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Engineering Design of a Drift Tube for PEFP DTL II

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1. Introduction

As the second stage of the PEFP(Proton Engineering Frontier Project) whose final goal is to develop 100MeV, 20mA proton accelerator, Engineering design of the DTL(Drift Tube Linac) II is in proceeding. In this paper, the details of design of the DT(Drift Tube) and EQM(Electro-Quadrupole Magnet) will be reported

2. DT and EQM design

2.1 Design constraints

Some parameters of the DTs for PEFP DTL II were as follows

- Bore radius: 10 mm
- Outer diameter : 135 mm
- Face angle : 40°
- Integrated field of the EQM : 2T

Considering the vacuum tightness, the minimum thickness of the DT is limited to 3mm because DT is composed of OFHC. So, Bore radius of the EQM is determined to 13mm

2.2 EQM design

First, optimum pole radius of the EQM of which bore radis is 13mm was calculated using poisson code with the 2-D model shown in figure 1. Pore radius was determined as 15mm considering the calculation result of the field gradient and harmonic field strength as shown in table 1.

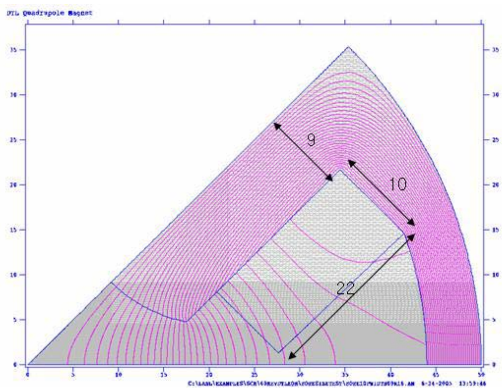

Figure 1. 2-D modeling of the magnetic calculation for the EQM

Table 1. result of the Magnetic calculation

r	Grad [gauss/cm]	Harmonic [%]
14	3233	0.0126
15	**3258**	**0.0015**
16	3287	0.0108

Field gradient dependent on the current was as shown in figure 2. when outer diameter of the yoke is 100mm or 102mm, it was verified that no magnetic saturation occurs under the current of 2000A

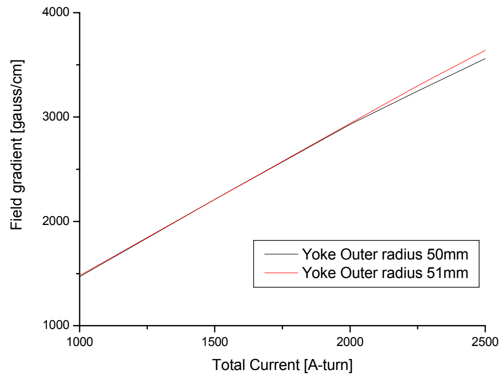

Figure 2. Field gradient of the EQM dependent on current

Inside structure of the DT to maximize the space for EQM was designed. With that design, EQM length was 65mm. Effective length of that magnet was over 75mm from the 3-D magnetic calculation as shown in figure 3.

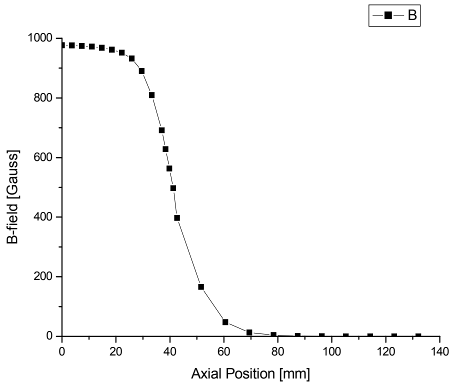

Figure 3. Axial distribution of the quadrupole field of the EQM

So required total current was 1800A-turn which is under the current that magnetic saturation starts to acquire the integrated field 2T

We fabricated the prototype EQM using the hollow conductor of 4.6mm * 4.6mm as shown in figure 4 and some parameters of the prototype EQM is summarized in the Table 2.

Figure 4. Prototype EQM.

Table 2. Parameters of the Prototype EQM

continuous winding	
core outer diameter	104mm
core inner diameter	88mm
core length	65mm
pole width	18mm
conductor dimension	4.62*4.62
coil turn number	6.5 turns
total coil length	6m
conductor resistance :	6mΩ
flow rate at 4 atm of Δ P	1SLM
temperature increase	
at design current 1800 A-turn	8°C

2.3 DT design

Inside structure of the DT was designed as shown in figure 5. According to the structural analysis, the maximum equivalent stress was about 11MPa which is smaller value of the 50MPa, the yield strength of the annealed copper.

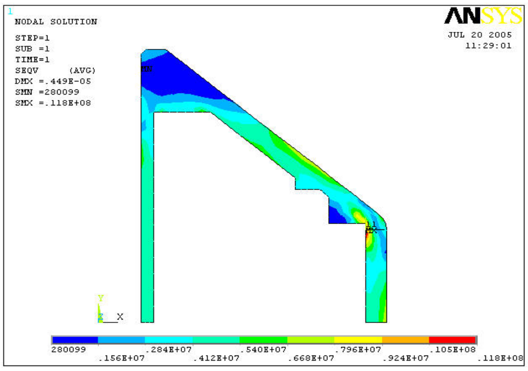

Figure 4. Result of the structural analysis : the Equivalent stress.

3. Summary

DT and EQM for PEFP DTL II was designed. It was verified that EQM satisfied the required parameters from the physical design of the DTL II. It was verified also that DT design which contained the EQM satisfied the structural requirements.