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UNIVERSITY EXAMINATIONS 2024/2025

FOURTH YEAR FIRST SEMESTER EXAMINATION FOR DEGREE OF BACHELOR OF EDUCATION TECHNOLOGY IN MECHANICAL ENGINEERING

EMT 3250: APPLIED THERMODYNAMICS II

DATE: JANUARY 2025 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a. Gas turbine power cycle principles are being used by engineers in modern day; briefly explain any two major areas where they are being used (6 marks)

b. The modern jet aircrafts use the **modified** Brayton power cycle principles today;

   i. With the aid of a diagram briefly explain the working principle of the Jet engine power cycle (4 marks)

   ii. Show it on a T-S diagram (3 marks)

c. Air enters the compressor of a Jet engine operating on a Brayton power cycle at 1.5MPa, 25^0C and leaves the compressor with a pressure of 3MPa in an air-standard. The maximum temperature in the cycle is 300^0C. Determine:

   i. The compressor exit temperature (4 marks)

   ii. The turbine exit temperature (4marks)

   iii. Cycle efficiency (3 marks)

   (Cp = 1.005KJ /KG K)

d. In the process of improving the efficiency of the Brayton gas turbine cycle, several components were added to the original design. With the aid of diagrams, briefly explain the principle of working of

   a. Regenerator (4 marks)
   b. Intercooler (4 marks)

QUESTION TWO (15MARKS)

a. Briefly explain two areas in which compressed air can be used as a business to earn a living in Kenya (5 marks)

b. The photo below shows one of the key areas where compressed air is used in construction industry,

   i. briefly explain how compressed air is used for digging hard grounds. (4 marks)
   ii. As a maintenance technician briefly explain what your work will be with regard to the compressor using the knowledge you have gained here. (3 marks)

Fig. Q2(b) : Jack Hammer

d. A Single-cylinder, single-acting air compressor has a cylinder diameter of 100mm and a stroke length of 200mm. It draws air into its cylinder at a pressure of 200kpa at 25°C. The air is then compressed to a pressure of 500kPa. If the compressor runs at a speed of 2 rev/sec, Determine. Mass of air compressed per cycle (3marks

Assume the compression process follows PV^n = constant. N= 2rev/sec = 120rpm PV^n = 1.4

QUESTION THREE (15MARKS)

a. The Rankine power cycle is a vapour power cycle used for power generation;
   i. With the aid of a diagram, briefly explain the working principle of a Rankine power cycle. (4 marks)
   ii. Show the working principle of the Rankine cycle on a T_S diagram (3 marks)

b. The Rankine cycle is an ideal vapour cycle used in the power production at the geothermal plants in Olkaria.
   i. Briefly explain how the Rankine cycle is used in the generation of electricity in Olkaria. (4 marks)
   ii. Steam generated at a power plant at 5.0 MPa and 400.°C is fed to a turbine. Exhaust from the turbine enters a condenser at 10 kPa where it is condensed to a saturated liquid, which is then pumped to the boiler. What is the thermal efficiency of a Rankine cycle assuming it is working at an **ideal Carnot cycle** (4 Marks)

QUESTION FOUR(15MARKS)

a. Nozzles are key engineering devices utilized in numerous engineering systems
   i. Briefly explain the working principle of a nozzle. (5 marks)
   ii. Name and briefly explain any two areas in which nozzles are today being used by engineers for the benefit of humanity. (5 marks)

b. As an aircraft technician expert, design a nozzle to provide exit velocity of the exhaust from an aircraft engine of 100m/s if the inlet velocity is 50m/s and the mass flowrate through the system is 2.5kg/s. (Hint estimate the inlet x-sectional area. (5 marks)

QUESTION FIVE(15MARKS)

a. Name and briefly explain any three types of fuels used for combustion in the Kenyan society today one each from solid, liquid and gaseous fuels;

(6 marks)

b. A gas consists of 30% methane (CH4) and 70% propane (C_3H_8) by volume. Assume complete combustion.

i. **Balance the equations** and calculate, the stoichiometric air –to – fuel ratio

(5 Marks)

ii. What is the percentage air ratio in methane used in the above in the combustion? (4 marks)