Reg. No: 23BME0280

BH/K/TX

Final Assessment Test - November 2024

VIT
Vellore Institute of Technology

Course: BMEE303L - Thermal Engineering Systems

Class NBR(s): 3786 / 3787 / 3788 / 3789

Slot: B2+TB2

Time: Three Hours

Max. Marks: 100

- KEEPING MOBILE PHONE/ANY ELECTRONIC GADGETS, EVEN IN 'OFF' POSITION IS TREATED AS EXAM MALPRACTICE
- DON'T WRITE ANYTHING ON THE QUESTION PAPER

General Instructions:

i) Steam Tables with Mollier Chart, Refrigeration Tables, Psychrometric Chart

ii) Assume suitable data, if any.

Answer ALL Questions

(10 X 10 = 100 Marks)

1. Explain different stages of combustion in SI engines with a suitable diagram. Identify the factors affecting the ignition lag in SI engines.

2. The test on a two-stroke diesel engine was carried out for one hour and the following observations were recorded.

Frictional power absorbed = 1.5 kW;
Speed of the engine = 600 rpm;
Brake torque = 120 Nm;
Fuel consumed = 2.5 kg;
Calorific value of fuel = 40.3 MJ/kg;
Cooling water circulated = 818 kg;
Rise in temperature of cooling water = 10°C;
Temperature of exhaust gas = 345°C;
Room temperature = 25°C;
Air Fuel ratio = 32:1;

Determine the following parameters.

(a) Brake power.
(b) Indicated power.
(c) Mechanical efficiency.
(d) Indicated thermal efficiency.
(e) Draw a heat balance sheet both on a minute and percentage basis.

3. A single-acting, two-stage reciprocating air compressor with perfect intercooling delivers 10.5 kg/min of air at a pressure of 16 bar. The compressor takes in air at 1 bar and 27 °C. Its compression and expansion process follows the law $PV^{1.3} = C$. Calculate the following.

(a) Power required to drive the compressor.
(b) Isothermal efficiency.
(c) Free air delivery.
(d) Heat transferred in the intercooler.
(e) If the compressor runs at 440 rpm, the clearance ratios for its LP and HP cylinders are 0.04 and 0.06, respectively, calculate the volumetric efficiencies and the swept volumes for each cylinder.

4. Steam enters a convergent-divergent nozzle at 2 MPa and 400°C with a negligible velocity. The steam flow rate is 2.5 kg/s and it exits at a pressure of 300 kPa. The flow is isentropic between the nozzle entrance and throat and overall nozzle efficiency is 93 %. Determine the following:

(a) Velocity at the throat.

(b) Velocity at exit.

(c) Throat area.

(d) Exit area.

5. What are the advantages of a steam turbine over a gas turbine? Give the fundamental difference between impulse and reaction turbines.

6. How a vapour absorption refrigeration system (VARS) is different from a vapour compression refrigeration system (VCRS)? Describe the working principle of a simple VARS with a schematic diagram. How do you calculate the coefficient of performance of VARS?

7. The following conditions are given for a hall that needs to be air-conditioned.

Outdoor condition: 39°C DBT, 20°C WBT;

Required comfort condition: 20°C DBT, 60% RH;

Seating capacity of the hall: 1200;

Amount of outdoor air supplied: 0.3 m^3/min per person;

If the required condition is achieved first by adiabatic humidification and then by cooling, evaluate the following.

(a) The capacity of the cooling coil in tonnes.

(b) The capacity of the humidifier in kg/hr.

8. The observations recorded after the conduct of a retardation test on a single-cylinder diesel engine are as follows.

Rated power = 10 kW; Rated speed = 500 rpm

Determine the frictional power and indicated power for the engine.

S. No	Drop in speed	Time for fall of speed at no load, t_2 (s)	Time for fall of speed at 50 % load, t_3 (s)
1	500-400	7	2.2
2	500-350	10.6	3.7
3	500-325	12.5	4.8
4	500-300	15.0	5.4
5	500-275	16.6	6.5
6	500-250	18.9	7.2

9.a) A refrigerator works between the temperature limits of -7 °C and 27 °C. The vapour is dry at the end of adiabatic compression. There is no under-cooling and the evaporation is carried out by the throttle valve. Determine the following

(a) The coefficient of performance.

(b) Compressor power to remove 180 kJ/min.

The properties of the refrigerant are mentioned below.

Temp. (°C)	Enthalpy (kJ/kg)		Entropy (kJ/kg-K)	
	Liquid (h_f)	Latent (h_{fg})	Liquid (s_f)	Vapour (s_g)
-7	-30	1298	-0.108	4.75
27	115	1173	4.27	4.33

OR

9.b) A refrigerating plant works between temperature limits of -5 °C and 25°C. The working fluid Ammonia has a dryness fraction of 0.62 at the entry to the compressor. If the machine has a relative efficiency of 55 %, calculate the amount of ice formed during 24 hours. The ice is to be formed at 0 °C from water at 15 °C and 6.4 kg of ammonia is circulated per minute. The specific heat of water is 4.187 kJ/kg and the latent heat of ice is 335 kJ/kg.

Properties of Ammonia (at -40 °C) are mentioned below.

Temperature (°C)	Liquid heat (kJ/kg)	Latent heat (kJ/kg)	Entropy of liquid (kJ/kg-K)
25	298.9	1167.1	1.124
-5	158.2	1280.8	0.630

10.a) In a gas turbine plant, air is compressed through a pressure ratio of 6:1 from 15 °C. It is then heated to the maximum permissible temperature of 750°C and expanded in two stages each with an expansion ratio of $\sqrt{6}$, the air being reheated between the stages to 750°C. A heat exchanger allows the heating of the compressed gases through 75 % of the maximum range possible. The isentropic efficiencies of the compressor and turbine are 0.8 and 0.85, respectively. Evaluate the following

(a) The cycle efficiency.

(b) The work ratio.

OR

10.b) The pressure ratio of an open-cycle gas turbine power plant is 5.6. Air is taken at 30°C and 1 bar. The compression is carried out in two stages with perfect intercooling in between. The maximum temperature of the cycle is limited to 700°C. Assuming the isentropic efficiency of each compressor stage as 85 % and that of the turbine as 90 %. Determine the power developed and efficiency of the plant, if the air flow is 1.2 kg/s. The mass of the fuel may be neglected, and it may be assumed constant properties of air.

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