Ministry of Higher Education and Scientific Research

Al-Mustaqbal University

Department of Chemical Engineering and petroleum Industrials

Week: one

Combustion engineering

3ed Stage

The nature of combustion

Combustion or burning is the sequence of exothermic chemical reactions between a fuel and an oxidant accompanied by the production of heat and conversion of chemical species. The release of heat can produce light in the form of either glowing or a flame. Fuels of interest often include organic compounds (especially hydrocarbons) in the gas, liquid or solid phase.

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

$$CH_{4(g)} + 2O_{2(g)} \rightarrow CO_{2(g)} + 2H_2O_{(g)}$$

A simple example can be seen in the combustion of hydrogen and oxygen, a reaction commonly used to fuel rocket engines:

$$H_{2(g)} + \frac{1}{2}O_{2(g)} \rightarrow H_2O_{(g)}$$

The result is water vapor, with a standard enthalpy of reaction at 298.15 K and 1 atm of −242 kJ/mol.

Equilibrium, a wide variety of major and minor species will be present, such as carbon monoxide, hydrogen and even carbon (soot or ash). As actual combustion reactions come to air, which is 78 percent

nitrogen, will also create small amounts of several nitrogen oxides, commonly referred to as NOx . increasing surface area to increase reaction rate is a method used in engineering practice for example liquid spray combustors which are used in burners ,diesel engines increases in surface area can also produce undesirable results such as accidental explosions .Another common method of causing fast reaction is to increase the temperature.

Complete combustion

In complete combustion, the reactant burns in oxygen, producing a limited number of products. When a hydrocarbon burns in oxygen, the reaction will primarily yield carbon dioxide and water. When elements are burned, the products are primarily the most common oxides. Carbon will yield carbon dioxide, sulfur will yield sulfur dioxide . NOx species appear in significant amounts above about 2,800 °F (1,540 °C), and more is produced at higher temperatures. The amount of NOx is also a function of oxygen excess.

In most industrial applications and in fires, air is the source of oxygen (O2). In air, each mole of oxygen is mixed with approximately 3.76 mol of nitrogen.

Incomplete combustion

Incomplete combustion will only occur when there is not enough oxygen to allow the fuel to react completely to produce carbon dioxide and water. It also happens when the combustion is quenched by a heat sink, such as a solid surface or flame trap.

For most fuels, such as diesel oil, coal or wood, pyrolysis occurs before combustion. In incomplete combustion, products of pyrolysis remain un burnt and contaminate the smoke with noxious particulate matter and gases. Partially oxidized compounds are also a concern; partial oxidation of ethanol can produce harmful acetaldehyde, and carbon can produce toxic carbon monoxide.

The quality of combustion can be improved by the designs of combustion devices, such as burners and internal combustion engines. Further improvements are achievable by catalytic after-burning devices (such as catalytic converters) or by the simple partial return of the exhaust gases into the combustion process.,

Smoldering

Smoldering is the slow, low-temperature, flameless form of combustion, sustained by the heat evolved when oxygen directly attacks the surface of a condensed-phase fuel. It is a typically incomplete combustion reaction. Solid materials that can sustain a smoldering reaction include coal, cellulose, wood, cotton, tobacco,

and dust. Common examples of smoldering phenomena are the persistent combustion of biomass behind the flaming fronts of wildfires.

Rapid combustion

The Bunsen burner used in heating, sterilization, and combustion. The gas can be natural gas (which is mainly methane) or a liquefied petroleum gas, such as propane, butane, or a mixture of both. The Bunsen burner consists of a metal tube on a base with a gas inlet at the lower end of the tube, which may have an adjusting valve; openings in the sides of the tube can be regulated by a admit as much air as desired. The mixture of air and gas (optimally about 1 part gas to 3 parts air) is forced by gas pressure to the top of the tube, where it is ignited with a match. It burns with a pale blue flame, the primary flame, seen as a small inner cone, and a secondary, almost colorless flame, seen as a larger, outer cone, which results when the remaining gas is completely oxidized by the surrounding air

boiler

A boiler is a device which burns gas, oil, electricity, or coal in order to provide hot water. A boiler incorporates a firebox or furnace in order to burn the fuel and generate heat. The generated heat is transferred to water to make steam, the process of boiling. This produces saturated steam at a rate which can vary according to the pressure above the boiling water. The higher furnace temperature, the faster the steam production. The saturated steam thus produced can then either be used immediately to produce power via a turbine and alternator, or else may be further superheated to a higher temperature.

internal combustion engine

The internal combustion engine is an engine in which the combustion of a fuel (normally a fossil) occurs with an oxidizer (usually air) .the mixture of air and petrol vapor is compressed and ignited by an electric spark and the essential chemical reaction is the oxidation of

hydrocarbon molecules . It is essential that the combustion of the fuel in the cylinder of an internal combustion engine should proceed in a regular way .After the reaction is initiated by a spark ,a flame should spread rapidly and smoothly through the gas mixture and the expanding gas drives the piston down the cylinder.

In an internal combustion engine (ICE) the expansion of the high-temperature and high-pressure gases produced by combustion apply direct force to some component of the engine. The force is applied typically to pistons, turbine

blades, or nozzle. This force moves the component over a distance, transforming chemical energy into useful mechanical energy.