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**SUBJECT : Nuclear , Industrial Chemistry and Metallic State**

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**TOPIC : Gaseous Fuels**

Fuel is a substance which, when burnt, i.e. on coming in contact and reacting with oxygen or air, produces heat. Thus, the substances classified as fuel must necessarily contain one or several of the combustible elements : carbon, hydrogen, sulphur, etc. In the process of combustion, the chemical energy of fuel is converted into heat energy. To utilize the energy of fuel in most usable form, it is required to transform the fuel from its one state to another, i.e. from solid to liquid or gaseous state, liquid to gaseous state, or from its chemical energy to some other form of energy via single or many stages.

**Calorific value of fuels**

The calorific value of a fuel is the qunantity of heat produced by a given mass of fuel on complete combustion . In the SI system it is measured in KJ/g. In CGS units it is in calories per gram.

**Principles of Classification of Fuels**

Fuels may broadly be classified in two ways, i.e.

(a) according to the physical state in which they exist in nature – solid, liquid and gaseous, and

(b) according to the mode of their procurement – natural and manufactured.

**Solid Fuels and Their Characteristics**

Solid fuels are mainly classified into two categories, i.e. natural fuels, such as wood, coal, etc. and manufactured fuels, such as charcoal, coke, briquettes, etc. The various advantages and disadvantages of solid fuels are given below :

(a) They are easy to transport. (b) They are convenient to store without any risk of spontaneous explosion. (c) Their cost of production is low. (d) They posses moderate ignition temperature. Disadvantages (a) Their ash content is high. (b) Their large proportion of heat is wasted. (c) They burn with clinker formation. (d) Their combustion operation cannot be controlled easily. (e) Their cost of handling is high.

**Liquid Fuels and Their Characteristics**

The liquid fuels can be classified as follows : (a) Natural or crude oil, and (b) Artificial or manufactured oils.

The advantages and disadvantages of liquid fuels can be summarized as follows :

1. **Advantages**

(a)They posses higher calorific value per unit mass than solid fuels. (b) They burn without dust, ash, clinkers, etc. (c) Their firing is easier and also fire can be extinguished easily by stopping liquid fuel supply. (d) They are easy to transport through pipes. (e) They can be stored indefinitely without any loss. (f) They are clean in use and economic to handle. (g) Loss of heat in chimney is very low due to greater cleanliness. (h) They require less excess air for complete combustion. (i) They require less furnace space for combustion.

1. **Disadvantages**

(a) The cost of liquid fuel is relatively much higher as compared to solid fuel. (b) Costly special storage tanks are required for storing liquid fuels. (c) There is a greater risk of five hazards, particularly, in case of highly inflammable and volatile liquid fuels. (d) They give bad odour. (e) For efficient burning of liquid fuels, specially constructed burners and spraying apparatus are required.

**Gaseous Fuels and Their Characteristics**

Gaseous fuels occur in nature, besides being manufactured from solid and liquid fuels. The advantages and disadvantages of gaseous fuels are given below :

Advantages Gaseous fuels due to erase and flexibility of their applications, possess the following **advantages over solid or liquid fuels** :

1. They can be conveyed easily through pipelines to the actual place of need, thereby eliminating manual labour in transportation. (b) They can be lighted at ease. (c) They have high heat contents and hence help us in having higher temperatures. (d) They can be pre-heated by the heat of hot waste gases, thereby affecting economy in heat. (e) Their combustion can readily by controlled for change in demand like oxidizing or reducing atmosphere, length flame, temperature, etc. (f) They are clean in use. (g) They do not require any special burner. (h) They burn without any shoot, or smoke and ashes. (i) They are free from impurities found in solid and liquid fuels.
2. **Disadvantages**

(a) Very large storage tanks are needed. (b) They are highly inflammable, so chances of fire hazards in their use is high.

**Natural Gas**

Natural gas is generally associated with petroleum deposits and is obtained from wells dug in the oil-bearing regions.

The approximate composition of natural gas is : CH4 = 70.9%, C2H6 = 5.10%, H2 = 3%, CO + CO2 = 22% The calorific value varies from 12,000 to 14,000 kcal/m3 . It is an excellent domestic fuel and is conveyed in pipelines over very large distances. In America, it is available to a great extent, and so, is quite popular as a domestic fuel. It is now used in manufacture of chemicals by synthetic process. It is a colourless gas and is non-poisonous. Its specific gravity is usually between 0.57 to 0.7.

**Water Gas**

Water gas is essentially a mixture of combustible gases CO and H2 with a little fraction of non-combustible gases. It is made by passing alternatively steam and little air through a bed of red hot coal or coke maintained at about 900 to 1000oC in a reactor, which consists of a steel vessel about 3 m wide and 4 m in height. It is lined inside with fire-bricks. It has a cup and cone feeder at the top and an opening at the top for the exit of water gas. At the base, it is provided with inlet pipes for passing air and steam. Reactions Supplied steam reacts with red hot coke (or coal) at 900-1000oC to form CO and H2. C + H2O → CO + H2 – 29 kcal ; C + O2 → CO2 + 97 kcal

**Composition**

The average composition of water gas is : H2 = 51%; CO = 41%; N2 = 4%; CO2 = 4%. Its calorific value is about 2,800 kcal/m3.

**Uses**

It is used as (a) a source of hydrogen gas, (b) an illuminating gas, and (c) a fuel gas.  **1 Semi water Gas**

Combustion of carbon in air is an exothermic process.So some heat generated during the manufacture of Producer gas will be lost.But the reaction of steam and red hot carbon is an endothermic process . Therefore, if a mixture of air and stream in appropriate proportions is passed over red hot carbon the whole of the heat generated can be used .The heat liberated by the combustion of carbon maintains the temperature necessary for the formation of water gas by action of stream on carbon. We get a mixture of water gas and producer gas. This mixture is called Semiwater gas.

**Composition**

The average composition of semi water gas is : H2 = 15%; CO = 30%; N2 = 55%; CO2 = 10% CH4 = 2%.

**Uses**

It is used as (a) fuel in the steel industry, (b) the production of power in internal combustion engines, and (c) synthesis of ammonia.

**Carburetted water gas**

Water gas is used to coal gas where both plants are used side by side. So water gas is called a diluting gas. Water gas has a much lower calorific value than coal gas. So this must be enriched when it is used as a diluting gas. This effects by carbureting. This is done by adding gaseous hydrocarbons obtained by cracking petroleum oils. Thus carburetted water gas containing hydrocarbons.

**Composition**

The average composition of carburetted water gas is : H2 = 34 - 38 % ; CO = 23 -28 % ; saturated hydrocarbons = 17 - 21 % ; unsaturated hydrocarbons = 13 - 16 % ; CO2 = 0.2 - 2.2 % N2 = 2.5 -5.0 % .

**Uses**

It is used as (a) industrial fuel (b ) heating and lighting purposes.

**Producer Gas**

Producer gas is essentially a mixture of combustible gases carbon monoxide and hydrogen associated with non-combustible gases N2, CO2, etc.

It is prepared by passing air mixed with little steam (about 0.35 kg/kg of coal) over a red hot coal or coke bed maintained at about 1100oC in a special reactor called gas producer. It consists of a steel vessel about 3 m in diameter and 4 m in height. The vessel is lined inside with fire bricks. It is provided with a cup and cone feeder at the top and a side opening for the exit of producer gas. At the base it has an inlet for passing air and steam. The producer at the base is also provided with an exit for the ash formed.

The gas production reactions can be divided into four zones as follows :

**Ash Zone**

The lowest zone consists of mainly of ash, and therefore, it is known as ash zone.

**Combustion Zone**

The zone next to the ash zone is known as oxidation or combustion zone. Here the carbon burns and forms CO and CO2. The temperature of this zone is about 1100oC. The following reactions take place.

C + O2 → CO2 + 94 kcal CO2 + C → 2CO -39 kcal

**Reduction Zone**

Here carbon dioxide and steam combines with red hot carbon and liberates free hydrogen and carbon monoxide. The reactions are : CO2 + C → 2CO – 94 kcal ; C + H2O → CO + H2 29 kcal ; C + 2H2O → CO2 + 2H2 – 19 kcal All these reduction reactions are endothermic, so, the temperature in the reduction zone falls to 1000oC.

**Distillation Zone**

In this zone (400 – 800oC) the incoming coal is heated by outgoing gases by giving sensible heat to the coal. The heat given by the gases and heat radiated from the reduction zone helps to distillate the fuel thereby volatile matter of coal is added to the outgoing gas.

**Composition**

The average composition of producer gas is CO = 22.3%, H2 = 8.12%; N2 = 52.55%; CO2 = 3%. Its calorific value is about 1,300 kcal/m3 .

**Uses**

It is cheap, clean and easily preparable gas and is used (i) for heating open-hearth furnaces (in steel and glass manufacture), muffle furnaces, retorts (used in coke and coal gas manufacture), etc. and (iii) as a reducing agent in metallurgical operations.

**Liquified petroleum gas**

Liquified petroleum gases **( LPG** ) are composed of those hydrocarbons which are gasesous at normal atmospheric pressure but may be condensed to liquids at normal temperature by the application of moderate pressure. These hydrocarbons are propane, propylene, butane, isobutane and butylene. Commercial LPG invariably consists of mixtures of two or more of these hydrocarbons. The LPG marketed by Indian Oil Corporation is called Indane.

**Indane**

Indane is the trade name of commercial butane and butane – propane mixture marketed by Indian oil corporation .

1.Commercial butane contain about 15% propane and 85% butane.

2.Butane – propane mixture contains 50% butane and 50% propane . Like all LPGs, Indane is stored in containers as a liquid but is generally drawn and used as a gas. A small amount o ethyl mercaptan is added with LPG to detect the leakage of the gas.

**Uses** It is the best domestic fuel.

**Oil Gas**

Oil gas is obtained by cracking kerosene oil. Oil in a thin steam is allowed to fall on a stout red hot cast iron retort, which is heated in coal fired furnace. The resulting gaseous mixture passes out through a bonet cover to a hydraulic main, a tank containing water. Here tar gets condensed. Then at the testing cap, the proper cracking of oil is estimated from the colour of the gas produced. A good oil gas should have a golden colour. By proper adjusting the supply of air, gas of required colour can be obtained. The gas is finally stored over water in gas holders.

**Composition**

The average composition of oil gas is : CH4 = 25.30%; H2 = 50-55%; CO = 10.12%; CO2 = 3%. Its calorific value is about 6,600 kcal/m3 .

**Uses** It is used as laboratory gas.

**Gobar gas**

Gobar gas is the fuel obtained by the fermentation of a mixture of cattle dung and water, inside a circular pit in the absence of air. The bacteria in the dung bring about the fermentation. A gobar gas plant is a device to convert cattle dung and other organic water into bio-gas and a good quality of manure. Gobar gas mainly consists of methane and little ethane.

The bio- gas produced by the gobar gas plant is clean and odourless and can be transported wherever needed .The gobar gas is more economical than dung cake.

**Uses**

1. It is used for domestic fuels.
2. It is used for lighting purpose.
3. It is used to run stationary diesel engines.
4. Gobar gas is safe to use since it is less likely to cause an explosion.