Department of Mechanical, Materials and Manufacturing Engineering

The University of Nottingham

Electromechanical Devices MMME2051

Exercise Sheet 5 – Induction motors

5.1 A three-phase induction motor with two pole-pairs is star-connected to a 400 V 50 Hz supply. The rotor of the motor has a resistance of 4 Ω and a standstill reactance of 16 Ω referred to the stator windings.

(a) What is the synchronous speed of the motor?

(b) What is the rms voltage across each winding (phase) of the motor's stator?

(c) At what value of slip, and hence at what speed and torque, will pull-out (leading to stalling) occur?

(d) The full-load (rated) speed of the motor is 1430 rev min^{-1}. What is the slip at this speed, and hence what are the full-load torque and power?

(e) Identify the most important influence on the running speed of an induction motor. How could you go about varying the speed of an induction motor?

1500 rev min^{-1}; 230.9V; 0.25, 1125 rev min^{-1}, 31.8 Nm; 0.0467, 11.49 Nm, 1720 W. Last point is for discussion in seminar – see middle of Lecture 7!

5.2 A 3-phase 415V 6 pole 50Hz star-connected inductor motor has rotor resistance 0.9Ω/phase and rotor standstill reactance 3.6Ω/phase referred to the stator windings. At full load the slip is 0.04.

(a) Calculate the speed, torque and mechanical output power at full load.

(b) Calculate the starting torque assuming that the rotor is of the simple construction (i.e. not dual cage) and hence obeys the theoretical model given in the notes.

960 rev min^{-1}, 71.3Nm, 7.17kW, 107.5Nm

5.3 A 3-phase 220V star-connected 6 pole 60Hz induction motor with rotor resistance 1.6Ω/phase and standstill rotor reactance 16Ω/phase referred to the stator windings.

(a) What torque will be produced if the motor is running at a constant speed of 1160 rev min^{-1}?

(b) At what per-unit slip, and hence what speed, will the motor run if it drives a constant load torque of 10 Nm? (Hint: write an equation for torque in terms of slip *s* then solve then rearrange and solve the quadratic equation in *s*).

7.22 Nm, 0.0534, 1136 rev min^{-1}

(tackle this question after Lecture 7)

5.4 A star-connected 3-phase 415V 4 pole 50Hz induction motor delivers full load power of 9625W when it runs at 1425 rev min^{-1}. Assuming that the torque *vs.* speed characteristic is linear over the motor's normal operating range calculate the speed when the motor drives a load torque of 44.45Nm.

1448.3 rev min^{-1}

5.5 A star-connected 3-phase 415V 4 pole 50Hz induction motor, which has rotor resistance 0.8Ω/phase and rotor standstill reactance 4Ω/phase referred to the stator windings, runs at 1425 rev min^{-1}.

(a) Calculate per unit slip, total torque developed and mechanical output power.

(b) Repeat the calculations when the motor speed is 1450 rev min^{-1}

0.05, 64.5Nm, 9624W; 0.0333, 44.45Nm, 6749W.

5.6 A star-connected motor is available with the following specificaiton: 3000W, 415V, 50 Hz, 1450 rev min^{-1}.

(a) What is its rated torque?

(b) Assuming that the torque *vs.* speed characteristic is linear over the motor's normal operating range, at what speed will it run at its rated voltage if it is supplying a constant torque of 15 Nm?

(c) If the supply voltage were to fall to 381V line-to-line, at what speed would the motor run when supplying the same torque of 15 Nm?

19.76 Nm, 1462 rev min^{-1}, 1455 rev min^{-1}