MAGNETIC CIRCUITS

FORMULAS :

* $B = \frac{\phi}{A}$ wb/m^2 (or) Tesla.

* $mmf = N \times I$ AT → ampere turns.

* $H = \frac{mmf}{l} = \frac{N \times I}{l} = \frac{B}{\mu_0 \mu_r}$ AT/m

* $\mu_0 = 4\pi \times 10^{-7}$

  $\mu_r = 1$ (for air)

* $S_{(Rm)} = \frac{l}{\mu_0 \mu_r A}$ AT/wb $= \frac{Ni}{\phi}$

* $A = \frac{\pi d^2}{4}$ m^2

* $l = \pi D$ m

* ϕ (flux) → wb. $= \frac{mmf}{reluctance}$

ϕ → flux

A → Area.

B → flux density

mmf → Magnetomotive force

N → no.of turns. of coil.

H → Magnetic field strength (or) Magnetic field intensity (or) Magnetising force.

S → Reluctance (opp. to flow of flux).

d → inner diameter of ring

D → Mean diameter.

l → mean circumference (or) mean length (or), mean magnetic path.

Toroidal core :

It is a circular core

Applications : Transformers, inductors to power electronic circuits.

* Permeability : (μ)

A property of magnetic material which indicates the ability of magnetic circuit to carry magnetic flux

$\mu = \frac{B}{H}$, $\mu_r = \frac{\mu}{\mu_0}$

Hopkinson's law :

MMF = flux x reluctance

It is known as Ohm's law of magnetic circuit.

⇒ A magnetizing force of 8000 A/m is applied to circular magnetic circuit of mean diameter of mean diameter 30cm by passing a current through a coil wound on circuit. If the coil is uniformly wound around the circuit and has 750 turns, find i.

Sol^n)

$H = 8000\ A/m$

$D = 30 \times 10^{-2}\ m.$

$N = 750$

$l = \pi D = 30\pi \times 10^{-2} m.$

$\therefore H = \frac{N \times i}{l}$

$\Rightarrow i = \frac{H \times l}{N} = \frac{8000 \times \cancel{30}\pi \times 10^{-2}}{\cancel{750}\ 25}$

$\Rightarrow i = 10.05\ A$

⇒ Determine mmf req. to generate total flux of 100 μWb in air air gap coil 0.2 cm long. The cross sectional area of air gap is 25 cm².

Sol^n)

$\phi = 100 \times 10^{-6}\ Wb$

$l = 0.2 \times 10^{-2}\ m.$

$A = 25 \times 10^{-4}\ m^2$

$\cancel{mmf = \frac{l}{\mu_0 \mu_r A}}$

$\cancel{mmf = \frac{0.2 \times 10^{-2}}{4\pi \times 10^{-7} \times 25 \times 10^{-4}}}$

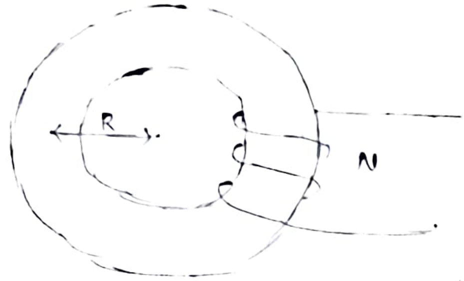
$B = \frac{\phi}{A} = \frac{100 \times 10^{-6}}{25 \times 10^{-4}} = 4 \times 10^{-2}\ Wb/m^2$

$H = \frac{B}{\mu_0 \mu_r} = \frac{4 \times 10^{-2}}{4\pi \times 10^{-7}} = 3.18 \times 10^{4}\ AT/m$

$mmf = H \times l = 3.18 \times 10^{4} \times 0.2 \times 10^{-2} = 63.7\ AT$

B in Toroidal core :

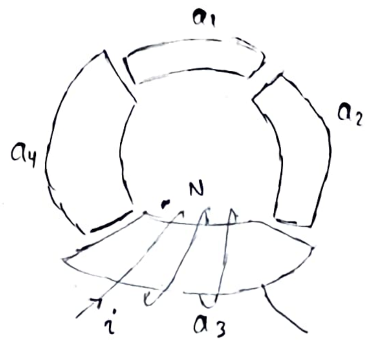
$$B = \frac{\mu N i}{2\pi R}$$



Series Magnetic Circuits :

Total reluctance $\Rightarrow S = \sum_{i=1}^{n} S_i$

where $S_i = \dfrac{l_i}{a_i \mu_0 \mu_{ri}}$

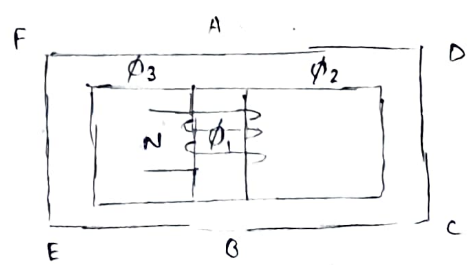


Total mmf $= \phi S$

$= \phi \left[\sum_{i=1}^{n} S_i \right]$

$= \sum \dfrac{B_i l_i}{\mu_0 \mu_{ri}} = \sum_{i=1}^{n} H_i l_i$

Parallel Magnetic Circuits :



$\phi_1 = \phi_2 + \phi_3$

S_1 = reluctance of BA $= \dfrac{l_1}{a_1 \mu_0 \mu_{r1}}$

S_2 = reluctance of AB,CD $= \dfrac{l_2}{a_2 \mu_0 \mu_{r2}}$

S_3 = reluctance of AFEB $= \dfrac{l_3}{a_3 \mu_0 \mu_{r3}}$

Total mmf or AT $= \phi_1 S_1 + \phi_2 S_2 = \phi_1 S_1 + \phi_3 S_3$

like

$i_1 = i_2 + i_3$

in current dc

we have

$\phi_1 = \phi_2 + \phi_3$

in magnetic circuit

LEAKAGE flux:

$$\phi = \phi_u + \phi_L$$

$\phi_u \rightarrow$ usefull flux

$\phi_L \rightarrow$ leakage flux.

Leakage co-efficient or leakage factor:

$$\lambda = \frac{\phi}{\phi_u}$$

⇒ An iron ring of 400 cm mean circumference is made from iron of cross section $20 cm^2$. Its permeability is 500. If it is wound with 400 turns, what current would be required to produce flux of 0.01 wb?

Soln

$l = 400 \times 10^{-2}$ m.

$A = 20 \times 10^{-4}$ m^2.

$\mu = 500$.

$N = 400$.

$\phi = 0.01$ wb.

$$H = \frac{Ni}{l} \Rightarrow i = \frac{Hl}{N}.$$

⇒ ~~A three x:~~ $\mu = \frac{B}{H} \Rightarrow H = \frac{B}{\mu} = \frac{\phi/A}{\mu} = \frac{0.01}{20 \times 10^{-4} \times 500} = 10^{-2}.$

$$i = \frac{(10^{-2})(400 \times 10^{-2})}{400} = \underline{\underline{10^{-4} \text{ A}}}.$$