P1)

$$I_2 = \frac{150 \times 10^3}{240} = 625 \text{ A}$$

$$\frac{I_2}{a} = 62.5 \angle -36.8^\circ = 50 - j37.5 \text{ A}$$

$$aV_2 = 2400 \angle 0^\circ = 2400 + j0 \text{ V}$$

$$a^2R_2 = 0.2\ \Omega \quad \text{and} \quad a^2X_2 = 0.45\ \Omega$$

Hence

$$E_1 = (2400 + j0) + (50 - j37.5)(0.2 + j0.45)$$
$$= 2427 + j15 = 2427 \angle 0.35^\circ \text{ V}$$

$$I_m = \frac{2427 \angle 0.35^\circ}{1550 \angle 90^\circ} = 1.56 \angle -89.65 = 0.0095 - j1.56 \text{ A}$$

$$I_c = \frac{2427 + j15}{10{,}000} \approx 0.2427 + j0 \text{ A}$$

$$I_0 = I_c + I_m = 0.25 - j1.56 \text{ A}$$

$$I_1 = I_0 + \frac{I_2}{a} = 50.25 - j39.06 = 63.65 \angle -37.850^\circ \text{ A}$$

Thus, the primary voltage is

$$V_1 = (2427 + j15) + (50.25 - j39.06)(0.2 + j0.45)$$
$$= 2455 + j30 = 2455 \angle 0.7^\circ \text{ V}$$

$$VR = \frac{2455 - 2400}{2400} * 100 = 2.3\ \%$$

$$P_i = I_c^2 R_c \ , \ P_{Cu} = I_1^2 R_1 + I_2^2 R_2$$

$$P_i + P_{Cu} = 2.18 \text{ KW}, \quad P_{O/P} = 150 * 0.8 = 120 \text{ KW}$$

$$\eta = \frac{120}{120 + 2.18} * 100 = 98.2\%$$

P2

$$aV_2 = 2400 \angle 0^0 \text{ V}$$

$$\frac{I_2}{a} = 50 - j37.5 \text{ A}$$

$$R_1 + a^2 R_2 = 0.4 \ \Omega$$

$$X_1 + a^2 X_2 = 0.9 \ \Omega$$

$$V_1 = (2400 + j0) + (50 - j37.5)(0.4 + j0.9)$$

$$= 2453 + j30 = 2453 \angle 0.7° \text{ A}$$

$$I_c = \frac{2453 \angle 0.7°}{10 \times 10^3} = 0.2453 \angle 0.7° \text{ A}$$

$$I_m = \frac{2453 \angle 0.7°}{1550 \angle 90°} = 1.58 \angle -89.3° \text{ A}$$

$$I_0 = 0.2453 - j1.58 \text{ A}$$

$$I_1 = 50.25 - j39.08 = 63.66 \angle -37.9° \text{ A}$$

$$\text{percent regulation} = \frac{2453 - 2400}{2400} \times 100 = 2.2\%$$

$$\text{efficiency} = \frac{120 \times 10^3}{120 \times 10^3 + (63.66)^2(0.4) + (0.2453)^2(10 \times 10^3)}$$

$$= 0.982 = 98.2\%$$

Notice that the approximate circuit yields results that are sufficiently accurate.

O.C

$R_c' = \frac{(120)^2}{80} = 180\,\Omega$, $a = \frac{450}{120} = 3.75$

$R_c = a^2 R_c' = \underline{\underline{2530\,\Omega}}$

$I_c' = \frac{120}{R_c'} = 0.667\,A$, $I_m' = \sqrt{I_o^2 - I_c'^2} = 4.15\,A$

$X_m' = \frac{120}{I_m'} = 28.94\,\Omega$

$X_m = a^2 X_m' = \underline{\underline{407}}\,\Omega$

S.C

$Z_{e_1} = \frac{9.65}{22.2} = 0.435\,\Omega$

$R_{e_1} = \frac{120}{(22.2)^2} = \underline{\underline{0.243}}\,\Omega$

$X_{e_1} = \sqrt{Z_{e_1}^2 - R_{e_1}^2} = \underline{\underline{0.361}}\,\Omega$

$I_{1FL} = \frac{10000}{450} = 22.2\,A$

Voltage Drop $\simeq I_1 (R_{e_1} \cos\phi + X_{e_1} \sin\phi) \simeq 9.2\,V$

$VR = \frac{9.2}{450} * 100 = 2.04\,\%$

$\eta_{FL} = \frac{10000 * 0.8}{10000 * 0.8 + 80 + 120} * 100 = 97.57\,\%$

at half load

$\eta = \frac{\frac{1}{2} * 10000 * 0.8}{\frac{1}{2} * 10000 * 0.8 + 80 + (\frac{1}{2})^2 * 120} * 100 = 97.34\,\%$

P4

(a) $I_t = \frac{P_{rated}}{V_t} = \frac{10{,}000}{250} = 40\ A$

$I_f = \frac{V_t}{R_f} = \frac{250}{125} = 2\ A$

$I_a = I_t + I_f = 40 + 2 = 42\ A$

$E_a = V_t + R_a I_a = 250 + (0.2)(42) = 258.4\ V$

(b) $\omega_m = \frac{2\pi n}{60} = \frac{2\pi(1750)}{60} = 183.26\ rad/sec$

$P_{dev} = E_a I_a = (258.4)(42) = 10{,}852.8\ W$

$T_e = \frac{P_{dev}}{\omega_m} = \frac{10{,}852.8}{183.26} = 59.2\ N\text{-}m$

(c) $VR = \frac{E_a - V_t}{V_t} \times 100 = \frac{258.4 - 250}{250} \times 100 = 3.36\%$

(d) $P_{cu} = I_a^2 R_a + I_f^2 R_f = (42)^2(0.2) + (2)^2(125) = 852.8\ W$

$P_{out} = 10{,}000\ W$

$P_{in} = P_{out} + P_{cu} + P_{rotational} = 10{,}000 + 852.8 + 450 = 11{,}302.8\ W$

$\eta = \frac{P_{out}}{P_{in}} = \frac{10{,}000}{11{,}302.8}\ 100\% = 88.5\%$

III) The no Load Saturation curve for a speed of 1500 rpm

a) $\frac{E_1}{E} = \frac{K_a \phi_{p_1} \omega_{m_1}}{K_a \phi_p \omega_m} \implies E = E_1 \frac{\omega_m}{\omega_{m_1}}$

$E = E_1 \frac{1500}{1800}$ (for a given field current the speed affects E proportionaly $E \propto$ speed)

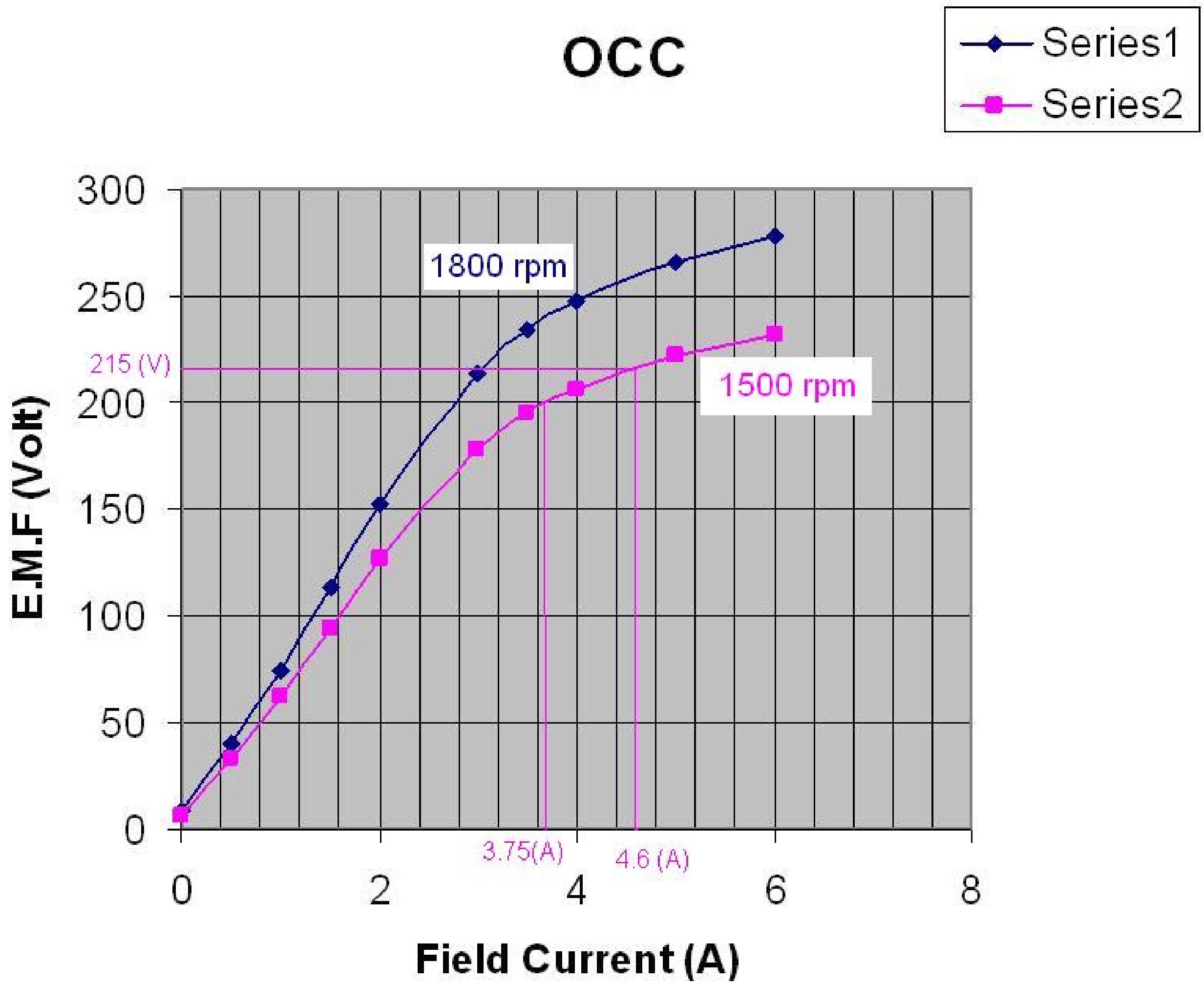
(V) E	6.67	33.33	61.67	94.17	126.7	177.5	195	206.7	221.7	231.7
(A) I_f	0	0.5	1.0	1.5	2.0	3.0	3.5	4.0	5.0	6.0

Both Plots are attached

b) when $I_f = 4.6$ A, $E = 215$ V at 1500 rpm.
taken from the graph

E at 1000 rpm is $215 \times \frac{1000 \text{ rpm}}{1500} = 143.33$ V

c) For a given field current, E = 120V at 900 rpm, this is equivalent to $E = 120 \times \frac{1500}{900} = 200$ V at 1500 rpm. From the graph the corresponding field current is 3.75 Amp.


OCC
Series1
Series2
1800 rpm
1500 rpm
215 (V)
3.75(A)
4.6 (A)
E.M.F (Volt)
Field Current (A)
300
250
200
150
100
50
0
0
2
4
6
8