Transactions of the Korean Nuclear Society Spring Meeting
Jeju, Korea, May 22, 2009

Conceptual Design of an Octupole Magnet for PEFP Beamlines

Bum-Sik Park, Han-Sung Kim, Hyeok-Jung Kwon, Ji-Ho Jang, Yong-Sub Cho
PEFP, KAERI, P.O.Box 105, Yusong, Daejeon, Korea
**Corresponding author: bspark@kaeri.re.kr*

1. Introduction

The Proton Engineering Frontier Project(PEFP) will supply the 20MeV and 100MeV proton beams to the users. 10 beam lines have been designed and will be installed not only for the demonstration test of beam utilization technologies but also for the industrial applications until 2012.

For the various field applications, the proton beam with wide uniform distribution has been required. There are several methods to irradiate the large area at the target. For the raster scan and the wobbling, the uniform irradiation is accomplished by sweeping small beams with a pair of dipole magnets[1-2]. But these scanning methods have some disadvantages to apply the pulsed beam. And there are several passive methods which using thick absorbers, occulting rings and scatterers[3]. These methods also have problems. So we studied, the non-linear optical method, the octupole magnet which can bend the tails of Gaussian beam back toward the center by the strong fields away from the center[4]. In this study, design requirements and designed parameters of the octupole magnet for PEFP beamlines are described.

2. Requirements

According to the design of beam optics, the required specifications were deduced for the PEFP beamlines. The requirements of PEFP octupole magnet are summarized in Table 1.

Table 1. Design requirements

Item	Specification
Aperture radius	55mm
Pole tip field	6kG
Effective length	400mm

3. Magnet Design

3.1 2D Calculation

Because of the eight-fold symmetry of a symmetric octupole, it is modeled the 1/16 of the octupole. Figure 1 shows the calculations of the magnetic flux lines. In Figure 2, the magnetic field distribution according to the current was described along the radial distance from the center of the magnet. The current is normalized with the excitation current for 6kG pole tip field.

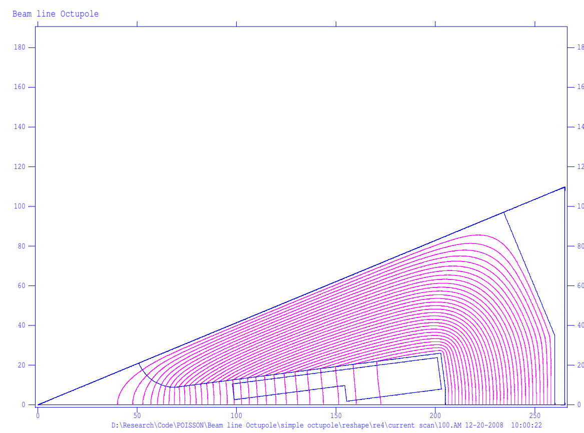

Figure 1. 2D POISSON calculations for the octupole manget. Only the 1/16 of cross-section has been modeled. The remains are symmetric.

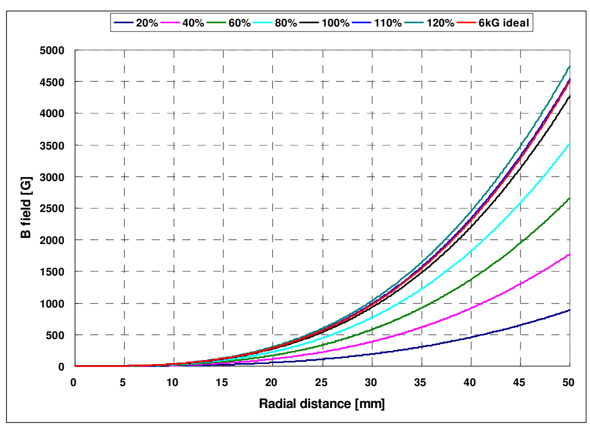

Figure 2. Magnetic field distributions according to the current and radial distance by 2D calculations.

3.2 3D Calculation

According to the beam optics calculations, the required octupole strength is determined as 3606 T/m^3. In Figure 3, the octupole strength was compared with the 2D and the 3D calculations according to the current. The current was normalized with the excitation current of required magnetic pole tip field.

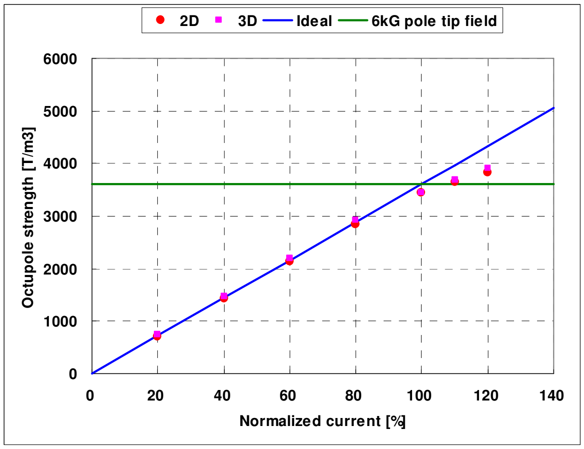

Figure 3. Octupole strength according to the current normalized with the excitation current for 6kG pole tip field

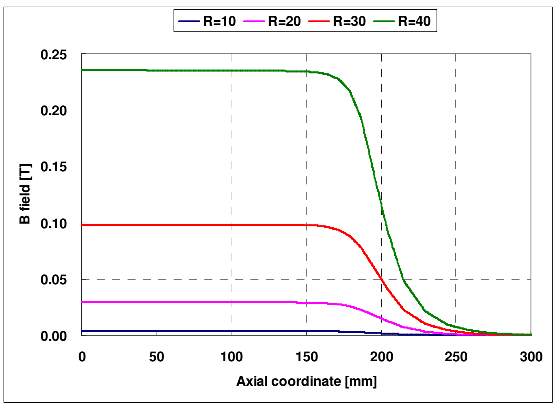

Figure 4. Magnetic field distribution according to the axial direction, the beam path, applied the 110% of normalized current.

The yoke length of octupole was determined as 380mm. Figure 4 shows the magnetic field distributions according to the axial direction at the different radial positions. Figure 4 also shows that there is no relation between the radial position and the effective length. The relation between effective length of octupole and the normalized current was also listed in Table 2. The designed parameter of octupole was summaried in Table 3.

4. Conclusions

According to the magnetic field simulation of 2D and 3D, the conceptual design of PEFP octupole magnet has been determined. The yoke length is 380mm and the effective length is 405mm.

Table 2. Effective length of octupole magnet according to the normalized current

Normalized current [%]	Effective length [mm]
20	406.8
40	406.7
60	406.0
80	407.3
100	405.7
110	405.2
120	404.3

Table 3. Designed parameters of PEFP octupole magnet

Yoke length	380mm
Effective length	~ 405mm
Total length	420mm
Transverse length	520mm
Octupole strength	3648 T/ m^3

Acknowlegment

This work was supported by Ministry of Education, Science and Technology of Korea.

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