DEM
DEPARTAMENTO
DE ENGENHARIA MECÂNICA
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Equipamentos Térmicos

1^{st} Test (Second chance) - 12 June 2015

Part II - Restricted Open Book

1. (8.0 v.) 430 kmol.h^{-1} of combustion gases are generated from the incineration of 850 kg.h^{-1} of waste with methane. The incineration process occurs with 15% of excess air. On a mass basis the waste is composed by 28% H_2O, 32% C, 16% H, 9% O, 7% N and 8% inerts. Assume complete reactions and consider 7% heat losses in the combustion chamber. Air and methane are supplied at 15.6 °C. The lower heating value (LHV) of methane corresponds to 1.2×10^4 kcal.kg^{-1}. Assume for the inert fraction of the waste a constant specific heat equal to 0.65 kcal.kg^{-1}.K^{-1}.

   (a) (3.5 v.) Determine the composition (on a molar basis) of the combustion gases per 100 kg of waste burned. (If not computed consider that per 100 kg of waste burned, 0.82 kmol of CH_4 and 9.18 kmol of O_2 are consumed which will generate 34.79 kmol of N_2, 11.12 kmol of H_2O, 3.48 kmol of CO_2 and 1.20 kmol of O_2)

   (b) (2.5 v.) Equation (1) allows for the determination of the heat content in the combustion products, Q_{out} [kcal], as a function of its temperature, T [°C], through its sensible heat.

$$Q_{out}(T) = \alpha + \beta T + \gamma T^2 \tag{1}$$

   Determine the constants α, β and γ per 100 kg of waste burned. Consider the datum temperature (T_{ref}) equal to 15.6 °C. Notice that Equation (1) neglects third-order terms. (If not computed consider $Q_{out}(T) = -5734.53 + 366.67T + 0.06T^2$)

   (c) (2.0 v.) Knowing that the flue gases leave the combustion chamber at 1600 °C, determine the lower heating value (LHV) of the waste.

2. (2.0 v.) It is intended to oxidize the carbon monoxide content of a gas with the following composition: 5.7 kmol of CO, 11.4 kmol of H_2O and 10.7 kmol of N_2. For such purpose, 40.7 kmol of air are added to the gas in a combustion chamber. The combustion chamber operates at a temperature and pressure equal to 800 °C and 1 atm, respectively. Consider that the CO oxidation reaction only starts after a complete mixing between the gas and air. Estimate the required residence time in the combustion chamber to decrease the mole fraction of CO in the mixture from its initial value to 100 ppm.