2506/305
AIRCRAFT MECHANICAL
TECHNOLOGY II
Oct./Nov. 2017
Time: 3 hours

THE KENYA NATIONAL EXAMINATIONS COUNCIL

DIPLOMA IN AERONAUTICAL ENGINEERING

(AIRFRAMES AND ENGINES OPTION)

MODULE III

AIRCRAFT MECHANICAL TECHNOLOGY II

3 hours

INSTRUCTIONS TO CANDIDATES

You should have the following for this examination
Non-programmable scientific calculator;
Thermodynamic and Transport properties of fluid tables by Rogers and Mayhew.
This paper consists of ***EIGHT*** *questions in* ***TWO*** *sections;* ***A*** *and* ***B****.*
Answer ***THREE*** *questions from section* ***A*** *and* ***TWO*** *questions from section* ***B*** *in the answer booklet provided.*
All questions carry equal marks.
Maximum marks for each part of a question are as shown.
Candidates should answer the questions in English.

This paper consists of 5 printed pages.

Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.

SECTION A: THERMODYNAMICS (60 marks)

*Answer **THREE** questions from this section.*

1. (a) Outline **two** types of working fluids considered in thermodynamics. (2 marks)

(b) State the following thermodynamic processes:

(i) isobaric;

(ii) adiabatic;

(iii) polytropic.

(6 marks)

(c) (i) Show that the work done during a reversible adiabatic process is expressed as

$$W = \frac{P_1V_1 - P_2V_2}{\gamma - 1}$$

Where:

- P_1V_1 and P_2V_2 are initial pressure and volume and final pressure and volume respectively;
- γ is the adiabatic index. (7 marks)

(ii) Air at a pressure of 1.02 bar and 22°C has a volume of 0.015 m^3 and is compressed in a cylinder reversibly and adiabatically to a pressure of 6.8 bar. Using the standard value of air from steam tables, calculate:

I. mass of air in the cylinder;

II. work done in the process.

(5 marks)

2. (a) State the second law of thermodynamics. (2 marks)

(b) Derive the expression of a heat pump efficiency operating on a carnot cycle in terms of heat source temperature (T_1) and heat sink temperature (T_2).

(7 marks)

(c) A refrigeration plant working on a carnot cycle produces 15 tonnes of ice per day from water at 0°C. The heat rejection to the atmosphere is at 28°C. A carnot cycle engine drives the refrigeration system of the plant and absorbs heat from the source at a temperature of 220°C, by use of liquid fuel of calorific value 44500 kJ/kg. If the enthalpy of fusion of ice is 334.5 kJ/kg, determine the following:

(i) power developed by the engine;

(ii) fuel consumed by the engine per hour.

(11 marks)

(a) Outline **two** classes of fuels. (2 marks)

(b) Define the following terms as applied to fuel combustion:

(i) stoichiometric air-fuel ratio;

(ii) actual air-fuel ratio;

(iii) mixture strength.

(3 marks)

(c) The ultimate analysis of a fuel showed 85% C and 15% H. The analysis of dry product showed 13.5% CO_2 and some CO with the remainder being N_2. Assuming air contains 23.3% O_2 by mass, determine the following:

(i) actual air-fuel ratio;

(ii) mixture strength.

(15 marks)

4. (a) Define the following terms as applied to gas turbines:

(i) work ratio;

(ii) thermal ratio;

(iii) effectiveness of a heat exchanger.

(3 marks)

(b) A gas turbine plant operating at a maximum temperature of 610°C has a compression ratio of 1:7. The high pressure (HP) turbine drives the compressor, while the low pressure (LP) turbine is coupled to the power output shaft. Air is drawn into the compressor at 15°C and a pressure of 1.01 bar. The isentropic efficiencies of the compressor, HP turbine and LP turbine are 0.82, 0.85 and 0.83 respectively.

(i) Draw the plant layout and T-S diagram of the plant.

(ii) Determine the work ratio.

(iii) Calculate the thermal efficiency of the plant.

(17 marks)

5. (a) State the following laws of heat conduction:

(i) Fourier's;

(i) Newton's.

(2 marks)

(b) A composite pipe of internal radius (r_1) and length (L) carries a fluid of heat transfer coefficient (h_{nf} at a temperature (t_{nf}). The pipe is insulated with two different layers at a radius of (r_2) and (r_3) respectively. The corresponding thermal conductivities of the layers are K_A and K_B. If the outer surface of the pipe is surrounded by air of heat transfer coefficient (h_{cf}), derive the expression of the rate of heat loss Q in terns of the given parameters. (14 marks)

(c) Exhaust gases at a temperature of 65°C flows through a pipe of 0.12 m diameter and 60 m long. The pipe is insulated by two layers of 60 mm and 40 mm thick respectively. The corresponding thermal conductivities of the insulation layers are 0.24 and 0.4 W/m-K. The inside and outside heat transfer coefficients are 60 and 12 W/m-K respectively. If the air surrounding the pipe is at 20°C, calculate the rate of heat loss. (4 marks)

SECTION B: FLUID MECHANICS (40 marks)

*Answer **TWO** questions from this section.*

6. (a) (i) Define the term specific speed of a centrifugal pump.

(ii) Stating the assumptions made, show that the specific speed of a centrifugal pump (N_s) is given by:

$$N_S = \frac{NQ^{\frac{1}{2}}}{H^{\frac{3}{4}}}$$

Where: N is the rotational speed;
Q is the pump discharge;
H is the pump operating head.

(8 marks)

(b) A centrifugal pump running at 1350 rev/min delivers 2.86 m^3/s of water. The inlet and outlet impeller diameters are 200 mm and 400 mm respectively. Water enters the pump radially at 18 m/s. At the outlet, the vanes are set backwards at an angle of 60° to the tangent in the direction of blade impeller rotation. If the width of the blade at outlet is 27 mm, calculate:

(i) the manometric efficiency for a delivery head of 50 m;

(ii) power input to the pump when the mechanical efficiency is 97%.

(12 marks)

7. (a) Stating the assumptions made, derive the expression for the frictional head loss when a fluid flows at a uniform velocity in a pipe of diameter D and length L, if the coefficient of friction is f.

(13 marks)

(b) A pipe of 560 m long and 150 mm diameter has a discharge of 3.5 m^3/min. If the coefficient of friction is 0.01, determine the frictional head loss in the pipe.

(7 marks)

8. (a) With the aid of a sketch, show that when a liquid flows through a sudden enlargement pipe from an area a_1 to a_2 and inlet flow velocity V_1, the head loss due to sudden enlargement h_L is given by:

$$h_L = \left(1 - \frac{a_1}{a_2}\right)^2 \frac{V_1^2}{2g}$$

Where: g is the gravitational force.

(14 marks)

(b) A pipe carrying a liquid enlarges suddenly from a diameter of 0.5 m to 1.0 m. If the loss of head due to sudden enlargement is 0.5 m, determine the discharge of the pipe.

(6 marks)

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