**Thermodynamics of Combustion**

**Incomplete combustion vs complete combustion**

C4H10 + 13/2 O2 = 4CO2 + 5H2O …. 2877 kJ/mol energy released

C4H10 + 9/2 O2 = 4CO + 5H2O ….. 1745 kJ/mol energy released

According to the above equations, 1132 /mol energy lost in the presence of incomplete combustion.

CO is emitted from the combsution of fuels as a result of incomplete combustion resulting either from

-oxygen deficiency

-quenching of combustion processes due to contact with cold surfaces, rapid expansion or a relatively excessive air supply.

How can you prevent CO emissions ?

-Removal from exhaust gases

-Complete combustion – successful oxidation with suitable catalysts

Combustion basically needs flow, mixing and chemical reaction. Chemical reaction is the most essential element.

What types of reactions are combustion reactions?

-Exothermic

-Oxidation

-Fast reactions – the fuels must vaporize for the reaction to occur. *They have to be transported into gaseous phase*.

Gaseous fuels are more attractive for practical use since they are already in gas phase and go into reaction faster than liquid or solid fuels ------ Gaseous fuels are more mobile, the molecules should collide with each other to go into the reaction.

**Factors affeting combustion processes** adapted fromD. Winterbone and A. Turan , "Advanced Thermodynamics for Engineers", 1996, Butterworth-Heinemann, pg. 208)

|  |  |  |
| --- | --- | --- |
| **Conditions** | **Type** | **Examples** |
| Time dependence | Steady combustion equipments  | Gas turbine, boilers |
| Unsteady combustion equipments | Diesel engine |
| **Spatial related** | 2-D | Bunsen burner |
| 3-D | Combustion chamber |
| **Fuel-oxidizer mixing** | Premixed | Spark ignition engine |
|  | Non- premixed | Diesel engine |
| **Phase of the medium** | Single | Petrol engines with completely gasified fuel |
| Multiphase | Coal fired boilers |
| **Flow of reactants** | Laminar | Some exceptions |
| Turbulent | Boilers |

**Enthalpy of reactants and products**

****

**HESS LAW-Calculation of heat of combustion of fuels**

In order to calculate the heat of combustion, heats of formation of reactants and products from their elements should be considered.

$$∆H\_{rxn}=∆H°\_{f,products}- ∆H°\_{f,reactants}$$

C4H10 + 13/2 O2 4CO2 + 5H2O

Formation of CO2 …. C(s) + O2 (g) CO2(g) $∆H°\_{f,CO2}=-393.5 kJ/mol$

Formation of H2O …. H2(g) + 1/2O2 (g) H2O (l) $∆H°\_{f,H2O}=-285.8 kJ/mol$

Formation of C4H10 …. 4C(s) + 5H2 (g) C4H10 $∆H°\_{f,C4H10}=-125.7 kJ/mol$

$∆H\_{rxn}$= 4 x (-393.5) + 5 x (-285.8) – (–$125.7)=$ –2877.3 kJ/mol butane

References:

Jefferson W. Tester and Michael Modell, “Thermodynamics and Its Applications”, 1996, Prentice Hall.

D. Winterbone and A. Turan , "Advanced Thermodynamics for Engineers", 1996, Butterworth-Heinemann.