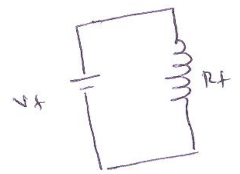
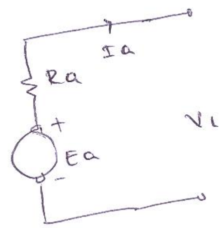
Problem 1





$P = 6$, $N = 1150$ rpm

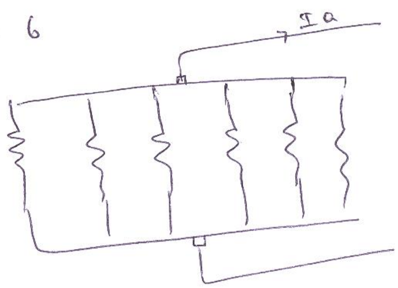
$Z = 120 * 8 = 960$

$E_g = 1.5$ V / conductor

$I_{conductor} = 4$ A

I- Lap connection

$a = P = 6$



conductor per Path $= \frac{960}{6} = 160$

induced emf per Path $= 160 * 1.5\text{ V} = 240$ V

a- $E_g = V_t = 240$ V

b- output current on full load $= 6 * 4$ A $= 24$ A

c- $\phi = ?$, $E_a = \frac{P \phi Z N}{60 a}$

$\Rightarrow \phi = \frac{E_g * 60 a}{P Z N} = \frac{240\text{ V} * 60 * 6}{6 * 960 * 1150} = 13.04$ mWb d- $P_d = E_a I_a$

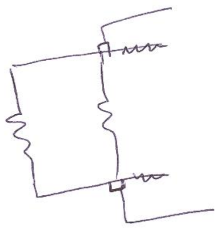
$= 240 * 24A$

$= 5.76$ kW

II - Wave connection

$P = 6$

$a = 2$



Number of conductor per path $= \frac{960}{2} = 480$

Induced emf per path $= 480 * 1.5V = 720V$

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

b- The output current on full load $= 2*4A = 8A$

c- $\phi = \frac{E_a * 60a}{PZN} = \frac{720*60*2}{6*960*1150} = 13.04$ mWb

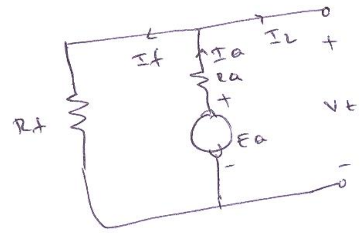
d- $P_d = E_a I_a$

$= 720V * 8A$

$= 5.76$ kW

Problem 2

- Shunt G



$R_a = 0.24\ \Omega$

$R_f = 250\ \Omega$

Load : 5 kW , 250 V

a- $I_L = \frac{5000\,W}{250\,V} = 20\,A$

$I_f = \frac{V_t}{R_f} = \frac{250\,V}{250\,\Omega} = 1\,A$

$I_a = I_f + I_L = 21\,A$

b- $E_a = V_t + I_a R_a$

$= 250 + (21)(0.24) = 255.04\ V$

c- $P_d = E_a I_a$

$= (255.04)(21) = 5.3558\ kW$

$P_d = T_e \cdot \omega_m$

$T_d = \frac{P_d}{\omega_m} = \frac{5.3558\,kW}{2\pi \times \frac{500}{60}} = 102.29\ N\text{-}m$

d- $P_{input} = P_{out} + P_{cu} + P_{rot}$

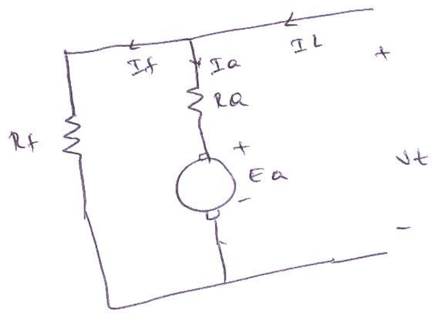
$P_{cu} = I_a^2 R_a + I_f^2 R_f = (21)^2(0.24) + (1)^2(250)$

$= 355.84\ W$

$P_{input} = 5000 + 355.84 + 645\,W = 6000.46\ W$

Problem 3

DC shunt motor



$R_a = 0.2\ \Omega$

$R_f = 110\ \Omega$

$P_{NL} = 1000\ W$

$V_t = 250\ V$

$\omega_{NL} = 1100\ rpm$

a -

$P_{NL} = V_T * I_{NL}$

$I_{LNL} = \frac{P_{NL}}{V_t} = \frac{1000\ W}{250\ V} = 4\ A$

$I_{fNL} = \frac{V_t}{R_f} = \frac{V_t}{R_f} = \frac{250\ V}{110\ \Omega} = 2.2727\ A$

$I_{aNL} = I_{LNL} - I_{fNL}$

$= 4 - 2.2727\ A = 1.727\ A$

$E_{aNL} = V_{tNL} - I_{aNL} * R_a$

$= 250 - 1.727 * 0.2 =$

$= 249.65\ V$

$\Rightarrow$ Rotational losses are

$P_{rot} = (E_{aNL})(I_{aNL})$

$= (249.65)(1.727)$

$= 431.153\ W$

OR, $P_{rot} = P_{NL} - I_f^2 R_f - I_{aNL}^2 R_a$

$= 1000 - (2.2727)^2 * (110) - (1.7273)^2 * (0.2)$

$= 431.23\ W$

b- $P_{INFL} = 14\ kW$

$V_T = 250V$

$I_{LFL} = \frac{P_{INFL}}{V_T} = \frac{14\ kW}{250\ V} = 56\ A$

$I_{fFL} = 2.2727\ A$

$\Rightarrow I_{aFL} = 53.728\ A$

$\rightarrow E_{aFL} = V_T - I_{aFL} * R_a$

$= 250 - (53.728)(0.2)$

$= 239.2544\ V$

Since armature reaction is neglected, $\phi_{NL} = \phi_{FL}$

$\frac{E_{aFL}}{E_{aNL}} = \frac{K \phi_{FL} \cdot \omega_{FL}}{K \phi_{NL} \cdot \omega_{NL}} = \frac{\omega_{FL}}{\omega_{NL}}$

$\Rightarrow \omega_{FL} = \frac{E_{aFL}}{E_{aNL}} * \omega_{NL}$

$= \frac{239.25}{249.65} * 1100 = 1054.2\ rpm$

c- Speed regulation

$$S_{reg} = \frac{\omega_{NL} - \omega_{FL}}{\omega_{FL}} * 100\%$$

$$= \frac{1100 - 1054.2}{1054.2} * 100\% = 4.34\%$$

d. The converted power

$$P_{converted} = E_{aFL} * I_{aFL}$$

$$= (239.25)(53.728)$$

$$= 12854.39 \text{ W}$$

$$P_{converted} = T_e \cdot \omega_{FL}$$

$$T_e = \frac{P_{converted}}{\omega_{FL}} = \frac{12854.39}{1054.2 * \frac{2\pi}{60}}$$

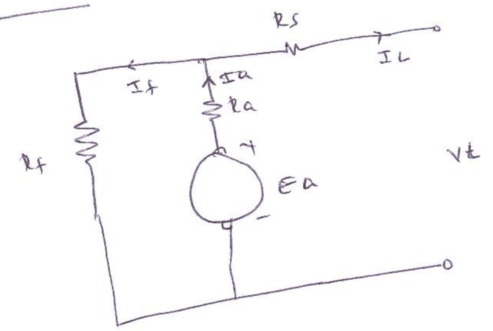
$$= 116.44 \text{ N-m}$$

e. $$\eta = \frac{P_{out}}{P_{in}} * 100\% = \frac{P_{conv} - P_{rot}}{P_{in}} * 100\%$$

$$= \frac{12854.39 - 431.23}{14000} * 100\%$$

$$= 88.73\%$$

Problem 4



$P_{out} = 240 \times 100A = 24\ kW$

$I_f = 3A \Rightarrow I_a = I_L + I_f$

$= 100 + 3 = 103\ A$

a - $E_a = V_t + I_a R_a + I_L R_S$

$= 240 + 103(0.05) + 100(0.01) = 246.15\ V$

b - $V_t = E_a - I_a R_a$

$= 246.15 - 103(0.05) = 241\ V$

$\Rightarrow R_f = \frac{V_t}{I_f} = \frac{241V}{3A} = 80.33\ \Omega$

c. $P_d = E_a I_a$

$= (246.15V)(103A)$

$= 25.35345\ kW$

d. $\eta = \dfrac{P_{out}}{P_{out} + P_{cu} + P_{Rot}}$

$P_{cu} = I_a^2 R_a + I_f^2 R_f + I_L^2 R_S$

$= (103)^2 (0.05) + (3)^2 (80.33) + (100)^2 (0.01)$

$= 500 + 722.97 + 100$

$= 1322.97$ W

$\eta = \dfrac{24\text{ kW}}{24\text{ kW} + 1.32297\text{ kW} + 2\text{ kW}} * 100\ \%$

$= 87.84\ \%$