Question 1

A shunt generator with 220 V output voltage, shunt circuit resistance Rfd = 220 Ω and total inductor circuit resistance is ∑Ra= 0.2 Ω. This generator is loaded with a 10 Ω load. And, its efficiency is 0.89.

a) Output current, armature current and excitation current,

b) Induced voltage,

c) Induced power and output power (electrical power),

a)

$$I_{laod} = \frac{V}{R_{load}} = \frac{220}{10} = 22\ A$$

$$I_{fd} = \frac{V}{R_{fd}} = \frac{220}{220} = 1\ A$$

$$I_a = I_{laod} + I_{fd} = 22 + 1 = 23\ A$$

b)

$$E_a = V_a + \sum R_a\ I_a$$

$$E_a = 220 + (23x0.2) = 224{,}6\ V$$

c)

$$P_{end} = E_a\ I_a = 224{,}6\ x\ 23 = 5165{,}8\ W$$

$$P_{elk} = V\ I_{load} = 220\ x\ 22 = 4840\ W$$

Question 2

When loaded at the nominal power of a 2HP DC shunt motor with a pole voltage of 210 V, its efficiency is 82%. The shunt excitation winding resistance is 310 Ω, the total armature resistance is 0.25 Ω. When motor is operated at full load,

a) The current drawn from the DC supply,

b) Armature current

$$\eta = \frac{\text{Output Power}}{\text{Input Power}} = \frac{P_{mec}}{P_{elk}}$$

$$P_{mec} = 736\ x\ 2 = 1472\ W$$

$$P_{elk} = \frac{P_{mec}}{\eta} = \frac{1472}{0.82} = 1795\ W$$

$$P_{elk} = V\ I$$

$$I_{sup} = \frac{1795}{210} = 8.54\ A$$

c)

$$I_{sup} = I_a + I_{fd}$$

$$I_{fd} = \frac{V}{R_{fd}} = \frac{210}{310} = 0{,}67\ A$$

$$I_a = 8{,}54 - 0{,}67 = 7{,}87\ A$$

Question 3

The number of parallel of the rotor winding is 2a=2p. a 4-pole shunt generator with a nominal speed of 1200 rpm is excited and an excitation flux of generator is 0.04Wb. The number of conductors in the rotor is 300 and the total resistance of the windings on the q-axis of the generator is 0.1 Ω. Current flowing through armatüre is 160 A. Calculate the output voltage of the generator.

$$2a = 2p$$

$$E_a = z_a \frac{p}{a}\frac{n}{60}\ \phi_{fd}$$

$$E_a = 300\ \frac{2}{2}\ \frac{1200}{60}\ 0.04 = 240\ V$$

$$E_a = V_a + \sum R_a\ I_a$$

$$V_a = 240 - (0.1\ x\ 160) = 224\ V$$

Question 4.

A magnetic circuit with a single air gap is shown in Fig. 1.24. The core dimensions are:

Cross-sectional area $A_c = 1.8 \times 10^{-3}$ m^2
Mean core length $l_c = 0.6$ m
Gap length $g = 2.3 \times 10^{-3}$ m
$N = 83$ turns

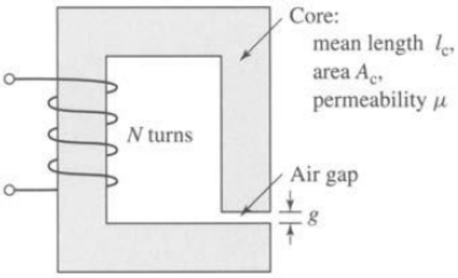


Figure 1.24 Magnetic circuit for Problem 1.1.

Assume that the core is of infinite permeability ($\mu \to \infty$) and neglect the effects of fringing fields at the air gap and leakage flux. (*a*) Calculate the reluctance of the core $\mathcal{R}_c$ and that of the gap $\mathcal{R}_g$. For a current of $i = 1.5$ A, calculate (*b*) the total flux ϕ, (*c*) the flux linkages λ of the coil, and (*d*) the coil inductance L.

Part (a):

$$\mathcal{R}_c = \frac{l_c}{\mu A_c} = \frac{l_c}{\mu_r \mu_0 A_c} = 0 \quad \text{A/Wb}$$

$$\mathcal{R}_g = \frac{g}{\mu_0 A_c} = 1.017 \times 10^6 \quad \text{A/Wb}$$

part (b):

$$\Phi = \frac{NI}{\mathcal{R}_c + \mathcal{R}_g} = 1.224 \times 10^{-4} \quad \text{Wb}$$

part (c):

$$\lambda = N\Phi = 1.016 \times 10^{-2} \quad \text{Wb}$$

part (d):

$$L = \frac{\lambda}{I} = 6.775 \quad \text{mH}$$

Question 5

Repeat Question 4 for a finite core permeability of $\mu = 2500\,\mu_0$

part (a):

$$\mathcal{R}_c = \frac{l_c}{\mu A_c} = \frac{l_c}{\mu_r \mu_0 A_c} = 1.591 \times 10^5 \quad \text{A/Wb}$$

$$\mathcal{R}_g = \frac{g}{\mu_0 A_c} = 1.017 \times 10^6 \quad \text{A/Wb}$$

part (b):

$$\Phi = \frac{NI}{\mathcal{R}_c + \mathcal{R}_g} = 1.059 \times 10^{-4} \quad \text{Wb}$$

part (c):

$$\lambda = N\Phi = 8.787 \times 10^{-3} \quad \text{Wb}$$

part (d):

$$L = \frac{\lambda}{I} = 5.858 \quad \text{mH}$$

Question 6

The magnetic circuit of Fig. 1.26 consists of rings of magnetic material in a stack of height h. The rings have inner radius R_i and outer radius R_o. Assume that the iron is of infinite permeability ($\mu \to \infty$) and neglect the effects of magnetic leakage and fringing. For:

$R_i = 3.4$ cm
$R_o = 4.0$ cm
$h = 2$ cm
$g = 0.2$ cm

calculate:

a. the mean core length l_c and the core cross-sectional area A_c.

b. the reluctance of the core $\mathcal{R}_c$ and that of the gap $\mathcal{R}_g$.

For $N = 65$ turns, calculate:

c. the inductance L.

d. current i required to operate at an air-gap flux density of $B_g = 1.35$T.

e. the corresponding flux linkages λ of the coil.

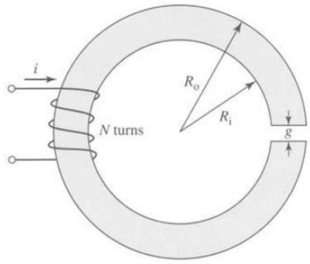


Figure 1.26 Magnetic circuit for Problem 1.9.

part (a):

$$l_c = 2\pi(R_o - R_i) - g = 3.57 \quad \text{cm}; \qquad A_c = (R_o - R_i)h = 1.2 \quad \text{cm}^2$$

part (b):

$$\mathcal{R}_g = \frac{g}{\mu_0 A_c} = 1.33 \times 10^7 \quad \text{A/Wb}; \qquad \mathcal{R}_c = 0 \quad \text{A/Wb};$$

part (c):

$$L = \frac{N^2}{\mathcal{R}_g + \mathcal{R}_g} = 0.319 \quad \text{mH}$$

part (d):

$$I = \frac{B_g(\mathcal{R}_c + \mathcal{R}_g)A_c}{N} = 33.1 \quad \text{A}$$

part (e):

$$\lambda = NB_gA_c = 10.5 \quad \text{mWb}$$

Question 7

When the secondary side of a 50 kVA, 33000/1000 V one-phase transformer is short-circuited and subjected to a short-circuit test at rated current, (V1)sc = 180V, Psc =600W and When the transformer is no-load, V_{20} = 1000V , I_{10} = 1.5A , P_0=180W. Find the efficiency of the transformer with iron and copper losses in case of inductive operation (cos φ =0.9) at rated current.

$$P_{Fe} = P_0 = 180\ W$$

$$P_{cu} = P_{sc} = 600\ W$$

$$I_2 = \frac{50000}{1000} = 50A$$

$$\eta = \frac{V_2 x I_2 x \cos\varphi}{V_2 x I_2 x \cos\varphi + P_{Fe} + P_{cu}} = \frac{1000x50x0{,}9}{1000x50x0{,}9 + 600 + 180} = \%\ 98.3$$

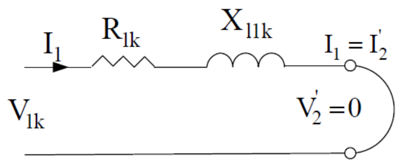
Question 8

There is a single-phase transformer which has label values that 300 kVA, 50 Hz, 11000/2300 voltage. This transformer's resistances and reactances are R_1 = 1.28 Ω R_2= 0.0467 Ω X_{l1} = 4.24 Ω X_{l2} = 0.162 Ω. When no-load current is neglected and resistance and reactance of secondary are referred to primary,

a) Find voltage at short-circuit current

b) Find short-circuit current.

a)



$$V_{1k} = Z_{1k} \, x \, I_1$$

$$a = \frac{11000}{2300} = 4.78$$

$$Z_{1k} = R_{1k} + j\, X_{1k}$$

$$R_{1k} = R_1 + R_2' = R_1 + (a^2 \, x \, R_2) = 1{,}28 + [(4{,}78)^2 \, x \, 0{,}0467] = 2{,}34 \, \Omega$$

$$X_{1k} = X_1 + X_2' = X_{l1} + (a^2 \, x \, X_{l2}) = 4{,}24 + [(4{,}78)^2 \, x \, 0{,}0467] = 7{,}94 \, \Omega$$

$$Z_{1k} = 2{,}34 + j\, 7{,}394$$

$$I_1 = \frac{300 \, x 10^3}{11000} = 27{,}27 \, A$$

$$V_{1k} = Z_{1k} \, I_{1k} = 8{,}28 \, x \, 27{,}27 = 226 \, V$$

b)

$$(I_1)_{sc} = \frac{V_1}{Z_{1k}} = \frac{11000}{8{,}28} = 1328 \, A$$

Question 9

When the secondary side of a 10 kVA, 4800/240 V one-phase transformer is short-circuited and subjected to a short-circuit test at rated current, (V1)k=180V, Pkd=180W. If the magnetizing current is neglected; Find the short-circuit resistance and reactance of the transformer for the secondary reduction to primary.

$$I_1 = \frac{10000}{4800} = 2{,}038 \, A$$

$$P_{sc} = R_{1k} \, x \, I_1^2$$

$$R_{1k} = \frac{180}{2{,}038^2} = 41{,}47\ \Omega$$

$$Z_{1k} = \frac{V_{1k}}{I_1} = \frac{180}{2{,}038} = 86{,}41\ \Omega$$

$$X_{1\mathrm{lk}} = \sqrt{86{,}41^2 - 41{,}47^2} = 75{,}8\ \Omega$$