FUELS AND COMBUSTION

Problem 1

Hydrogen burns in pure oxygen in a chemically correct (stoichiometric) mixture. Write the combustion equation.

(a) Calculate the mass of products per unit mass of hydrogen.

(b) Calculate the lower heating value of hydrogen if its higher heating value is 61100 Btu/lbm.

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Problem 2

Write the balanced chemical equation for the combustion of methane in stoichiometric air. Use the table of heats of formation to determine the heats of reaction of methane (in Btu/lbm and Btu/lb-mole), with products and reactants all at the standard state and product water as liquid. What are the values if the product water is vapor? Would the heat of reaction be different if the combustion were in pure oxygen? Compare your results with tabulated heating values for methane.

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Problem 3

Determine the heat transferred when ethane is burned

(a) in stoichiometric air, and

(b) in 100% excess air.

In both cases the reactants are in the standard state and products at 1000 K. Use a heat of formation of .36,420 Btu/lb-mole.

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Problem 4

A fuel oil burned in a steam generator has a composition which may be represented by $C_{14}H_{30}$. A dry-basis ue-gas analysis shows the following volumetric composition:

CO_2 11.226%,

O_2 4.145%,

CO 0.863%, and

N_2 83.766%.

Write the complete combustion equation for 1 mol of fuel and calculate:

(a) the air-to-fuel ratio by mass,

(b) the excess air in percent, and

(c) the mass of water vapor in the flue gases per unit mass of fuel.

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Problem 5

Purified syngas derived from coal (3 CO + H_2 + 3.76 N_2) is used to generate power in an open Brayton cycle. 2800 m^3 per minute of this syngas enters a gas turbine combustion chamber at 200 °C, where it burns adiabatically in 150 % theoretical air. The exhaust products drive a gas turbine and leaves at 600 °C. Calculate the thermal power input to the turbine in MW_{th}.

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Problem 6

Gasoline, sometimes represented as C_8H_{18}, is burned in 25 % excess air mass. What are the mass and mole stoichiometric and actual air-fuel ratios? Determine the mass and mole fractions of the combustion products.

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Problem 7

An adiabatic combustor burns methane with 400% excess air. Both air and methane are initially at 298 K. What is the exit temperature?

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Problem 8

A chemically correct mixture of gaseous methane and air at 25 °C is admitted into a nozzle where it is completely combusted. Calculate the nozzle exit velocity in feet per second if the exit temperature is 2000 K.

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Problem 9

A natural gas has the following ultimate analysis by mass:

H_2 23.3 %,   C 74.72 %, N_2 0.76%, and O_2 1.22%.

The flue gases have the following volumetric analysis:

H_20 15.583 %, CO_2 8.387 %, N_2 72.805 %, and O_2 3.225%.

(a) Calculate the theoretical air used in combustion.

(b) Calculate the dew point, in _C, if the ue gases are at 2 bar.

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