THE KENYA POLYTECHNIC

ELECTRICAL/ELECTRONICS ENGINEERING

DEPARTMENT

HIGHER DIPLOMA IN ELECTRICAL ENGINEERING

END OF YEAR II EXAMINATIONS

NOVEMBER 2006

MACHINES & UTILIZATION

3 HOURS

INSTRUCTIONS TO CANDIDATES:

You should have the following for this examination:

Answer booklet

Calculator/Mathematical tables

Answer any FIVE of the following EIGHT questions.

All questions carry equal marks and the maximum marks for each part of a question are as shown.

This paper consists of 4 printed pages.

1. (a) Describe the construction of the wound rotor induction motor and give its areas of application. (2 marks)

   (b) Explain the term cogging as used in induction. (2 marks)

   (c) The per-phase parameters of an equivalent circuit, a 415v, 3-phase, star-connected, 4-pole induction motor are:

   $R_1=2R'_2=0.2\Omega$ $X'_2=0.2\Omega$

   $X_1=0.5\Omega$ $Xm=20\Omega$

   If the motor mechanical and iron losses at 1462.5rpm is 850 watts, sketch the diagram and calculate:

   (i) Input current

   (ii) Input power

   (iii) Output torque and efficiency (16 marks)

2. (a) State the THREE applications of synchronous motors. (3 marks)

   (b) Derive the expression for the maximum power of a synchronous machine. (7 marks)

   (c) A 900kW, 3-phase, star-connected, 6600v, 24-pole, 50Hz synchronous motor has a synchronous reactance of 4Ω per phase, the resistance being negligible. The excitation is adjusted for unity power factor operation. Calculate the maximum torque for the operation. (10 marks)

3. (a) Explain the principle of electrical resistance welding.

   (b) Derive the expression for the total power generated in dielectric heating.

   (c) From the following data for a 3-phase arc furnace, calculate the time taken to melt the steel.

Current	-6kA	Specific heat of steel	-0.12kcal/kg
Resistance	-0.004Ω	Latent heat of steel	-8.9kcal/kg
Reactance	-0.006Ω	Initial temperature	-25^0C
Arc voltage	-50v	Final temperature	-1400^0C
Mass of steel	-5000kg	Overall efficiency	55%

4. (a) Explain giving examples of the following:
   (i) Primary refrigerant (ii) Secondary refrigerant (4 marks)
   (b) Explain with the aid of a diagram the principle and the method of electrostatic precipitation in air conditioning. (8 marks)
   (c) An electrical motor gives a temperature rise of 22^0C after one hour and 34^0C after 2 hours. The machine has the same value of heating and cooling time constants. If the machine is switched off after the two hours and allowed to cool for 1.2hrs, calculate:
   (i) The time constant
   (ii) Temperature after 1.2 hours cooling. (8 marks)
5. (a) (i) State any TWO requirements of electrical braking systems.
   (ii) Explain using diagrams the plugging method of braking in a d.c series motor. (7 marks)
   (b) Derive the expression for the time taken by a motor to accelerate to a given speed. (5 marks)
   (c) A 415v, 700rpm, 40kW d.c shunt motor takes a full load current of 90A. The current during starting varies linearly between 1.2 to 1.6 times the full load current. The motor has a moment of inertia of 25kg-m^3. Calculate the time taken to accelerate the motor to rated speed against the full load torque. (8 marks)
6. (a) Explain the term "Load equalization" as used in industrial drives. (3 marks)
   (b) Derive the equation for the moment of inertia of a motor coupled to a flywheel after the load has been removed. (6 marks)
   (c) Explain using diagrams the "pole changing" method of speed control in inductive motors. (5 marks)
   (d) A 30kW, 3-phase, 8-pole, 50Hz induction motor is fitted with a flywheel which supplies a load torque of 1200n.m for 12 seconds followed by no load period when the flywheel regains full speed. Full load slip is 0.05 and

efficiency 95%. If the motor has linear characteristics, calculate the moment of inertia of the flywheel if motor torque is not to exceed twice full load torque. (6 marks)

7. (a) Describe with the aid of a diagram the construction and principle of operation of Schirage motor. (14 marks)

   (b) Calculate the fundamental, third and fifth harmonic breadth factors for a stator with 36 slots wound for 3-phase, 4-poles. (6 marks)

8. (a) (i) Describe with the aid of diagrams how the linear motion of an induction motor may be achieved.

   (ii) List at least THREE applications of linear motors. (9 marks)

   (b) (i) State any TWO differences between variable reluctance and hybrid stepper motors.

   (ii) Explain using the torque/pulses per second characteristics the terms 'start range' and 'slew range' of a stepper motor. (7 marks)

   (c) A motor has a duty cycle of 5kW for 5min, 10kW for 3 min, 13kW for 8 min and stopped for 6min. Calculate the continuous rating of the motor if a factor of 3 is assumed. (4 marks)