15/23

2	2/10
3	6/10
4	22/24
5	45/10

University of Jordan

Electrical Eng. Dept

EE 090371 Electrical Machines (1) First Exam.

8-3-2017

الاسم: محمد مفيد أحمد أبو حاشية رقم التفقد 20 الرقم الجامعي 0144235

15/16

Q1) In a 4-poles machine, the poles, rotor and yoke are made of the same magnetic material with the following data for magnetization curve:

B (Tesla)	0.6	0.9	1.1	1.5	2	2.5
H (kA/m)	0.1	0.2	1.05	1.15	1.2	2.0

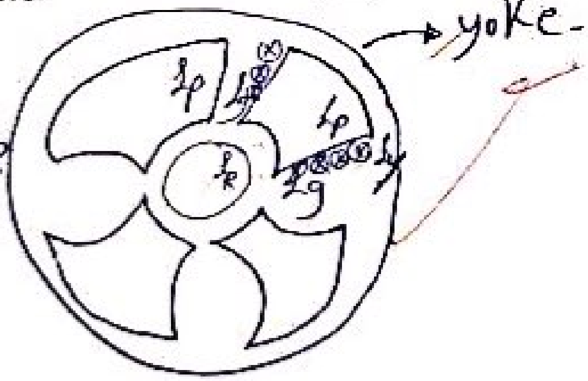
For a closed loop between two adjacent poles, the lengths of flux path in this loop for the various components in METER are as follows:

Pole=0.2, air gap=0.005, rotor=0.1 and yoke=0.4

It is required to have the following flux densities at the various Components:

Component	Pole	Air gap	Rotor	Yoke
B (Tesla)	1.5	0.86	0.9	1.1

By SKETCHING the magnetic structure and WRITING the relevant expression EVALUATE the required mmf per pole. [16]



$mmf = Ni = H_p l_p + H_g l_g + \frac{1}{2} H_y l_y + \frac{1}{2} H_R l_R$

$\Rightarrow mmf \Rightarrow$

$H_p = 1.15$ KA/m

$H_y = 1.05$ KA/m

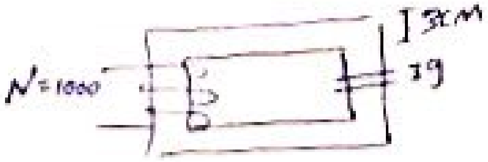
$H_R = 0.2$ KA/m

$H_g = \frac{B}{\mu_0} = \frac{0.86}{4\pi \times 10^{-7}} = 684.366$ KA/m

$mmf = (1.15K)(0.2) + (684.366K)(0.005) + \frac{1}{2}(0.2K)(0.1) + \frac{1}{2}(1.05K)(0.4)$

$mmf = 3871.83$ A.t.

Scanned by CamScanner



$g = 0.12\,cm$

$l_c = 30\,cm$

Q2) A rectangular laminated core contains an air gap with length of 0.12 cm and has one coil wound on it. The core has a thickness of 3 cm and width of 2.5 cm. The mean length of flux path is 30 cm, stacking factor is 0.93 and $\mu_r = \infty$. By using the given data and taking fringing field into account, evaluate the self inductance of the coil if it has 1000 turns. [10]

$A_{Total} = (3\,cm) * (2.5\,cm) = 7.5 \times 10^{-4}\, m^2$

$\Rightarrow A_c = A_T * S.F = 6.975 \times 10^{-4}\, m^2$

$L = \frac{N^2}{\mathcal{R}} = \frac{N^2 \mu A}{l}$, $e = L\frac{di}{dt}$

$\mathcal{R} = \mathcal{R}_g + \mathcal{R}_c$

$Ni = \phi(R_c + R_g)$

$L = \frac{(1000)^2 * 4\pi \times 10^{-7} * \infty * 6.975 \times 10^{-4}}{30 \times 10^{-2}} = \infty$

* the value of self inductance of a coil depend on μ so it is also depend on μ_r by the relation $L = \frac{N^2 \mu_0 \mu_r A}{l} \Rightarrow$ so when $\mu_r \to \infty$, L is also $\to \infty$

Q3) If the applied voltage to the primary of a transformer at no-load and its frequency are doubled, show by using mathematical derivation what will happen to its Eddy and Hysteresis losses. [10]

Voltage & f are doubled.

we Know that:

eddy losses represented by: $P_e = V f^2 B_m^2 \tau^2 K_e$

Hysteresis losses represented by: $P_h = A_h * f * V = K_h B_m^n f V$

* Now the change happen on the voltage @ No load & the frequency but from P_e & P_h we Notice that they does not depend on the voltage, on the other hand they depend on the frequency

so $f_{new} = 2 f_{old}$

$\Rightarrow P_e = M_1 f^2$

$P_h = M_2 f$

where M_1 & M_2 are constants.

so $P_{e_{new}} = M_1 * 4 f^2$ & $P_h = M_2 * 2f$

from that $P_{e_{new}} = 4 P_{e_{old}}$ & $P_{h_{new}} = 2 P_{h_{old}}$

Notice that Hysteresis losses is doubled.

& the Eddy losses become 4-times its old value.

Q4) Conventional O/C and S/C tests were performed on (40/2.4) kV transformer with the following readings

$a = 16.67 : 1$

O/C: I=9.1 A P=1925 W

S/C: I=12.5 A P=4075 W

a-Find the parameters of the transformer which can be evaluated from the O/C test and referred to HV side. [12]

we can find from o/c test R_c & X_m.

$\Rightarrow$ $P_{oc} = 1925\,W$, $I_{oc} = 9.1\,A$, $V_{oc} = 2.4\,K\,Volt$.

* By conventinal: o/c test applied @ LV side so 2.4KV should be the rated voltage.

R_c can be evaluated from $R_c = \frac{V_{oc}^2}{P_{oc}} \Rightarrow \boxed{R_c = 2992.2\,\Omega}$

$|Y| = \frac{I_{oc}}{V_{oc}} = 3.79 \times 10^{-3} = \sqrt{\frac{1}{R_c^2} + \frac{1}{X_m^2}}$

so X_m can be evaluated:

solving $\Rightarrow$ $\boxed{X_m = 264.77\,\Omega}$

* But these values in LV so in HV side: (reflect to a-side)

$R_c = a^2(2992.2)$

$X_m = a^2(264.77)$

$\Rightarrow$ $\boxed{R_c = 831.5\,K\Omega \quad X_m = 73.58\,K\Omega}$

b-Find the values of parameters which can be evaluated from the S/C test in PU by using the transformer ratings as base values. [12]

* By Convential S/C test applied @ HV side

we have:

$\boxed{P_{sc} = 4075\,W \quad I_{sc} = 12.5\,A \quad V_{sc} = 40\,KV}$

we can find from S/c test R_{eq} & X_{eq}.

so $R_{eq} = \frac{P_{sc}}{I_{sc}^2} \Rightarrow \boxed{R_{eq} = 26.08\,\Omega}$

where $|Z| = \frac{V_{sc}}{I_{sc}} = 3200 = \sqrt{R_{eq}^2 + X_{eq}^2}$

to find X_{eq}: solving: $\boxed{X_{eq} = 3199.89\,\Omega}$

* Now R_{eq}, X_{eq} which had been evaluated in HV side, so we find the base @ HV: $|S| = |I_{sc}| \times |V_{sc}| = (12.5)(40K) \Rightarrow S = 500\,KVA$.

take $\boxed{S_b = 500\,KVA \;\&\; V_b = 40\,K\,Volt}$ $\Rightarrow Z_b = \frac{V_b^2}{S_b} = \frac{(40 \times 10^3)^2}{500 \times 10^3} \Rightarrow \boxed{Z_b = 3200\,\Omega}$

Continue $\Rightarrow$

⇒ Contine Q_4 (part b):

we have $R_{eq} = 26.08\,\Omega$, $X_{eq} = 3199.89\,\Omega$

& $Z_b = 3200\,\Omega$

so PU values will be as follows:

$$R_{eq(PU)} = \frac{R_{eq}}{Z_b} = \frac{26.08}{3200} \Rightarrow R_{eq(PU)} = 0.326 \text{ PU}$$

$$X_{eq(PU)} = \frac{X_{eq}}{Z_b} = \frac{3199.89}{3200} \Rightarrow X_{eq(PU)} = 39.999$$

the values are (in PU):

$R_{eq(PU)} = 0.00815$ PU

$X_{eq(PU)} = 0.99997$ PU