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(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY EXAMINATIONS

2023/2024 ACADEMIC YEAR

FOURTH YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN EDUCATION TECHNOLOGY

COURSE CODE: TEM 471

COURSE TITLE: THERMODYNAMICS II

DATE: 5/12/2023 **TIME: 8:00 AM – 10:00 AM**

INSTRUCTIONS TO CANDIDATES

1. This paper consists of **FOUR** questions
2. Answer Question **ONE (Compulsory)** and any other **TWO** Questions
3. All symbols have their usual meaning

TIME: 2 Hours

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over

QUESTION ONE [30 marks]

1. Calculate the ideal air standard cycle efficiency based on the Otto cycle for a petrol engine with a cylinder bore of 50 mm, a stroke of 75 mm, and a clearance volume of 21.3 cm^3. **(4 Marks)**

2. In a gas turbine unit, air is drawn at 1.02 bar and 15 °C, and is compressed to 6.12 bar. Calculate the thermal efficiency and the work ratio of the ideal constant pressure cycle when the maximum cycle temperature is limited to 800 °C. **(7 Marks)**

3. Calculate the efficiency of the following ideal cycles when undergone by a perfect gas with a γ value of 1.4:

a) a Stirling cycle operating between a hot reservoir at 600K and a cold reservoir at 300K; **(1 Mark)**
b) a Brayton cycle with a pressure ratio of 8; **(1 Mark)**
c) an Otto cycle with a compression ratio of 8; **(3 Marks)**
d) a Diesel cycle with a compression ratio of 12 and a cut-off ratio of 2. **(3 Marks)**

4. A steam power plant uses steam as a working fluid and operates at a boiler pressure of 5 MPa, dry saturated, and a condenser pressure of 5 kPa. Determine the cycle efficiency for (a) the Carnot cycle and (b) the Rankine cycle. Also, show the T-s representation for both the cycles. **(11 Marks)**

QUESTION TWO [20 marks]

1. An oil engine takes air at 1.01 bar, 20°C, and the maximum cycle pressure is 69 bar. The compressor ratio is 18/1. Calculate the air standard thermal efficiency based on the dual combustion cycle. Assume that the heat added at constant volume equals the heat added at constant pressure. **(10 Marks)**

2. A diesel engine has an inlet temperature and pressure of 15 °C and 1 bar, respectively. The compression ratio is 12/1, and the maximum cycle temperature is 1000°C. Determine the air standard thermal efficiency based on the diesel cycle **(10 Marks)**

QUESTION THREE [20 marks]

1. Analyzing the dry exhaust gas from an internal combustion engine gave 12 % CO_2, 2% CO, 4% CH_4, 1% H_2, 4.5% O_2, and 76.5% N_2. Calculate the proportions of mass of carbon to hydrogen in the fuel, assuming it to be a pure hydrocarbon, and the air/ fuel ratio used **(10 Marks)**
2. A steam power plant operates between a boiler pressure of 42 bar and a condenser pressure of 0.035 bar. Calculate for these limits the efficiency, the work ratio, and the specific steam composition

a) for a Carnot cycle using wet steam, **(3 Marks)**

b) for a Rankine cycle with dry saturated steam at entry to the turbine **(4 Marks)**

c) for the Rankine cycle of (ii), when the expansion process has an isentropic efficiency of 80% **(3 Marks)**

QUESTION FOUR [20 marks]

1. The gravimetric analysis of a coal sample is given as 80% C, 12% H, and 8% ash. Calculate the stoichiometric A/F ratio and the analysis of the products by volume **(5 Marks)**
2. In a regenerative steam cycle employing two closed feed heaters, the steam is supplied to the turbine at 40 bar and 500 °C and is exhausted to the condenser at 0.035 bar. The intermediate bleed pressures are obtained such that the saturation temperature intervals are approximately equal, giving pressures of 10 and 1.1 bar. Calculate

(i) the amount of steam bled at each stage **(4 Marks)**

(ii) The work output of the plant per kilogram of boiler steam **(3 Marks)**

(iii) The cycle efficiency of the plant **(4 Marks)**

Assume ideal processes where required.

3. A gas engine is supplied with natural gas of the following composition: CH_4 93%, C_2H_6 3%, N_2 3%, CO 1%. If the air-fuel ratio is 30 by volume, calculate the analysis of the dry products of combustion. It can be assumed that the stoichiometric air-fuel ratio is less than 30. **(4 Marks)**

END