B. E. FTBE Second Year Second Semester Examination 2019

THERMAL ENGINEERING

Time: Three hours Full Marks: 100

Answer any ***five*** questions.

All parts of the same question must be answered at the same place.

Q.1

Write the first law of thermodynamics for a closed system undergoing a thermodynamic cycle. Hence, derive the first law for a closed system, undergoing a change of state. Simplify the derived equation for a stationary closed system undergoing a change of state. Also find the heat transfer and work transfer for such a system undergoing an isobaric change of state, in terms of its properties at the initial and final states. Show the process on P-v diagram. **[2+8+2+6+2=20]**

Q.2

(a) Write the steady state steady flow energy equation for a control volume with one inlet and one outlet. Make a neat sketch of the control volume and state what each symbol represents. **[8]**

(b) Utilising the steady state steady flow energy equation for a control volume, derive an expression for the velocity at the exit of a steam nozzle in terms of appropriate properties at the inlet and the outlet of the nozzle, stating all the assumptions. **[7]**

(c) The following data are obtained from a throttling calorimeter:

Pressure in the steam main = 0.8 MPa

Pressure after throttling = 0.1 MPa

Temperature after throttling = 125 ^{0}C

Determine the dryness fraction of the steam in the main pipeline. **[5]**

Q.3

(a) State the assumptions made during an air standard cycle analysis. What is the utility of air standard cycle analysis? **[6]**

(b) Derive an expression for the thermal efficiency of an air standard Otto cycle in terms of compression ratio and index of isentropic compression. **[7]**

(c) Using *T-s* plot, compare the efficiencies of air standard Otto cycle and air standard Diesel cycle for the same maximum pressure and same heat input. **[7]**

Q.4

(a) Plot the following processes for steam, identifying the saturation zone in each case. The initial state is wet steam and the final state is superheated. On each plot, draw a pair of graphs, indicating their relative magnitudes. **[6]**

(i) isobaric process on *h-s* plane

(ii) isothermal process on *P-v* plane

(b) Comment on the slope of the isobars in the saturation zone and in the superheated zone on the *h-s* plane. Justify your answer. **[6]**

(c) A piston-cylinder arrangement contains 0.5 kg of steam with an initial dryness fraction of 0.5 and a pressure of 800 kPa. The steam is heated isobarically to a

final temperature of 230 ^{0}C. Find the heat and work transferred during the process. **[8]**

Q.5

(a) In a steam power plant, working on simple Rankine cycle, discuss the effect of increasing the temperature of steam at the inlet of the turbine on the following quantities:

(i) quality of exit steam from the turbine, (ii) condenser heat duty, (iii) thermal efficiency of the cycle and (iv) pump work.

Your answer should be in the form of either of '*increases*', '*decreases*' or '*remains unchanged*'. Give brief justification for each of your answer. Assume that all other parameters remain unchanged. **[12]**

(b) Draw the schematic diagram of a simple steam power plant working on simple ideal Rankine cycle and draw the corresponding cycle on *T-s* diagram. **[8]**

Q.6

(a) Draw the schematic diagram of a steam power plant running with regenerative open feed water heater. Plot the cycle on *T-s* diagram. Compare an open feed water heater and a closed feed water heater. **[10]**

(b) Draw the schematic diagram of a steam power plant with three stages of turbine expansion and two stages of reheating. Plot the cycle on *T-s* diagram. What happens to the net work of the cycle during reheating?. **[10]**

Q.7

(a) Draw a neat sketch of a fire tube boiler and label its different parts. **[12]**

(b) What are the functions of safety valve, water level indicator, economizer and air preheater in a boiler? Against each item, state their location and indicate whether they are mountings or accessories. **[8]**

Table 1: Properties of saturated steam

T_{sat} (^0C)	P_{sat} (kPa)	v_f (m^3/kg)	v_g (m^3/kg)	h_f (kJ/kg)	h_g (kJ/kg)	s_f (kJ/kgK)	s_g (kJ/kgK)
95	84.609	0.0010401	1.9808	398.09	2667.6	1.2504	7.4151
120.21	200	0.001061	0.88578	504.71	2706.3	1.5302	7.1270
170.44	800	0.0011149	0.2441	721.13	2769.1	2.0462	6.6628

Table 2: Properties of superheated steam

P=100 kPa				P=800 kPa			
T_{sup} (^0C)	v (m^3/kg)	h (kJ/kg)	u (kJ/kg)	T_{sup} (^0C)	v (m^3/kg)	h (kJ/kg)	u (kJ/kg)
100	1.6959	2675.8	2506.2	200	0.2609	2839.8	2631.1
150	1.9367	2776.6	2582.9	250	0.2932	2950.4	2715.9