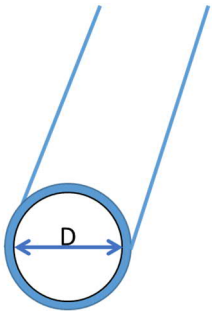
Exercise

A cylindrical superconducting shell of diameter D=25,6 mm is carrying a current I_{rms}= 1968 A at a frequency f=50 Hz. We aim at calculating the hysteresis losses per meter length of the superconductor as function of its critical current density 100 A/m<J_c< 1000 A/m. For this purpose, we use a semi-empirical equation for the power loss per unit volume:



$$P_{hys} = \frac{f \cdot \hat{B}^3}{12\mu_0^2 \cdot J_c \cdot a} \text{ [W/m}^3\text{]}$$

Where a is the thickness of the conductor. For this purpose, we need first to calculate the flux density B near the superconductor.

a. Use the Ampere law to calculate the magnetic field strength H around the conductor (assume the flux path equal to πD the inner perimeter of the cylindrical conductor).
b. Calculate the magnetic flux density near the conductor (use the permeability of vacuum for this purpose)
c. Use the given equation and the calculated flux density and calculate the hysteresis losses per unit length of the conductor as a function of J_c (note that the equation makes use of the pick value of flux density. Note also that you can get read of the thickness a by approximating the surface with S=πDa)
d. Plot the behavior of hysteresis losses as function of J_c. Use Matlab or similar for this purpose.