Mansoura University		**3 rd Year Mech. Power**
Faculty of Engineering	**January 2014**	**Theory of Combustion**
Mech. Power Eng. Dept.		**Time allowed : 3 hrs.**

Combustion and steam tables are allowed
Answer the following questions :-

Question (1)

a) Define the excess air ratio, the equivalence ratio, and the relative fuel air ratio.
b) Normal octane C_8H_{18} is burnet with dry air. The volumetric analysis of products on dry basis is CO_2 = 11%, O_2 = 4%, CO = 1% and N_2 = 84%. Determine: (I) A/F ratio. (II) the equivalence ratio. (III) the percentage of excess air used.
c) What are the higher and lower heating values of a fuel? How do they differ?
d) Calculate the product temperature of methane, CH_4 – air mixture at 300 K, burning with 15 excess air at 0.1 MPa pressure.

Question (2)

a) What are the factors that affect on the combustion time losses.
b) A steady flow combustion chamber is supplied with 1 kmol of CO gas at 77° C and 400 kPa and with 2.5 kmol of air at 25° C and 400 kPa. The combustion products leave the combustion chamber at 3000 K and 400 kPa. If the combustion gases consist of CO_2, CO, O_2, and N_2, determine : (I) the equilibrium composition of the product gases, and (II) the heat transfer from the combustion chamber.

Question (3)

a) Starting from the air standard cycles discuss the method of study to obtain the useful power of the engine. Also compare between the actual and fuel air cycles.
b) A spark ignition engine of compression ratio 8 and uses a gaseous fuel, of heating value of 12.6 kJ / lit and has the volumetric analysis : H_2 = 0.4, CH_4 = 0.27, CO = 0.13, CO_2 = 0.03, N_2 = 0.12, and O_2 = 0.05. The excess air ratio is 0.5. At the beginning of compression, the temperature and pressure are 100° C and 1 ata respectively. Calculate the following taking into consideration the dissociation effect : (I) the maximum temperature and pressure in the engine cylinder. (II) the indicated work of the cycle and the thermal efficiency. (III) the engine power and the brake mean effective pressure (b.m.e.p.) if it has four cylinder of 10 and 15 cm diameter and stroke respectively and running at 3000 rpm take the volumetric and mechanical efficiencies to be 0.9 and 0.95 respectively. Given that the heating value of CO to CO_2 is 282.9 MJ/kmol.

Question (4)

a) What is the difference between the pressure rise coefficient and the pressure recovery factor.

b) For an ideal gas obtain an expression for the ratio of the velocity of sound where M = 1 to the velocity of sound based on the stagnation temperature, (C^*/C_o).

c) Products of combustion enter the nozzle of a gas turbine at the design conditions of 400 kPa, 1000 K, and 200 m/sec, and they exit at a pressure of 270 kPa at a rate of 3 kg/sec. Assuming isentropic flow, determine whether the nozzle is converging or converging-diverging. Also find the exit velocity and the exit area. Take k = 1.4 and C_p = 1.16 kJ/(kg.K) for the combustion products.

Question (5)

a) How do intercooling, reheating, and regeneration affect the efficiency of a Brayton cycle, and how do they accomplish it?

b) A gas turbine engine with regeneration operates with two stages of compression and two stages of expansion. The overall pressure ratio of the cycle is 16. The air enters the first stage of the compressor at 320 K and each stage of the turbine at 1500 K. The compressor and turbine efficiencies are 88 and 94 percent respectively, and the effectiveness of the intercooler is 0.9 and the efficiency of the regenerator is 85 percent. Determine the back work ratio and the thermal efficiency of this gas turbine cycle. Also calculate the mass flow rate of air needed to develop a net power of 80 MW if the total mechanical efficiency is 0.9. Assuming constant specific heats for air at room temperature.

Good Luck

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