Summary:

During a combustion process, the components that exist before the reaction are called reactants and the components that exist after the reaction are called products.

Air-Fuel Ratio:

The ration of the mass of air to the mass of fuel during a combustion process is called the air-fuel ratio *AF*.

$$AF = \frac{m_{AIR}}{m_{FUEL}}$$

A combustion process is complete if all the carbon in the fuel burns to CO_2*, all the hydrogen burns to* H_2O *and all the sulfur burns to* SO_2*.*

Theoretical Air:

The minimum amount of air needed to complete the combustion of a fuel is called the *stoichiometric* or *theoretical air*. The air in excess of the stoichiometric amount is called the *excess air*.

Ex: 300 % *excess air* → 400 % *theoretical air*

Dew-Point Temperature of Combustion Products:

The dew-point temperature of the products is the temperature at which the water vapor in the products starts to condense as the products are cooled at constant pressure.

$$T_{dp} = T_{sat} @ P_v$$

Conservation of Energy:

For an *open system*, the conservation of energy relation for chemically reacting steady-flow systems can be expressed per unit mole of fuel as:

$$Q_{in} + W_{in} + \sum N_r \left(\bar{h}_f^o + \bar{h} - \bar{h}^o\right)_r = Q_{out} + W_{out} + \sum N_p \left(\bar{h}_f^o + \bar{h} - \bar{h}^o\right)_p$$

For a *closed system*, the conservation of energy can be expressed as:

$$Q_{in} + W_{in} + \sum N_r \left(\bar{h}_f^o + \bar{h} - \bar{h}^o - P\bar{v}\right)_r = Q_{out} + W_{out} + \sum N_p \left(\bar{h}_f^o + \bar{h} - \bar{h}^o - P\bar{v}\right)_p$$

*The $P\bar{v}$ terms are negligible for solids and liquids and can be replaced by R_uT for gases that behave as ideal gases.

Where:

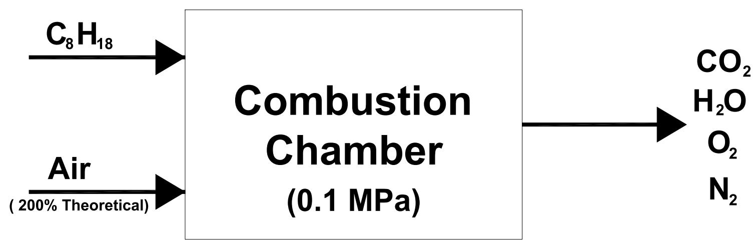
$\bar{h}_f^o$ is the enthalpy of formation at reference conditions (25°C, 1 atm)

$\bar{h}$ is the enthalpy per Kmol

$\bar{h}^o$ is the enthalpy per Kmol at reference conditions (25°C, 1 atm)

Question 1:

Determine the mole fractions of the products of combustion when octane, C_8H_{18}, is burned with 200% theoretical air. Also, determine the air-fuel ratio and the dew-point temperature of the products if the pressure is 0.1 MPa.



Question 2:

A small gas turbine uses C_8H_{18} (l) for fuel, with 400% theoretical air. The air and fuel enter at 25°C and the products of combustion leave at 900K. The output of the engine and the fuel consumption are measured, and it is found that the specific fuel consumption is 0.25 kg/s of fuel per megawatt output. Determine the heat transfer from the engine per kmol of fuel. Assume complete combustion.