A.9: Prototype dipole magnet development for 700 MeV booster synchrotron

The existing booster dipole magnets of booster synchrotron were made in the year 1995 and since then working satisfactorily for acceleration of electron beam up to 550 MeV. These are the 60^0 sector type laminated magnets, epoxy glued, made from 0.35 mm thick CRGO Si steel. The bonding between the glued laminations is weakened over the period of time, which prevents its operation up to 700 MeV. The up-gradation of dipole magnets have been taken up with improved fabrication techniques and field homogeneity (0.05%) in order to extract beam at 700 MeV for the injection into Indus-2. In this report, prototype development of dipole magnets and its characterization is presented.

The new magnets are required to be operated from 0.037 Tesla (20 MeV) to 1.3 Tesla (700 MeV) with a repetition rate of 1.5 Hz. At very low excitation like 0.037T at 20 MeV, the field uniformity in the pole gap (52 mm) is dominated by the spatial variation of the remanent field. To select suitable soft magnet cores in order to investigate the effect of remanent field on its field quality, two short length (0.8 m) dipole magnets (silicon and low carbon steel cores) were made and tested. It has been observed that the field quality of the silicon steel dipole magnet is greatly affected by remanence as compared to the low carbon steel dipole magnet. Figure A.9.1 shows the spatial variation of the remanent field for these magnets.

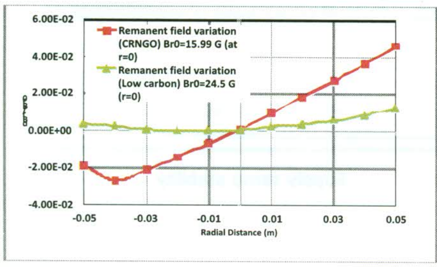

Fig. A.9.1: Remanent field variation in the pole gap

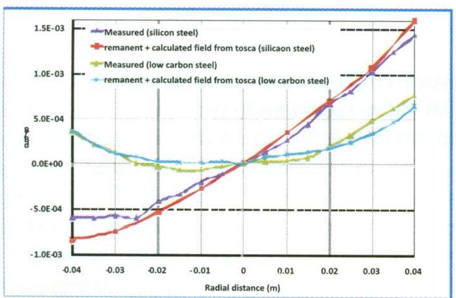

Fig.A.9.2: Comparison of the measured and simulated results.

Magnet design code like OPERA-3D (TOSCA solver) does not take into account the effect of remanent field. At very low excitation i.e. 0.037 T @ 20 MeV, superimposition of remanent fields with calculated fields from TOSCA led to an excellent agreement with the measured results as shown in Fig. A.9.2. At lower excitation close to injection energy, the radial field quality is observed better for low carbon steel magnet than that of Si steel magnet.

Therefore, it was decided to fabricate an actual size prototype dipole magnet using 1.5 mm thick low carbon steel laminations. Magnet assembly has been designed and fabricated from two geometrically identical half laminated cores, having provision for finish machining at their poles. Number of small sector angled laminated blocks were fabricated that consist of a group of cut laminations and full size laminations for making 60° sector core. All the sector core blocks, glued entry and exit profiled blocks were inserted in between non-magnetic stainless steel end plates in a stacking fixture and compressed to the outer core arc length of 1977 mm with a lamination packing factor (> 95 %) and to a sector angle of 60 degrees, then welded and finish machined. The pole gap geometrical accuracy was maintained to 52 +/- 0.050 mm in the entire length of the assembled magnet. Figure A.9.3 shows the prototype dipole magnet assembly and the details of half lamination.

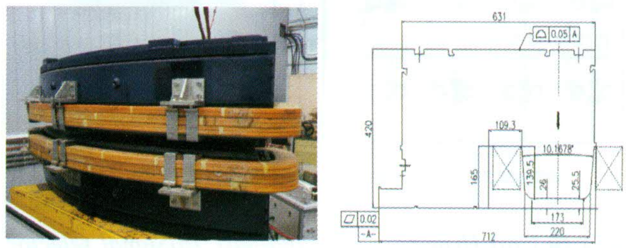

Fig. A.9.3: Prototype dipole magnet assembly (half lamination details shown at right).

Measured magnetic field uniformities inside the pole gap of prototype magnet at different energies are shown in Fig. A.9.4.

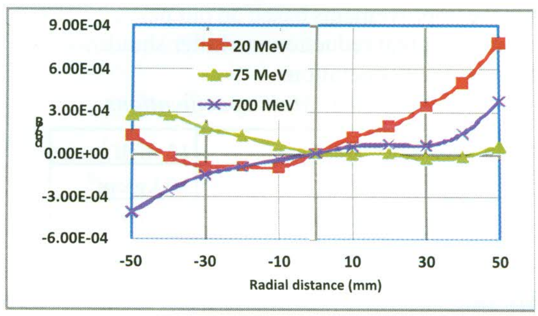

Fig. A.9.4: Measured magnetic field uniformity in pole gap of proto type dipole magnet.

Reported by:
K. Sreeramulu (sreeram @rrcat.gov.in), S.Das, Vanshree Thakur and R.S.Shinde