1-1

$P_2 = P_N = 7.5kW$

$\frac{P_2}{P_1} \times 100\% = \eta_N \Rightarrow P_1 = 8.4746kW$

$P_1 = U_N I_N \Rightarrow I_N = 38.521A$

$T_N = 9550 \cdot \frac{P_2}{n_N} = 47.75 N \cdot m$

1-2

① $P_2 = P_N = 180kW$

$\frac{P_2}{P_1} \times 100\% = \eta_N \Rightarrow P_1 = 201.1173kW$

$P_1 = U_N I_N \Rightarrow I_N = 874.423A$

② $P_1 = U I_N = 87.4423kW$

$P_2 = P_1 \cdot \eta_N \Rightarrow P_2 = 78.266kW$

1-6

$P_2 = P_N = 2.2kW$

$P_1 = \frac{P_2}{\eta_N} = 2.5581kW$

$I_N = \frac{P_1}{U_N} = 11.628A$

$\left.\begin{array}{l} P_e = E_a I_N \\ E_a = U_N - I_N \cdot R_a \end{array}\right\}$

$\Rightarrow P_e = 2.313kW$

$P_{cua} = I_N^2 R_a = 245.136W$

$P_0 = P_e - P_2 = 113W$

$T_e = 9550 \frac{P_e}{n_N} = 14.73 N \cdot m$

$T_2 = 9550 \frac{P_2}{n_N} = 14.01 N \cdot m$

$T_0 = T_e - T_2 = 0.72 N \cdot m$

1-8

$I_f = \frac{U_N}{r_f} = 2.4176A$

$I_N = I_f + I_{aN} = 77.4176A$

$\left.\begin{array}{l} P_e = E_a I_{aN} \\ E_a = U_N - I_{aN} R_a \end{array}\right\}$

$\Rightarrow P_e = 15.038kW$

$\left.\begin{array}{l} P_2 = P_e - P_0 \\ P_0 = P_{Fe} + P_m \end{array}\right\}$

$\Rightarrow P_2 = 14.240kW$

$T_2 = 9550 \frac{P_2}{n_N} = 135.992 N \cdot m$

$P_1 = U_N I_N = 17.032kW$

$\eta_N = \frac{P_2}{P_1} \times 100\% = 83.61\%$

2-16

① $E_{aN} = U_N - I_N \cdot R_a$

$= 99.696V$

$P_0 = P_e - P_N$

$P_e = E_{aN} I_N$

$\Rightarrow P_0 = 466.38W$

$T_0 = 9550 \frac{P_0}{n_N}$

$\Rightarrow T_0 = 2.969 N \cdot m$

② $n_0 = \frac{U_N}{C_e \Phi_N}$

$E_{aN} = C_e \Phi_N \cdot n_N$

$\Rightarrow C_e \Phi_N = 0.06646$

$\Rightarrow n_0 = 1655 r/min$ 理想

$T_0 = C_T \Phi \cdot I_a'$

$E_a' = U_N - I_a' R_a$

$E_a' = C_e \Phi_N \cdot n_0'$

$\Rightarrow n_0' = 1639 r/min$ 实际

③ P_2直接用输出端算!

$n = 800 r/min$

$E_a' = C_e \Phi \cdot n = 53.168V$

对串电阻 $E_a' = U_N - I_N(R_a + R_e)$

$\Rightarrow R_e = 1.639 \Omega$

$P_1 = U_N I_N = 4.928kW$

$\eta = \frac{P_2}{P_1} \times 100\% = 38.88\%$

对降压 $E_a' = U' - I_N R_a$

$\Rightarrow U' = 63.472V$

$P_1 = U' I_N = 2.844 kW$

$\eta = \frac{P_2'}{P_1} \times 100\% = 67.37\%$

从输入端计算需要重新计算各种损耗

$P_e' = E_a' I_N = 2.382kW$

$P_2' = P_e' - P_0 = 1.916kW$

如何不对!

$P_2 = \frac{T_{eN} \cdot n}{9550}$ 从输出端算更简单

$= 9550 \frac{P_N}{n_N} \cdot n$

$= 2.133kW$

2-17

① $T_e = C_T \Phi \cdot I_a$

$= C_T \frac{1}{3} \Phi_N I_a = C_T \Phi_N I_N = T_{eN}$

$\Rightarrow I_a = 3 I_N = 309 A$

$E_a' = U_N - I_a R_a$

$E_a' = C_e \frac{1}{3} \Phi_N \cdot n'$

$\Rightarrow n' = 1224 r/min < n_{max} = 1500$

$E_a = U_N - I_N R_a$

$E_a = C_e \Phi_N \cdot n_N$

$\Rightarrow C_e \Phi_N = 0.4029$

$\because I_a = 3 I_N > I_N \therefore$ 不能长期运行

② $T_e = C_T \Phi \cdot I_a$

$= 9.55 \frac{E_a}{n} I_a$

$= 9.55 \frac{U_N - I_a R_a}{n} I_a$

由题意有 $I_a = I_N = 103 A$

$E_a = C_e \frac{1}{3} \Phi_N \cdot n'$

$E_a = U_N - I_N R_a$

$\Rightarrow n' = 1550 r/min < n_{max}$,

$I_a = I_N$

$\Rightarrow$ 能长期运行

4-5

堵转时短路试验 $\Rightarrow \frac{1-s}{s}=0$ $s=1$ 不转

$$I_k=\frac{U_k/\sqrt{3}}{\sqrt{(r_1+r_2')^2+(x_1+x_2')^2}}$$

$$P_k=3I_k^2(r_1+r_2')$$

$$x_1=x_2'$$

$$\Rightarrow \begin{cases} r_2'=0.418\,\Omega \\ x_1=3.149\,\Omega \\ x_2'=3.149\,\Omega \end{cases}$$

空载试验 $\Rightarrow$ 转 $\Rightarrow$ 考虑机械损耗!

$$P_{10}-P_m=3(I_{10}^2r_1+I_{10}^2r_m)$$

$$\Rightarrow r_m=3.444\,\Omega$$

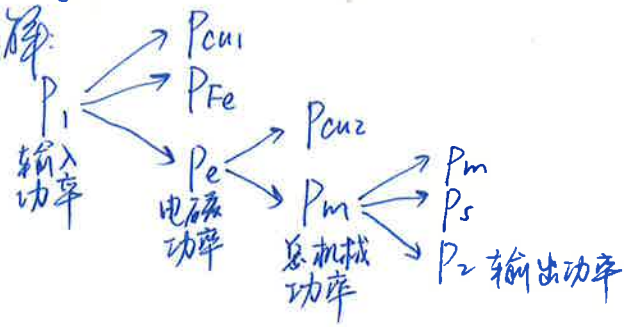
$$I_{10}=\frac{U_N/\sqrt{3}}{\sqrt{(r_1+r_m)^2+(x_1+x_m)^2}}$$

$$\Rightarrow x_m=37.289\,\Omega$$

$\therefore x_1=3.149\,\Omega$, $r_2'=0.418\,\Omega$,

$x_2'=3.149\,\Omega$, $r_m=3.444\,\Omega$, $x_m=37.289\,\Omega$

4-8



由题目数据有

$$P_2=P_1-P_{Cu1}-P_{Fe}-P_{Cu2}-P_m-P_s$$

$$=6.32\times10^3-341-167.5-237.5-45-29$$

$$=5.5\,kW$$

$$\eta=\frac{P_2}{P_1}\times100\%=87.03\%$$

$$s=\frac{P_{Cu2}}{P_e}=\frac{237.5}{6.32\times10^3-341-167.5}=0.041$$

4极 $\rightarrow$ 2对极 ($p=2$!)

$$n_s=\frac{60f_1}{p}=750\ r/min$$

$60\times50/2$, $p=2$, 1500

$$n=(1-s)n_s=719.25\ r/min$$

1438 1439 转速取整数

$$T_e=9550\frac{P_e}{n_s}=\frac{6.32-0.341-0.1675}{750}\times9550$$

$$=74.00\ N\cdot m$$

37.00 N·m

$$T_2=9550\frac{P_2}{n}=73.03\ N\cdot m$$

36.50 N·m

$\therefore \eta=87.03\%$, $s=0.041$,

$n=719.25$ r/min (1439), $T_e=74.00\ N\cdot m$ (37.00),

$T_2=73.03\ N\cdot m$ (36.5) ✓

解：在额定工作条件下 $n_s=1000$

$$S_N=\frac{n_s-n_N}{n_s}=\frac{1000-976}{1000}=0.024$$

$$S_{crN}=S_N(\lambda_T+\sqrt{\lambda_T^2-1})$$

$$=0.092$$

~~$T_N=9550\frac{P_N}{n_N}=733.86N\cdot m$~~ 无关，不用求

~~$T_{max}=\lambda_T T_N=1504.42N\cdot m$~~

又 $I_{2N}=\dfrac{E_{2N}/\sqrt{3}}{\sqrt{(\frac{r_2}{S_N})^2+X_2^2}}$ $r_2=\frac{E_{2N}}{I_{2N}\sqrt{3}}\cdot S_N=$

$$T_N=\frac{9.55\times3\,E_{2N}I_{2N}}{n_s}\times\frac{r_2/S_N}{\sqrt{(r_2/S_N)^2+X_2^2}}$$

解得 $r_2=$ ~~0.133Ω~~ 0.0139Ω (0.0157)

~~$X_2=0.974\Omega$~~

$S_{cr}\propto r_2'$ $\propto r_2$

① 当串入0.2Ω时 S_{cr}' 最大

$$S_{cr}'=\frac{0.2+r_2}{r_2}\cdot S_{crN}$$

思路√ $S'=\frac{0.2+r_2}{r_2}\cdot S_N \Rightarrow S'=0.330$

$=$ ~~1.416~~ ~~1.264~~

$\therefore n'=(1-S_{cr})n_s=$ ~~-416~~ 670 r/min

恒转矩

$\therefore$ 电机调速范围为 ~~-416~~~1000 r/min (670~976)

② 理想空载下 $n_0\approx n_s$，

$$S=\frac{n_s-n_N}{n_s}=0.024$$ $\frac{n_s-n'}{n_s}=\frac{1000-670}{1000}=33\%$

③ 设0.05Ω，0.1Ω，0.2Ω时电机转差率为 S_1,S_2,S_3，临界转差率为 S_{cr1},S_{cr2},S_{cr3}

~~$T_N=\dfrac{2}{\frac{S_{cr1}}{S_1}+\frac{S_1}{S_{cr1}}}T_{max}$~~

~~$S_{cr1}=\frac{0.05+r_2}{r_2}S_{crN}$~~

~~解得 $S_1=0.888$ 或 0.846~~

$S_{cr1}=\frac{0.05+r_2}{r_2}\cdot S_{crN}$

$S_{cr1}=S_1(\lambda_T+\sqrt{\lambda_T^2-1})$

解得 $S_1=0.110$

$n_1=(1-S_1)n_s=890$ r/min

同理可得

$S_2=0.197$，

$n_2=(1-S_2)n_s=803$ r/min

$S_3=$ ~~0.096~~ 0.369，

$n_3=(1-S_3)n_s=631$ r/min

恒转矩 ① $r=0.2$，$n=670$ ✓

② $r=0.1$，$S=\frac{0.1+r_2}{r_2}\cdot S_N=0.177$，$n=823$ ✓

③ $r=0.05$，$S=\frac{0.05+r_2}{r_2}S_N=0.100$，$n=900$ ✓

5-13

取 $p=2$，有 $n_s=1500$

$$S_N=\frac{n_s-n}{n_s}=0.033$$

$$S_{crN}=S_N(\lambda_T+\sqrt{\lambda_T^2-1})$$

$$=0.123$$

$$I_{2N}=\frac{E_{2N}}{\sqrt{(\frac{r_2}{S_N})^2+X_2^2}}$$

$$T_N=9.55\times3\frac{E_{2N}I_{2N}}{n_s}\cdot\frac{r_2/S_N}{\sqrt{(r_2/S_N)^2+X_2^2}}$$

$$T_N=\frac{P_N}{n_N}\times9550$$

$\Rightarrow r_2=0.121\Omega$

(1) 由题有 $S=\frac{n_s-n}{n_s}=0.3$

~~$S_{cr}=S(\lambda_T+\sqrt{\lambda_T^2-1})=1.120$~~

~~$\frac{S_{cr}}{S_{crN}}=\frac{r_2+r_e}{r_2}\Rightarrow r_2+r_e=1.102\Omega$~~

$$\lambda=\frac{T_{max}}{T_L}=\frac{T_{max}}{0.8T_N}=\frac{5}{4}\lambda_T$$

$$S_{cr}=S(\tfrac{5}{4}\lambda_T+\sqrt{(\tfrac{5}{4}\lambda_T)^2-1})=1.437$$

$$\frac{S_{cr}}{S_{crN}}=\frac{r_2+r_e}{r_2}\Rightarrow r_2+r_e=1.414\Omega$$

5-13

$s_{cr1} = s_N(\lambda_T + \sqrt{\lambda_T^2 - 1})$

$s_N = \frac{n_s - n_N}{n_s} = 0.033$

$s_{cr1} = 0.123$

① 对于串电阻调速有

$s = \frac{n_s - n}{n_s} = 0.3$

$\lambda = \frac{T_m}{T_L} = \frac{T_m}{0.8T_N} = \frac{5}{4}\lambda_T = 2.5$

$s_{cr2} = s(\lambda + \sqrt{\lambda^2 - 1})$

$= 1.437$

对于原曲线

$\frac{r_2}{s_N} = \frac{E_{2N}/\sqrt{3}}{I_{2N}}$

$\Rightarrow r_2 = 0.098\,\Omega$

$\frac{r_2 + R_e}{r_2} = \frac{s_{cr2}}{s_{cr1}} = \frac{1.437}{0.123}$

$\Rightarrow R_e = 1.047\,\Omega$

② 降压调速有

$s_{cr1} = 0.123$

$s = 0.3 > s_{cr1}$

$\Rightarrow$ 无法用降压调速达到所需转速

$n' = (1 - s_{cr1}) \cdot n_s$

$= 1316\ r/min$

$\Rightarrow$ 转速在 1316 r/min 以上才可降压调速

③ 变频调速

对原曲线

a点: $0.8T_N = \frac{2s_a}{s_{cr1}} \cdot T_m$

N点: $T_N = \frac{2s_N}{s_{cr1}} T_m$

$\Rightarrow s_a = 0.8 s_N = 0.026$

$\Delta n_a = s_a n_s = 39.6$

对变频后曲线

$n_{s2} = n + \Delta n_a = 1090\ r/min$

$\frac{n_{s2}}{n_{s1}} = \frac{f_{12}}{f_{1N}}$

$\Rightarrow f_{12} = 36.33\,Hz$

$\frac{U_{1N}}{f_{1N}} = \frac{U_{12}}{f_{12}}$

$\Rightarrow U_{12} = 276.11\,V$