Fermilab

TM-1300
2751.000

AN APERTURE STUDY

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March 1985

A simple computer study was done to compare the effect of an aperture reduction from 5cm to 4cm on the cable conductor requirements. Two extreme cases were considered; first the same cable, and second, the cable width was changed to be the same radial percentage of the aperture. The current density was then adjusted to produce the same central field. The field quality was computed at 2/3 aperture. The starting assumptions for the study were as follows:

1. Allowed wedges
2. Scaled conductor thickness aperture
   (most efficient)
3. Start with 'FNAL' SSC design type (air core)
   44turn/quadrant
4. 1.5cm adequate radial collar thickness
5. Optimize harmonics to within 1 order of magnitude for sextupole on all acceptable configurations
6. Low carbon steel saturation
7. 6T central field
8. Coil IR's - a) 2.604cm
   b) 2.380cm
   c) 2.25 cm
   d) 2.13 cm
   e) 2.00 cm
9. Cables - a) .135 x .983 .03" strand diameter-25 strands/cable
   b) .123 x .983 (1) .028" strand diameter-28 strands/cable
   .898 (2)
   c) .117 x .983 (1) .0265" strand diameter-28 strands/cable
   .849 (2)
   d) .111 x .983 (1) .0253" strand diameter
   .804 (2)
   e) .104 x .983 (1) .024" strand diameter
   .755 (2)

Numbers to use as a gauge:

Cu/Sc Vol Saver 1.8/1 low β 1.4/1

44.5KG ═ $48.6 kA/cm^2$

The cases considered for the iron designs were the extremes: first, that the iron was only a shield and contributed $\lesssim$ 1% to central field, second, that the iron was only brought in as close as it could be and not be saturated (linear) and third, that the iron was as close to the collars as it could be - maximum transfer function.

Design #'s	Iron Radius (cm)	IR (cm)	Conductor Type	J Current density at 6.0T kA/cm^2	2 dimen High Field Percent	Current 6.0T (kA)
100	20.32	2.604	a	53.4	1.08	7.09
101	18.57	2.38	b (1)	54.5	1.077	6.592
102	18.57	2.38	b (2)	58.6	1.08	6.470
103	17.56	2.25	c (1)	54.9	1.073	6.315
104	17.56	2.25	c (2)	61.7	1.074	6.131
105	16.62	2.130	d (1)	55.5	1.079	6.060
106	16.62	2.130	d (2)	65.1	1.081	5.810
107	15.61	2.00	e (1)	56.4	1.073	5.770
108	15.61	2.00	e (2)	69.5	1.08	5.456

<u>Air Core</u> <u>Iron Shielded</u>

Design #'s	Iron Radius (cm)	IR (cm)	Conductor Type	J Current density at 6.0T kA/cm^2	2 Dimen High Field Percent	Current 6.0T (kA)
180	7.65	2.604	a	44.9	1.037	5.955
181	6.90	2.38	b (1)	45.3	1.035	5.477
182	7.0	2.38	b (2)	48.7	1.038	5.380
183	6.77	2.25	c (1)	46.0	1.038	5.291
184	6.55	2.25	c (2)	51.6	1.05	5.126
185	6.65	2.13	d (1)	46.9	1.04	5.117
186	6.29	2.13	d (2)	54.9	1.046	4.897
187	6.25	2.00	e (1)	47.4	1.038	4.846
188	6.06	2.00	e (2)	59.0	1.044	4.636

Linear Cold Fe Solutions

	Harm(x 10^{-2}) 30	50
190	.09	.003
191	.08	.001
192	.12	.001
193	.11	.007
194	.16	.008
195	.14	.008
196	.22	.009
197	.14	-.012
198	.25	.015

Design #'s	Iron Radius (cm)	IR (cm)	Conductor Type	J Current density at 6.0T kA/cm^2	2 Dimen High Field Percent	Current 6.0T (kA)
110	6.15	2.604	a	41.0	1.036	5.435
111	5.90	2.38	b (1)	42.8	1.058	5.173
112	5.73	2.38	b (2)	45.8	1.06	5.061
113	5.77	2.25	c (1)	43.5	1.057	5.005
114	5.50	2.25	c (2)	48.6	1.06	4.827
115	5.65	2.13	d (1)	44.4	1.058	4.844
116	5.29	2.13	d (2)	51.7	1.063	4.611
117	5.52	2.0	e (1)	45.5	1.057	4.660
118	5.06	2.0	e (2)	55.6	1.06	4.365

<u>Non Linear Fe</u> (As close as possible)

(Finite μ not taken into account)

<u>Cold Fe</u>

	HARM (10^{-2}) 30	50	Aperture
130	.111	.03	1.7
131	.101	.01	1.55
132	.161	.04	1.55
133	.14	- .01	1.45
134	.24	.04	1.45
135	.18	- .03	1.39
136	.31	.03	1.39
137	.16	- .03	1.31
138	.33	.04	1.31

Field Quality

Not Optimized

Completely

The results of the study seem to indicate that the smaller the aperture the higher the current density needed to obtain a given central magnetic field. See the following sets of graphs.

Aperature Study
Talk ADM 12/13/84