Department of Chemical Engineering
Thapar Institute of Engineering & Technology, Patiala

Course: Material and Energy Balances UCH301

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Material Balances on Processes involving Combustion

- Combustion is a rapid reaction of fuel with oxygen.
- The significance of combustion reactions lies in the tremendous amount of energy that is released during these reactions.
- When a fuel is burned, carbon present in the fuel reacts with oxygen to form either CO_2 or CO.
- When CO is formed during the reaction the combustion is partial or incomplete. When CO_2 is formed the combustion is complete.

- Hydrogen in the fuel reacts to form H_2O.
- Sulfur in the fuel reacts to form SO_2.
- The products of combustion are collectively called “flue gas” or “stack gas”.
- Composition of flue gas is reported either on wet basis or on dry basis.
- When composition of flue gas is defined on wet basis, the water vapor present in the flue gas are included while calculating the composition of flue gas.

- When composition of flue gas is defined on dry basis, the water vapor present in the flue gas are not included while calculating the composition of the flue gas.
- Orsat analysis is a technique for flue gas analysis. The data reported by Orsat analysis is on “dry basis”.
- Theoretical air/oxygen: The amount of air required for complete combustion of the fuel being fed to the reactor.
- %Excess air= {(Air fed – air required)/air required}*100

Exercise

A flue gas contains 20 kg CO_2, 40 kg CO, 40 kg H_2O. Calculate the composition of the flue gas on wet basis and on dry basis.

Solution

Basis: 100 kg flue gas

Component	Mass (kg)	kMol	Mol% (wet)	kMol (dry basis)	Mol% (dry)
CO_2	20	20/44=0.454	(0.454/4.105)*100 = 11.06	0.454	(0.454/1.883)*100 = 24.11
CO	40	40/28=1.429	34.81	1.429	75.89
H_2O	40	40/18=2.222	54.13	-	
Total	100	4.105	100	1.883	100

Exercise

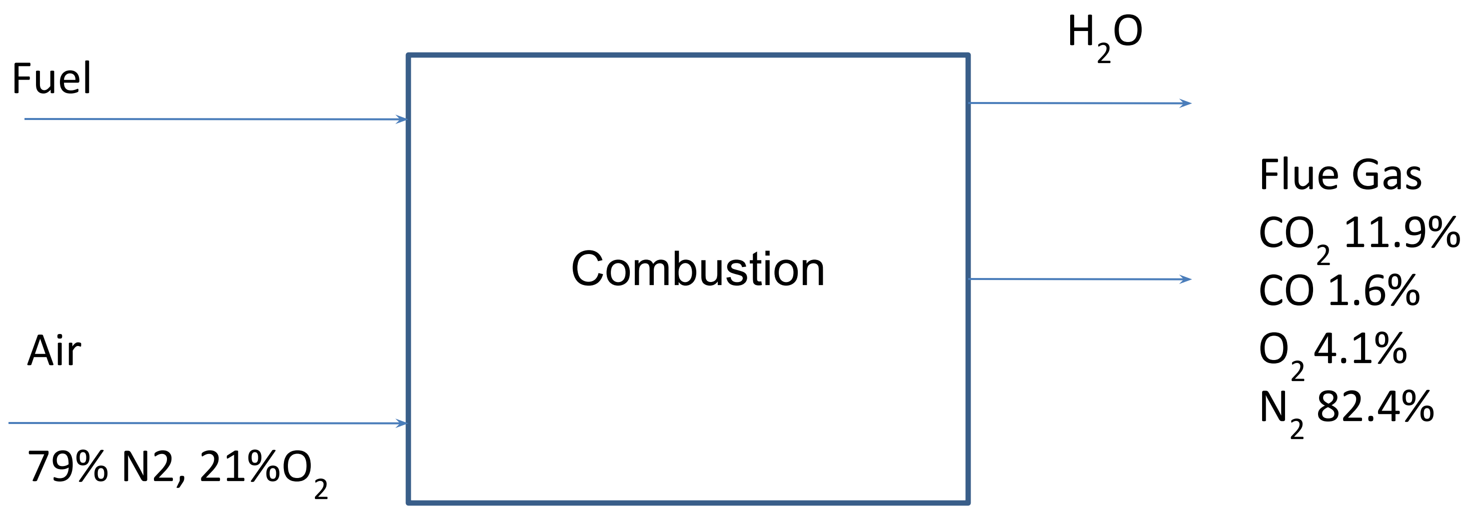
A flue gas has the following composition on dry basis: CO_2 = 11.9%; CO= 1.6%; O_2 = 4.1%; N_2 = 82.4%

Calculate the percentage excess air supplied for combustion.

Solution

Basis : 100 mol of dry flue gas

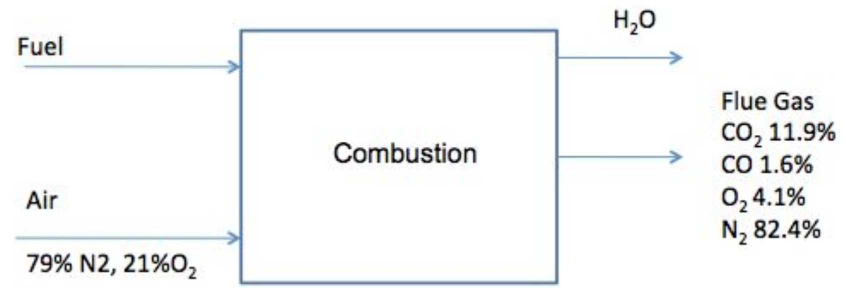
This gas contains: CO_2 =11.9 mol, CO =1.6 mol, O_2=4.1mol, N_2 = 82.4 mol



Applying Balance on N_2 (inert):

N_2 in = N_2 Out

N_2 in = 82.4 mol



Therefore, mol of air in = 82.4/0.79 = 104.3 mol

O_2 entered with N_2 = 104.3*0.21

= 21.9 mol

Combustion of CO to CO_2 would have used = 1.6/2 =0.8 mol O_2

Excess O_2 = O_2 in flue gas-O_2 that should have combined with CO

= 4.1 – 0.8 = 3.3 mol

% excess air = (3.3/(21.9-3.3))*100 = 17.7%