2018 Fall

Q. A three phase, 45KW, 6 pole, 960 rpm induction motor has a constant load torque of 270 N-m and at a wide intervals additional torque of 1350 N-m for 10 seconds. Calculate:

i. The moment of inertia of flywheel used for load equalization if motor torque is not to exceed twice the rated value.
ii. Time taken after removal of additional load, before the motor torque becomes 630 N-m.

Soln:-

Given, ~~P = 45 KW~~

Power (P) = 45 KW

no. of poles (p) = 6

N = 960 rpm

load torque (T_L) = Constant load torque + addition load torque for 10 seconds

= 270 + 1350 = 1620 N-m

(i) For moment of inertia of flywheel,

Given condition, motor torque (T_m) = $2 T_{Full\ load}$

we have, $P = T \times \omega \Rightarrow T = P/\omega$

$\therefore T_{Full\ load} = \frac{45 \times 10^3}{2\pi N/60}$ $\left[\because \omega = \frac{2\pi N}{60}\right]$

= ~~895.2 N-m~~ 447.6 N-m

And, $T_m = 2 T_{full\ load} = 2 \times 447.6 = 895.2$ N-m

$N_s = \frac{120 f}{P} = \frac{120 \times 50}{6} = 1000$ rpm

Full load slip (s) $= N_s - N = 1000 - 960 = 40$ rpm

Also we have,

$S = K T_{\text{Full load}}$ where, S = slip in rad/sec

So, $\frac{2\pi \times 40}{60} = K \times 447.6$

$\therefore K = 0.00936$

Now, Torque developed by motor is given as

$T_M = T_L - (T_L - T_0) e^{-t/JK}$

(T_L ← const. load torque)

$\Rightarrow 895.2 = 1620 - (1620 - 270) e^{-10/0.00936J}$

$\Rightarrow e^{(-1068.4/J)} = 0.537$

$\Rightarrow \frac{1068.4}{J} = \log_e \left(\frac{1}{0.537}\right) = 0.622$

$\therefore J = 1717.7 \text{ kg-m}^2$

Hence, moment of inertia of flywheel $= 1717.7 \text{ kg-m}^2$

(ii) For time taken after removal of additional load

We have,

$$T_M = T_0 + (T_M' - T_0)\, e^{-t/JK}$$

T_0 → const. load torque

T_M' → torque developed by motor at which load is removed suddenly

$$\Rightarrow 630 = 270 + (895.2 - 270)\, e^{-t/(0.00936 \times 1717.7)}$$

$$\Rightarrow e^{t/16.08} = 1.737$$

$$\Rightarrow \frac{t}{16.08} = \log_e 1.737$$

$$\therefore t = 16.08 \times \log_e 1.737 = 8.879 \text{ sec} \quad \#$$

Assignment 4:

2.22 A 6 pole, 50 Hz, 3-phase wound rotor induction motor has a flywheel coupled to its shaft. The total moment of inertia of motor-load-flywheel is 1000 kg-m^2. Load torque is 1000 N-m of 10 sec duration followed by a no load period which is long enough for the drive to reach its no load speed. Motor has a slip of 3% at a torque of 500 N-m. Calculate
(i) Maximum torque developed by the motor.
(ii) Speed at the end of deceleration period.
Assume motor speed-torque curve to be a straight line in the operating range.

2.23 A motor equipped with a flywheel has to supply a load torque of 600 N-m for 10 sec followed by a no load period long enough for the flywheel to regain its full speed. It is desired to limit the motor torque to 450 N-m. What should be the moment of inertia of the flywheel? The no load speed of the motor is 600 rpm and it has a slip of 8% at torque of 400 N-m. Assume the motor speed-torque characteristic to be a straight line in the range of operation. Motor has an inertia of 10 kg-m^2.

2.24 A 3-phase, 100 kW, 6 pole, 960 rpm wound rotor induction motor drives a load whose torque varies such that a torque of 3000 N-m of 10 sec duration is followed by a torque of 500 N-m of duration long enough for the motor to attain steady-state speed. Calculate moment of inertia of the flywheel, if motor torque should not exceed twice the rated value. Moment of inertia of the motor is 10 kg-m^2. Motor has a linear speed-torque curve in the region of interest.

2.25 Solve Problem 2.24, when the motor has speed torque characteristic such that from no load to twice the rated torque the speed-torque curve is a straight line parallel to torque axis and at twice the rated torque the characteristic is parallel to the speed axis. Minimum motor speed is to be restricted to 60% of the synchronous speed.

Answers:

2.22 (i)796.55 N-m (ii)952.2 rpm

2.23 564 kg-m^2

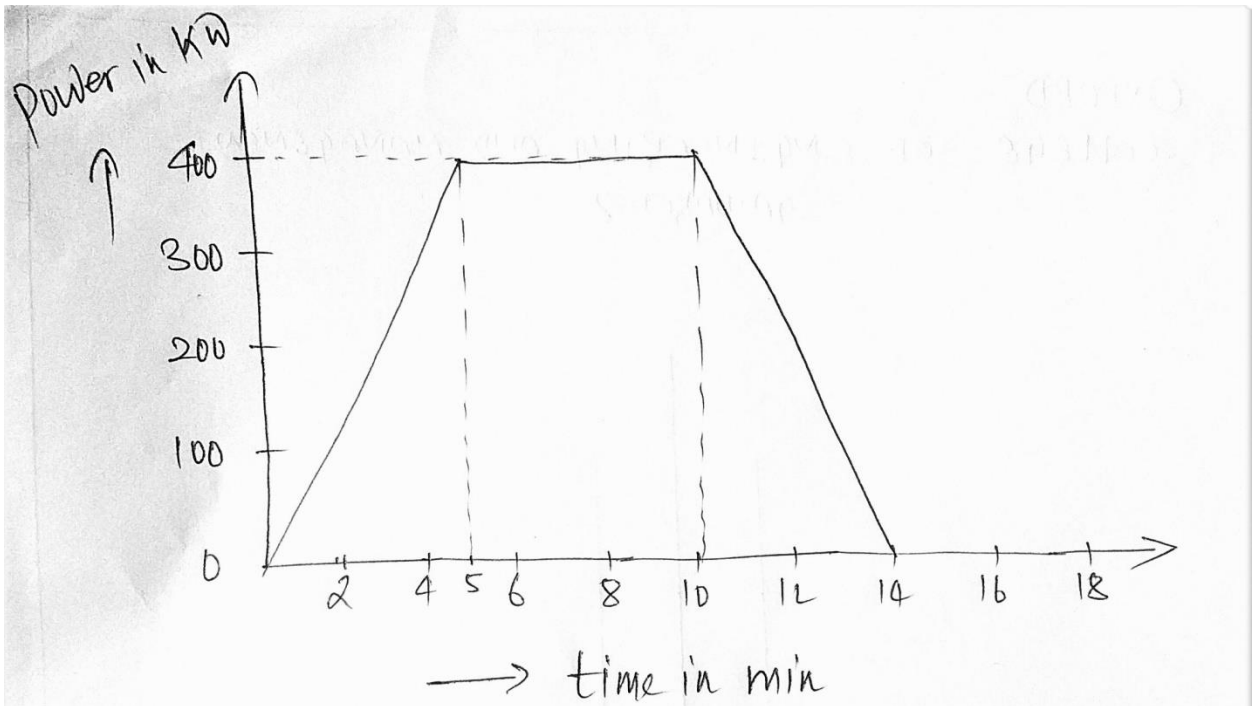
2.24 2611 kg-m^2

2.25 231.25 kg-m^2

2015 spring

Q. A constant speed drive has following duty cycle :

i. load rising 0 to 400 KW: 5 min
ii. uniform load 400 KW: 5 min
iii. regenerative power 400KW returned to supply: 4 min
iv. remain idle: 10 min



The equivalent power is given by

$$P_{eq} = \left[\frac{\frac{1}{3}\{(400)^2 \times 5\} + (400)^2 \times 5 + \frac{1}{3}\{(400)^2 \times 4\}}{24}\right]^{1/2}$$

$= 231$ KW

Assignment 5:

Q. A motor driving a colliery winder has to deliver a load rising uniformly from zero to maximum of 1500 KW in 20 sec during the accelerating period , 70 KW for 40 sec during the full speed period and during the decelerating period of 10 sec, when the regenerative braking takes place the KW which is returned to the supply fall from an initial value of 250 to zero. The interval of decking(period of rest)before the next load cycle starts in 20 sec. Estimate the suitable rating of the motor. **(2018 spring)**