

ECE370 POWER & ENERGY SYSTEMS

Review problems for Test 2

1. A 1200 V dc shunt motor is rated at 500 hp, 3000 rpm. It has an armature resistance of 0.17Ω and a total field circuit resistance of 120Ω . It draws a current of 350 A from the supply when delivering rated load. Ignore magnetic saturation and determine:
 - a) Rated output torque.
 - b) Rated developed torque.
 - c) Rated efficiency.
 - d) Rotational losses at rated speed.
 - e) Speed when the load is changed, causing the line current to drop to 200 A. (Field resistance is unaltered.)
 - f) Developed torque for the conditions in part (e).
 - g) Horsepower output for the conditions in part (e), if $P_{\text{ROT}} \propto \text{speed}^2$

(1187 Nm 1236 Nm 88.8% 15.3 kW 3067 rpm 690.8 Nm 276 hp)

2. A 240 V dc series motor is rated at 15 hp, 2000 rpm. It has an armature resistance of 0.3Ω and field resistance of 0.2Ω . It draws a current of 57 A from the supply when delivering rated load. Ignore magnetic saturation and determine:
 - a) Rated output torque.
 - b) Rated developed torque.
 - c) Rated efficiency.
 - d) Rotational losses at rated speed.
 - e) Speed when the load is changed, causing the line current to drop to 20 A.
 - f) Developed torque for the conditions in part (e).

(53.4 Nm 57.6 Nm 81.8% 865.5 W 6199 rpm 7.09 Nm)

3. A 295 hp, 600 V, dc shunt motor has a rated speed of 2500 rpm and draws 420 A when supplying rated load. Armature resistance is 0.1Ω , and total field circuit resistance is 30Ω . Determine:
 - a) Rated output torque and rated developed torque.
 - b) Rated efficiency and rotational losses at rated speed.
 - c) Line (supply) current if the field resistance is changed to 40Ω . (Developed torque remains constant)
 - d) Shaft speed for the conditions in part (c).
 - e) Horsepower output for the conditions in part (c), if $P_{\text{ROT}} \propto \text{speed}^2$

(840.6 Nm 855.6 Nm 87.3% 3930 W 548.3 A 3254 rpm)

4. The following information is taken from the nameplate of a separately-excited DC generator.

Armature: 60 kW, 600 V, 0.15 Ω .

Field: 120 V, 2.5 A

At its rated speed of 2000 rpm the no-load torque is measured at 19.1 Nm.

Ignore armature reaction and magnetic saturation.

- a) For rated load conditions determine:
- Rated Driving Torque
 - Rated Efficiency
 - Load Impedance
- b) Determine the terminal voltage, kW output and the efficiency if the field current is reduced to 2 A, and the speed is increased to 2500 rpm, causing the rotational losses to become 6 kW. The load impedance is unchanged.
- (312.7 Nm 91.2% 6 Ω 600 V 60 kW 88.6%)

5. A 750 MVA, 25 kV, 4 pole, synchronous generator has a synchronous reactance of 1.25 Ω . The per-phase excitation voltage is determined by $|E_f| = 65 I_f$. Determine:
- The load angle (δ) when rated load is supplied at rated voltage and 0.85 lagging.
 - The field current required.
 - The phasor diagram.
 - Shaft torque if the overall efficiency is 90%
 - If you neglect saturation, what is the %VR?
($\delta = 35.5^\circ$ VR = 119.8%)

6. A three-phase induction motor has the following information on its nameplate.

4.16 kV, 60 Hz, 230 A, 0.948 lag, 2000 hp, 702 rpm.

Determine: (show your method clearly for full credit)

- # of poles and rated slip.
 - Rated output torque.
 - Rated efficiency.
 - Rated air-gap power if the stator losses are constant at 28 kW.
 - Rated mechanical power developed.
 - Electrical losses in the rotor.
 - Mechanical Rotational losses at rated speed.
- ($s = 2.5\%$, $\eta = 95\%$ $P_{ag} = 1543$ kW $P_{rot} = 12.5$ kW)

7. Given the following equivalent circuit is a three-phase, wye-connected, 480 V, 60 Hz, 864 rpm, squirrel-cage induction motor with rotational losses of 4287 W, determine:
- Magnitude of rated input current.
 - Rated power factor.
 - Rated shaft horsepower.
 - Rated output torque.
 - Rated efficiency.
 - Starting current.
 - Starting pf.

$$R_1 = 0.025 \, \Omega, \quad R_2' = 0.04 \, \Omega, \quad X_1 = X_2' = 0.08 \, \Omega, \quad R_c = 25 \, \Omega, \quad X_m = 10 \, \Omega.$$

$$(I_1 = 278.7 \angle -14.2 \, \text{A}, \quad P_D = 202 \, \text{kW}, \quad \eta = 88\%, \quad I_{\text{Start}} = 1613 \angle -67.9 \, \text{A})$$

- 8.
- Determine the **exact** equivalent circuit for a 4160 V, 60 Hz, 2 pole, three-phase, 75 hp, squirrel-cage induction motor, given the following test data:

Test performed	Voltage (V) (line)	Current (A)	Total Power (W)
No-load	4160	1.2	4000
Locked-rotor	962	10	5000
Rotational loss	-	-	2000
DC (applied across 2 phases)	125	10	-

- Use the foregoing data to **estimate** the efficiency when rated load is supplied.
($R_2' = 10.42 \, \Omega$, $X_2' = 26.5 \, \Omega$, $R_c = 8542 \, \Omega$)