FUEL

Definition:

Whenever a substance is burnt in air or oxygen with the evolution of heat, the process is called combustion and the substance which is burnt is called combustible substance. In the process of combustion, the chemical energy of fuel is converted into heat energy and light energy.

The heat evolved during combustion can be used for household purposes or economically for industrial purposes. All combustible substances which contain carbon as the main constituent are called fuels. Thus fuel can be defined as any combustible substance, containing carbon as the main constituent which on proper burning produces heat that can be used economically for domestic and industrial purposes and in the generation of power.

$$\text{Fuel} + O_2 \longrightarrow \text{Products} + CO_2 + \text{Heat}$$

Classification:

The fuels are broadly classified in two ways, depending on the state of matter

1. Primary Fuels: These include the naturally occurring fuels that are found free on the earth's crust. These are classified as
    i. Solid fuels for eg wood, peat, lignite, coal etc
    ii. Liquid Fuels for eg. Petroleum, crude oil etc.
    iii. Gaseous Fuels like natural gas etc.
2. Secondary or Derived Fuels: These are artificially derived or manufactured from primary fuels. These are further classified into
    i. Solid fuels for eg coke, charcoal, petroleum coke, pulverized coal etc.
    ii. Liquid Fuels for eg. Gasoline, diesel oil, kerosene, coal tar, LPG, alcohol etc.
    iii. Gaseous Fuels like coal gas, water gas, biogas, blast furnace gas etc.

Natural Fuels	Manufactured Fuels
Solid Fuels	
Wood Coal Oil shale	Tanbark, Bagasse, Straw Charcoal Coke Briquettes
Liquid Fuels	
Petroleum	Oils from distillation of petroleum Coal tar Shale-oil Alcohols, etc.
Gaseous Fuels	
Natural gas	Coal gas Producer gas Water gas Hydrogen Acetylene Blast furnace gas Oil gas

Characteristics of a good fuel

While selecting an ideal fuel for domestic or industrial purpose we should keep in mind that the fuel selected must possess the following characteristic properties.

1. It should possess high calorific value.
2. It should have low moisture content as moisture reduces the heating value of fuel
3. It should have low non-combustible substance as its presence reduces heating value and produces more ash
4. It should have proper ignition temperature. The ignition temperature of the fuel should neither be too low nor too high. Very low ignition temperature is harmful for storage and transport while high ignition temperature causes difficulty in igniting the fuel.
5. It should be easy to handle, store and transport.
6. It should not produce poisonous products during combustion. In other words, it should not cause pollution.
7. It should burn with more efficiency and less smoke.
8. It should be easily available in plenty.
9. It should be cheap.
10. It should have moderate rate of combustion.
11. Combustion should be easily controllable i.e., combustion of fuel should be easy to start or stop as and when required.

Relative Merits of Solid, Liquid and Gaseous Fuels

Fuel Characteristics	Solid Fuels	Liquid Fuels	Gaseous Fuels
1. Calorific Value	least	higher	highest
2. Cost	cheap	Costly than solid fuels	costliest
3. smoke	Is produced	Is produced from higher carbon and aromatic components but burning is clean	Is not produced
4. ash	Always produced	Not produced	Not produced
4. environmentally friendly	no	no	yes
5. storage	easy	Should be stored in closed containers	Must be stored in closed containers
6. handling cost	high	low	low
7. safety	highest	least	least
8.Ignition temperature	high	low	least

Calorific Value of a Fuel

It is defined as the amount of heat produced by the complete combustion of a given mass of a fuel, usually expressed in joules per kilogram. It is expressed in two forms:

Gross Calorific Value (GCV) or High Calorific Value (HCV):

It is the total amount of heat generated when a unit mass of fuel is completely burnt and the products of combustion are allowed to cool down to room temperature.

When a fuel containing hydrogen is burnt, the hydrogen present in fuel produces steam. If the products of combustion are allowed to cool to room temperature, the latent heat of condensation of steam gets included in the measured heat. This is called the gross calorific value (GCV)

Net Calorific Value (NCV) or Low Calorific value (LCV)

It is the net amount of heat produced when unit mass of fuel is completely burnt and the products are allowed to escape.

Net Calorific Value = Gross Calorific Value – Latent heat of condensation of steam

= Gross Calorific Value – Latent heat of vaporization of water vapor

= Gross Calorific Value – (Mass of hydrogen per unit weight of fuel burnt x 9/100 x Latent heat of vaporization of water vapor)

For the reaction; $H_2 + \frac{1}{2}O_2 \longrightarrow H_2O$

2g 18g

1g 9g

One part by weight of hydrogen gives nine parts by weight of H_2O.

Let H% be the hydrogen content in a fuel.

Thus 1 g of fuel contains H/100 g of H_2

H/100 g of H_2 will produce 9*H/100 g of H_2O (because 1g of H_2 produces 9g of H_2O)

=0.09H*(latent heat of steam) =0.09H*587 cal/g

Latent heat of steam = 587cal/g of water vapor produced.

Thus,

NCV = HCV – 0.09 x H x 587

where H = mass of hydrogen in fuel

Units of calorific value of fuel:

Calorific values of solid and liquid are expressed in Calories/g (cal/g) or kilocalories/kg (kcal/kg) or British Thermal unit/pound (BTU/lb)

Calorific values of gaseous fuels are expressed in kilocalories/m^3 (kcal/m^3) or British Thermal unit/ft^3 (BTU/ ft^3)