

Estimate of eddy current power loss in the dipole vacuum chamber

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ESTIMATE OF EDDY CURRENT POWER LOSS
IN THE DIPOLE VACUUM CHAMBER

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ESTIMATE OF EDDY CURRENT POWER LOSS IN THE DIPOLE VACUUM CHAMBER

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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

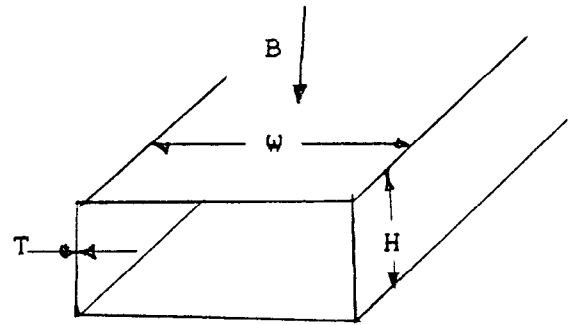
$$V = \dot{B} X L$$

and power can be expressed

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

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)

$P_{\text{side}} = 50 \text{ watts/m}$

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

$P_{\text{total}} = 51.5 \text{ watts/m}$

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.