Q.2 b. A coil of 300 turns and of resistance 10 Ω is wound uniformly over a steel ring of mean circumference 30 cm and cross-sectional area 9 cm^2. It is connected to a supply at 20 V D.C. If the relative permeability of the ring is 1500, Calculate:

(i) The Magnetising Force (ii) Reluctance
(iii) M.M.F (iv) Flux

Answer:
Given: N = 300: R=10Ω; l=30 cm or 0.3 m;
A= 9 cm^2 = $9*10^{-4}$ m^2; Supply Voltage =20V; μ_r =1500

(i) The magnetizing force H;

$$H = \frac{NI}{l} = \frac{N \times \left({}^{V}\!/_{R}\right)}{l} = \frac{30 \times \left({}^{20}\!/_{10}\right)}{0.3} = 2000\frac{AT}{m} \text{ (Ans)}$$

(ii) The reluctance, S:

$$S = \frac{l}{A\mu_o\mu_r} = \frac{0.3}{4\pi \times 10^{-7} \times 1500 \times 9 \times 10^{-4}}$$
$$= 176.84 \times 10^3 \frac{AT}{Wb} \text{ (Ans)}$$

(iii) The m.m.f:

$$m.m.f = NI = 300 \times \left({}^{V}\!/_{R}\right) = 300 \times \left({}^{20}\!/_{10}\right) = 600\ AT \text{ (Ans)}$$

(iv) The flux

$$\emptyset = \frac{m.m.f}{reluctance} = \frac{600}{176.84 \times 10^3} = 3.39 \times 10^{-3}\ Wb \text{ (Ans)}$$

Q.3 b. The primary and secondary windings of a 40KVA, 6600/250V single phase transformer have resistance of 10 ohms and 0.02 ohms respectively. The total leakage reactance is 35 **Ω** as referred to the primary winding. Find full load regulation at power factor of 0.8 lagging.

Answer:

Given Primary Voltage, V_1 =6,600V; Secondary Voltage, V_2 =250V
Transformation ratio

$$K = \frac{V_2}{V_1} = 0.0378$$

Equivalent resistance of transformer referred to secondary

$$R_{02} = K^2R_1 + R_2 = 0.03435\ \Omega$$

Equivalent leakage reactance of transformer referred to secondary

$$X_{02} = K^2X_{01} = 0.05022\ \Omega$$

Secondary rated current,

$$I_2 = \frac{Rated\ KVA \times 1{,}000}{V_2} = 160A$$

Power factor, $\cos\emptyset = 0.8$ and $\sin\emptyset = 0.6$

Full load regulation

$$F.L.R = \frac{I_2 R_{02}\cos\emptyset + I_2 X_{02}\sin\emptyset}{E_2} \times 100 = 3.687\%\ Ans$$

Q.4 b. A 4-pole, 220V shunt motor has 540 lap-wound conductor. It takes 32 A from the supply mains and develops output power of 5.59 KW. The field winding takes 1 A. The armature resistance is 0.9 Ω and the flux per pole is 30 mWb. Calculate

(i) the speed

(ii) the torque developed in Newton meters.

Answer:

Armature current,

$$I_a = I_L - I_{sh} = 32 - 1 = 31A$$

Back emf,

$$E_b = V - I_a R_a = 220 - 31 \times 0.9 = 192.1\ V$$

Since

$$E_b = \emptyset Z \frac{N}{60} \times \frac{P}{A} =$$

So Speed,

$$N = \frac{E_b \times 60}{\emptyset Z} \times \frac{A}{P} = 711.5\ \text{rpm} \quad (\textbf{Ans}).$$

Torque developed,

$$T_e = \frac{9.55 \times E_b \times I_a}{N} = 79.93\ \text{Nm} \quad (\textbf{Ans}).$$

Shaft Torque

$$T_{sh} = \frac{9.55 \times \text{output in watts}}{N} = 75.1\ \text{Nm}\ (\textbf{Ans}).$$

Q.5 b. A 3300V star-connected synchronous motor has synchronous impedance of 0.4+j5 Ω per phase. For an excitation e.m.f. of 4000V and motor input power of 1000KW at rated voltage. Compute the line current and Power factor.

Answer:

Given

$$V_t = \frac{3300}{\sqrt{3}} = 1905.3\ V$$

$$E_f = \frac{4000}{\sqrt{3}} = 2309.5\ V$$

$$Z_s = \sqrt{0.4^2 + 5^2} = 5.016\ V$$

$$\alpha_z = \tan^{-1}\frac{0.4}{5} = 4.57^0$$

Per phase power input to motor

$$P_{im} = \frac{E_f \times V_t}{Z_s}\sin(\delta - \alpha_z) + \frac{V_t^2}{Z_s^2} r_a$$

$\sin(\delta - \alpha_z) = 0.314$

$\delta = 22.88^0$

$$I_a Z_s = \sqrt{\left(V_t^2 + E_f^2 - 2 \times V_t \times E_f \cos\delta\right)}$$

$I_a = 184.43$ A

$3V_t I_a \cos\theta = 1000{,}000W$

$\cos\theta = 0.9486$ Lead (**Ans**)

Q.6 b. In a 6-pole, 3-phase, 50 Hz induction motor with star connected rotor, the rotor resistance per phase is 0.3 Ω, the reactance at standstill is 1.5 Ω per phase and an e.m.f. between the slip-rings on open-circuit is 175V. Calculate

(i) Slip at a speed of 950 rpm

(ii) Rotor e.m.f. per phase

(iii) Rotor frequency and reactance at a speed of 950 rpm

Answer:

Synchronous speed**,**

$$N_s = \frac{120 \times f}{P} = 1{,}000 \text{ rpm}$$

Rotor speed, N =950 rpm

i. Slip

$$s = \frac{N_s - N}{N_s} = 0.05 = 5\ \% \quad (\textbf{Ans})$$

ii. Rotor emf per phase at standstill.

$$E_2 = \frac{175}{\sqrt{3}} = 101 \text{ V} \quad (\textbf{Ans})$$

iii. Rotor frequency at a speed of 950 rpm

$f' = sf = 2.5$ Hz (**Ans**)

Standstill rotor reactance,

X_2=1.5Ω/phase

Rotor reactance at a speed of 950 rpm = s X_2 = 0.75Ω per phase **(Ans.)**

b. Explain how direct sunlight can be converted into electricity.

Answer: Page Number 595 of Text Book

Text Book

Basic Electrical Engineering, D.P. Kothari and I.J. Nagrath, Tata McGraw-Hill Publishing Company Limited, 2nd Edition, 13th Reprint 2006