Answer on Question#78446 - Physics - Electromagnetism

A circular iron ring has a mean circumference of 1.5 m and cross-sectional area of 0.01 m^2. A saw cut of 4 mm wide is made in the ring. Calculate the magnetizing current required to produce a flux of 0.8 mWb in the gap if the ring is wound with a coil of 175 turns. Assume relative permeability of iron as 400 and leakage factor 1.25.

Solution:

The magnetic field produced by the coil is given by

$$B = \mu_0 \mu_r \frac{NI}{l},$$

where l – the length of the coil, with N – number of turns, $\mu_0 = 4\pi \cdot 10^{-7} \frac{\text{Wb}}{\text{A·m}}$ – magnetic constant, μ_r – relative permeability of the core, I – the magnetizing current.

The flux produced by such coil is equal to product of magnetic field and cross-sectional area (A) of the coil:

$$\Phi = B \cdot A = \mu_0 \mu_r \frac{NIA}{l}$$

Due to the leakage the resulting (useful) flux Φ_u would be smaller than this by leakage factor λ:

$$\Phi_u = \frac{\Phi}{\lambda} = \mu_0 \mu_r \frac{NIA}{l\lambda}$$

Thus we get

$$I = \frac{\Phi_u l \lambda}{\mu_0 \mu_r NA}$$

It is given that $l = 1.5\ \text{m}$, $\mu_r = 400$, $N = 175$, $\Phi_u = 0.8\ \text{mWb}$, $\lambda = 1.25$, $A = 0.01\ \text{m}^2$, therefore

$$I = \frac{\Phi_u l \lambda}{\mu_0 \mu_r NA} = \frac{0.8\ \text{mWb} \cdot 1.5\ \text{m} \cdot 1.25}{4\pi \cdot 10^{-7} \frac{\text{Wb}}{\text{A} \cdot \text{m}} \cdot 400 \cdot 175 \cdot 0.01\ \text{m}^2} = 1.7\ \text{A}$$

Answer: 1.7 A.

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