FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI
DEPARTMENT OF MECHANICAL ENGINEERING
RAIN SEMESTER EXAMINATIONS 2018/2019 SESSION
COURSE: MEE 204 ENGINEERING THERMODYNAMICS II TIME: 3 HOURS DATE: 31/10/2019

Instructions: Answer Question one and any other three

1. (a) An engine working on Otto cycle has a compression ratio of 8.5:1 and a cylinder gas temperature of 330K at BDC on the compression stroke. If the law of compression is $PV^{1.3}=C$ and the law of expansion is $PV^{1.25}=C$. If the maximum cycle temperature is 2200°C, calculate the thermal efficiency and work ratio of the engine. **10Marks**

(b) A mixture of gases has the following composition by mass: N_2, 60%; O_2, 25%; CO_2, 15%. A mass of 0.7kg of the mixture initially at 1bar and 27°C is compressed to 5bar. The composition can be assumed to be a reversible non-flow polytropic process with a polytropic index of 1.2. Find the work, heat transfer and change in entropy. The values of Cp for the constituents are; N_2 1.040kJ/kgK, O_2 0.918 kJ/kgK and CO_2 0.846 kJ/kgK **10 Marks**

(c) A Rankine steam power plant operates on the regenerative cycle with one open feedwater heater. Steam enters the turbine at 15bar, 300°C. Condenser pressure is 0.1bar. Some steam is extracted from the turbine at 5bar and enters the feedwater heater. The condensate is pumped to the feedwater heater at 5bar. The boiler feedwater leaves the feedwater heater as saturated liquid at 5bar. Neglecting the pump work, determine the mass fraction of the working fluid delivered by the condenser. **10 Marks**

2. (a) An air standard dual-combustion cycle has a mean effective pressure of 10.24bar. The minimum pressure and temperature are 1.013bar and 25°C respectively while the compression ratio is 17.5 1. Calculate the maximum cycle temperature when the cycle thermal efficiency is 62.8% and the maximum cycle pressure is 65bar. **10 Marks**

(b) A gas turbine unit has a pressure ratio of 7.5 and a maximum cycle temperature of 780°C. The isentropic efficiencies of the compressor and turbine are 0.87 and 0.91 respectively. Calculate the cycle thermal efficiency, work ratio of the plant and the power output of an electric generator geared to the turbine when the air enters the compressor at 27°C at the rate of 12.38kg/s. Take C_p = 1.005kJ/kgK and $\gamma = 1.4$ for the compression process and take C_p = 1.15kJ/kgK and $\gamma = 1.333$ for the combustion and expansion process **14 Marks**

3. Butane [C_4H_{10}] is burned in dry air and the wet products of combustion contain 5% by volume of oxygen. The nitrogen brought in with the air should be considered as inert.

(a) Write down the stoichiometric reaction equation

(b) By considering the wet products of combustion, determine the excess air proportion in the actual process

(c) Construct a table showing the dry products of combustion for the reaction with excess air and determine the proportions by mole and by mass. **23 Marks**

4. A steam power plant operates on the simple Rankine cycle. The boiler delivers steam to the turbine at 20bar, 350°C. After expansion in the turbine to some intermediate stage, a fraction of the steam is extracted at a pressure of 10bar and reheated in the boiler to a temperature of 400°C. It is finally expanded in the low pressure turbine to 0.1bar. Sketch the T – S diagram and determine the turbine work. **23 Marks**

5. A heat pump operates on the ideal vapor compression cycle and uses refrigerant R-134a as the working fluid. Condenser temperature is 45°C and evaporator temperature is 4°C.

(a) Identify the cycle processes on a T – S diagram.

(b) Calculate the superheat and compressor work

(c) Determine the COP for the cooling and heating modes respectively. **23 Marks**