

Energy Process and Systems Engineering

Assignment 2

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Problem 1: Air Quantity – Mole Fractions (Mode: Molecules)

Given: Mole fractions of fuel components x_i ; Molar weights MW_i

To determine: Minimum air demand $X_{air,min}$; Actual air demand $X_{air,in}$

Formulas:

1. **Mixture molar weight of fuel:**

$$MW_{fuel} = \sum_i x_i MW_i \quad (1)$$

2. **Mass fraction of fuel component:**

$$x_{mi} = \frac{x_i MW_i}{MW_{fuel}} \quad (2)$$

3. **Stoichiometric air demand (moles of O₂):**

$$X_{O_2,min} = \sum_j v_{O_2,j} n_j$$

where $v_{O_2,j}$ are stoichiometric coefficients of O₂ for each combustible component j .

4. **Total air demand (including excess air λ):**

$$X_{air,in} = \lambda X_{air,min} \quad (3)$$

Problem 2: Air Quantity – Mass Fractions (Mode: Elements)

Given: Mass fractions of elements x_{mi} (C, H, S, ...); Molar weights MW_i

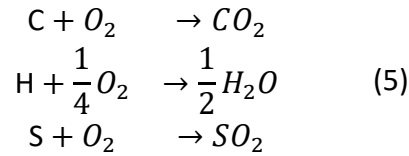
To determine: Minimum air demand $W_{air,min}$; Actual air demand $W_{air,in}$

Formulas:

1. **Convert mass fractions to mole fractions:**

$$x_i = \frac{x_{mi}/MW_i}{\sum_i x_{mi}/MW_i} \quad (4)$$

2. **Stoichiometric air demand using elemental reactions:**



3. Total air demand including excess:

$$W_{air,in} = \lambda W_{air,min} \quad (6)$$

Problem 3: Exhaust Gas – Mole Fractions (Mode: Molecules)

Given: Input molar flow N_{in} ; Mole fractions $x_{i,in}$; Stoichiometric matrix ν ; Extent of reaction ξ_j

To determine: Output molar flow N_{out} ; Mole fractions $x_{i,out}$

Formulas:

1. Molar flow of each component exiting the system:

$$N_{i,out} = x_{i,in}N_{in} + \sum_j \nu_{i,j}\xi_j \quad (7)$$

2. Total molar flow leaving system:

$$N_{out} = \sum_i N_{i,out} \quad (8)$$

3. Exhaust gas mole fraction:

$$x_{i,out} = \frac{N_{i,out}}{N_{out}} \quad (9)$$

Problem 4: Exhaust Gas – Mass Fractions (Mode: Elements)

Given: Mass fractions x_{mi} ; Stoichiometric matrix for elements; Extent of reaction ξ_j

To determine: Exhaust gas composition in mass fractions $x_{ex,out,mass}$

Formulas:

1. Moles of elements reacting:

$$n_i = \frac{x_{mi}}{MW_i} \quad (10)$$

2. **Mass of exhaust components:**

$$m_{i,out} = n_i MW_i + \sum_j v_{i,j} \xi_j MW_i \quad (11)$$

3. **Mass fraction of exhaust component:**

$$x_{i,out,mass} = \frac{m_{i,out}}{\sum_i m_{i,out}} \quad (12)$$