MAGNET DIVISION NOTES

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Task Force: Coil Geometry Analysis

Title: Harmonics due to Unclosed Iron Laminations

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Harmonics due to Unclosed Iron Laminations

R. Gupta and S. Kahn

In an earlier note[1] Morgan computed the effect of unclosed iron laminations on the low field harmonics with the help of computer code MDP. MDP gave very small change in harmonics due to this imperfection. Recently the magnet DD0017 is found to have large a_1' (about 4 units) and b_1' (about 3 to 6 units for Z $<$ 500 inches and -8 units for Z $>$ 500 inches). MDP calculations do not explain these numbers based on unclosed iron lamination theory. It was thought that may be MDP is not reliable for such analysis and these computations should be done with POISSON or PE2D.

We use POISSON to examine the change in harmonics due to symmetrically split iron laminations. As in MDP calculations, we assume a uniform 20 mil gap (10 mil + 10 mil), both in horizontal and in vertical plane. A special care was taken to avoid the changes in mesh when modelling the split (air gap). At the midplane, a new region was created which is iron for the closed laminations and is air for the unclosed. At the aperture, the change due to split is so small that the mesh remains practically the same. Please see Table 1 and Table 2 for the results of calculations. We find that the POISSON and MDP results agree quite well.

We use PE2D to examine the unallowed harmonics. PE2D provides a simple mechanism to reflect the mesh from the first quadrant into other quadrants. Two asymmetric cases were examined. The first case has a gap of 125 mils above the midplane but not below. Only the right half is modelled. Boundary conditions are used to impose reflection symmetry about the X = 0. Figure 1 shows a sketch of the model. This model consequently has right-left symmetry and up-down asymmetry. We expect that odd b_n' should vanish. Table 3 gives deviations in harmonics between this model with the gap opened on the upper midplane on both the right and left side. The harmonic deviations are normalized so that they correspond to a gap of 10 mils. The second case models the upper half plane with a gap of 125 mils on the right hand side. Boundary conditions impose reflection symmetry about the midplane. Figure 2 shows this model. The results of the calculation of harmonic deviations are given in Table 4. Since we have a right-left asymmetry we

expect that odd $a_n^{'}$ do not exist. The harmonic deviations are normalized so that they correspond to a gap of 10 mils (since there is up-down symmetry there is a full separation of 20 mils).

From the results presented the opening of the yoke as an explanation of the large $b_1^{'}$ or $a_1^{'}$ is unlikely. To obtain a $b_1^{'}$ of the order of -8 units would require a gap of $\frac{1}{2}$ inch.

References

1. G. Morgan, "The Magnetic Properties of Horizontally Split vs Vertically Split Iron Laminations in the SSC Dipole", Magnet Division Note No. 193-1 (SSC-MD-144), Sep 19, 1986.

Table 1: Values of the change (unclosed-closed) in the Transfer Function and Field Harmonics due to unclosed laminations in Horizontally Split case

Computer Code	$\delta TF/(TF)_0$ 10^{-4}	$\delta b_2^{'}$ 10^{-4}	$\delta b_4^{'}$ 10^{-4}	$\delta b_6^{'}$ 10^{-4}	$\delta b_8^{'}$ 10^{-4}	$\delta b_{10}^{'}$ 10^{-4}
POISSON	-36.8	-0.34	0.01	0.00	0.00	0.00
MDP	-35.1	-0.33	-0.01	0.00	0.01	0.00

Table 2: Values of the change (unclosed-closed) in the Transfer Function and Field Harmonics due to unclosed laminations in Vertically Split case

Computer Code	$\delta TF/(TF)_0$ 10^{-4}	$\delta b_2^{'}$ 10^{-4}	$\delta b_4^{'}$ 10^{-4}	$\delta b_6^{'}$ 10^{-4}	$\delta b_8^{'}$ 10^{-4}	$\delta b_{10}^{'}$ 10^{-4}
POISSON	-9.7	-0.54	-0.01	0.00	0.00	0.00
MDP	-9.1	-0.55	0.01	0.00	0.00	0.00

Table 3: Deviations in Transfer Function and Field Harmonics due to a 10 mil gap in the Upper Plane on both the Left and Right Side. (See figure 1) All entries are units of 10^{-4}. The harmonics are calculated at 1 cm.

n	$\delta b_n'$	$\delta a_n'$
0	-5.31^*	-0.057
1	– –	-0.069
2	-0.198	-0.037
3	– –	-0.003
4	-0.009	0.007
5	– –	0.000
6	-0.002	-0.004
7	– –	0.000
8	-0.002	0.001
9	– –	-0.001
10	-0.001	-0.001

Table 4: Deviations in Transfer Function and Field Harmonics due to a 10 mil gap in the Right Plane in both the Upper and Lower Half. (See figure 2) All entries are units of 10^{-4}. The harmonics are calculated at 1 cm.

n	$\delta b_n'$	$\delta a_n'$
0	-7.43^*	0.077
1	-0.176	– –
2	-0.224	-0.126
3	-0.017	– –
4	-0.035	-0.067
5	0.002	– –
6	0.002	-0.038
7	0.000	– –
8	0.003	-0.030
9	0.001	– –
10	0.006	-0.022

* indicates relative deviation in transfer function, i.e. $\frac{\delta TF}{(TF)_0}$.

Figure 1:

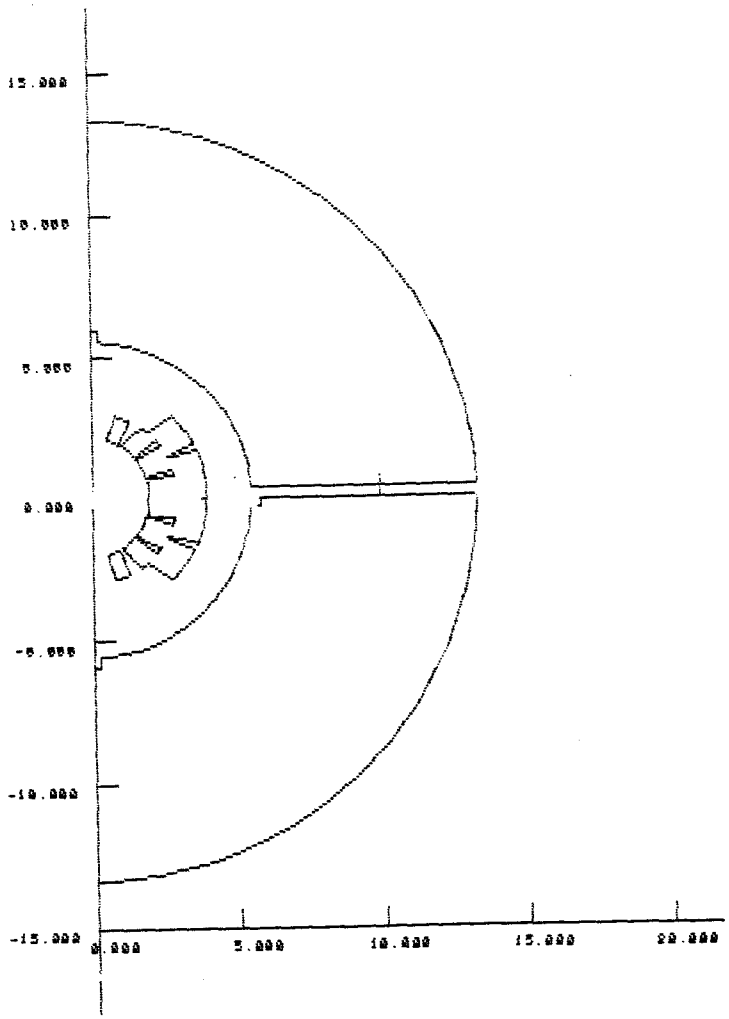
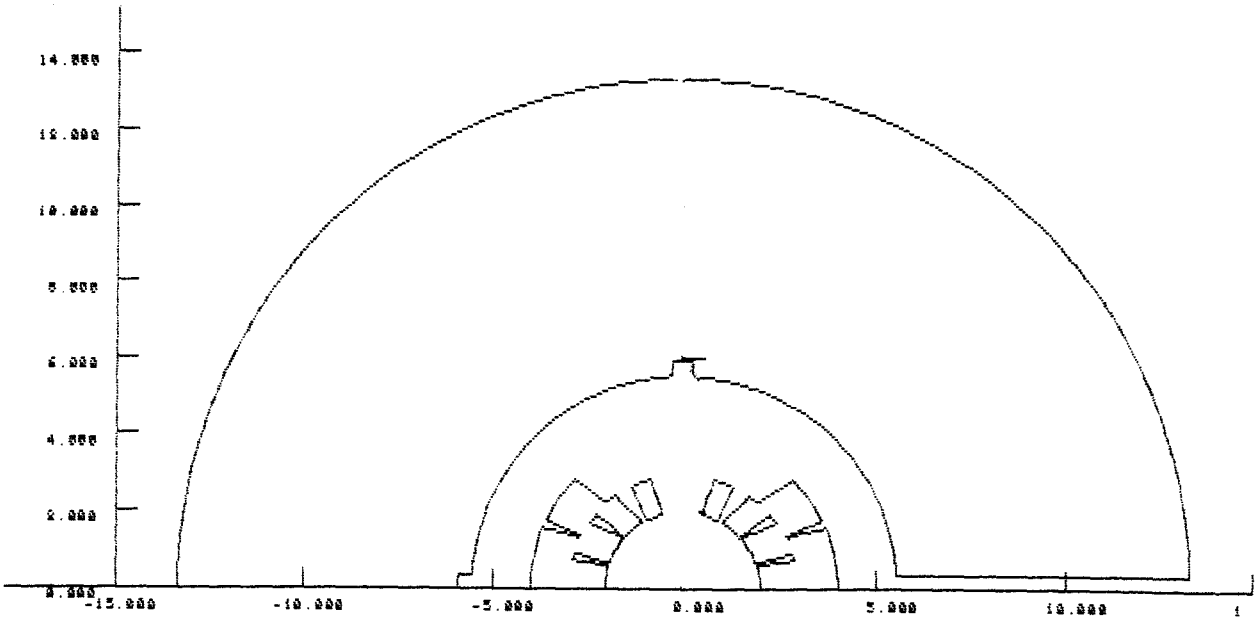


Figure 2:



PE2D