3D MAGNETIC FIELD COMPUTATIONS AND COMPARISON WITH MEASUREMENTS*

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Abstract

3D calculations have been made for an H frame magnet mounted in a steel box for a d-c separator. In the computations, steel is assumed to be of infinite premeability. Measurements have been made on this magnet, which are compared with the computations.

A picture frame magnet with coils on the return legs has been mounted symmetrically within a rectangular steel box with rectangular cut-out in each of its two end faces. The picture frame has inside dimensions 13-1/2-in. x 13-1/2-in. with a length of 6-1/4-in.; the frame thickness being 3/4-in. The clearance between the frame and the steel box is 3/4-in. except at the ends, in the z-direction, where it is greater, because the length of the steel box is 2 L = 16-7/8 in. The dimensions of the rectangular cut-out are 8-in. in the y-direction, which is the direction of the main flux, and 1-5/8-in. in the x-direction. The two legs of the magnet are wound with a thin coil.

Hall probe measurements on this not very carefully assembled model magnet were integrated and are tabulated below together with the corresponding computations, see Table I.

TABLE I

$$\int_{-L}^{L} B_y(x=0;y)\,dz \Big/ \int_{-L}^{L} B_y(0;0)\,dz - 1$$

y (in.)	Measurement	Computation
0	0	0
+0.5	0.05%	0.125%
-0.5	0.16%	
+1.25	0.59%	1.4%
-1.25	0.86%	
-2.25	2.66%	5.3%

The computations were made with a simple program using scalar potentials, which was written within one day and which executed correctly the next day on the CDC 6600 computer. The edit part of the program took then a week to complete. An octant of the real model is used for reasons of symmetry. The boundary potentials are zero except at the iron core where V = y (V = const = y_{coil} at the yoke).

Rapid iteration by the extrapolated Liebmann method with Frankel-Young convergence of potentials is used. The edit subprogram fits a Taylor series truncated after the third order terms; central difference differentiation is being used in order to obtain the integrals H_x dz and H_y dz. The computed results of Table I have been obtained with a problem space of 91500 points total. The potentials here are written into large core memory of the CDC 7600. Two-hundred and sixty iterations bring the residual down to less than 2×10^{-4}, corresponding to displacements of the $\int_{-L}^{L} B\,dz$ values of less than 3×10^{-3}. The cost of running this problem on the CDC 7600 was $154.

The program has meanwhile been completed with current cuts and shims for the magnet presently under construction.

The two important uses of this program were, to develop the three-dimensional aspects for a new subroutine of the ray tracing program. A set of selected points will then be measured and used in the ray tracing computations; and to learn about accuracy requirements and shimming techniques for the magnet.

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