Indian Institute of Technology Bombay
EE 114 Power Engineering 1 (S2)
2021-2022, Semester 2
Assignment 7

1. A 3-ϕ 50 Hz induction motor has a full-load speed of 1440 RPM. For this motor calculate,
   (a) The number of poles.
   (b) Full-load slip and rotor frequency.
   (c) The speed of the stator field with respect to the
      i. Stator structure.
      ii. Rotor structure.

   [Ans: (a) No. of poles= 4, (b) s_{Fl} = 0.04 and $f_r = 2$ Hz, (c) i. 1500 RPM, ii. 60 RPM]

2. A 3-ϕ induction motor at full-load draws 0.25 times the starting current. Neglect the stator resistance and stator leakage inductance. If the starting torque is 1.5 times of the full-load torque,
   (a) Find the full-load slip.
   (b) Determine the slip at which the motor develops the maximum torque.
   (c) Determine the maximum torque developed by the motor as percent of full-load torque.

   [Ans: (a) 0.09375, (b) 0.390 (c) 220 %]

3. A 3-ϕ, 11 kV, 50 Hz, 4 pole induction motor is taking 50 kW input power at 0.8 lagging power factor, when running at a slip of 0.03. Stator copper loss is 500 W and rotational loss is 1.5 kW. If core loss is negligible, find
   (a) Rotor copper loss.
   (b) Output power.
   (c) Efficiency of the motor.
   (d) Shaft torque.

   [Ans: (a) 1.485 kW, (b) 46.515 kW (c) 93.03 %, (d) 305.2 Nm]

4. A 3-ϕ, 4 pole, 1440 RPM, 50 Hz induction motor has star connected rotor winding, having rotor resistance of 0.2 Ω/phase and a standstill leakage reactance of rotor is 1 Ω/phase. When the stator is energized at rated voltage and frequency, the rotor induced emf at stand still is 120 V/phase. Calculate the rotor current, rotor power factor and torque, both at starting and at full-load.

   [Ans: At starting: I_{start} = 117.66 A/phase, pf = 0.196 lag, $\tau_{start} =$ 52.86 Nm

   At full-load: I_{Fl} = 23.53 A/phase, pf = 0.9806 lag, $\tau_{Fl} =$ 52.86 Nm]

5. A 3-ϕ, 6 pole, 50 Hz wound rotor induction motor has a full-load speed of 960 RPM with its slip rings short circuited. The motor drives a constatnt load torque. If the rotor speed is reduced to

   (a) 800 RPM

   (b) 400 RPM

   by inserting external resistance in the rotor circuits, compute the ratio of the rotor copper losses at the two reduced speeds with that of the full-load.

   [Ans: (a) 5 times, (b) 15 times]

6. A 7.5 kW, 400 V, 3-ϕ, 50 Hz, 6 pole squirrel cage induction motor operates at 4 % slip at full-load when rated voltage and frequency is applied. Assuming a linear relationship between torque and slip in operating region, calculate the no-load speed of the motor when the supply voltage is reduced to half its rated value. The no-load torque inside the motor is 6 Nm. Neglect the stator resistance and leakage inductance.

   [Ans: 988.4 RPM]

7. A 3-ϕ induction motor has an efficiency of 90 % when the load is 37 kW. At this load the stator and rotor copper losses each equals the iron loss. COnsider core loss along with mechanical loss. The mechanical losses are one third of the no-load loss. Calculate the slip at the given load.

   [Ans: 0.0294]

8. A 3-ϕ, 208 V (phase), 6 pole, 60 Hz induction motor has the following equivalent circuit parameters R_1 = 0.075 Ω, R_2' = 0.11 Ω, L_1 = L_2' = 25 mH and L_m = 15 mH. The motor drives a fan load which varies with the square of the speed as given by:

$$T_{fan} = 12.7 \times 10^{-3}\omega^2$$

   Determine the speed, torque and power of the motor when it is connected to the rated supply and driving the fan load. Consider that for low slip operation the motor torque is proportional to the slip. Neglect the rotational losses and use the approximate equivalent circuit shown below.

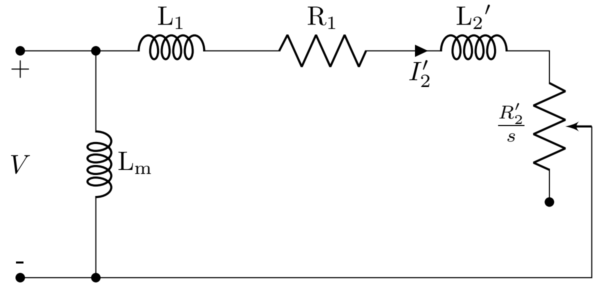

Figure 1: Approximate equivalent circuit

   [Ans: Speed = 1158 RPM, Torque = 186.7 Nm, Output power = 22.64 kW]

9. A 10 kW, 400 V, 4 pole delta-connected squirrel cage induction motor gave the following test results:

No-load test: 400 V, 8 A, 250 W
Blocked rotor test: 90 V, 35 A, 135 W

The DC resistance of the stator winding per phase is 0.6Ω. Calculate the rotational losses and equivalent circuit parameters.

[Ans: $P_{L\ rotational}$ = 203.92 W, $X_1 = X_2' = 2.158\ \Omega$, $r_1 = 0.72\ \Omega$, $r_2' = 0.402\ \Omega$, $X_m = 84.352\ \Omega$]