Final Assessment Test – April 2019

Course: MEE2003 - Thermal Engineering Systems
Class NBR(s): 2695 / 2965 / 2995 / 3099
Time: Three Hours

Slot: C1+TC1+V2
Max. Marks: 100

General Instructions:

i. Use of approved steam tables, refrigeration tables & psychometric charts are permitted
ii. Missing data if any, may be suitably assumed

Answer any FIVE Questions
(5 X 20 = 100 Marks)

1. a) Explain the working principle of common rail fuel injection system with neat sketch. [10]

b) The following observations were made during a trial of a single cylinder, four stroke gas engine having cylinder diameter of 18 cm and stroke 24 cm. [10]

Duration of trial = 30 min
Total number of revolution = 9000
Total number of explosion = 4450
Mean effective pressure = 5 bar
Net load on the brake wheel = 40 kg
Effective diameter of brake wheel = 1 m
Total gas used at NTP = 2.4 m^3
Calorific value of gas at NTP = 19 MJ/m^3
Total air used = 36 m^3
Pressure of air = 720 mm Hg
Temperature of air = 17°C
Density of air at NTP = 1.29 kg/m^3
Temperature of exhaust gas = 350°C
Room temperature = 17°C
Specific heat of exhaust gases = 1 kJ/kg K
Cooling water circulated = 80 kg
Rise in temperature of cooling water = 30°C

Draw up a heat balance sheet in percentage. Take R = 287 J/kg K.

2. a) Write short notes on boiler mountings and accessories. [10]

b) A Morse test on a 12 cylinder, two stroke compression ignition engine of bore 40 cm and stroke 50 cm running at 200 rpm gave the following readings [10]

CONDITION	BRAKE LOAD (N)	CONDITION	BRAKE LOAD (N)
All firing	2040	7th cylinder	1835
1st cylinder	1830	8th cylinder	1860
2nd cylinder	1850	9th cylinder	1820
3rd cylinder	1850	10th cylinder	1840
4th cylinder	1830	11th cylinder	1850
5th cylinder	1840	12th cylinder	1830
6th cylinder	1855	All firing	2060

The output is found from the dynamometer using the following relation

$$bp = \frac{WN}{100} \text{ in kW}$$

Where, W: brake load in Newton, N: speed in rpm

Calculate:

i. Total indicated power
ii. Mechanical efficiency
iii. Brake mean effective pressure

3. a) Steam at a pressure of 15 bar and dryness fraction 0.97 is discharged through a convergent-divergent nozzle to a back pressure of 0.2 bar. The mass flow rate is 9 kg/kWh. If the power developed is 220 kW, Determine: i) Throat pressures, ii) Number of nozzles required if each nozzle has a throat of rectangular cross section of 4 mm X 8 mm. iii) If 12% of the overall isentropic enthalpy drop reheats by friction the steam in divergent portion find the enthalpy at the exit. [10]

b) A single stage double acting air compressor delivers 5 m^3 of free air per minute at 1 bar pressure and 20°C temperature to 7.5 bar with the following data: Speed= 300 RPM; Mechanical efficiency= 90%; Pressure loss in passing through intake valves = 0.04 bar; Temperature rise of air during suction stroke = 12°C; Clearance volume= 5% of stroke volume; Index of compression and expansion, n= 1.3; Length of the stroke = 1.3 times the cylinder diameter. Calculate, i) Power input to the shaft; ii) The volumetric efficiency iii) The cylinder diameter. [10]

4. A steam power plant has steam entering at 70 bar, 450°C into HP turbine. Steam is extracted at 30 bar and reheated upto 400°C before being expanded in LP turbine upto 0.075 bar. Some portion of steam is bled out during expansion in LP turbine so as to yield saturated liquid at 140°C at the exit of open feed water heater. Considering HP and LP turbine efficiencies of 80% and 85% determine the cycle efficiency. Also give layout and T-s diagram. [20]

5. a) A closed cycle gas turbine using argon as the working fluid has a two stage compression with perfect intercooling. The overall pressure ratio is 9 and pressure ratio in each stage is equal. Each stage has an isentropic efficiency of 85%. The turbine is also two stage with equal pressure ratio with inter-stage reheat to original temperature. Each turbine stage has an isentropic efficiency of 90%. The turbine inlet temperature is 1100 K and the compressor inlet is 27°C. Find i) The work done per kg of fluid flow, ii) The work ratio iii) The overall efficiency. The properties of argon and exhaust can be taken same and they are: Cp = 0.5207 kJ/kgK, γ = 1.667 and R = 0.20813 kJ/kgK. [10]

b) How actual vapour compression refrigeration cycle differs from theoretical cycle? Explain with the help of p-h and T-S diagrams. [10]

6. a) A R-12 vapour compression refrigeration system operating at a condenser temperature of 40°C and an evaporator temperature of 0°C develops 15 tons of refrigeration. Using p-h diagram for R-12, Determine: i) Discharge temperature and mass flow rate of refrigerant circulated. ii) Theoretical horse power of the compressor iii) Heat rejected in the condenser iv) The Carnot and actual COP of the cycle. [10]

b) A small GDN 11 thermal engineering systems lab of 25 persons capacity has to be provided with summer air-conditioning [10]

System has the following data :

Outside conditions: 34 DBT and 28 WBT

Inside conditions: 24 DBT and 50% RH

Volume of air supplied = 0.4 m^3/min/person

Sensible heat loads for 25 persons and lab equipment = 50, 000 kJ/h

Sensible heat gain through walls, glass, roofs = 75,600 kJ/h

Latent heat gain from 25 persons = 42,000 kJ/h

Find, i) sensible heat factor of the plant ii) capacity of the plant in TON iii) Bypass factor of coil, if apparatus dew point is 15°C.