

Estimate of eddy current power loss in the dipole vacuum chamber

Y. Y. Lee

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Collider Accelerator Department
Brookhaven National Laboratory

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ESTIMATE OF EDDY CURRENT POWER LOSS
IN THE DIPOLE VACUUM CHAMBER

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Y. Y. LEE
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ACCELERATOR DEVELOPMENT DEPARTMENT
Brookhaven National Laboratory
Upton, N.Y. 11973

ESTIMATE OF EDDY CURRENT POWER LOSS IN THE DIPOLE VACUUM CHAMBER

Y. Y. LEE

Recently there was some concern about the heating of the vacuum chamber in the booster dipoles due to the eddy current. A crude estimate of the eddy current power loss in the vacuum chamber of the dipole magnet is done. Suppose we can approximate the vacuum chamber cross section as a rectangle of width W height H and thickness T . The voltage generated at the side wall can be expressed by

$$V = \dot{B} W/2 L$$

where \dot{B} ; rate of magnetic field rise

L ; length of the chamber

The power in the side wall can be expressed

$$P_{\text{side}} = 2V^2 / (72 \cdot 10^{-8} L/H/T)$$

where 72×10^{-8} is resistivity of the vacuum chamber material.

$$P_{\text{side}} = 6.94 \cdot 10^5 \dot{B}^2 W^2 L H T$$

The voltage at distance X from the center on the top and bottom plate can be expressed

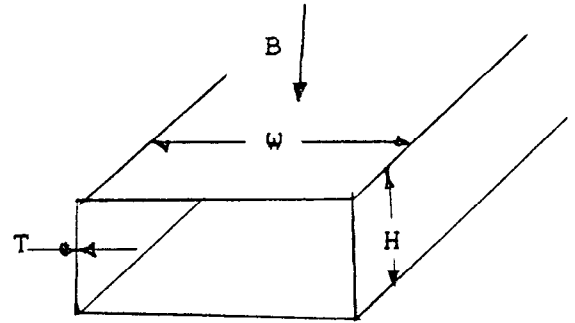
$$V = \dot{B} X L$$

and power can be expressed

$$\begin{aligned} P_{\text{T and B}} &= 2 \int_{-W/2}^{W/2} V^2 T / (72 \cdot 10^{-8} L) dx \\ &= 2.78 \cdot 10^6 T L \dot{B}^2 \int_{-W/2}^{W/2} X^2 dx \\ &= 2.78 \cdot 10^6 T L \dot{B}^2 W^3 / 12 \end{aligned}$$

and the total power is

$$P_{\text{total}} = 6.94 \cdot 10^5 \dot{B}^2 W^2 L T (H + W^3/3)$$



for example, if we assume

\dot{B} ; 6.5 Tesla/sec

W; .15 m (6 inches)

T; 2 mm

H; 3.8 cm (1.5 inches)

P_{side} = 50 watts/m

$P_{\text{T and B}}$ = 1.5 watts/m

P_{total} = 51.5 watts/m

The power losses are significant. However, compared to the estimated power requirement of 400 watts/m in order to bake the vacuum chamber at the temperature of 200°C, temperature rise expected, due to continued pulsing, does not seem too excessive.