Tutorial - Induction Motors

1. The slip will be 1 if the rotor is stationary. The rotor frequency equals to stator.

2. $P_{stator} = 3 I_1^2 R_1 = 3 \times 22.6^2 \times 0.2$

$P_{Cu} = 306\ W$

$P_{AG} = P_{in} - P_{Cu} = 15.7 - 0.3 = 15.4\ kW$

$n_s = \frac{120}{P} f = \frac{120}{2} \times 60 = 3600\ rpm$

$s = \frac{3600 - 3502}{3600} = 0.0272$

$P_{RCu} = s P_{AG} = 0.0272 \times 15.4 = \underline{419\ W.}$

3. $Z_f = R_f + jX_f = \left(\frac{R_2}{s} + jX_2\right) \;//\; jX_m$

$$Z_f = \frac{1}{\left(\frac{0.1}{0.01} + j0.2\right)^{-1} + \left(\frac{1}{j10}\right)}$$

$Z_f = 4.9 + j5\ \Omega.$

$Z_{eq} = R_1 + jX_1 + Z_f = 0.1 + j0.2 + 4.9 + j5$

$\underline{Z_{eq} = 5 + j5.2\ \Omega.}$

$\omega_m = (1-s)\omega_s = (1-0.01) \times \omega_s = 0.99\omega_s$

$n_s = \frac{120}{P} f = \frac{120}{6} \times 60 = 1200\ rpm.$

$\Rightarrow \omega_s = \frac{1200 \times 2\pi}{60} = 125.7\ rad/s$

$\Rightarrow \omega_m = 0.99\omega_s = 0.99 \times 125.7$

$\underline{\omega_m = 123.2\ rad/s}$

4. $P_{AG} = n \cdot I_1^2 R_f = 3 \times 18.8^2 \times 5.41$

$P_{AG} = 5740\ W.$

$P_{shaft} = P_{conv} - \text{Losses}.$

$= (1-s) P_{AG} - 403$

$= (1-0.02) \times 5740 - 403$

$P_{shaft} = 5220\ W$

$T_{shaft} = \frac{P_{shaft}}{\omega_m} = \frac{5220}{123.2}$

$T_{shaft} = 42.4\ Nm$

5. a) $P_{in} = \sqrt{3}\, V_L I_L \cos\theta = \sqrt{3} \times 480 \times 60 \times 0.85$

$P_{in} = 42.4\ kW.$

$P_{AG} = P_{in} - P_{scl} - P_{core} = 42.4 - 2 - 1.8$

$P_{AG} = 38.6\ kW$

b) $P_{conv} = P_{AG} - P_{rcl} = 38.6 - 0.7$

$P_{conv} = 37.9\ kW$

c) $P_{out} = P_{conv} - P_{fric+wind} = 37.9 - 0.6$

$P_{out} = 37.3\ kW$

d) $\eta = \frac{P_{out}}{P_{in}} \times 100 = \frac{37.3}{42.4} \times 100$

$\eta = 88\%$