

Required Homework 9

Induction Machine Operation

The equivalent circuit parameters of a 100 hp, 460 V (rms), 60 hz, 4 pole, three phase induction motor are:

$$\begin{array}{lll} r_1 = 0.0369\Omega & x_1 = 0.284\Omega & x_m = 9.93\Omega \\ r_2 = 0.407\Omega & x_2 = 0.284\Omega & \text{Neglect core loss} \end{array}$$

For operation with rated voltage and frequency, the performance at rated speed and zero speed is:

Rated Speed = 1770 rpm

$$I_1 = 108 \text{ A rms} \quad P_{in} = 77.35 \text{ Kw} \quad T = 402.5 \text{ Nm} \quad P_{out} = 74.600 \text{ Kw} \quad S = 0.0167$$

$$\cos \theta = 0.899 \quad P_g = 75.87 \text{ Kw} \quad I^2R_2 = 1.267 \text{ Kw} \quad \text{eff} = 96.5 \%$$

Starting = Zero Speed

$$I_1 = 470 \text{ A rms} \quad P_{in} = 49.96 \text{ Kw} \quad T = 135.1 \text{ Nm} \quad P_{out} = 0 \text{ w} \quad S = 1.0$$

a) Operating at reduced voltage with full torque results in higher slip and poorer performance. Evaluate the performance if the voltage drops to 85% and the speed drops to 1755 (S = 0.0248) in order to still supply rated torque.. (25 points)

$$\begin{array}{l} 85\% \text{ Rated Voltage} \\ \text{Slip} = \underline{0.0248} \\ I_1 = \underline{\hspace{2cm}} \text{ A} \\ P_{in} = \underline{\hspace{2cm}} \text{ w} \\ T = \underline{403} \text{ Nm} \\ P_o = \underline{\hspace{2cm}} \text{ hp} \\ \cos \theta = \underline{\hspace{2cm}} \\ P_g = \underline{\hspace{2cm}} \text{ w} \\ I^2R_2 = \underline{\hspace{2cm}} \text{ w} \\ \text{eff} = \underline{\hspace{2cm}} \% \end{array}$$

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b) Use the equivalent circuit to find the slip and the speed that result in maximum torque (reasonable approximations encouraged). If the rotor resistance could be increased, what new value of r_2 would result in maximum torque at starting (zero speed). (25 points)

$$S_{MT} = \underline{\hspace{2cm}}$$

$$\text{Speed} = \underline{\hspace{2cm}} \text{ rpm}$$

$$\text{new } r_2 = \underline{\hspace{2cm}} \Omega$$

c) Use the starting performance data to find the voltage ratio (V_o/V_{in}) of a transformer starter which will limit the **transformer input side** starting current to 150% of rated motor current (no new equivalent circuit computations are necessary). What is the motor current and torque in % of the rated values for this starting condition. (25 points)

$$V_o/V_{in} = \underline{\hspace{2cm}}$$

$$I_1 = \underline{\hspace{2cm}} \%$$

$$T = \underline{\hspace{2cm}} \%$$

d) Evaluate the motor performance at 20 hz with constant volts/hz and at the same slip frequency as in part a ($S = 3 \times 0.0167 = 0.050$). Recall that except for the effect of stator resistance the current and torque should be the same as rated values so your answers should be “close” to those given in the problem statement. (25 points)

$$I_1 = \underline{\hspace{2cm}} \text{ A}$$

$$P_{in} = \underline{\hspace{2cm}} \text{ w}$$

$$T = \underline{\hspace{2cm}} \text{ Nm}$$

$$P_o = \underline{\hspace{2cm}} \text{ hp}$$

$$\cos \theta = \underline{\hspace{2cm}}$$

$$P_g = \underline{\hspace{2cm}} \text{ w}$$

$$I^2 R_2 = \underline{\hspace{2cm}} \text{ w}$$

$$\text{eff} = \underline{\hspace{2cm}} \%$$