MECHANICAL DESIGN AND FABRICATION OF A PROTOTYPE UNDULATOR FOR INDUS- 2

T. Veerabhadhraiah, Gautam Sinha, S. S. Prabhu
AMTD, RRCAT, Indore 452013

Abstract

An Apple II type undulator is proposed for 2.5 GeV SRS. For initial studies of magnetic parameters and manufacturing feasibilities, a 6 periods prototype undulator of period length 72 mm and pole gap 20 mm is under development. Mechanical structure with stringent tolerances is required to achieve the required field quality. Stress analysis has been done to study the deflection under the magnetic forces. The prototype structure along with the magnet block holders has been made and mechanical dimensions and geometric tolerances have been measured. In this paper we present the preliminary mechanical design and assembly of static parts of prototype undulator structure.

INTRODUCTION

The use of insertion devices that produce variable polarized light (linear, circular and elliptical) is increasing in the scientific community. Wealth of information about the properties of materials can be obtained by utilizing the controllable polarization of the radiation. Modern days SRS demand very stringent field quality (first integral better than 50 G.cm). Very precise mechanical structure is absolutely essential to achieve the required field quality. This motivated us to analyze the structural part of the pure permanent magnet (PM) Apple II undulator that can produce radiation in the energy range of 100 eV to 1000 eV. NdFeB permanent magnet blocks are planned to generate the required magnetic field. This prototype magnet has 6 periods with entry and exit blocks, overall length 522 mm. In this article the efforts for development of prototype undulator are briefly described.

Table 1: Parameters of prototype Undulator

Parameters	Value
Peak vertical field	7.6T
Peak horizontal field	5.0T
Period length	72 (4x18)mm
Pole gap minimum	20-30mm
Length of magnetic structure	522mm
Max. vertical force/row	1956 N
Max. horizontal force/row along beam axis	1000 N
Max. horizontal force/row transverse to beam axis	3940 N

MECHANICAL DESIGN AND FABRICATION

The prototype magnetic structure consists of 4 quadrants of NdFeB permanent magnetic block arrays. For changing polarization of the magnetic field, sliding arrangement will be provided to diagonal arrays (bottom back and top front).

The permanent magnets of size 18x40x40 mm^3 will be assembled on 'magnet holding blocks' (Fig. 1) made out of aluminium alloy (A2014-T6). These blocks will be assembled on stainless steel (SS 316) beam to form an array of magnetic structure as shown in Fig. 3. Figure 2 shows orientation of two arrays. In this undulator two arrays will be fixed (bottom front and top back) and rest two are movable (bottom back and top front). The movable quadrants will be mounted on very precise linear motion(L/M) guides and the sliding of quadrants will be carried out using ball screw and step motors. Bottom two arrays will be assembled on a bottom horizontal beam and top arrays on to the top horizontal beam. These horizontal beams will be assembled on vertical frame. Figure 4 shows the overall view of prototype undulator.

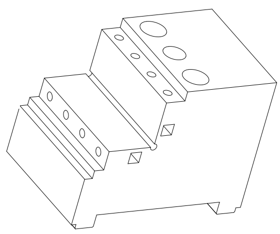

Figure 1: Magnet holding block.

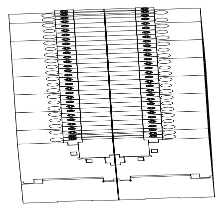

Figure 2: Orientation of two arrays.

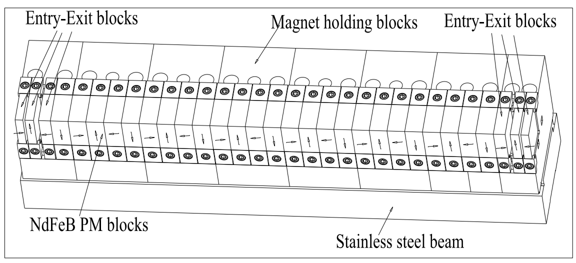

Figure 3: Assembly of array of magnets with magnetic direction orientation.

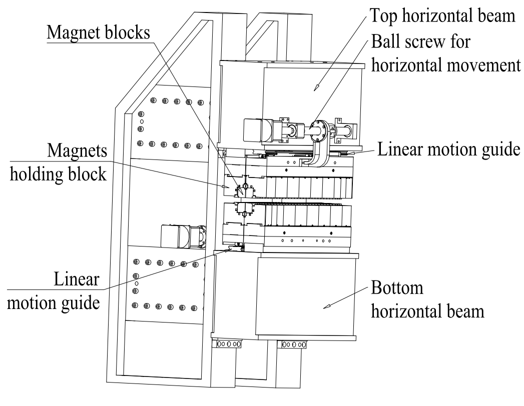

Figure 4: Prototype Undulator Magnet for Indus-2.

The major challenge of designing such undulator is to keep the field integrals within acceptable limit for all gaps and phases. We have chosen three end blocks at each end. Simulation results indicate that with this arrangement, we will be able to get the variation of the first field integral within 50 G·cm for all phases without using any correction coils. The variation of the vertical (By) and transverse (Bx) field on the nominal axis along the beam direction for circular polarisation mode at 20 mm pole gap is shown in Fig. 5. The presence of phase difference between the vertical and transverse field is quite evidence from the figure but the field amplitude is same, which is the required condition for generating circular polarisation. It is also evident that the vertical and transverse fields are symmetric and asymmetric, respectively with respective to the midpoint of the undulator.

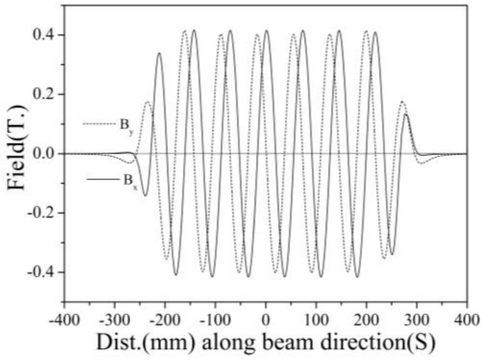

Figure 5: Variation of vertical field (B_y) and transverse field (B_x) along the beam direction for circular polarisation mode.

Magnetic forces are tabulated in the table 1. To achieve these field integral the pole gap and orientation of magnetic blocks in rows with entry and exit blocks are very important. The frame and horizontal beams of the prototype undulator is designed such that for a typical vertical magnetic force of 4 kN the deflection of the girder is 0.006mm as shown in Fig. 6.

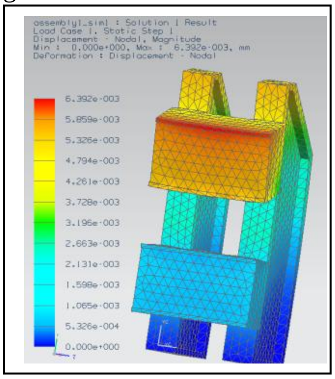

Figure 6: Deflection analysis results of assembly of frame and horizontal beams for vertical magnetic forces

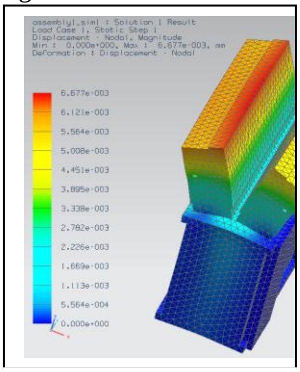

Figure 7: Deflection analysis results of assembly of two arrays on horizontal beam for horizontal magnetic forces

Horizontal beams design is also checked for deflections due to typical horizontal (attractive/repulsive) forces between two magnetic arrays transverse to beam axis. A horizontal force of 4 kN leads to the deflection of 0.007mm as shown in Fig. 7.

Figure 8: Photograph of assembled supporting structure.

Figure 8 shows the photograph of the mechanical structure of prototype Undulator. The procurement of L/M guides, ball screws, permanent magnetic blocks is under process. In this photograph the length of magnetic arrays assembled is 150 mm only. The important geometrical tolerances measured on this structure are tabulated in table 2.

Table 2: Measured geometrical tolerances

Parallelism of bottom surface of top horizontal beam wrt top surface of bottom horizontal beam	0.020mm
Flatness of bottom surface of top horizontal beam	0.010mm
Flatness of top surface of bottom horizontal beam	0.010mm

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[1] Construction of Elliptical Undulators for Eletra, B. Diviacco, R. Bracco, EPAC 2000, Vienna, Austria.

[2] Fabrication and Measurement of PLS EPU6 Undulator, D.E. Kim, H.G. Lee, Pohang Accelerator Laboratory, Korea, Proc. APAC 1998.