EE 306 – Term 172

Solution HW # 4: DC Machines

Solution P1:

$P = 6, \quad Z = 120 \times 8 = 960$

$E_q = 1.5\ V/\text{conductor}$

$I_{conductor} = 4A, \quad N = 1150$ rpm

$a = 2$ (wave winding)

No. of Conductors per path $= \frac{960}{2} = 480$

Induced emf per path $= 480 \times 1.5$
$= 720V$

(a) No-load terminal voltage $= 720V$

(b) The output current at fullload $= 8A$

(c) $\phi = \frac{E_a \times 60 \times a}{PZN} = \frac{720 \times 60 \times 2}{6 \times 960 \times 1150}$

$\phi = 13.04\ mWb$

(d) $P_d = E_a I_a = 720 \times 8$

$\boxed{P_d = 5.76\ kW}$

Solution P2:

4.8 (a) $I_a\big|_{rated} = \frac{6000}{120} = 50\ A$

At $I_f = 1.0\ A$ and 1200 rpm $\rightarrow E_a = 120V$.

$V_t = 120 - 50 \times 0.2 = 110V$.

$P_o = 110 \times 50 = 5500\ W$, $P_{in} = 120 \times 50 + 400 = 6400\ W$

$Eff. = \frac{5500}{6400} \times 100\% = 85.94\%$

(b) At $I_f = 1.0\ A$ and 1500 rpm $\rightarrow E_a = 120 \times \frac{1500}{1200} = 150V$

$V_t = 150 - 50 \times 0.2 = 140\ V$.

$P_o = 140 \times 50 = 7000\ W$

$P_{in} = 150 \times 50 + 400 \times \frac{1500}{1200} = 8000\ W$

$Eff. = \frac{7000}{8000} \times 100\% = 87.5\%$

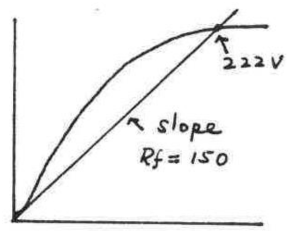
Solution P3:

4.13 1(a) $E_a\big|_{max}$ will occur at $R_{fc} = 0$

Draw field resistance line for

$R_f = R_{fw} = 150\Omega$

$E_a(max) = 222\ V$

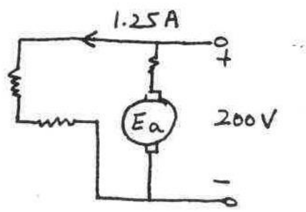


(b) $I_a(rated) = \frac{20,000}{200} = 100\ A$

$V_t\ (rated) = 200\ V$

$R_f = \frac{200}{1.25} = 160\Omega$

$R_{fc} = 160 - 150 = 10\Omega$



(c) $E_a = V_t + I_a R_a = 200 + 100 \times 0.1 = 210V$

$P_{dc} = E_a I_a = 210 \times 100 = 21000\ W$

$\omega_m = \frac{1800}{60} \times 2\pi = 188.5\ rad./sec.$

$T = \frac{E_a I_a}{\omega_m} = \frac{21000}{188.5} = 111.41\ N.m$

Solution P4:

A six poles short shunt compound DC generator running at 1200 rpm delivers 25 KW to a load resistance at a terminal voltage of 250 V. The resistance of the armature, shunt field resistance and the series field resistance are 0.12 Ω, 125 Ω and 0.05 Ω respectively. The efficiency of the machine at the given load is 82%.

(a) Draw the equivalent circuit

(b) Estimate the input power and the corresponding applied input torque

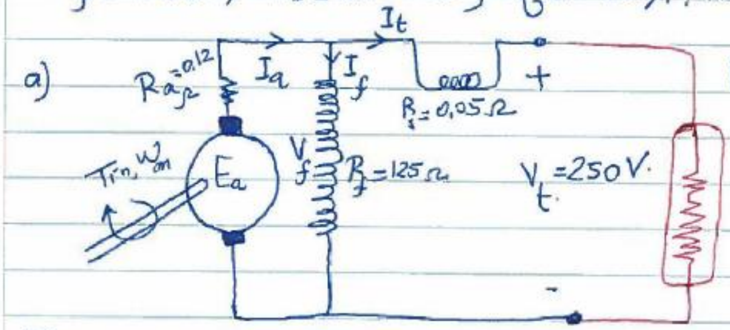
(c) Find the developed power and the corresponding developed torque

$p = 6$, Short Shunt Compound generator

$\omega = 1200\ rpm$, $R_f - 250$, $V_t = 250\ V$, $R_a = 0.12\ \Omega$,

$R_f = 125\ \Omega$, $R_s = 0.05\ \Omega$, $\eta = 82\ \%$, $P_{out} = 25\ kW$

a)



$P_{out} = 25\ kW$

$\omega_m = \frac{2\pi \times 1200}{60} = 125.66\ rd/sec.$

b)

$\eta = \frac{P_{out}}{P_{in}} \times 100\% \Rightarrow P_{in} = \frac{P_{out}}{\eta} = \frac{25}{0.82} = 30.488\ kW$

$P_{in} = T_{in} \times \omega \Rightarrow T_{in} = \frac{P_{in}}{\omega} = \frac{30.488 \times 10^3}{125.66} = 242.65\ N.m$

c)

$P_{dev} = E_a I_a$, $I_t = P_{out}/V_t = \frac{25 \times 10^3}{250} = 100\ A$

$E_a = V_f + I_a R_a$, $V_f = V_t + I_t \times R_s = 250 + (100)(0.05)$

$V_f = 255\ V$

$I_f = V_f/R_f = 255/125 = 2.04 A$, $I_a = I_f + I_t = 2.04 + 100 = 102.04\ A$

$I_a = 102.04\ A$, $E_a = 255 + (102.04)(0.12) = 267.2448\ V$

$P_{dev} = (267.2448)(102.04) = 27.26965\ kW$

$T_{dev} = P_{dev}/\omega = (27269.65/125.66) =$

$T_{dev} = 217.011\ N.m$

Solution P5:

4.26 (i) From no-load condition, rotational loss is

$P_{rot} = E_a I_a = (240 - 20 \times 0.5) \times 20 = (240 - 1) \times 20 = 4780\ \text{W}$

This can be assumed constant if the speed variation is small

(ii) $P_f = 240 \times 120 = 2880\ \text{W}$

(iii) $P_a = E_a I_a = (240 - 300 \times 0.05) \times 300 = 67500\ \text{W}$

$P_{out} = 67500 - 4780 = 62720\ \text{W}$

$P_{arm} = 240 \times 300 = 72000\ \text{W}$

$P_{in} = P_{arm} + P_f = 72000 + 2880 = 74880\ \text{W}$

$\text{Eff} = \frac{62720}{74880} \times 100\% = 83.8\%$

Solution P6:

4.27 $E_a|_{1100} = 500 - 100 \times 0.25 = 475\ \text{V}$

$E_a|_{900} = 475 \times \frac{900}{1100} = 388.6\ \text{V}$

$I_a|_{1100} = 100\ \text{A}$

$I_a|_{900} = 100 \times \frac{900}{1100} = 81.8\ \text{A}$

$IR = V - E_a = 500 - 388.6 = 111.4\ \text{V}$

$R = \frac{111.4}{81.8} = 1.36\ \Omega$

$R_{series} = 1.36 - 0.25 = 1.11\ \Omega$

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