2-1

解：

$$C_e\phi_N = \frac{U_N - I_{aN}R_0}{n_N} = \frac{440 - (255-5)*0.078}{500} = 0.841$$

(1) $T_N = 9550\frac{96}{500} = 1833.6(N*m)$

(2) $T_{eN} = C_T\phi_N I_{aN} = 9.55*0.841*255 = 2007.9(\mathrm{N*m})$

(3) $n_0 = \frac{U_N}{C_e\phi_N} = \frac{440}{0.841} = 523.2(rpm)$

(4) $I_{a0} = \frac{T_0}{C_T\phi_N} * \frac{T_{eN}-T_N}{9.55*0.841} = \frac{2007.9-1833.6}{9.55*0.841} = 21.7A$

$I_0 = I_{a0} + I_{fN} = 21.7 + 5 = 26.7(A)$

$n_0' = \frac{U_N - I_{a0}R_a}{C_e\phi_N} = \frac{440 - 21.7*0.078}{0.841} = 521.2(r/min)$

(5) $\mathrm{n} = \frac{U_N - I_{aN}(R_a+R_e)}{C_e\phi_N} = \frac{440-250(0.078+0.1)}{0.841} = 470.3(r/min)$

2-2

解：

$$R_a = \frac{1}{2}\left(\frac{U_N I_N - P_N}{I_N^2}\right) = \frac{1}{2}\left(\frac{220*305-60000}{305^2}\right) = 0.038(\Omega)$$

$$C_e\phi_N = \frac{220 - 305*0.038}{1000} = 0.2084$$

(1) $\begin{cases} T_e = 0 \\ n = n_0 = \frac{U_N}{C_e\phi_N} = \frac{220}{0.2084} = 1055.7(N*m) \end{cases}$

$\begin{cases} T_e = 9.55C_e\phi_N I_N = 9.558*0.2084*305 = 607(N*m) \\ n_N = 1000rpm \end{cases}$

(2) $\begin{cases} T_e = 0 \\ n_0 = 1055.7rpm \end{cases}$

$\begin{cases} T_e = 607N*m \\ n = \frac{U_N - I_N(R_a+R_e)}{C_e\phi_N} = \frac{220-305(0.038+0.4)}{0.2084} = 414.6rpm \end{cases}$

(3) $\begin{cases} T_e = 0 \\ n_0 = \frac{110}{0.2084} = 527.8r/min \end{cases}$

$\begin{cases} T_e = 607N*m \\ n = 527.8 - (1055.7 - 1000) = 472rpm \end{cases}$

(4) $\begin{cases} T_e = 0 \\ n_{01}^* = \frac{U_N}{0.8C_e\phi_N} = \frac{220}{0.8*0.2084} = 1319.6r/min \end{cases}$

$\begin{cases} T_e = 607N*m \\ n = \frac{U_N}{0.8C_e\phi_N} - \frac{R_a}{9.55(0.8*0.2084)^2}T_e = \frac{220}{0.8*0.2084} - \frac{0.038}{9.55(0.8*0.2084)^2} * 607 = 1319.6 - 86.9 = 1232.7rpm \end{cases}$

2-3

解：

$$C_e\phi_N = \frac{440 - 50 * (0.5 * \frac{440}{50})}{550} = 0.4$$

(1) $\mathrm{n} = \frac{U_N - I_N R_N}{C_e \phi_N} = \frac{440 - 50 * \frac{U_N}{I_N}}{0.4} = \frac{440 - 440}{0.4} = 0$

(2) $550 = \frac{440 - 50 * (0.5 * \frac{440}{50})}{0.4} \qquad n_0 = \frac{440}{0.4} = 1100rpm$

(3) $C_e\phi_N = 0.4$

$1000 = \frac{440 - 50R_a}{0.4} \qquad R_a = \frac{440 - 400}{0.4} = 0.8(\Omega)$

(4) $T_{eN} = C_T \phi_N I_N = 9.55 * 0.4 * 50 = 191(N * m)$

$P_e = \frac{T_{eN} n_N}{9550} = \frac{191 * 1000}{9550} = 20(KW)$ 或 $P_{\mathrm{e}} = E_a I_N = (440 - 50 * 0.8) * 50 = 20(\mathrm{KW})$

(5) $\begin{cases} T_e = 0 \\ n_0 = 1100rpm \end{cases} \quad \begin{cases} T_{eN} = 191N * m \\ n_N = 1000r/min \end{cases}$

$\begin{cases} T_e = 0 \\ n_0 = 1100rpm \end{cases} \quad \begin{cases} T_{eN} = 191N * m \\ n = 0 \end{cases}$

$\begin{cases} T_e = 0 \\ n_0 = 1100rpm \end{cases} \quad \begin{cases} T_{eN} = 191N * m \\ n_N = 550r/min \end{cases}$

2-4

解：

$$R_a = \left(\frac{1}{2} \sim \frac{2}{3}\right) * \frac{220 * 53.4 - 10000}{53.4^2} = 0.3065 \sim 0.4087(\Omega)$$

(1) $K_I = \frac{I_{st}}{I_N} = \frac{\frac{220}{0.3065 \sim 0.4087}}{53.4} = 13.44 \sim 10.08$

(2) $R_{st} = \frac{U_N}{1.5 I_N} - R_a = \frac{220}{1.5 * 53.4} - (0.3065 \sim 0.4087) = 2.44 \sim 2.34(\Omega)$

(3) $U_a = 1.5 I_N R_a = 1.5 * 53.4 * (0.3065 \sim 0.4087) = 24.6 \sim 32.7(V)$

2-6

解：

$$C_e\phi_N = \frac{220 - 94 * 0.15}{1000} = 0.2059$$

(1) $R_{st} = \frac{U_N}{I_{st}} - R_a = \frac{220}{180} - 0.15 = 1.07(\Omega)$

(2) $n_{sc} = \frac{U_N - I_{sc}(R_a + R_{st})}{C_e \phi} = \frac{220 - 65 * (0.15 + 1.07)}{0.2059} = 683(r/min)$

$n = \frac{220}{0.2059} - \frac{1.22}{9.55 * 0.2059^2} T_e = 1068.5 - 3T_e$

或 $\begin{cases} n_0 = 1068.5 \\ I_a = 0 \end{cases} \quad \begin{cases} n_{sc} = 683 \\ I_{sc} = 65 \end{cases} \quad \begin{cases} n = 0 \\ I_{st} = 180 \end{cases}$

$(T_e = 0 \qquad T_{sc} = 127.8 \qquad T_{st} = 353.94)$

$T_M = \frac{(GD_M^2 + GD_C^2) 9.8}{375} * \frac{R_a + R_{st}}{9.55 * 0.2059^2} = 0.0427$

$$\mathrm{n} = I_{sc}\left(1 - e^{-\frac{t}{T_M}}\right) = 683\left(1 - e^{-\frac{t}{0.0427}}\right)$$

$$I_a = I_{sc} + (I_{st} - I_{sc})\mathrm{e}^{-\frac{t}{T_M}} = 65 + (180 - 65)e^{-\frac{t}{0.0427}} = 65 + 115e^{-\frac{t}{0.0427}}$$

(3) $t_{st} = (3\sim4)T_M = (3\sim4) * 0.0427 = 0.128\sim0.171(s)$

$$\hat{t_{st}} = T_M l_M \frac{n_{st} - n_{sc}}{n_x - n_{sc}} = 0.0427 l_M \frac{-n_{sc}}{\frac{1}{2}n_{sc} - n_{sc}} = 0.04207 l_M^2 = 0.0296(\mathrm{s})$$

2-7

解：

(1) 下坡时$T_e = T_f - T_W = -0.4T_{eN}$

$$\mathrm{n} = \frac{U_N}{C_e\phi_N} - \frac{R_a}{C_e C_T \phi_N^2}(T_f - T_N)$$

式中：$C_e\phi_N = \frac{440 - 76*0.377}{1000} = 0.41135$

$$T_{eN} = C_T\phi_N I_N = 9.55 * 0.41135 * 76 = 298.56(N * m)$$

$$n = \frac{440}{0.41135} - \frac{0.377}{9.55 * 0.41135^2}(-0.4 * 298.56) = 1069.6 + 27.86 = 1097.5(\mathrm{r/min})$$

$\because 1097.5 > n_0 = 1069.6$　电机处于回馈制动运行状态。

(2) $R_e = 0$ 时 $\mathrm{n} = 1097.5(\mathrm{r/min})$

$R_e = 0.5\Omega$ 时

$$\mathrm{n} = \frac{U_N}{C_e\Phi_N} - \frac{R_a + R_e}{C_e C_T \Phi_N^2}\left(T_f - T_W\right) = \frac{440}{0.41135} - \frac{0.377 + 0.5}{9.55 * 0.41135^2}(-0.4 * 298.56)$$

$$= 1069.6 + 64.8 = 1134.4(\mathrm{rpm})$$

2-8

解：

$$C_e\phi_N = \frac{110 - 35.2 * 0.35}{750} = 0.13024$$

(1) $R_b = \frac{E_a}{2I_N} - R_a = \frac{U_N - I_N R_a}{2I_N} - R_a = \frac{110 - 35.2*0.35}{2*35.2} - 0.35 = 1.0375(\Omega)$

(2) $n = -\frac{R_a + R_b}{C_e\phi_N} I_N = -\frac{0.35 + 1.0375}{0.13024} * 35.2 = -375(r/min)$

(3) $-500 = -\frac{0.35 + R_b}{0.13024} * 35.2$

$$R_b' = \frac{500 * 0.13024}{35.2} - 0.35 = 1.5(\Omega)$$

$$I_{am} = -\frac{E_a}{R_a + R_b'} = -\frac{U_N - I_N R_a}{R_a + R_b'} = -\frac{110 - 35.2 * 0.35}{0.35 + 1.5} = -52.8(A)$$

$$\frac{I_{am}}{I_N} = \frac{52.8}{35.2} = 1.5 \qquad I_{am} = 1.5 I_N$$

2-9

解：

$$E_a = U_N - I_N R_a = 110 - 112.1 * 0.1 = 98.79(V)$$

$C_e\phi_N = \frac{E_a}{n_N} = \frac{98.79}{750} = 0.13172$

$T_{eN} = C_T\phi_N I_N = 9.55 * 0.13172 * 112.1 = 141(N*m)$

(1) $R_b = \frac{U_N+E_a}{2.2I_N} - R_a = \frac{110+98.79}{2.2*112.1} - 0.1 = 0.747(\Omega)$

(2) $n = 0 \quad E_a = 0 \quad U_N = I_a(R_a + R_b)$

$I_a = \frac{110}{0.1+0.747} = -129.9(A)$

$T_e = -9.55 * 0.13172 * 129.9 = -163.4(N*m)$

$\because 163.4 > T_{eN} = 141(N*m)$ $\therefore$ 能反向起动。运？速度。

$\mathrm{n} = -\frac{U_N}{C_e\phi_N} - \frac{R_a+R_b}{C_e\phi_N} I_N = \frac{110}{0.13172} - \frac{0.1+0.747}{0.13172} * (-112.1) = -114.3(\mathrm{r/min})$

(3) $\mathrm{n} = -\frac{U_N}{C_e\phi_N} - \frac{R_a+R_b}{C_e\phi_N} I_N = -\frac{110}{0.13172} - \frac{0.847}{0.13172} * 112.1 = -1556(\mathrm{rpm})$

处于反向回馈制动状态

(4) $\mathrm{n} = \frac{-U_N - I_N R_a}{C_e\phi_N} \qquad -607 = \frac{-110-0.1I_a}{0.13172}$

$I_a = -300.46(A)$

$300.46 > 2.2I_N = 246.62$ 超过允许值

$\mathrm{n} = -\frac{U_N}{C_e\phi_N} - \frac{I_N R_a}{C_e\phi_N} = \frac{-110-112.1*0.1}{0.13172} = -920.2(r/min)$

$920.2 > n_0 = 835.1$ 反向回馈制动运行

2-10

解：

$R_a = \frac{1}{2} * \frac{110*185 - 17000}{185^2} = 0.0489(\Omega)$

$C_e\phi_N = \frac{110 - 185*0.0489}{1000} = 0.101$

(1) $\mathrm{n} = \frac{U_N - 0.8I_N R_a}{C_e\phi_N} = \frac{110-0.8*185*0.0489}{0.101} = 1017\left(\frac{r}{min}\right)$

$0 = E_a - 1.8I_N(R_a + R_b)$

$R_b = \frac{C_e\phi_N n}{1.8I_N} - R_a = \frac{0.101*1017}{1.8*185} - 0.0489 = 0.26(\Omega)$

(2) $-U_N = E_a - 1.8I_N(R_a + R_b)$

$R_b' = \frac{110 + 0.101*107}{1.8*185} - 0.0489 = 0.59(\Omega)$

(3) 皆为 $T_b = -1.8T_{eN} = -1.8 * 9.55 * 0.101 * 185 = -321.2(N*m)$

(4) 能耗制动 $T_e = 0$

反接制动

$I_a = \frac{-U_N}{R_a + R_b'} = -\frac{110}{0.0489 + 0.59} = -172.2(\mathrm{A})$

$T_b = -9.55 * 0.101.172.2 = -166(N*m)$

2-11

解：

$$C_e\phi_N = \frac{220 - 30.3 * 0.74}{1000} = 0.19758$$

$$T_{eN} = 9.55 * 0.19758 * 30.3 = 57.17(N * m)$$

$$E_a = 220 - 0.8 * 30.3 * 0.74 = 202.06(V)$$

(1) $R_b = \frac{U_N + E_a}{2I_N} - R_a = \frac{220+202.06}{2*30.3} - 0.74 = 6.225(\Omega)$

$$n_a = \frac{220}{0.19758} - \frac{0.74}{9.55 * 0.19758^2} T_e = 1113.5 - 1.985T_e = 1113.5 - 1.985 * 0.8 * 57.17$$
$$= 1022.7(\text{r/min})$$

$$n_b = -\frac{U_N}{C_e\phi_N} - \frac{R_a + R_b}{C_e\phi_N} * 0.8I_N = -\frac{220}{0.19758} - \frac{0.74 + 6.225}{0.19758} * 0.8 * 30.3$$
$$= -1113.5 - 854.5 = -1968(\text{rpm})$$

(2) $U_N = -C_e\phi_N n + 0.8I_N(R_a + R_b')$

$$R_b' = \frac{U_N + C_e\phi_N n}{0.8I_N} - R_a = \frac{220 + 0.19758 * 380}{0.8 * 30.3} - 0.74 = 11.43(\Omega)$$

(3) $U_N = C_e\phi_N n_a + I_a(R_a + R_b'')$

$$I_a = \frac{U_N - C_e\phi_N n_a}{R_a + R_b''} = \frac{220 - 0.19758 * 1022.7}{0.74 + 12} = 141(A)$$

$$\text{n} = \frac{220 - (0.74 + 12) * 0.8 * 30.3}{0.19758} = -449.5(r/min)$$

(4) $\text{n} = 0$，$E_a = 0$，故 $0 = U_N - 0.8I_N(R_a + R_b''')$

$$R_b''' = \frac{220}{0.8 * 30.3} - 0.74 = 8.34(\Omega)$$

2-13

解：

$$C_e\phi_N = \frac{440 - 76 * 0.377}{1000} = 0.41135$$

(1) $\text{n} = \frac{U_N - 0.8I_aR_a}{C_e\phi_N} = \frac{440-0.8*76*0.377}{0.41135} = 1014(r/min)$

(2) 能耗制动：

$$-500 = -\frac{R_a + R_b}{C_e\phi_N} * 0.8I_N = -\frac{0.377 + R_b}{0.41135} * 0.8 * 76$$

$$R_b = \frac{500 * 0.41135}{0.8 * 76} - 0.377 = 3(\Omega)$$

验证：

$$0 = E_a + I_{am}(R_a + R_b)$$

$$I_{am} = -\frac{C_e\phi_N n}{R_a + R_b} = -\frac{0.41135 * 1014}{0.377 + 3} = -123.5(A)$$

$123.5 > 2I_N = 152\ A$　　瞬时过载

(3) 倒拖制动：

$$-500 = \frac{U_N - 0.8I_N(R_a + R_b')}{C_e\phi_N} = \frac{440 - 0.8 * 76(0.377 + R_b')}{0.41135}$$

$$R_b' = \frac{440 + 500 * 0.41135}{0.8 * 76} - 0.377 = 10.24(\Omega)$$

(4) 电压反接制动需逐渐降压，或串电阻后降压，以保持$I_{am} < 2I_N$

$$-500 = \frac{-U - 0.8I_N R_a}{C_e\phi_N}$$

$$\mathrm{U} = 500 * 0.41135 - 0.8 * 76 * 0.377 = 182.75(\mathrm{V})$$

2-14

解：

(1) $\mathrm{n} = \frac{U_N - I_a R_a}{C_e\phi_N} = \frac{440 - 0.377(-60)}{0.41135} = 1069.6 - 55 = 1124.6(r/min)$

(2) $0 = E_a + I_N(R_a + R_b)$

$$R_b = \frac{0.41135 * 500}{76} - 0.377 = 2.33(\Omega)$$

$$T_e = 9.55 * 0.41135 * 76 = 298.56(N * m)$$

$$T_2 = T_{eN} + T_0 = T_{eN} + (T_{eN} - T_N) = 2T_{eN} - T_N = 2 * 9.55 * 0.41135 * 76 - 9550\frac{29}{1000}$$

$$= 320(N * m)$$

其中 $T_0 = T_{eN} - T_N = 21.61(N * m)$

验证： $I_{am} = -\frac{1000 * 0.41135}{2.707} = 152(A) = 2I_N$

(3) $-600 = \frac{440 - 50(0.377 + R_b')}{0.41135}$ $\qquad R_b' = 13.36(\Omega)$

$$T_e = 9.55 * 0.41135 * 50 = 196.42(N * m)$$

$$T_2 = T_e + T_0 = 196.42 + 21.61 = 218.03(N * m)$$

$$P_2 = -\frac{600}{9550}T_2 = -\frac{600}{9550} * 218.03 = -13.7(KW)$$

$$P_1 = 440 * 50 = 22(KW)$$

$$P_{cu} = 50^2(13.36 + 0.377) = 34.34(KW)$$

2-15

解：

$$C_e\phi_N = \frac{110 - 319 * 0.025}{1000} = 0.102$$

$$\mathrm{n} = \frac{U_N - 0.85I_N R_a}{C_e\phi_N} = \frac{110 - 0.85 * 319 * 0.025}{0.102} = 1078 - 66 = 1012(r/min)$$

$$R_a + R_b = \frac{E_a}{1.8I_N} = \frac{0.102 * 1012}{1.8 * 319} = 0.18(\Omega)$$

$$n_{sc} = -\frac{R_a + R_b}{C_e\phi_N} * 1.8I_N = \frac{-0.18}{0.102} * 1.8 * 319 = -478.5(rpm)$$

$$T_M = \frac{(GD_M^2 + GD_L^2)g}{375} * \frac{R_a + R_b}{9.55C_e\phi_N^2} = \frac{(5.9 + 1.2) * 9.8}{375} * \frac{0.18}{9.55 * 0.102^2} = 0.336(S)$$

位能：$\mathrm{n} = n_{sc} + (n_{st} - n_{sc})\mathrm{e}^{-\frac{t}{T_M}} = -478.5 + (1012 + 478.5)\mathrm{e}^{-\frac{t}{0.336}}$

$$= -478.5 + 1490.5\mathrm{e}^{-\frac{t}{0.336}}$$

$$\mathrm{t} = (3\sim4)T_M = (3\sim4) * 0.336 = 1\sim1.344(S)$$

反抗：1012~0 rpm 位能负载 $\mathrm{n} = -478.5 + 1490.5\mathrm{e}^{-\frac{t}{0.336}}$

$$t = T_M l_n \frac{n_{st} - n_{sc}}{n_x - n_{sc}} = 0.336 \frac{1012 + 478.5}{478.5} = 0.382(S)$$

2-16

解：

$$C_e\phi_N = \frac{220 - 158 * 0.1}{750} = 0.2723$$

$$T_{eN} = 9.55 C_a \phi_N I_N = 9.55 * 0.2723 * 158 = 410.87(N * m)$$

(1) $n_{st} = \frac{220}{0.2723} - \frac{0.1}{9.55*0.2723^2} T_L = 807.9 - 0.1412 T_L = 807.9 - 0.1412 * 293 = 766.5(\mathrm{r/min})$

(2) $R_a + R_b = \frac{U_N + E_a}{2I_N} = \frac{220+0.2723*766.5}{2*158} = 1.3567(\Omega)$

$$n_{sc} = -\frac{U_N}{C_e\phi_N} - \frac{R_a + R_b}{9.55 C_e \phi_N^2} T_L = \frac{-220}{0.2723} - \frac{1.3567}{9.55 * 0.2723^2} T_L$$

$$n_{sc} = -807.9 - 1.916 T_L = -807.9 - 1.916 * 293 = -1369.3(r/min)$$

$$T_M = \frac{GD_M^2 + GD_L^2}{375} * \frac{R_a + R_b}{9.55 C_e \phi_N^2} = \frac{8.5 * 9.8}{375} * \frac{1.3567}{9.55 * 0.2723^2} = 0.426(S)$$

$$n = n_{sc} + (n_{st} - n_{sc})\mathrm{e}^{-\frac{t}{T_M}} = -1369.3 + (766.5 + 1369.3)\mathrm{e}^{-\frac{t}{0.426}}$$

$$= -1369.3 + 2135.8\mathrm{e}^{-\frac{t}{0.426}}$$

$$t_1 = 0.426 ln \frac{766.5 + 1369.3}{1369.3} = 0.189(S)$$

$$t_2 = 0.426 ln \frac{1369.3}{-807.9 + 1369.3} = 0.38(S)$$

$$t_{反向} = (3\sim4) T_M = (3\sim4) * 0.426 = 1.278\sim1.704(S)$$

$$t_3 = t - t_1 - t_2 = 0.898\sim1.324(S)$$

(3) $n_{sc} = 807.9 - 1.916(-293) = -246.5(r/min)$

$$t_{反接} = n_{sc} + (n_{st} - n_{sc})\mathrm{e}^{-\frac{t}{T_M}} = -1369.3 + 2135.8\mathrm{e}^{-\frac{t}{0.426}}$$

$$n_{反动} = -246.5 + 246.5\mathrm{e}^{-\frac{t}{0.426}}$$

$$t_1 = 0.426 ln \frac{766.5 + 1369.3}{1369.3} = 0.189(S)$$

$$t_2 = (3\sim4) T_M = 1.278\sim1.704(S)$$

$$\mathrm{t} = t_1 + t_2 = 0.189 + (1.278\sim1.704) = 1.467\sim1.893(S)$$

2-18

解：

$$C_e\phi_N = \frac{220 - 158.5 * 0.1}{1000} = 0.20415$$

$$T_{eN} = 9.55 * 0.20475 * 158.5 = 309(N * m)$$

(1) $\mathrm{n} = \frac{220-0.8*158.5*0.1}{0.20415} = 1015.5(rpm)$

(2) $\mathrm{n} = \frac{220-0.8*158.5*(0.1+0.3)}{0.20415} = 829.2(r/min)$

(3) $I_{am}=\frac{U-E_a}{R_a}=\frac{188-0.20415*1015.5}{0.1}=-193.14(\mathrm{A})$

$$\mathrm{n}=\frac{188-0.8*158.5*0.1}{0.20415}=858.5(r/min)$$

(4) $I_a=\frac{0.8T_{eN}}{C_T\phi}=\frac{0.8*9.55*0.20415*158.5}{0.8*0.20415*9.55}=158.5(A)$

$$n=\frac{220}{0.8*0.20415}-\frac{0.1}{0.8^2*9.55*0.20415^2}*0.8*9.55*0.20415*158.5$$

$$=\frac{220}{0.8*0.20415}-\frac{0.1*158.5}{0.20415}=1250(r/min)$$

2-20

解：

$$C_e\phi_N=\frac{110-0.23*44.8}{1500}=0.06646$$

(1) $T_0=T_{eN}-T_N=9.55*0.06646*44.8-9550\frac{4}{1500}=2.967(N*m)$

(2) $n_0=\frac{110}{0.06646}-\frac{0.23}{9.55*0.06646^2}*2.967=1639(r/min)$

(3) $800=\frac{110-44.8(0.23+R_e)}{0.06646}$

$$R_e=\frac{110-800*0.06646}{44.8}-0.23=1.0386(\Omega)$$

$$800=\frac{U-44.8*0.23}{0.06646}$$

$$\mathrm{U}=800*0.06646+44.8*0.23=63.5(\mathrm{V})$$

$P_{1R}=110*44.8=4.928(KW)$

$P_{1V}=63.5*44.8=2.8450(KW)$

$P_{2R}=P_{2V}=T_N\Omega=\frac{P_N}{\Omega_N}\Omega=\frac{P_N}{1500}*800=2.133(KW)$

$\eta_R=\frac{P_{2R}}{P_{1R}}*100\%=\frac{2.1333}{4.928}*100\%=43.3\%$

$\eta_V=\frac{P_{2V}}{P_{1V}}*100\%=\frac{2.1333}{2.8448}*100\%=75\%$

串R_e增加了$P_{CU}=I_N^2R_e=44.8^2*1.0386=2.0845(KW)$

2-21

解：

$$C_e\phi_N=\frac{220-103*0.18}{500}=0.4029$$

$T_{eN}=9.55*0.4029*103=396.33(N*m)$

(1) $T_L=T_{eN}=9.55C_e\phi_NI_N=9.55*\frac{1}{3}C_e\phi_NI_a$

$I_a=3I_N=3*103=309(A)$

$I_a=3I_N>2.5I_N$ 不能长期运行

$$\mathrm{n}=\frac{220}{C_e\phi_N}*3-\frac{0.18}{9.55\left(\frac{1}{3}C_eP_N\right)^2}*9.55C_e\phi_N I_N=\frac{220}{0.4029*3}-\frac{0.18*103*9}{0.4029}$$

$$=1638-414=1224\left({}^{r}/_{min}\right)<n_{max}=1500r/min$$

(2) $\because \frac{T_L n}{9550}=\frac{T_{eN}n_N}{9550}$ $\therefore 9.55*\frac{1}{3}*C_e\phi_N I_a n=9.55C_e\phi_N I_N n_N$

$\frac{1}{3}I_a n=I_N n_N$ $\because$ 恒功率$I_a=I_N=103(\mathrm{A})$

$\therefore n=3n_N=3*500=1500(\mathrm{r/min})$

能长期运行

2-22

解：

$$C_e\phi_N=\frac{220-68.7*0.224}{1500}=0.1364$$

$$n_0=\frac{220}{0.1364}=1612.9(\mathrm{r/min})$$

$$\triangle n_N=n_0-n_N=1612.9-1500=112.9(r/min)$$

(1) R_e: $s=\frac{n_0-n_{min}}{n_0}$ $n_{min}=n_0(1-s)=1612.9(1-0.3)=1129(r/min)$

U: $\mathrm{s}=\frac{\triangle n_N}{n_{01}}$ $n_{01}=\frac{1612.9}{0.3}=376.3(r/min)$

$n_{min}=n_{01}-\triangle n_N=376.3-112.9=263.4(r/min)$

(2) R_e: $D=\frac{1500}{1129}=1.33$

U: $D=\frac{1500}{263.4}=5.69$

(3) $R_e=\frac{220-0.1364*1129}{68.7}-0.224=0.7366(\Omega)$

$U=C_e\phi_N n_{01}=0.1364*376.3=51.3(V)$

(4) R_e: $P_1=U_N I_N=220*68.7=15.114(KW)$

$P_2=P_e-P_0\approx P_e=E_a I_N=0.1364*1129*68.7=10.5795(KW)$

U: $P_1=UI_N=51.3*68.7=3.524(KW)$

$P_2=0.1364*263.4*68.7=2.468(\mathrm{KW})$

2-24

解：

$$C_e\phi_N=\frac{440-76*0.377}{1000}=0.41135$$

(1) $n_0=\frac{440}{0.41135}=1069.6(r/min)$

$n_{min}=n_{0min}+\triangle n_N=250+(1069.6-1000)=180.4(r/min)$

$S_{max}=\frac{\triangle \mathrm{n}}{n_{0min}}=\frac{1069.6-1000}{250}=0.278=27.8\%$

(2) $C_e\phi=\frac{U_N}{n_{0max}}=\frac{440}{1500}=0.2933$

$$n_{max} = \frac{440 - 0.377 * 76}{0.2933} = 1402.5(r/min)$$

(3) D $= \frac{n_{max}}{n_{min}} = \frac{1402.5}{180.4} = 7.77$

2-25

解：

$$C_e\phi_{NM} = \frac{220 - 305 * 0.058}{1000} = 0.2023$$

(1) n $= \frac{E_{aG}}{C_e\phi_{NM}} - \frac{(R_{aM}+R_{aG})I_N}{C_e\phi_{NM}} = \frac{230}{0.2023} - \frac{(0.042+0.058)*305}{0.2023} = 1136.9 - 150.8 = 986(r/min)$

S $= \frac{1136.9 - 986}{1136.9} = 0.133 = 13.3\%$

(2) $n_{0min} = \frac{n_{0min}-n_{min}}{S} = \frac{1136.9-986}{0.3} = 503(r/min)$

$n_{min} = 503 - (1136.9 - 986) = 503 - 150.9 = 352(r/min)$

$n_{max} = 1.2n_{NM} = 1.2 * 1000 = 1200(r/min)$

$D = \frac{1200}{352} = 3.41$

(3) $n_{min} = \frac{n_{max}}{D} = \frac{1200}{10} = 120(r/min)$

$S_{max} = \frac{n_{0max} - n}{n_{0min}} = \frac{1136.9 - 986}{120 + (1136.9 - 986)} = 0.557 = 55.7\%$