ELECTROTECHNICS SOLUTION HTTTC BAMBILI 2009

EXERCISE 1 :

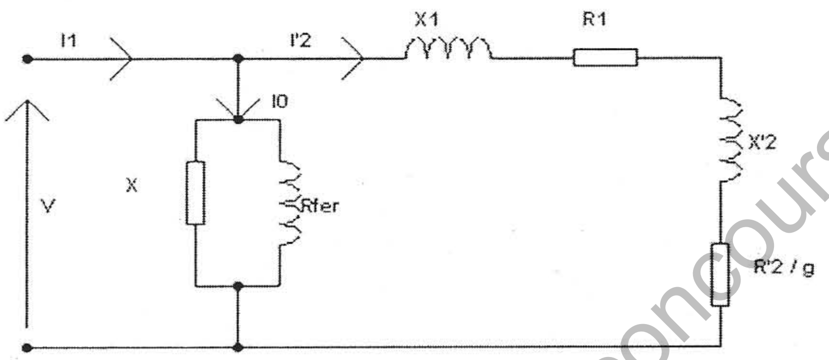
Data : P=50Hp ;

U=575V ;p=2 ;f=60Hz ;R_1=0.17Ω ;R_2=0.24Ω ;X_1=0.55Ω ;X_2=0.6Ω ;I_0=18A ;

P_0=2490W

1.1- For g=0.033, $P_{fer}=P_{rot}$ determine :

1.1.1- The value of the current and power factor



- **Value of the current I_1**

$$\boxed{\underline{I_1} = \underline{I_2} + \underline{I_0}} \;;$$

$$\underline{I_2'} = \frac{V}{\left(R_1 + \frac{R_2}{g}\right) + j(X_1 + X'_2)} = \frac{575/\sqrt{3}}{\left(0.17 + \frac{0.24}{0.033}\right) + j(0.55 + 0.6)}$$

$$= \frac{331.976}{7.442 + j1.16}$$

$$\underline{I_2'} = 44.087\angle - 8.78° \;\; (A)$$

I_0 = 18A

But $P_0=3VI_0\cos\phi_0$ → $Cos\varphi_0 = \frac{P_0}{3V.I_0}$

$$Cos\varphi_0 = \frac{2490}{3x331.976x18} = 0.1388 \;\rightarrow\; \varphi_0 = 82.01° \,;$$

Then

- $\underline{I_1} = \underline{I_2} + \underline{I_0} = 44.087\angle - 8.78° + 18\angle 82.01°$;

$\underline{I_1} = 43.57 - j6.729 + 2.502 + j17.82$;

$\underline{I_1} = 46.07 + j11.091 = 47.388\angle 13.53°$;

$\boxed{\underline{I_1} = 47.388\angle 13.53°\ (A)}$

- Power factor

$\underline{I_1} = 47.388\angle 13.53°\ (A) \rightarrow Cos\varphi = \cos(13.53) = 0.972$

$\boxed{Cos = 0.972;\ \text{Leading}}$

1.1.2- Developed torque

The developed power is

$P_2 = 3.I'^2_2(\frac{R'_2}{g})$;

So $\boxed{T_2 = \frac{P_2}{2\pi N_s}}$

Then

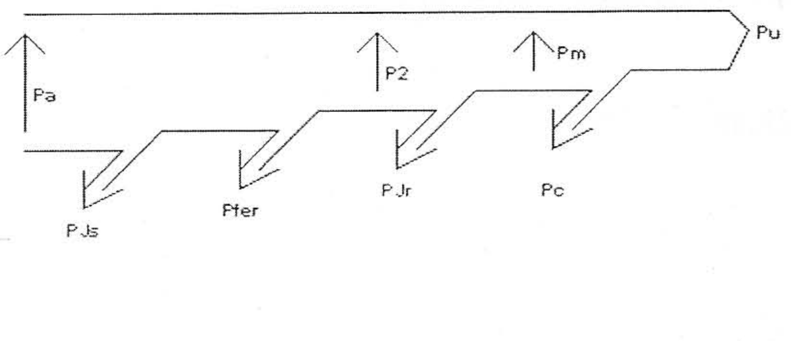
$$P_2 = 3.44.087^2\left(\frac{0.24}{0.03}\right) = 42407.20W$$

And then since f=60Hz and p=2 $\rightarrow N_s = \frac{f}{p} = \frac{60}{2}$; $N_s = 30rps = 1800rev/min$

$T_2 = \frac{P_2}{2\pi N_s} = \frac{60x42407.20}{2\pi x1800}$;

$\boxed{T_2 = 225.09Nm}$

1.1.3- Mechanical power P_m



$P_m = P_2 - P_{Jr} = P_2 - g.P_2 = (1-g)_{P2}$; $\boxed{P_m = (1-g)P_2}$

$P_m =$ (1-0.033)42407.20 ; $\boxed{P_m = 41007.7624W}$

1.1.4-The efficiency

$$\boxed{\eta = \frac{P_u}{P_a} = \frac{P_u}{P_2+P_{fer}+P_{Js}}} \quad ;$$

but $P_{fer} = P_{rot} = gP_2 = 0.033x42407.20 = 1399.43$

and $P_{Js} = 3R_1I_1^2 = 3x0.17x47.388^2 = 1145.26W$

$$\eta = \frac{50x736}{42407.20+1145.26+1399.43}; \qquad \boxed{\eta = 81.86\%}$$

1.2- Calculation of the current at starting (I_{st})

At starting N=0 → $g = 1$

$$I_{2st} = \frac{V}{\sqrt{(R_1 + R'_2)^2 + (X_1 + X'_2)^2}} = 271.91\angle 70.38°$$

$I_0 = 18\angle 82.01°$

Then $\boxed{\vec{I}_{st} = \vec{I}_{2st} + \vec{I}_0}$; $\boxed{\vec{I}_{st} = 289.56\angle 71.1° \,(A)}$

EXERCISE 2

Data:

- 10 pump: 0.75KW, cosϕ=0.75, η=0.76

  8 pump: 3KW, cosϕ=0.8, η=0.87

  K_u=0.9 ; K_s=0.9
- 15 three phase resistor: 2KW

  K_u=1; K_s=1

I- Determine the circuit breaker current Q_1 , Q_2, and Q_3

- Power on Q_2 line

Appliance	P_u (KW)	η	K_u	K_s	cosϕ	P_a(KW)	Q_a(KVAR)
10pumps Of 1.75KW Each	7.5	0.76	0.9	0.9	0.75	08	7.05
08 pumps Of 3KW each	24	0.87	0.9	0.9	0.8	22.35	16.76
					Total	30.55	23.81

$$S_{Q_2} = \sqrt{P_a^2 + Q_a^2} = \sqrt{30.35^2 + 23.81^2} = 38.575$$

$$S_{Q_2} = 38.575\ KVA \rightarrow \boxed{I_{Q_2} = \frac{S_{Q2}}{\sqrt{3}U}} = 101.2; \quad \boxed{I_{Q_2} = 101.23\ A}$$

- Power on Q_3 line

Appliance	P_u (KW)	η	K_u	K_s	cosϕ	P_a(KW)	Q(KVAR)
15 3~ Resistance 2KW	30	1	1	1	1	30	00

$$S_{Q_3} = 30KVA$$

$$\boxed{I_{Q_3} = \frac{S_{Q3}}{\sqrt{3}U}} \quad ; = \frac{30000}{\sqrt{3}x220} = 78.73A ; \quad \boxed{I_{Q_3} = 78.73A}$$

- Power on Q_1 line

$$S_{Q_1} = \sqrt{\left(P_{ap} + P_{aR}\right)^2 + Q_p^2} \; ; = \sqrt{(30.35 + 30)^2 + (23.81)^2} = 64.877KVA$$

$$\boxed{I_{Q_1} = \frac{S_{Q1}}{\sqrt{3}U}}$$

$= \frac{64877}{\sqrt{3}x220} = 170.25A$;

$I_{Q_1} = 170.25A$

EXERCISE 3:

3.1 Determination of the total apparent power (S_T)

Receptor (A)

$P_A = S_A cos\varphi$

$P_A = 15x0.6;$ $P_A = 9KW$

$Q_A = S_A \sin(cos^{-1}0.6)$

$Q_A = 15x0.8$; $Q_A = 12KVAR$

Receptor (B)

$P_B = S_B cos\varphi$

$P_A = 12x0.9;$ $P_A = 10.8KW$

$Q_B = S_B \sin(cos^{-1}\varphi)$

$Q_A = 12x\sin(cos^{-1}0.9)$; $Q_A = 5.23KVAR$

Load	KW	KVAR
A	9	12
B	10.8	5.23
Total	19.8	17.23

Therefore

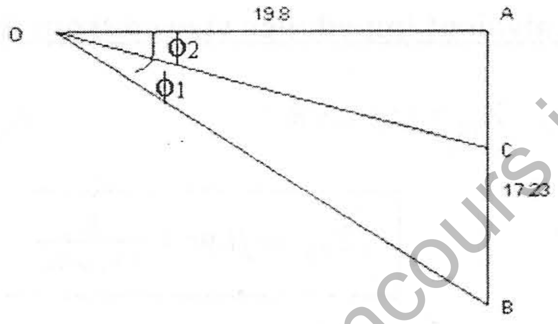
$S_T = \sqrt{P_{AB}^2 + Q_{AB}^2}$; $S_T = \sqrt{19.8^2 + 17.23^2} = 26.25KW$; $S_T = 26.25KW$

3.2 Determination of the power factor

$cos\varphi = \frac{P_{AB}}{S_T}$; $cos\varphi = \frac{19.8}{26.25}$; $Cos\varphi = 0.75$

3.3 To raise the power factor to 0.98

- Determination of the set reactive power



As previously determined,

AB = 17.23KVAR ; similarly AC = 19.8tan(11.48) = 4

BC = AB – AC → BC = 17.23 - 4 = 13.23KVAR

BC = Q_C ; Q_C=13.23KVAR

This is the total KVA required

- The capacity of the capacitor

Since in the capacitive circuit: I=V/X_C ,

Multiplying both side by V so that

$Q_c = VI = \frac{V^2}{X_c}$ (Volt ampere reactive)

Thus $X_c = \frac{V^2}{Q_c} = \frac{220^2}{13230} = 3.66\Omega$

$C = \frac{1}{2\pi f X_c}$; $C = \frac{1}{2\pi x 60 x 3.66}$; $C = 725\mu F$