THE INSTITUTION OF ENGINEERS SRI LANKA

PART 1 EXAMINATION – NOVEMBER 2010

105 THEMODYNAMICS

[Time allowed : 3 hours]

[Answer any **five questions**, all question carry equal marks]

Thermodynamic Property Tables of Steam, Air and R-12 are provided.
All assumptions made should be stated clearly.

Q1. (a) Explain the following terms briefly

(i) Specific heat of a substance at constant volume

(ii) Specific heat of a substance at constant pressure

(iii) Heat, Work and Energy

(b) Derive a general expression for the work done during a polytropic process.

(c) Three grams of nitrogen gas at 6 bar and 160 °C in a frictionless piston-cylinder device is expanded adiabatically to double its initial volume, then compressed at constant pressure to its initial volume and finally compressed again at constant volume to its initial state. Draw the process in P-v diagram and calculate the net work done on the gas.

Q2. (a) State and interpret Kelvin-Planck statement of the Second Law of Thermodynamics with relevant to an application.

(b) Explain the Carnot principles drawn from the Kelvin-Planck and Clausius statements of the Second Law of Thermodynamics.

(c) Air is compressed from 1 bar at 15 °C to 6 bar at 110 °C, in a steady –flow device, Determine;

(i) The entropy change of air passing through the compressor.

(ii) The entropy change for the overall process, if there is heat transfer between the air and the environment at 15 °C, and the actual shaft work input is 200 kJ/kg.

Q3. (a) Explain terms "property" and "state" in thermodynamics giving suitable examples.

(b) With a suitable P-v diagram of a pure substance explain the following terms

(i) Mixture of saturated liquid-vapor

(26)

(ii) Subcooled liquid

(iii) Saturated liquid and saturated vapor

(iv) Superheated vapor

(c) A rigid tank of 0.03 m^3 volume contains a mixture of liquid water and water va 80 kPa. The mass of the mixture in the tank is 12 kg. Calculate the heat added a the quality of the mixture when the pressure inside the tank is raised to 7 kPa.

Q4. (a) What are the characteristics of a steady-flow process?

(b) Explain differences between steady and unsteady flow processes giving suitable examples.

(c) An insulated rigid tank having 5 kg of air at 3 bar and 30 °C is connected to an air supply line at 8 bar and 50 °C through a valve. The valve is then slowly opened to allow the air from the supply line to flow into the tank until the tank pressure reaches 8 bar. The valve is closed finally. Determine,

(i) The final temperature of the air in the tank.

(ii) The amount of air added to the tank.

Q5. (a) What are the recommended properties of a refrigerant used in a refrigeration cycle?

(b) In a commercial refrigerator, refrigerant-12 enters the compressor as superheated vapor at 0.18 MPa and -10 °C at a rate of 0.045 kg/s and leaves at 0.96 MPa and 60 °C. The refrigerant is cooled in the condenser to 30 °C and 0.84 MPa and is throttled to 0.21 MPa. Neglecting any heat transfer and pressure drops in the connecting lines between the components, determine;

(i) The rate of heat removed from the refrigerated space.

(ii) Power input to the compressor.

(iii) The adiabatic efficiency of the compressor.

(iv) The Coefficient of Performance of the refrigerator.

Q6. (a) What is the purpose of open or close feed-water heater in a Regenerative Rankin Cycle?

(b) A steam power plant as shown in Fig. Q6 operates on the ideal regenerative Rankine cycle with one open feed-water heater. Steam enters the turbine at 3 MPa and 400 °C

and is condensed in the condenser at a pressure of 10 kPa. So[illegible] of steam leaves the turbine at a pressure of 0.6 MPa and enters the open [illegible]eater. Determine,

(i) : The fraction of the steam extracted from,the turbine.

(ii) The thermal efficiency of the cycle.

Q7. (a) What are the air-standard assumptions utilized to reduce the complexities associated with the analysis of actual gas power cycles.

(b) An ideal Otto cycle has a compression ratio of 8. At the beginning of the compression stroke, the air is at 101 kPa and 22 °C, and 900 kJ/kg of heat is added to it during the constant-volume heat addition process. Considering the variation of specific heats of air with temperature, determine;

(i) The maximum temperature and pressure encountered during the cycle.

(ii) The net work output.

(iii) The thermal efficiency of the cycle.

(iv) The mean effective pressure for the cycle.

Q8. (a) Derive an expression for the thermal efficiency of Diesel engines under cold air-standard conditions.

(b) An ideal diesel cycle using air as the working fluid has a compression ratio of 16 and a cutoff ratio of 2. The intake conditions are 100 kPa, 20 °C, and 2000 cm^3. Using the cold-air standard assumption, determine;

(i) The temperature and pressure at the end of each process.

(ii) The net work output.

(iii) The thermal efficiency.

(iv) The mean effective pressure.

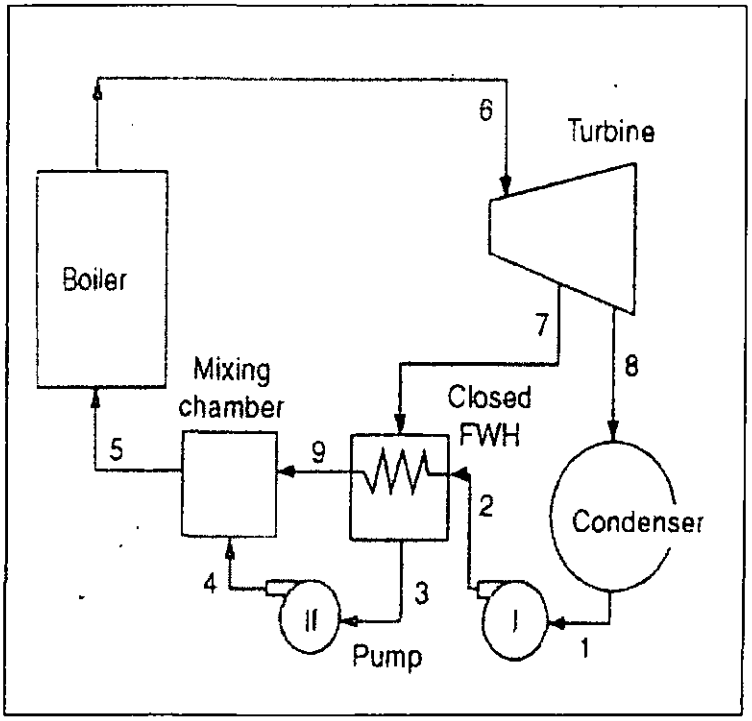

Figure Q6