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Conceptual Design of 110-degree Bending Magnet for 3-MV Tandem Accelerator Beam Line at KOMAC

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1. Introduction

The 3-MV tandem accelerator, manufactured by HVEE(High Voltage Engineering Europa, Netherlands), was installed at Seoul National University in 1998. Since then the machine had been operated for C-14 AMS(Accelerator Mass Spectrometry) and many applications with beams. Figure 1 shows the machine at Seoul National University.

Fig. 1. 3-MV tandem accelerator at Seoul National University

The machine will be moved to KOMAC and will be installed with the original C-14 accelerator mass spectrometry beam line and new three beam lines for ion implantations, ion beam analysis such as PIGE (Proton Induced Gamma Emission), and beam irradiations for nuclear material test. The two ion sources, Duoplamatron type and sputter type, will supply gaseous (proton, helium) and metal (carbon, silicone, copper, gold, and so on) ions according to the user demands.

Due to the limited space at KOMAC the tandem and the beam lines will be installed in a 110-degree cross line as shown in Figure 2, not in a straight line at Seoul National University. To bend beams along the beam lines, a new 110-degree bending magnet is required.

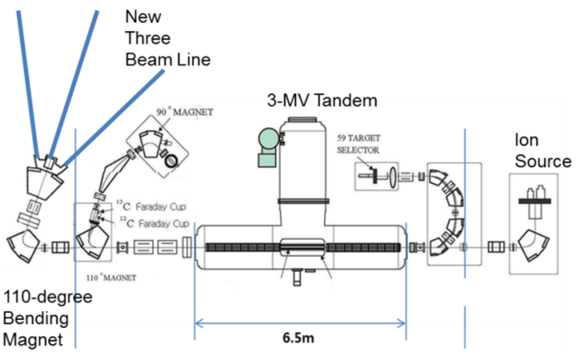

Fig. 2. New layout of 3-MV tandem accelerator and new three beam lines at KOMAC.

2. 110-degree bending magnet

2.1 Basic design parameters

For heavy metal ion irradiations, the 110-degree bending magnet should have high magnetic rigidity (magnetic flux density times bending radius). The reference beam is a Fe of mass number 52, charge state +2, energy 9 MeV. Then the magnetic rigidity should be 1.56 Tm. Considering the size and the material of the magnet, the bending radius and the pole gap are 1.2 m and 35 mm respectively. Table I shows the design parameters for the 110-degree bending magnet.

Table I: Design parameters

Reference Particle	9-MeV $^{52}Fe^{+2}$
Bending Angle	110 degree
Magnetic Rigidity	1.56 Tm
Bending Radius	1.2 m
Magnetic Flux Density	1.3 T
Magnetic Rigidity	1.56 Tm
Pole Gap	35 mm

2.2 Entrance and Exit Angles of Magnet [1]

The entrance angle α and the exit angle β of a bending magnet are defined as shown in Figure 3. R is a bending radius and φ is a bending angle.

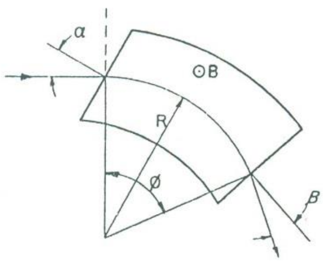

Fig. 3. Entrance and exit angles of bending magnet.

From transfer matrix analysis, the transfer matrix of the magnet for horizontal direction H and vertical direction V are given by

$$H = \begin{bmatrix} \frac{\cos(\varphi-\alpha)}{\cos\alpha} & \sin\varphi \\ -\frac{\sin(\varphi-\alpha-\beta)}{\cos\alpha\cdot\cos\beta} & \frac{\cos(\varphi-\beta)}{\cos\beta} \end{bmatrix} \quad (1)$$

$$V = \begin{bmatrix} 1-\varphi\tan\alpha & \varphi \\ \varphi\tan\alpha\cdot\tan\beta-\tan\alpha-\tan\beta & 1-\varphi\tan\beta \end{bmatrix} \quad (2)$$

The condition for the double focusing in horizontal and vertical directions of a beam by the edge focusing of the magnet is

$$\tan\alpha = \tan\beta = \frac{1}{2}\tan\varphi/2 \quad (3)$$

For φ = 110 degree, α = β = 35.5 degree. Figure 3 shows the horizontal and vertical image distances of 110 degree magnet with α = β = 35.5 degree. In the range of the object distance from 1.0 to 2.0 in the unit of φ, the nearly exact double focusing is obtained.

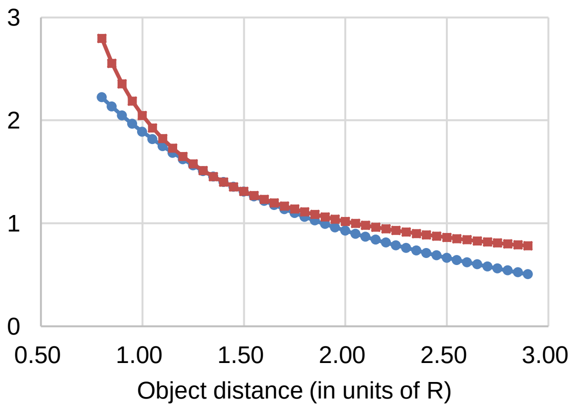

Fig. 4. Horizontal (□) and vertical (○) image distances of 110-degree magnet with α = β = 35.5 degree.

2.3 Beam Optics

To check the double focusing property of the 110-degree bending magnet, the beam optics simulation of the bending magnet alone has been done. Figure 5 shows the result of the simulation using the optics code provided by NEC (National Electrostatics Corp., USA). The horizontal and vertical image sizes at the focal points are same with the object sizes.

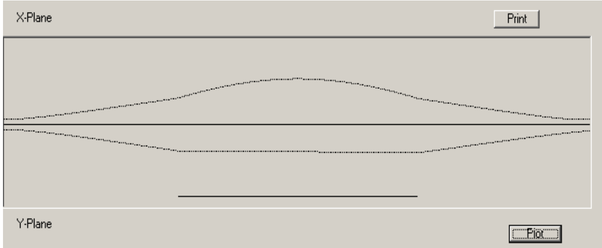

Fig. 5. Beam optics simulation of 110-bending magnet.

3. Conclusions

The conceptual design of the 110-degree bending magnet for the new beam lines of 3-MV tandem accelerator has been done. The most design parameter has been determined and the optics of the bending magnet itself has been simulated. For the next step, the end-to-end simulation, from the ion sources to the target stations, will be done and the detail mechanical design of the bending magnet and the beam line components will be performed.

ACKNOWLEGEMENT

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REFERENCES

[1] Albert Septier, Focusing of Charged Particles, Academic Press, New York, 1967.