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10ME/AU43

Fourth Semester B.E. Degree Examination, June 2012
Applied Thermodynamics

Time: 3 hrs. Max. Marks:100

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

PART – A

1 a. Explain the following with reference to a combustion process:
i) Percent excess air ii) Enthalpy of formation
iii) Adiabatic flame temperature iv) Enthalpy of combustion. **(08 Marks)**

b. The products of combustion of an unknown hydrocarbon C_x H_y have the following composition as measured by an Orsat apparatus:
CO_2 = 8.0%, CO = 0.9%, O_2 = 8.8%, N_2 = 82.3%. Determine:
i) The composition of the fuel
ii) The air-fuel ratio
iii) The percent excess air used and
iv) Dew point temperature of the product if the total pressure of the product is 1.01325 bar. **(12 Marks)**

2 a. Derive an expression for efficiency of diesel cycle in terms of compression ratio, cut-off ratio and specific heats ratio. **(08 Marks)**

b. An air-standard limited pressure cycle has a compression ratio of 15 and compression begins at 0.1 MPa, 40 $^{\circ}$C. The maximum pressure is limited to 6 MPa and the heat added is 1675 kJ/kg. Compute:
i) The heat supplied at constant volume per kg air
ii) The heat supplied at constant pressure
iii) The cycle efficiency
iv) The cut-off ratio and
v) m.e.p of the cycle. **(12 Marks)**

3 a. Explain the 'William's line method for calculating the frictional power in an IC Engine. **(04 Marks)**

b. A test on a two-stroke engine gave the following results at full load:
Speed = 350 rpm, Net brake load = 65 kg_f, m.e.p = 3 bar, Fuel consumption = 4 kg/h,
Jacket cooling water flow rate = 500 kg/h, Jacket cooling water temperature rise = 20 $^{\circ}$C,
Air used per kg of fuel = 32 kg, Cylinder diameter = 22 cm, Stroke = 28 cm,
Effective brake drum diameter = 1 m, CV of fuel = 43 MJ/kg, Cp_g = 1 kJ/kg,
Exhaustgas temp = 400 $^{\circ}$C, Room temperature = 20 $^{\circ}$C.
Find the mechanical efficiency and also draw a heat balance sheet on minute and percentage basis. **(10 Marks)**

c. A 4-cylinder petrol engine has a rated output of 52 kW at 2000 rpm. A Morse test is carried out and the brake torque readings are 177, 170, 168 and 174 N-m respectively. For normal running at this speed, the BSFC is 0.25 kg/kW–h and C.V of fuel used is 42500 kJ/kg. Calculate the mechanical and brake thermal efficiency. **(06 Marks)**

4 a. Draw a schematic diagram and show the actual regenerative vapour power cycle. Also derive an expression for its efficiency. **(08 Marks)**

b. An ideal Rankine cycle with reheat is designed to operate according to the following specification:
Pressure at the inlet of HP turbine = 20 MPa.
Temperature of steam at the inlet of HP turbine = 550 °C.
Temperature of steam at the end of reheat = 550 °C.
Pressure of steam at the turbine exit = 15 kPa
Quality of steam at the turbine exit = 90%. Determine:
i) Reheat pressure ii) Temperature in the condenser
iii) Ratio of pump work to turbine and iv) Cycle thermal efficiency. **(12 Marks)**

PART – B

5 a. What are the advantages of multi-stage compression? **(04 Marks)**

b. Derive an expression for volumetric efficiency of a single stage reciprocating air compressor in terms of clearance factor (K), pressure ratio $\left(P_2/P_1\right)$ and index of compression (n). **(04 Marks)**

c. A single acting, two-stage air-compressor delivers air at 17 bar when the pressure and temperature of air at the end of suction are 1 bar and 303 k. The interstage pressure is 4 bar and there is perfect intercooling. If LP cylinder diameter is 23 cm and common stroke is 15 cm and speed of the compressor is 350 rpm. Determine:
i) Volumetric efficiency of LP stage compressor.
ii) Heat transfer in the inert cooler in kJ/min and
iii) Capacity of the motor required to drive the compressor if the mechanical efficiency is 85%.
Assume the clearance volume of LP compressor = 5% of stroke volume. The compression and expansion in both cylinders follow the law $PV^{1.25}$ = constant. **(12 Marks)**

6 a. What are the advantages of closed cycle gas turbine over the open cycle gas turbine plant? **(04 Marks)**

b. Write a short note on jet-propulsion. **(04 Marks)**

c. In an open cycle gas turbine plant, air enters the compressor at 1 bar and 27°C. The pressure after compression is 4 bar. The isentropic efficiencies of the turbine and compressor are 85% and 80% respectively. Air fuel ratio is 80:1. Calorific value of the fuel used is 42000 kJ/kg. Mass flow rate of air is 2.5 kg/s. Determine the power output from the plant and the cycle efficiency. Assume Cp and γ to be same for both air and products of combustion. **(12 Marks)**

7 a. Sketch and explain the Ammonia-Water absorption refrigeration system. **(08 Marks)**

b. What are the desirable thermodynamics and thermo-physical properties of a good refrigerant? **(04 Marks)**

c. In an air-refrigeration plant working on a reversed Brayton cycle, air enters into the compressor at 1 bar and-15 °C, where it is compressed to a pressure of 5.5 bar. Air enters the expander at 15°C. Determine:
i) COP of the cycle and
ii) Mass flow rate of air into the compressor per minute for 1 ton of refrigeration.
Assume both compression and expansion process are isentropic. **(08 Marks)**

8 a. Derive an expression for specific humidity of air-water vapour mixture. **(06 Marks)**

b. Sketch and explain the winter air-conditining showing the processes on a psychrometric chart. **(07 Marks)**

c. The dry and wet temperatures of atmospheric air at 101.325 KPa pressure are measured with a sling psychrometer and determined to be 25 °C and 15 °C respectively. Determine:
i) Dew point temperature ii) Specific humidity
iii) Relative humidity and iv) Enthalpy of moist air.
Use properties of table only, without using psychrometric chart. **(07 Marks)**

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