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10ME/AU43

Fourth Semester B.E. Degree Examination, July/August 2022

Applied Thermodynamics

Time: 3 hrs. Max. Marks:100

Note: Answer any FIVE full questions, selecting at least TWO questions from each part.

PART – A

1 a. Define the following:
(i) Stoichiometric air (ii) Enthalpy of formation
(iii) Calorific value (iv) Combustion efficiency
(v) Adiabatic flame temperature **(10 Marks)**

b. The volumetric composition of the 'dry' products of combustion of an unknown hydrocarbon fuel CxHy, gives: CO_2 = 12.1%, O_2 = 3.8%, CO = 0.9% and N_2 = 83.2%.
Determine: (i) The chemical formula of the fuel (ii) The air-fuel ratio
(iii) The percentage of excess air used **(10 Marks)**

2 a. State the assumptions made for the air standard cycle analysis. **(03 Marks)**

b. Derive the expression for air standard efficiency of Otto cycle in terms of compression ratio and ratio of specific heats. Show the cycle in both P-V and T-S diagrams. **(09 Marks)**

c. A diesel engine has a compression ratio of 14 and cut-off takes place at 6% of the stroke. Find the air standard efficiency. **(08 Marks)**

3 a. Explain briefly the following methods to determine the frictional power of IC engines:
(i) Morse test (ii) Willan's line method **(08 Marks)**

b. In a trial of a single-cylinder oil engine working on dual cycle, the following observations were made:

Compression ratio = 15
Oil consumption = 10.2 kg/h
Calorific value of fuel = 43890 kJ/kg
Air consumption = 3.8 kg/min
Speed = 1900 rpm
Torque on the brake drum = 186 N-m
Quantity of cooling water used = 15.5 kg/min
Temperature rise = 36°C
Exhaust gas temperature = 410°C
Room temperature = 25°C
C_p for exhaust gases = 1.2 kJ/kgK.

Calculate: (i) Brake power (ii) Brake specific fuel consumption
(iii) Brake thermal efficiency.

Draw heat balance sheet on minute basis. Assume C_p for cooling water as 4.18 kJ/kgK. **(12 Marks)**

4 a. Describe with the help of T-S diagram, the basic reasons why the Carnot cycle is not suitable as a standard of reference for vapour power cycles. **(06 Marks)**

b. Explain with the help of T-S diagram, the effect of superheating of steam on the performance of Rankine Cycle. **(06 Marks)**

c. Steam at 20 bar, 360°C is expanded in a steam turbine to 0.08 bar. It then enters a condenser where it is condensed to saturated liquid water. The pump feeds back the water into the boiler.
(i) Assuming ideal processes, find per kg of steam the net work and cycle efficiency.
(ii) If the turbine and the pump have each 80% efficiency, find the percentage reduction in the net work and cycle efficiency. **(08 Marks)**

PART – B

5 a. Derive an expression for work done in a reciprocating air compressor, (i) without clearance (ii) with clearance. **(08 Marks)**

b. Define the terms, Isothermal efficiency and Volumetric efficiency for a reciprocating air compressor. **(02 Marks)**

c. A single-stage single-acting air compressor delivers 0.6 kg of air per minute at 6 bar. The temperature and pressure at the end of suction stroke are 30°C and 1 bar. The bore and stroke of the compressor are 100 mm and 150 mm respectively. The clearance is 3% of the swept volume. Assuming the index of compression and expansion to be 1.3, find:
(i) Volumetric efficiency
(ii) Power required if the mechanical efficiency is 85%
(iii) Speed of the compressor in r.p.m. **(10 Marks)**

6 a. Derive an expression for the work output of a gas turbine in terms of pressure ratio, and maximum and minimum temperature T_3 and T_1. Hence show that the pressure ratio for maximum specific work output is $\left(\frac{T_3}{T_1}\right)^{\frac{\gamma}{2(\gamma-1)}}$. **(10 Marks)**

b. A gas turbine unit has a pressure ratio of 6:1, and maximum cycle temperature of 610°C. The isentropic efficiencies of the compressor and turbine are 80% and 82% respectively. Calculate the power output in Kilowatts of an electric generator coupled to the turbine when the air enters the compressor at 15°C at the rate of 16 kg/s. Take C_p = 1.005 kJ/kgK and γ = 1.4 for the compression process, and take C_p = 1.11 kJ/kgK and γ = 1.333 for the expansion process. **(10 Marks)**

7 a. With the help of a neat sketch, explain the working of aqua-ammonia (water is the absorbent and ammonia is the refrigerant) vapour absorption refrigeration system. **(06 Marks)**

b. Briefly explain air refrigeration cycle with the help of schematic. Show the cycle on T-S diagram. **(04 Marks)**

c. A refrigerator working on vapour compression system has 10 tonnes capacity, evaporator temperature of –10°C and a condenser temperature of 30°C. Assuming simple saturation cycle, and by using Freon-12 as the refrigerant, determine:
(i) Mass flow rate of refrigerant in kg/min (ii) Power input (iii) COP
Take Cp_v = 0.72 kJ/kgK **(10 Marks)**

8 a. Define the following:
(i) Dry bulb temperature (ii) Wet bulb temperature
(iii) Dew point temperature (iv) Specific humidity **(04 Marks)**

b. With neat sketches, explain
(i) Summer air conditioning for hot and dry weather
(ii) Winter air conditioning for mild cold and dry weather
Represent both the above systems on psychrometric chart, showing individual processes. **(08 Marks)**

c. Atmospheric air at 1.0132 bar has a DBT of 32°C and WBT of 26°C. Compute:
(i) The partial pressure of water vapour
(ii) The specific humidity
(iii) The dew point temperature
(iv) The relative humidity **(08 Marks)**

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