DESIGN AND SIMULATION RESULTS OF DIPOLE MAGNET FOR INSTITUTE OF PLASMA RESEARCH, GANDINAGAR

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Abstract

Design of a dipole magnet was carried for the separation of deuterons (D+) from D2+, D3+ at Institute of Plasma Research, Gandhinagar. This magnet will provide the proper path for selective positive ions (mass separation, energy of ions 20keV) from ion source to the accelerating part as well as provides the focusing effect with the same vertical/horizontal focusing point. The magnetic field of dipole magnet is 2kG in pole gap of 4 cm with entry/exit edge angle of 25.78^o for a bending angle of 90^o. In this paper, we will discuss the design of dipole magnet which includes coil design, optimization of pole width/top/backlag, and edge angle calculation. Field profile was obtained using POISSON 2D code [1] and TOSCA [2] for 3D simulation.

INTRODUCTION

C-type dipole magnet with bending radius 24cm centre toward back yoke is designed. This magnet will be fabricated using by TATA –A grade low carbon steel. The maximum operating field will be 2kG with the field quality of 1E-03 for ±2cm. Entry and exit edge angle is fixed and is 25.78^o for double focusing condition.

2D DESIGN RESULTS

2D Design is carried out using POISSON Code. Using this code, pole width with upper pole cut is optimised with coil cross section, top yoke width and back yoke width to minimise the magnet weight.

To get require field quality, a cut of 3cm x 4.5cm is applied at the inner side of pole near the top yoke. By doing this field quality and position of peak field in pole gap is optimised (For detail see Fig.1).

NI Calculation

The Ampere turns (NI) required to generate a magnetic (Bo) in gap (g) is given as:

$$\mathrm{NI}_{\mathrm{TOTAL}} = \frac{Bo(T) * g(m)}{\mu o} = 6366\, A - turn \quad (1)$$

So, require A-turn per pole is 3183, and the for air cool coil, coil cross section area for maximum current density (1 A/mm^2) is 3183 mm^2.

The field quality is with in 5E-04 for ±2cm at 2kG field (see fig2.).

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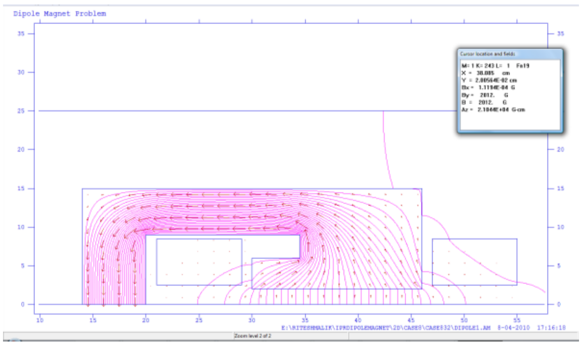

Figure 1: Flux line pattern in dipole magnet.

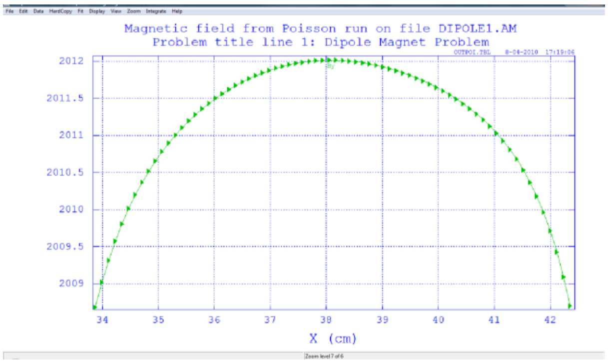

Figure 2: Field profile at 2kG.

3D DESIGN RESULTS

To carry out 3D design 2D optimized cross section is taken as input. 3D design was carried out using TOSCA code.

Edge angle Calculation for double focusing condition

For n = 0, Sox = Soz = So = 25 cm, Lo = Li = So/R = 25cm/24cm = 1.041667
Bending angle θ=90°
Then calculated edge angle, Entry angle u1=25.7753°
Edge exit angle u2=25.7754°

8cm x 6cm is the cross section of coil. 2.384kG is the magnetic field at current density of 80 A/cm^2.

MODELLER is used for modelling part and generation of input file for TOSCA. Following series of field colour contour diagram (see Fig.3, 4, 5 & 6.) are showing the magnetic field distribution/pattern in the iron of the magnet. Magnet dimension is optimise for 7~8kG in the top and back yoke at 2.4kG pole gap field. So, magnet mass and dimension is minimised in 3D modelling with out compromising results.

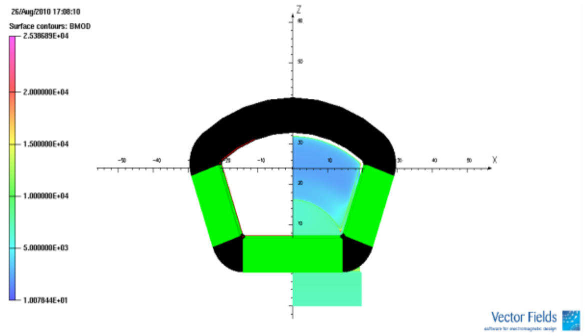

Figure 3: Field colour contour at 2.4kG for pole and back yoke.

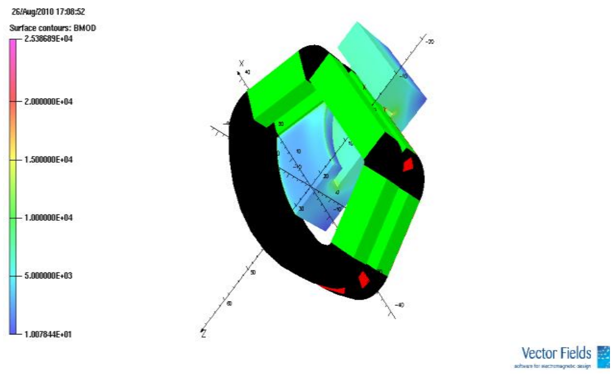

Figure 3:Field colour contour at 2.4kG for pole side and back yoke side.

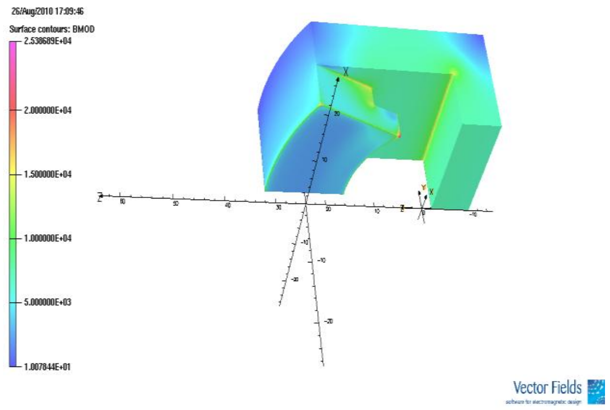

Figure 5: Field colour contour at 2.4kG for pole corner.

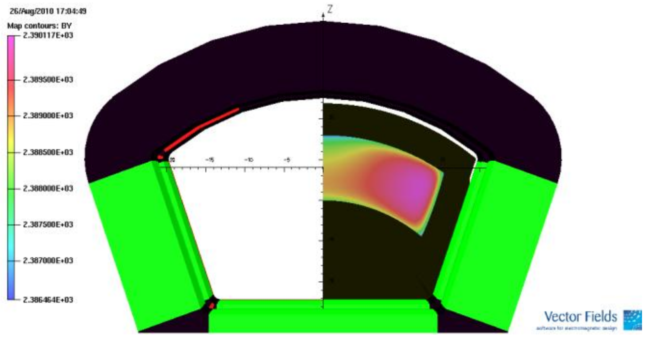

Figure 6: field colour contour at 2.4kG for pole gap.

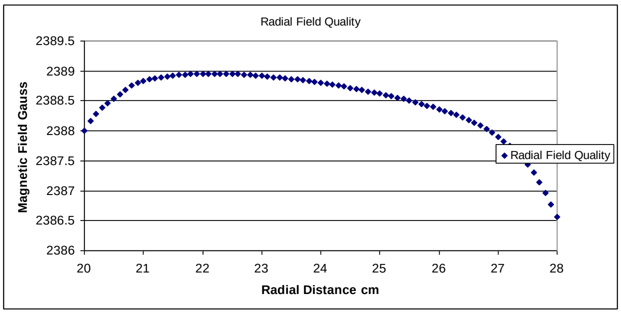

Figure 7: field profile at 2.4kG.

Figure7 shows the magnetic field pattern obtained using 3D simulation. It is obvious for the figure that field quality is within 1E-03 for ±2cm. the half effective length is 21.784cm and edge angle is 24.84°.

CONCLUSION

Entry and exit pole are chosen without taper. So, half effective length is more by ~3 cm and edge angle is less by ~1° from design value. This can be corrected by cutting the pole or by applying the taper, after the scanning of magnetic field with hall probe.

REFERENCES

[1] POISSON.
[2] Vector Fields.