COMBUSTION

Combustion or burning is a chemical process, an exothermic reaction between a substance (the fuel) and a gas (the oxidizer), usually O2, to release heat. In engineering more reference is towards combustion inengines, boilers and spontaneous ignition of fuels.

Combustion reaction

In a complete combustion reaction, a compound reacts with an oxidizing element, and the products are compounds of each element in the fuel with the oxidizing element. For example:

$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$ + heat

$CH_2S + 6\ F_2 \rightarrow CF_4 + 2\ HF + SF_6$ + heat

Rapid combustion

Rapid combustion is a form of combustion in which large amounts of heat and light energy are released. This often occurs as a fire. This is used in forms of machinery, such as internal combustion engines, and in thermobaric weapons [[1]].

Slower combustion

Slow combustion is a form of combustion which takes place at low temperatures. Cellular respiration|Respiration [[2]] is an example of slow combustion.

Complete combustion

In complete combustion, the reactant will burn in oxygen, producing a limited number of products. When ahydrocarbon burns in oxygen, the reaction will only yield carbon dioxide and water. When elements such as carbon, nitrogen, sulfur, and iron are burned, they will yield the most common oxides. Carbon will yield carbon dioxide. Nitrogen will yield nitrogen dioxide. Sulfur will yield sulfur dioxide. Iron will yield iron(III) oxide. Complete combustion is generally impossible to achieve unless the reaction occurs where conditions are carefully controlled (e.g. in a lab environment).

Incomplete combustion

In incomplete combustion there is an inadequate supply of oxygen for the combustion to occur completely. The reactant will burn in oxygen, but will produce numerous products. When a hydrocarbon burns in oxygen, the reaction will yield carbon dioxide, water, carbon monoxide, and various other compounds such as nitrogen oxides. Incomplete combustion is much more common and will produce large amounts of byproducts, and in the case of burning fuel in automobiles, these byproducts can be quite lethal and damaging to the environment.

Chemical equation

Generally, the chemical equation [[3]] for burning a hydrocarbon (such as octane) in oxygen is as follows:

$C_xH_y + (x + y/4)O_2 \rightarrow xCO_2 + (y/2)H_2O$

For example, the burning of propane is:

$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$

The simple word equation for the combustion of a hydrocarbon is:

Fuel + Oxygen → Heat + Water + Carbon dioxide.

Combustion of liquid fuels

Combustion of a liquid fuel in an oxidizing atmosphere actually happens in the gas phase, i. e. it is the vapour that burns, not the liquid. Therefore, a liquid will normally catch fire only above a certain temperature, its flash point. Below that temperature the liquid will not evaporate fast enough to sustain the fire.

Combustion of solid fuels

The act of combustion consists of three relatively distinct but overlapping phases:

Preheating phase, when the unburned fuel is heated up to its flash point and then fire point. Flammable gases start being evolved in a process similar to dry distillation.

Distillation phase or gaseous phase, when the mix of evolved flammable gases with oxygen is ignited. Energy is produced in the form of heat and light, flame is often visible.

Charcoal phase or solid phase, when the output of flammable gases from the material is too low for persistent presence of flame and the charred fuel does not burn rapidly anymore but just glows and later only smoulders.

Combustion temperatures

Assuming perfect combustion conditions, such as an adiabatic (no heat loss) and complete combustion, the adiabatic combustion temperature can be determined. The formula that yields this temperature is based on the first law of thermodynamics and takes note of the fact that the heat of combustion (calculated from the fuel's heating value) is used entirely for warming up fuel and gas (e.g. oxygen or air).

In the case of fossil fuels burnt in air, the combustion temperature depends on

the heating value

the stoichiometric air ratio [[4]] λ

the heat capacity of fuel and air

air and fuel inlet temperatures

The adiabatic combustion temperature increases for higher heating values and inlet temperatures and stoiciometric ratios towards one.

Typically, the adiabatic combustion temperatures for coals are around 1500 °C (for inlet temperatures of room temperatures and $\lambda = 1.0$), around 2000 °C for oil and 2200 °C for natural gas.

Source : http://engineering.wikia.com/wiki/Combustion