# A Study on Uniformity of a Magnet

P. Das[1], R. Bogi[2], A. Reza[1], A. K. Sikdar[1], A. Nandi[3]

[1]Variable Energy Cyclotron Centre, Kolkata, West Bengal, India
[2]Jalpaiguri Government Engineering College, Jalpaiguri, West Bengal, India
[3]Jadavpur University, Kolkata, West Bengal, India

## Abstract

Penning ion trap is a device used for three-dimensional confinement of ions for high precision nuclear and atomic physics studies. In a Penning ion trap, superposition of a strong homogeneous magnetic field and a weak quadrupole electric field confines the ions in a very small region. The uniformity and stability of magnetic field determines the confinement duration. An electromagnet has been fabricated in VECC for a room temperature Penning ion trap. As per design maximum axial magnetic field of 4.4 kgauss is expected. Elaborate cooling arrangements are made to keep the temperature of the coil within the permissible limit. A special type of coil with square cross section having a circular hollow inside is used for this purpose in which current flows through the outer portion of the coil and low conductivity water is circulated through the inner hollow. A COMSOL Multiphysics® simulation has been attempted to compute the magnetic field which is in reasonable agreement with measured values. A simulations study for the heat transfer to the circulating water is in progress. The heat transfer calculations are important to decide on the amount of mass flow rate of water required to maintain the temperature in the coil and the glass insulator within specified limits.

The magnet consists of two pancakes arranged vertically with a separation of 3cm with a central bore as shown in Figure 1. Each pancake consists of 32 helical coils and each helix has 7 turns. The coil carrying current is a hollow copper conductor having square cross-section. Low Conductivity Water (LCW) is circulated through the central bore of copper conductor for cooling. The spiral coil is casted in an epoxy for rigidity.

Simulation study has been performed using COMSOL Multiphysics® software considering a 2D axisymmetric model. Thus each pancake has been represented by 32×7 squares constructed at their respective positions each having a hole in them. A rectangle is created outside which borders the 32 blocks for filling in the insulation. A copy of this rectangular block is made and placed at a position symmetric with respect to the z=0 axis. A large domain boundary encloses the two pancakes as shown in Figure 2.

Magnetic field at the central point between two pancakes was determined using standard procedure. First we studied the effect of domain boundary dimension on magnetic field calculated. An optimal dimension of 1m X 1m was considered and magnetic field was calculated varying current density parameter which is in reasonable agreement with experimentally measured

shown in Figure 3. Magnetic field calculated along axis of the magnet was determined and spatial uniformity along axial direction is shown in Figure 4.

## Figures used in the abstract

**Figure 1**: Two pancakes of magnet with a central bore separated by 3cm gap having water cooling arrangement.

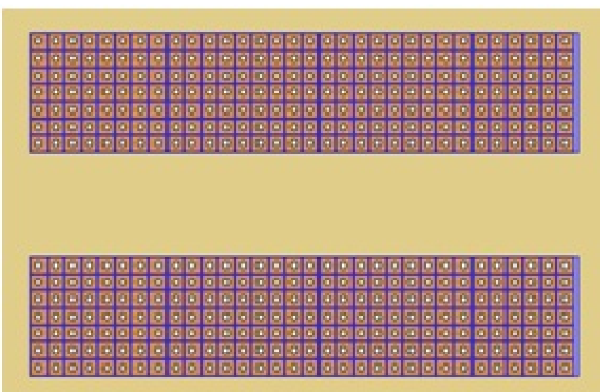

**Figure 2**: 2D representation of magnet coil.

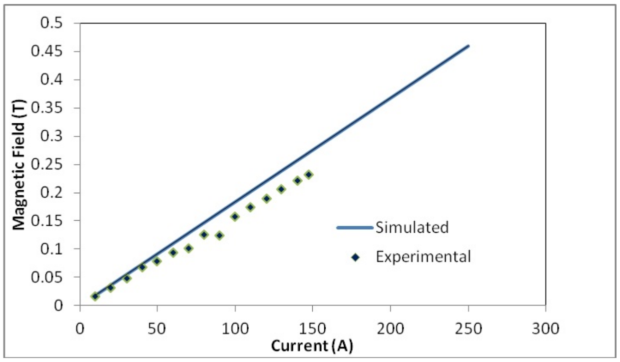


**Figure 3**: Magnetic field strength with current.

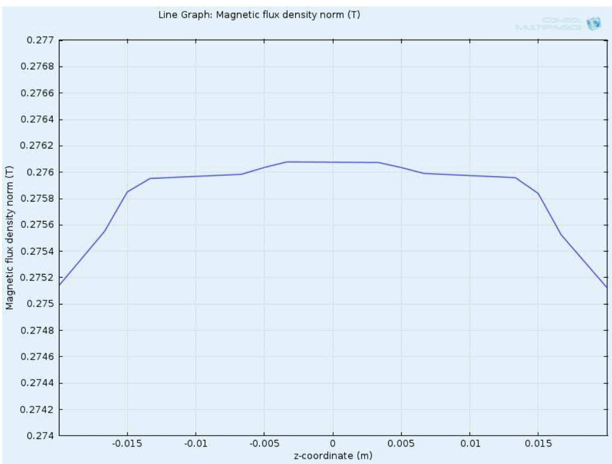


**Figure 4**: Uniformity of magnetic field along axis of the magnet.