EGERTON UNIVERSITY

UNIVERSITY EXAMINATIONS

NJORO

SECOND SEMESTER, 2013/2014 ACADEMIC YEAR

SECOND YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN ENGINEERING

MENT 225 - THERMODYNAMICS II

STREAM: MENT & AGEN **TIME: 2 HOURS**

DAY: WEDNESDAY, 8.30 – 11.30 A.M. **DATE: 28/05/2014**

INSTRUCTIONS:
The paper consists of FIVE Questions.
Answer any four questions.
All questions carry equal marks.
Steam tables are provided.

1. (a) Using a neat sketch, explain briefly the operation of an open-cycle gas turbine unit. Show the operation on a T-S diagram. (7 marks)

   (b) In a Marine gas turbine unit a high pressure stage turbine drives the compressor, and a Low pressure stage turbine drives the propeller through suitable gearing. The overall pressure ratio is 4 to 1, the mass flow rate is 60 Kgs/s the maximum temperature is 650^0C, and the air intake conditions are 1.01 bar and 25^0C. the isentropic efficiencies of the compressor high pressure turbine are 0.8, 0.83 and 0.85 respectively and the mechanical efficiency of both shafts is 98%. Neglecting kinetic energy changes and the pressure loss is combustion, calculate:

i) The pressure between turbine stages.
ii) The cycle efficiency.
iii) The shaft power.

(c) If the unit is fitted with a heat exchanger, calculate the cycle efficiency obtainable. Assume a thermal ratio of 0.75.

(10 ½ marks)

2. (a) i) Describe in detail two ways of classifying engines in respect to the type and arrangement of engines. (4 marks)

ii) Define the following terms as used in internal combustion engines.

- Indicated power.
- Brake power
- Friction power.

(3 marks)

(b) A four-cylinder, four stroke diesel engine has a bore of 212 mm and a stroke of 292 mm. At full load at 720 rev/min the bmep is 5.93 bar and the specific final consumption is 0.226 Kg/KWh. The air-fuel ratio as determined by exhaust gas analysis is 25 to 1. Calculate the brake thermal efficiency and the volumetric efficiency of the engine. Atmospheric conditions are 1.01 bar and 15^0C, and the net calorific value of the fuel may be taken as 44200 KJ/Kg. (6 ½ marks)

(c) If the engine is to be used as a dual-fuel engine to burn methane (calorific value 33480 KJ/m^3 at 1.013 bar and 15^0C) and has a pilot infection of oil of 10% of the input when running as a diesel engine. The air-fuel ratio for the oil is 25 to 1 as before, and for the methane 8.5 to 1. If the volumetric efficiency and the power output remain the same, what is the brake thermal efficiency of the engine when running on the dual fuel? (4 marks)

3. (a) State the following laws use in heat transfer.

i) Fourier's law of conduction. (1 mark)
ii) Newton's law of cooling. (1 mark)

(b) Show that heat transfer through a cylinder having internal radius of r_1 and external radius r_2 is given by

$$Q=\frac{2\bar{\Lambda}\lambda(t_1-t_2)}{\ln(r_2|r_1)}$$

(7 ½ marks)

(c) A steam main of 150 mm outside diameter containing wet steam at 28 bar is insulated with an inner layer of diatomaceous earth, 40 mm thick, and an outer layer of 85% magnesia 25 mm thick. The inside surface of the pipe is at the steam temperature and the heat transfer coefficient for the outside surface of the lagging is 17 W/m^2K. The thermal conductivities of diatomaceous earth and 85% magnesia are 0.09 and 0.06 W/MK respectively. Neglecting radiation, and the thermal resistance of the pipe wall, calculate the rate of heat loss per unit length of the pipe and the temperature of the outside surface of the lagging when the room temperature is 20^0C. (9 marks)

4. (a) Explain the following terms as applied to steam cycles.
   i) Efficiency ratio of a cycle. (1 mark)
   ii) Isentropic efficiency for compression process. (1 mark)
   iii) Specific steam consumption. (1 mark)

(b) Using a neat sketch show the Basic steam plant indicating the most important parts. (4 marks)

(c) A steam is supplied dry saturated at 40 bar to a turbine and the condenser pressure is 0.035 bar. If the plant operates on the Rankine cycle, calculate, per kilogram of steam:

   i) The work output neglecting the feed-pump work. (5 ½ works)
   ii) The work required for the feed pump. (1 ½ works)
   iii) The heat transferred to the condenser cooling water, and the amount of cooling water required through the condenser if the temperature rise of the water is assumed to be 55K. (1 ½ marks)
   iv) The head supplied. (1 marks)
   v) The Rankine efficiency. (½ mark)
   vi) The specific steam consumption. (1 mark)

5. (a) Define the following terms as used in psychrometry and air-conditioning:
   i) Specific humidity.
   ii) Relative humidity.
   iii) Percentage saturation.

(3 marks)

(b) The aid supplied to a room of a building in winter is to be at 17^0C and have a percentage relative humidity of 60%. If the barometric pressure is 1.01326 bar,

i) Calculate the specific humidity and determine the dew point under these conditions.

ii) If air at the condition above is passed at the rate of 0.5 m^3/sec over a cooling coil which is at a temperature of 6^0C, calculate the amount of vapour which will be condensed. Assume that the barometric pressure is the same as above, and that the air leaving the coil is saturated.

(7 ½ marks)

(c) The pressure in the evaporator of an ammonia refrigerator is 1.902 bar and the pressure in the condenser is 12.37 bar. Calculate the refrigerating effect per unit mass of refrigerant and the COP_{ret} for a a dry saturated vapour delivered to the condenser after isentropic compression and no undercooling of the condensed liquid. (7 marks)

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