Tutorial Sheet 5 - Induction Motor Variable Speed Control

The following questions consider 3 alternative speed control methods for an induction motor. The various solutions should be compared to highlight the improved efficiency of the inverter drive.

1. The basic induction motor has the following nameplate details and equivalent circuit parameters:

V_{line}	415 V
Number of poles	4
Frequency	50 Hz
Rated full-load speed	1455 RPM
R_1	0.2 Ω
X_1	0.9 Ω
R_2’	0.1 Ω
X_2’	0.7 Ω

Calculate the rated full-load (a) current, (b) torque, (c) output power, (d) power factor and (e) efficiency of the motor.

[(a) 61.8A, (b) 243.9 Nm, (c) 37.1 kW, (d) 0.91 lag, (e) 91.6%)]

2. The motor is now used on a 3-phase inverter supply and controlled to operate with constant flux. Find (a) the new frequency required to provide full-load torque at half-synchronous speed. The new (b) required line voltage. Calculate (c) the voltage boost. State (d) the current, (e) the power factor and (f) the efficiency.

[(a) 26.5 Hz, (b) 230 V, (c) 10.5 V, (d) 61.8 A, (e) 0.91 lag, (f) 84.7 %]

3. Assuming the original motor has a wound rotor with slip rings, calculate (a) the extra rotor resistance that should be added to give stable running at full-load torque, rated voltage and half-synchronous speed. The stator to rotor turns ratio is 1:2. What is the (b) current and (c) efficiency at this point?

[(a) 0.39 Ω, (b) 63.8 A, (c) 39.7%]

4. The rotor is now replaced by a high resistance cage rotor (necessary to produce the desired voltage control characteristic) having referred resistance R2’ = 0.3 Ω. What (a) voltage is required to produce half full-load torque at half-sync speed? Calculate the corresponding (b) power factor, (c) current and (d) efficiency.

[(a) 319 V, (b) 103.2 A, (c) 0.44 lag, (d) 37.5 %]