Solution

Tutorial sheet - 10

Electrical Science - 1

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Q1. Solution :

Given $E_1 = 2300V$, $E_2 = 230\ V$

$f = 50\ Hz$, $A = 0.05\ m^2$

$B = 1.1\ wb/m^2$

$B = \frac{\phi m}{A} \Rightarrow \phi m = B \cdot A$

$= 1.1 \times 0.05$

$= 0.055\ wb$

Emf eqn :-

$E_1 = 4.44 f \phi m N_1$

$2300 = 4.44 \times 50 \times 0.055 \times N_1$

$N_1 = \frac{2300}{12.21} \doteq 188.37 \approx 188$

$E_2 = 4.44 f \phi m N_2$

$230 = 4.44 f \phi m N_2$

$N_2 = \frac{230}{12.21} = 18.837 \approx 19$

Q2. Solution

Given $N_1 = 400$, $N_2 = 1000$

$A = 60\ cm^2 = 60 \times 10^{-4}\ m^2$

$f = 50\ Hz$, $E_1 = 520\ V.$

a) $B = \frac{\phi m}{A}$

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To find ϕm use EMF eq^n.

$$E_1 = 4.44 f \phi m N_1$$

$$\phi m = \frac{520}{4.44 \times 50 \times 400}$$

$$= \frac{520}{88,800} = 0.00585$$

$$\phi m = 5.855 \times 10^{-3} \text{ wb.}$$

So $$B = \frac{5.855 \times 10^{-3}}{60 \times 10^{-4}} = 0.9759 \text{ wb/m}^2$$

b) $$K = \frac{N_2}{N_1} = \frac{1000}{400} = 2.5$$

c) $$\frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

$$E_2 = K \times E_1 = 2.5 \times 520$$

$$E_2 = 1300 V$$

Q3. Solution

Given

$P_c = 120 W$, $\eta = 98\%$, $x = 1$

$(P.F) \cos \phi_2 = 1$, full-load VA $= 10 kVA$
$= 10 \times 10^3$ VA

Now

$$\eta = \frac{x \times \text{full-load VA} \times P.F}{(x \times \text{full-load VA} \times P.F) + P_i + x^2 P_c}$$

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putting all values

$$\frac{98}{100} = \frac{1 \times 10 \times 10^3 \times 1}{1 \times 10 \times 10^3 \times 1 + P_i + 120}$$

$$0.98 = \frac{10^4}{10^4 + P_i + 120}$$

$$P_i = 84.08 \text{ W}$$

For second Condition

$x = \frac{1}{2}$, $P.F = 0.8$

$$\eta = \frac{\frac{1}{2} \times 10 \times 10^3 \times 0.8}{\frac{1}{2} \times 10 \times 10^3 \times 0.8 + 84.08 + \left(\frac{1}{2}\right)^2 \times 120}$$

$$\eta = 97.23\%.$$

Q4 Solution

Given Full-load VA $= 400 \times 10^3$ VA

$\eta = 98.77$, $x = 1$, $PF = 0.8$

Case-I

$$\eta = \frac{x \times \text{Full-Load VA} \times P.F}{x \times \text{Full-Load VA} \times P.F + P_i + x^2 P_c}$$

$$\frac{98.77}{100} = \frac{1 \times 400 \times 10^3 \times 0.8}{1 \times 400 \times 10^3 \times 0.8 + P_i + P_c}$$

$$3.2 \times 10^5 + P_i + P_c = \frac{3.2 \times 10^5}{0.9877}$$

$P_i + P_c = 3985$ — (i)

Case-II

$\eta = 99.13\%$, $x = \frac{1}{2}$, $P.F = 1$

$$\frac{99.13}{100} = \frac{\frac{1}{2} \times 400 \times 10^3 \times 1}{\frac{1}{2} \times 400 \times 10^3 \times 1 + P_i + \left(\frac{1}{2}\right)^2 P_c}$$

$$2 \times 10^5 + P_i + \frac{P_c}{4} = \frac{2 \times 10^5}{0.9913}$$

$P_i + 0.25\,P_c = 1755$ — (ii)

Solving eq (i) & (ii)

$P_i = 1011.6\ W$

$P_c = 2973.3\ W$

Q5 <u>Solution</u>

Given $I_0 = 0.6\ A$ $\cos\phi_0 = 0.65$

$V_1 = 440\ V$

The iron-loss component

$I_w = I_0 \times \cos\phi_0$

$= 0.6 \times 0.65$

$I_w = 0.39\ A$

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Magnetizing component

$I_m = I_0 \sin\phi_0$

$= I_0 \sqrt{1-\cos^2\phi_0}$

$= I_0 \times \sqrt{1-(0.65)^2}$

$= 0.6 \times \sqrt{1-(0.65)^2}$

$I_m = 0.455\ A$

$R_0 = \frac{V_1}{I_w} = \frac{440}{0.39} = 1128\ \Omega$

$X_0 = \frac{V_1}{I_m} = \frac{440}{0.455} = 967\ \Omega$.

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