A.2: Development of mass spectroscopy analyser dipole magnets for BARC

Mass spectrometers with sector field magnetic analyzer are routinely used for the high precision and accurate measurements of isotope ratio of materials. Accelerator Magnet Technology Division (AMTD) has designed and developed various mass spectrometer analyzer dipole magnets (DP) as per the specifications of Technical Physics Division of BARC, Mumbai. Earlier nine magnets were developed and delivered to BARC. Recently, two dipole magnets have been designed, developed and characterized by AMTD. Table A.2.1 shows the specifications of recently developed dipole magnets.

Table A.2.1: Specifications of dipole magnets.

Description	DP-200R	DP-300R
Max. Magnetic field	0.8 T	0.7 T
Pole gap	14 mm	16.5 mm
Bending radius	200 mm	300 mm
Bending angle	90°	
Entry angle	26.5°	
Exit angle	26.5° (± 5°)	
Required Pole exit angle adjustment	± 5º with step size of 0.5º	
Radial magnetic field homogeneity	300 ppm in ± 20 mm from central radius.	

The magnets were designed using TOSCA 3-D code with simple pole end chamfers at the pole ends with 3 plain steps instead of Rogowski profile to achieve the required field quality. The core geometry of both the magnets is of C-type, made from two identical half core assemblies. The magnet cores were developed using 40 mm thick low carbon (C ~ 0.08%) steel plates. The geometrical accuracy in the pole gap of both the magnets was controlled within ± 0.020 mm on their nominal pole gap size for achieving the specified magnetic field homogeneity. The magnets were provided with simultaneous swiveling of pole edges (top & bottom) at their exit side to vary the edge angles up to ± 5º. DP-200R requires 5000 ampere-turn (AT) per pole and DP-300R requires 5200 AT per pole to achieve 0.8 T and 0.7 T respectively. Accordingly, two air cooled coils per magnet have been fabricated using enamelled copper winding strip of size 2.5 mm x 6 mm and the wound coils were impregnated with F-class epoxy resin. Figure A.2.1 shows the photographs of completed DP-200R and DP-300R dipole magnets.

The magnetic field measurements were carried out using a Hall probe attached to a 3-axis field measurement bench. The measurements were done at 0.3 T, 0.5 T, 0.7 T or 0.8 T magnetic fields. The measured magnet parameters include (i) magnetic length (ii) entry/exit edge angle (with exit angle rotation at 0º and ± 5º) (iii) current vs central magnetic field and (iv) magnetic field uniformity [$(B-B_0)/B_0$] in radial and longitudinal directions in both the magnets. Table A.2.2 shows the measured magnetic lengths in DP-200R magnet at 200 mm radius and in DP-300R magnet at 300 mm radius. Figure A.2.2 shows the magnetic field obtained with excitation current and Figure A.2.3 shows the measured radial field uniformity in DP-200R and 300-R magnets.

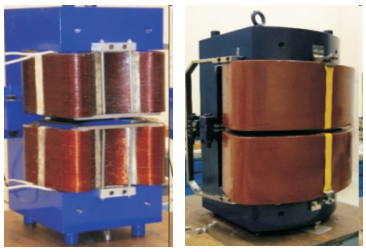

Fig. A.2.1: DP-200R (left) and DP-300R (right) dipole magnets.

Table A.2.2: Measured magnetic lengths.

Field (B)	DP-200R	DP-300R
0.3 T	318.17 mm	475.80 mm
0.5 T	318.69 mm	476.29 mm
0.8 T	318.60mm	476.92 mm at 0.7 T

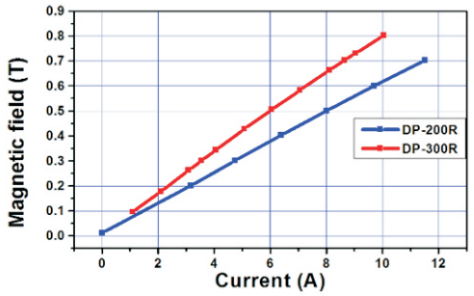

Fig. A.2. 2: Current vs central field in dipole magnets.

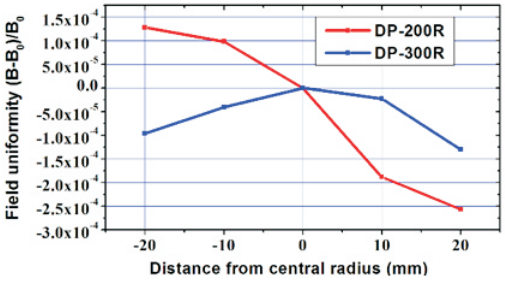

Fig. A.2.3: Measured radial field uniformity in DP-200R and 300-R magnets.

The results of field measurements of the magnets were accepted by Technical Physics Division, BARC, Mumbai.

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