Sheet (5)

Electrical Machines IV – 2016/2017

1 A 3-phase, Y-Connected, 400 V, 50 Hz, 4-pole induction motor has the following per phase parameters in Ohms referred To Stator Side: $R_1 = 0.15$, $X_1 = 0.45$, $R_2' = 0.12$, $X_2' = 0.45$, $X_m = 28.5$

- Compute The Stator Current and power factor when the motor is operated at rated voltage and frequency with slip = 0.04.

[Answer: $71.058 \angle -21.47°$, $Pf = 0.93$ Lagging]

2 A 220 V, 3-ϕ, 4-pole, 50 Hz, Y-Connected induction motor is rated 3.73 KW. The equivalent circuit parameters are:
$R_1 = 0.45\Omega$, $X_1 = 0.8\Omega$, $R_2' = 0.4\Omega$, $X_2' = 0.8\Omega$, $X_m = 30\Omega$
The Stator Core loss is 50 Watt and the rotational losses is 150 Watt.
For a slip of 0.04, find:

(i) input current.
(ii) power factor at input.
(iii) air-gap power "i.e: rotor power".
(iv) mechanical Power.
(v) electro-magnetic Torque "i.e: gross Torque".
(vi) output power, and
(vii) Efficiency.

[answer:
(i) $12.7 \angle -25.8°$ A
(ii) 0.9 Lag
(iii) 4125 Watt
(iv) 3960 Watt
(v) 26.3 Nm
(vi) 3810 Watt
(vii) 87.8%]

3 A 115 V, 60 Hz, 3-phase, Y-Connected, 6-pole induction motor has the following parameters of approximate Equivalent Circuit referred To The Stator side:
$R_1 + jX_1 = 0.07 + j0.3\ \Omega$, $R_2' + jX_2' = 0.08 + j0.3\ \Omega$
$R_c = 45.45\Omega$, $jX_m = j6.33\ \Omega$: For a slip of 2%

Find:
(a) Secondary Current. (b) primary Current (c) primary Pf.
(d) output power (e) gross Torque (f) input power.
(g) Efficiency.

[answer: (a) $16.15 \angle -8.4°$ A
(b) $21.66 \angle -36.4°$ A
(c) 0.805 Lag
(d) $P_{load} = 3067$ Watt
(e) 24.9 Nm
(f) 3470 Watt, (g) 88.3%]

4 A 3-phase, 400 V, Y-Connected induction motor has the following parameters of approximate equivalent circuit referred to the stator side:

$R_1 = 1\Omega$, $X_1 = 2\Omega$, $R_2' = 1.2\Omega$, $X_2' = 1.5\Omega$, $Z_{Mag.} = 4 + j40\ \Omega$

For a slip of 5%. Find:

(i) Rotor current, input current.
(ii) Efficiency.
(iii) input power factor.
(iv) output power

Assume A friction loss of 250 Watt

[answer:
(i) $9.15\angle -7.97^\circ$ A
$11.9\angle -36^\circ$ A
(ii) 82%
(iii) 0.81
(iv) 5477 Watt]

5 A 3-phase, 400 V, 6-pole, 19 KW induction motor has the following parameters of its approximate equivalent circuit:

$R_1 = 1.4\Omega$, $R_2' = 0.6\Omega$
$X_1 = 2\Omega$, $X_2' = 1\Omega$
$X_m = 50\Omega$, $f = 50$ Hz

The rotational losses is 275 W. For a slip of 0.03: determine

(a) The Line current, pf and power input.
(b) The shaft torque and mechanical output power
(c) The efficiency.

[answer: (a) $12.2\angle -30^\circ$, 0.866 Lag, 7320 W
(c) $T_{sh} = 62.9$ Nm, $P_{mech(tot)} = 6663$ W, $P_{mech(net)} = P_{out} = 6388$ W
(d) $\%\eta = 87.3\%$]

6 A 460 V, 25 hp, 60 Hz, 4-pole Y-Connected induction motor has the following parameters in Ohms referred to the stator side for an Exact equivalent circuit per phase:

$R_1 = 0.641\Omega$, $R_2' = 0.332\Omega$, $X_1 = 1.106\Omega$, $X_2' = 0.464$, $X_M = 26.3\Omega$

The total rotational losses are 1100 W. For a rotor slip of 2.2% at the rated voltage and rated frequency: Find:

(a) rotor speed (b) stator current (c) input power factor
(d) rotor current, rotor power, mechanical power, net output power.
(e) gross Torque, Load Torque (f) Efficiency

[answer: (a) 1760 rpm (b) $18.9\angle -33.6^\circ$ A (c) 0.833 lag
(d) $16.3\angle -4.32^\circ$ A, $P_{rotor} = 11956$ W, $P_{mech} = 11693$ W, $P_{net} = 10590$ W
(e) $T_{gross} = \frac{P_{rotor}}{\omega_s} = 63.4$ Nm, $T_{load} = T_{shaft} = \frac{P_{out}}{\omega} = 57.5$ N.m
(f) $\%\eta = 84.4\%$]

7 A 208 V, two-pole, 60 Hz Y-connected wound-rotor induction motor is rated at 15 hp. The Exact equivalent circuit has the following parameters per phase referred to the stator side:
$R_1 = 0.2\,\Omega$, $R_2 = 0.12\,\Omega$, $X_M = 15\,\Omega$, $X_1 = 0.41\,\Omega$, $X_2 = 0.41\,\Omega$
$P_{(fr+wd)} = 250$ W, $P_{core(STATOR)} = 180$ W. For a slip of 0.05. find:

(a) The Line Current
(b) The stator Copper losses.
(c) The air-gap power
(d) mechanical power
(e) Gross Torque
(f) output power and load Torque.
(g) Efficiency
(h) rotor speed in rpm & rad/sec.

[Answer: (a) $44.8\angle -25.4^\circ$ A (b) 1205 W (c) 13195 W
(d) $P_{mech} = 12535$ W (e) 35 Nm (f) 12290 W, 34.3 N.m
(g) $\%\eta = 84.3\%$ (h) 3420 rpm, 358 rad/sec]