DIPOLE MAGNETS FOR THE LNLS SYNCHROTRON LIGHT SOURCE

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Abstract

The Brazilian Synchrotron Radiation Laboratory (LNLS) is designing and building an electron storage ring for the production of VUV and soft x-ray photons. This paper describes the design of a 1.4 m long, 1.4 T (58 mm gap) staggered dipole magnet with a good field region (10^{-4}) of ± 10 mm. The laminated yoke is made out of commercial 1006 steel and the square copper coils are supplied with less than 300 A.

1. INTRODUCTION

The electron storage ring, under design at LNLS, requires 12 bending magnets operanting from 0.12 Tesla (at injection) to 1.40 Tesla (at 1.15 GeV)[1].

The design envisages a staggered C-type yoke, for easy extraction of synchrotron light, with a gap of 58 mm (Figure 1). The gap was initialy chosen according to the minimun requirements for the vacuum chamber and, then, adjusted in order to optimize the height of each coil pancake. The main parameters of the magnet are presented in Table 1.

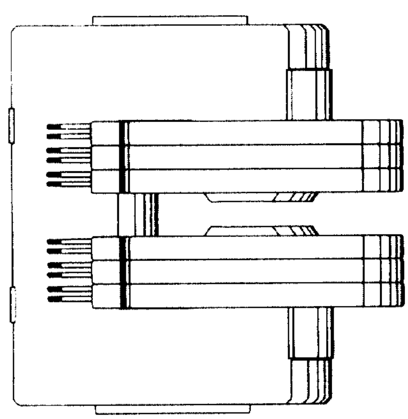

Figure 1: Dipole view

Operating field	0.12 to 1.4	T
Maximum design field	1.52	T
Gap (without shims)	58	mm
Excitation	68 ·	kA · turn
Operating current	20.8 to 236	A
Maximum design current	265	A
Shims height	0.6	mm
Required good field region:		
1.10^{-4}	± 10	mm
1.10^{-3}	± 30	mm
Total deflection	30	degrees
Yoke length	1.416	m
Bending radius	2.735	m
Power comsumption (1.4T)	12.4	Kw

Table 1: Main parameters of the bending magnets.

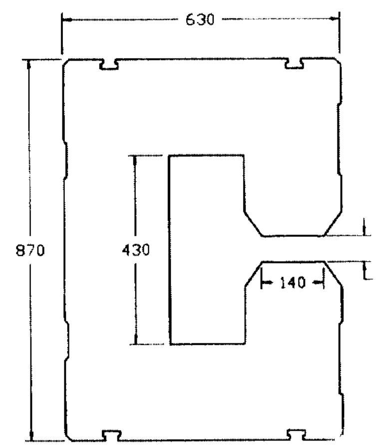

Figure 2: Dipole lamination

Two dimensional field calculations have been made in order to determine the dimensions of the laminations (Figure 2), using the code MAGNET[2]. The permeability curve, used in these calculations, was that of a 1006 steel produced by the Brazilian industry, measured at GANIL (France), using a semi-automatic permeameter[3]. The calculated homogenity for the extreme values of the field is shown in Figure 3.

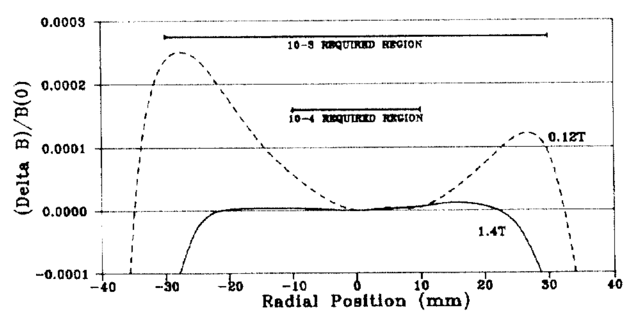

Figure 3: Field homogeneity at 1.4 T and 0.12 T

The magnet was design to be used with an up to 300A power supply[4] and 4 Atms maximum water pressure. As a result the coil window is some what larger than usualy and power consumption during operation relatively low.

2. YOKE ASSEMBLY

The first prototype is under constrqction. The 1.5 mm thick laminations will be punched with a two-stage die from cold-rolled 1006 steel with phosphate coating. The stacking bench, machined with the bending radius, uses the botton and front edges of the laminations as references.

The stacking procedure, without glue, uses, for compression, the endplates and the longitudinal plates which are welded to the laminations before releasing the hydraulic jacks (Figure 4). This procedure has the advantage that, during welding, the longitudinal plates are under tension while the laminations are compressed. Fixing holes, along the longitudinal plates, allow for moving one of the stop plates with jacks, so that partial stacks can be compressed.

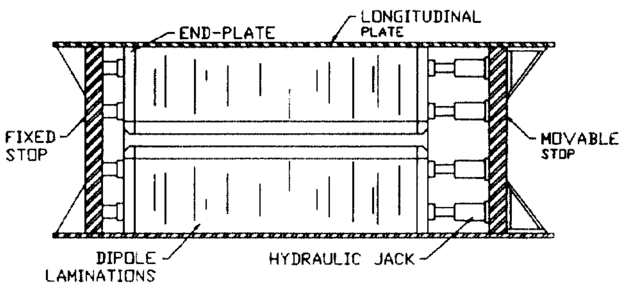

Figure 4: Stacking fixture

The curved plates, welded to the each side of the yoke, are not welded under tension. Their purpose is to fix the laminations to each other, in adition to the welding of the longitudinal plates, strengthening the yoke for torsion.

After welding, the longitudinal plates are cut close to the endplates.

3. COILS

Each magnet is excited by six pancakes, each one with two double-layer windings with 24 turns of 7/16" X 7/16", 7/32" internal diameter, OFHC hollow conductor. The conductor is insulated with 0.5 mm thick fiber glass sleeve. The pancakes are insulated from the yoke by 3 mm of fiber glass tape and open wave fiber glass cloth. The set is epoxy impregnated under vacuum.

Each winding is made of a single conductor (without joints). Half of the conductor is left on the spool, over the winding table, while the first half of the winding is being done. The main characteristics of the magnet coil is shown in Table 2.

Conductor copper cross-section	95.7	mm^2
Current density	2.46	A/mm^2
Total number of turns	288	
Number of pancakes	6	
Number of windings	12	
Packing factor	55	%
Water pressure	3.6	Atms.
Water temperature increase	11	^oC

Table 2: Characteristics of the bending magnet coil.

4. FIELD MAPPING SYSTEM

The field mapping equipment (Figure 5) was made out of the bench of a lathe with adapted stepper motors (1000 steps per revolution) and digital scales with a resolution of $5\mu m$ for both, longitudinal and transverse, movements. The total range is 1800 X 250 mm^2.

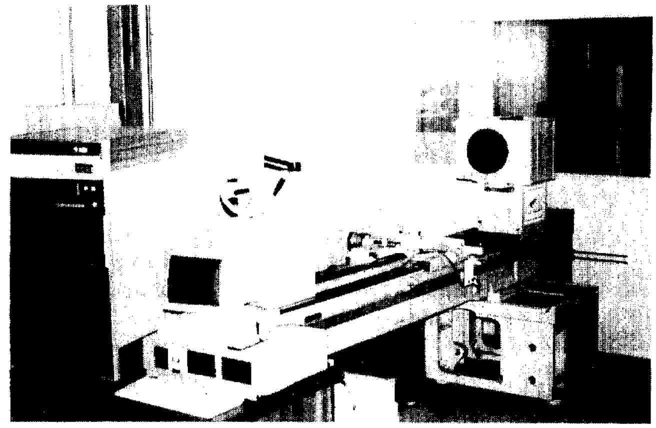

Figure 5: Field mapping system

Field measurements are made with temperature compensated Hall probes and a Teslameter GMW DTM141d. The probe support, made of laminated glass epoxy (G-10), is long enough to avoid relevant perturbation on the field by the steel bench.

The system is computer-controlled allowing for flexible and fast measurements. One of the softwares already developed, for example, moves the probe as if it were an electron, while it measures the field. The operator, in this case, has to place the probe in the initial position and supply the computer which energy data and initial direction of movement of the electron.

5. CONCLUSIONS

The most relevant aspects of the LNLS storage ring dipole design have been discussed. 2D calculations show sufficient field homogeneity for both injection and operating energy. A new procedure for the stacking of yoke laminations, which applies stresses to both parts to be welded, has been presented. A field mapping system was built and tested with a smaller 1 Tesla dipole magnet used as a spectrometer for the LNLS linear accelerator.

Acknowledgments

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References

[1] L.Lin, L. Jahnel & P. Tavares, "A Magnet Lattice for the LNLS UV Synchrotron Light Source" - This proceedings.

[2] Iselin, Ch., "MAGNET CODE" - CERN Program Library Long Write-up T600 (1989).

[3] Eveillard, C. et al: "Perméametre Automatique Destiné à la Mesure des Caractéristiques Magnétiques des Aciers du GANIL", Ganil 782/150/AI/121.

[4] D. Wisnivesky; A. C. Lira & J. A. Pomilio, "Bending Magnet Power Supply with Swithing Series Regulator" - This proceedings.