B. E. FTBE Second Year Second Semester Examination 2018

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

(a) 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. **[12]**

(b) A steam tank, built in the form of a cube with 1.5 m length of each side contains superheated steam at 100 kPa and 130 ^0C. Calculate the mass of the steam present in the vessel and the enthalpy and entropy of the steam. **[8]**

Q.2

(a) State the similarities between 'heat' and 'work'. **[4]**

(b) Find an expression for the work done by a piston-cylinder arrangement containing a gas during a polytropic process given by PV^n = constant in terms of n, P_1, V_1 and V_2. **[6]**

(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 = 120 ^0C

Determine the dryness fraction of the steam in the main pipeline. **[10]**

Q.3

(a) Derive an expression for the thermal efficiency of an air standard dual cycle in terms of compression ratio, pressure ratio, cut-off ratio and index of isentropic compression. **[12]**

(b) With the help of *T-s* plot, compare the efficiencies of the air standard Otto, Dual and Diesel cycles for the same compression ratio and equal heat input. **[8]**

Q.4

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

(i) a constant volume process on *T-s* plane

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

(b) Show how the slopes of an isobar will appear on the *h-s* plane in the wet and superheated steam zones. Mathematically establish your answer. **[8]**

(c) How do you find the power developed by a steam turbine and the rate of heat added in a steam boiler, using the first law for a control volume? **[6]**

Q.5

(a) Discuss the difficulties associated with running a steam power plant on Carnot cycle. **[6]**

(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. How do you compute the turbine power output, the rate of heat extracted in the condenser and the pump power input for this plant? **[14]**

Q.6

(a) What are the benefits of running a steam power plant with regenerative feed heating? Draw the schematic diagram of a steam power plant running with regenerative open feed water heater. Plot the cycle on T-s diagram. **[10]**

(b) Draw the schematic diagram of a steam power plant with reheating. What is the primary objective of reheating of steam? Draw the corresponding cycle on *T-s* diagram. **[10]**

Q.7

(a) Compare the pressure rating of a fire tube with that of a water tube boiler. Draw a neat sketch of a fire tube or a water tube boiler and label its different parts. **[12]**

(b) What are the functions of boiler mountings and accessories? Name one boiler mounting and one accessory, stating their functions and locations. **[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