ion beam current should be more than 1mA, which is equal to 6.24×10^{15} ions/s. The specifications of the 1-MV electrostatic accelerator are shown in Table I. The most important components for an electrostatic accelerator are a high voltage power supply, an ion source, and an accelerating column.

Table I: Specifications

Beam Current	Max. 1mA
Operating Voltage	0.2 – 1.0MV
Energy Stability	±0.5%
Ions	Gaseous
Power for Ion Source	<1kW
Life Time of Ion Source	>1,000 hrs

2.1 High Voltage Power Supply

The simplest method to produce 1MV is Van de Graff, which is mechanical transport of electric charges with insulating belt conveyor. But the Van de Graff is not suitable for high current. There are many possible cascade circuits to produce high current more than 1mA, such as Cockcroft-Walton and Dynamitron. The two capacitance-coupled circuits are suitable for 1MV and above with a high frequency generator. For around 1MV, inductance-coupled circuit is better for cost, reliability and electrical efficiency. Electron transformer rectifier (ELV) type, which was developed in Nuclear Physics Institute (Novosibirsk) for industrial electron accelerators [1], is chosen. The energy stability of ±0.5% can be obtained by the feedback control of the primary coil voltage that is supplied from the high frequency generator. The high voltage circuit is accommodated in a tank filled with SF_6 gas under a pressure of 0.5MPa. Due to the massive coils of ELV circuit, the high voltage power supply is installed in vertical position in a pressurized tank.

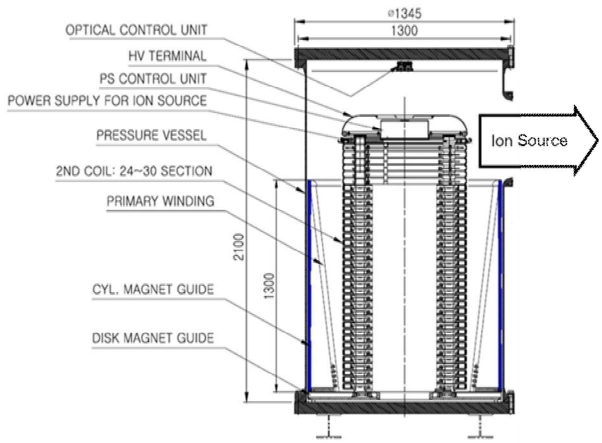

Fig. 1. ELV type 1-MV high voltage power supply in SF_6 tank.

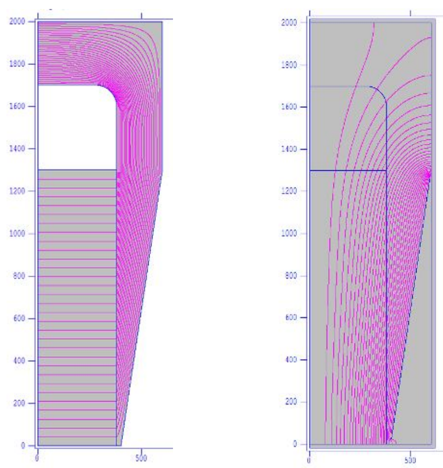

Fig. 2. Electric field (Left) and magnetic field (Right) in ELV type high voltage power supply calculated with POISSON code.

2.2 Ion Source

Because the ion source will be installed in the tank, the reliability and the life time of the ion source is very important. And also the electrical power to operate the ion source is limited less than 1kW, because the ion source power supply should be located on 1-MV high voltage. The most promising ion source, which can satisfy these requirements, is a Thonemann type rf ion source [2]. A solid-state 200-MHz rf generator and an 5-kV extraction power supply are required to operate the ion source with less than 1-kW electric power. For the easy change of ion spices, gases, such as nitrogen, oxygen, hydrogen etc, to the ion source will be supplied from the outside of the tank

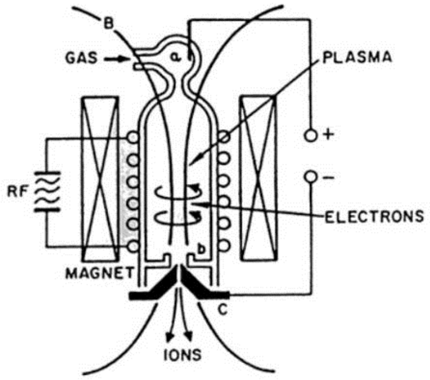

Fig. 3. Thonemann type rf ion source is considered as ion source for 1MV ion accelerator.

2.3 Accelerating Column

For better acceleration without beam loss, a shorter accelerating column is required. An accelerating column, which can hold more than 2-MV/m electric field, can be fabricated with the recent technology. Alumina has been chosen as insulator material because of its electrical insulating and mechanical property. The 0.5m-long brazed structure with alumina rings and metal electrode rings can be installed horizontally.

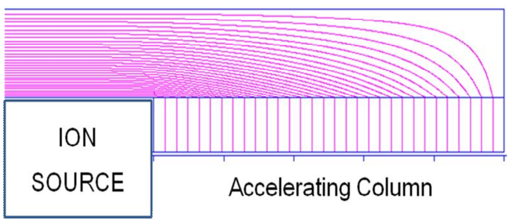

Fig. 4. Electric field of accelerating column in tank calculated with POISSON code.

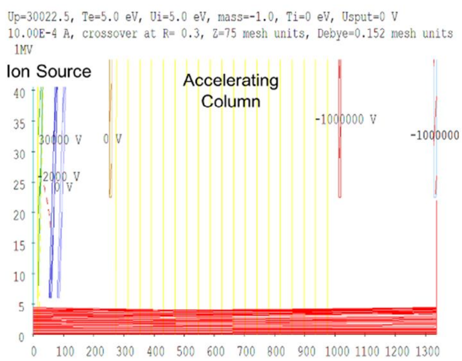

Fig. 5. 1-mA nitrogen ion beam trajectory through 1-MV accelerating column simulated with IGUN code.

2.4 Layout

The 1MV high voltage power supply will be installed vertically and the ion source and the accelerating column will be attached to the power supply horizontally. The beam center will be 1.8m high from floor. They will be accommodated in pressurized SF_6 tank. Accelerated beam will be delivered to target systems by beam transport system that will be developed according to the beam irradiation requirements, such as target size, dose rate, etc.

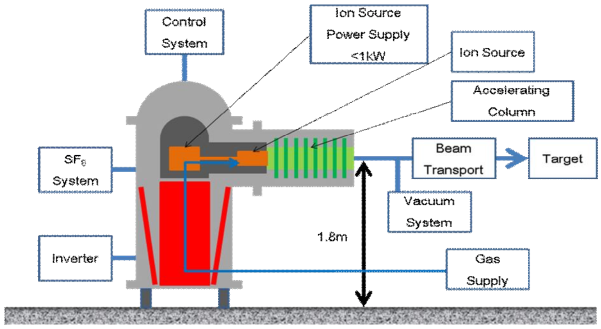

Fig. 6. Schematic layout of 1-MV ion accelerator.

3. Conclusions

The basic study on 1-MV electrostatic ion accelerator for industrial applications has been done. The key components are a high voltage power supply, an ion source, and an accelerating column. The feasibility study for fabrication is being performed. Especially the R&D for ion source is required. The 1-MV ion accelerator will be constructed with domestic companies and installed in the beam application research building, which is under construction in the site of KOMAC at Gyeongju.

Fig. 7. Beam application research building for 1-MV ion accelerator under construction.

REFERENCES

[1] E. A. Abramyan, Industrial electron accelerators and applications, Hemisphere publishing corporation, Washington, 1988.
[2] B. Wolf, Handbook of ion sources, CRC Press, Boca Raton, 1995.