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P.E.S. College of Engineering, Mandya - 571 401

(An Autonomous Institution affiliated to VTU, Belagavi)

Fourth Semester, B.E. - Mechanical Engineering

Semester End Examination; June - 2017

Applied Thermodynamics

Time: 3 hrs *Max. Marks: 100*

***Note**: i) Answer **FIVE** full questions, selecting **ONE** full question from each unit.*
ii) Thermodynamics data handbook is permitted.

UNIT - I

1 a. With the help of P-V and T-S diagram, derive an expression for the thermal efficiency of the Otto Cycle in terms of compression ratio. 6

b. Compare Otto and Diesel cycles, with the help of PV and T-S diagram, based on the following conditions. 6

i) When maximum cycle pressure and temperature are same.

ii) When compression ratio and heat addition are same.

c. A petrol engine works on Otto cycle under ideal conditions. The initial pressure before the beginning of compression of 101 kPa at 340 K. The pressure at the end of the heat addition process is 2.5 MPa. As per the details furnished by the manufacture engine has stroke length twice the bore. Engine bore is 300mm and clearance is $4x10^{-3}$ m^3. Determine: 8

i) Compression ratio

ii) The air standard efficiency

iii) The mean effective pressure.

2 a. Derive an expression for the optimum pressure ratio, for the maximum network output, in a Brayton cycle. What is corresponding cycle efficiency? 6

b. Explain the methods for improving the efficiency of Brayton cycle? 6

c. In a reheat gas turbine cycle, comprising one compressor and two turbines, air is compressed from 1 bar, 27ºC to 6 bar. The highest temperature in the cycle is 900ºC. The expansion in the first stage turbine is such that the work from it just equals the work required by the compressor. Air is reheated between the two stages of expansion to 850ºC. Assume that the isentropic efficiency of the compressor, the first stage and the second stage turbines are 85% each and that the working substance is air. Calculate the cycle efficiency. 8

UNIT - II

3 a. Discuss the effect of: 8

i) Boiler pressure

ii) Condenser pressure, on the performance of a Rankine cycle.

Contd….2

b. In –a reheat cycle, steam at 500ºC expands in a HP turbine till it is saturated vapour. It is then reheated at constant pressure to 400°C and then expanded in a LP turbine to 40º C. The maximum moisture content at the turbine exhausts is limited to 15% find; 12

i) the reheat pressure; ii) the pressure of steam of steam at the inlet to the HP turbine

iii) the net specific work output iv) the cycle efficiency

v) the steam rate. Assume all the ideal processes.

4 a. Sketch the flow diagram and the corresponding temperature - entropy diagram of reheat vapour cycle and derive an expression for the reheat cycle efficiency. What are the advantages gained by reheating the steam between stages? 10

b. Steam, from a boiler enters a turbine at 25 bars and expands to condenser pressure of 0.2 bar. Determine the Rankine cycle efficiency neglecting pump work. 10

i. When steam is 80% dry at turbine inlet.

ii. when steam is saturated at turbine inlet.

iii. when steam is superheated by 76.1ºC at turbine inlet.

iv. Represent above 3 processes on same T-S diagram.

UNIT - III

5 a. Show that for a multistage compressor $Z = \left[\frac{P_{X+1}}{P_1}\right]^{1/x}$ where Z = stage pressure ratio, x = number of stages, $\frac{P_{x+1}}{P_1}$ overall pressure ratio. 6

b. What are the advantages of multi-stage compressor. 4

c. A two stage, single acting reciprocating air compressor, with complete intercooling atmospheric air at 1 bar and 15ºC, compresses it polytropically (n = 1.3) to 30 bar. Both cylinders have the same stroke, calculate the diameter of the HP cylinder. The diameter of the LP cylinder is 300 mm. 10

6 a. Discuss applications of compressed air, and derive an expression for the volumetric efficiency of reciprocating air compressor. 10

b. In a 2-Stage air compressor, the work out is found to be 350 kJ/kg, of air. It is used to compress 1 kg of free air from 1 bar pressure and 32 º C initial temperatures. The value of n = 1.3 and R = 0.287 kJ/kgK. Find the intermediate pressure. 10

UNIT - IV

7 a. What do you mean by refrigerant, refrigeration and refrigerator? With a neat sketch, explain the working of vapour absorption refrigeration system 10

Contd…3

b. A simple NH_3 vapour compression system has a condenser temperature of 30ºC and evaporator temperature of -15ºC. The liquid is sub-cooled by 10ºC. Calculate, 10

i) Refrigerating effect ii) Mass flow rate per ton of refrigeration

iii) COP iv) Power per TR

v) Represent the process on P-H and T-S diagram,

C_p (vap) = 2.805 k/kgK, C_p (liq) = 4.606 kJ/kgK

8 a. Define; 10

i) Relative humidity ii) specific humidity

iii) Dew point temperature iv) Enthalpy of humid air

v) Degree of saturation.

b. A sling psychrometer reads 40ºC D.B.T. and 28ºC W.B.T. Calculate the following : 10

i) specific humidity ii) relative humidity

iii) Vapour density in air iv) Dew point temperature

v) Enthalpy of mixture per kg of dry air.

UNIT - V

9 a. List out the methods used for measuring friction power of an IC engine. Explain motoring test. 8

b. The following data were obtained from a Morse test on a 4-cylinder, 4-stroke cycle SI engine coupled to a hydraulic dynamometer, operating at constant speed of 1500 rpm. Brake load with all four cylinders firing = 296 N, Brake load with cylinder No. 1 not firing = 201 N, Brake load with cylinder No. 2 not firing = 206 N, brake load with cylinder No. 3 not firing = 192 N, brake load with cylinder No. 4 not firing = 200 N the brake power in kW is calcualted using the equation BP = WN/42300, where W is the break load in Newtons and N is the speed of the engine in rpm. Calculate : 12

i) Brake power ii) Indicated power

iii) Friction Power iv) Mechanical efficiency.

10 a. Explain Heat balance sheet. 6

b. During a trial of 60 minutes on a single, cylinder on engine having cylinder dia. 300mm, stroke 450mm and working on two stroke cycle, the following observation were made. 14

Total fuel used = 9.6 litres

Calorific value of fuel = 45000 kJ/kg

Total number of revolutions = 12624

Gross mean effective pressure = 7.24 bar

Pumping mean effective pressure = 0.34 bar

Net load on brake= 3150 N

Contd…4

Diameter of brake drum =1.78 m

Diameter of rope = 40 mm

Cooling water circulated =545 litres

Cooling water temperature rise = 25° C

Specific gravity of oil = 0.8.

Heat carried away by the exhaust gases = 15% total heat supplied.

Determine IP, BP and mechanical efficiency. Draw up the heat balance sheet on minute basis.

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