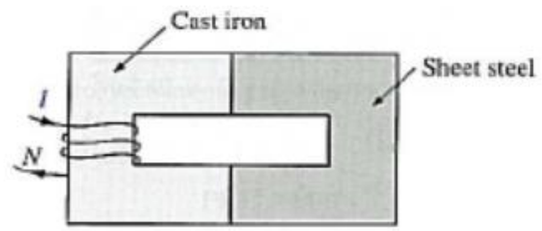
Q- Find the current necessary to stablish a flux of $\phi = 3*10^{-4}$ Wb in the series magnetic circuit (shown in figure) consist of two parts of cast iron and steel cores. Length of each core is l = 0.3 m and the area of cross-section is $A = 5*10^{-4}$ m^2. Relative permittivity of cast iron is 5000 and that of steel is 100. Number of turns in the coil is N = 100 turns.



Reading:

Analogues to the electric circuits where EMF in the circuit is driving the electric current (scalar quantity), we consider magnetic circuits in which Magnetomotive Force (MMF) driving magnetic flux in form of closed loops.

As ohms law gives the relation V= R*I, in a similar way we may write the relation

MMF = R*ϕ

Where R is a quantity analogue to the resistance in electric circuit, which creates oppose to the magnetic current (flux) in the magnetic circuit and is called reluctance of the circuit.

The quantity MMF is the cause which produces magnetic flux in the circuit and is given by the product of current and the number of turns in the coil of an electromagnet. Its units are Ampere turn.

If the current in the coil is I and the number of turns is n then MMF in the circuit is given by

MMF = M = n*I

The magnetic flux is the product of magnetic field and the area of the magnetic conductor and measured in Weber (Wb).

The reluctance of a part of the circuit can be calculated as

$$R = \frac{l}{\mu_0 \mu_r A}$$

Where $\boldsymbol{l}$ is the length of the circuit, $\boldsymbol{\mu_0}$ is the permeability of free space, $\boldsymbol{\mu_r}$ is the relative magnetic permeability of the material (dimensionless) and A is the cross-sectional area of the circuit.

Solution:

The reluctance of the circuit is given by the reluctance of the iron core and the reluctance of the steel core in series.

As the length of each part is l and the area of cross section is A the net reluctance in the circuit is given by

$$R = R_{Iron} + R_{steel}$$

Or $$R = \frac{l}{\mu_0 \mu_{Iron} A} + \frac{l}{\mu_0 \mu_{Steel} A}$$

or $$R = \frac{l}{\mu_0 A}\left(\frac{1}{\mu_{Iron}} + \frac{1}{\mu_{Steel}}\right)$$

or $$R = \frac{0.3}{4\pi * 10^{-7} * 5 * 10^{-4}}\left(\frac{1}{5000} + \frac{1}{100}\right)$$

[http://hyperphysics.phy-astr.gsu.edu/hbase/tables/magprop.html#c2]

Or R = $4.87*10^6$ A.turn/Wb

Now as

MMF = n*I = R*ϕ

We get

I = R*ϕ/n = $4.87*10^6*3*10^{-4}/100$ = 14.61 A

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