TYPES OF FUELS AND THEIR CHARACTERISTICS

Content

1. INTRODUCTION

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. In this way, the energy of fuels can be utilized more effectively and efficiently for various purposes.

Objectives

After studying this unit, you should be able to

- describe the classification of fuels,
- explain the various types of fuels and their characteristics, and
- know their applications in various fields.

2. 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.

None of these classifications, however, gives an idea of the qualitative or intensive value of the fuels, i.e. their power of developing the thermal intensity or calorimetric temperature under the normal condition of use, i.e. combustion of fuels in mixture with atmospheric air in stoichiometric proportion.

We shall now proceed with the further description of the fuels. A brief description of natural and manufactured fuels is given in Table 3.1.

Table 3.1 : Natural and Manufactured Fuels

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

3. 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. (Table 3.1).

The various advantages and disadvantages of solid fuels are given below :

Advantages

(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.

3.1. Woods and their Characteristics

The most commonly used and easily obtainable solid fuel is wood. It is the oldest type of fuel which man had used for centuries after the discovery of the fire itself. In India,

wood is used in almost every village, as well as in small towns and cities. In some parts of country such as Kashmir and Mysore, wood is used for industrial purposes as well.

Constituents of Wood

Wood is vegetable tissue of trees and bushes. It consists of mainly cellular tissue and lignin and lesser parts of fat and tar, as well as sugar.

The main constituents of several kinds of wood are given in Table 3.2.

Table 3.2 : Constituents of Wood (%)

Type of Wood	Water	Sugar	Fat-tar	Cellular Tissue	Lignin
Beach wood	12.57	2.41	0.41	45.57	39.14
Birch wood	12.48	2.65	1.14	55.62	28.21
Fir (Boot)	13.87	1.26	0.97	55.90	26.91
Pine wood	12.87	4.05	1.63	53.27	28.18

The constituents of cellular tissue and lignin of wood are given in Table 3.3.

Table 3.3 : Constituents of Cellular Tissue and Lignin of Wood (%)

Constituents	Cellular Tissue	Lignin
Carbon	44.4	54.58
Hydrogen	6.2	5.8-6.3
Oxygen	49.4	35.39

The cellular tissue has a definite chemical composition and thus has stable constituents, while those of lignin vary within narrow limits. Hence, the constituent elements of different kinds of wood are slightly variable. Table 3.4 gives the constituents elements of wood and the average values of constituents of wood are given in Table 3.5.

Table 3.4 : Constituents of different kinds of Wood (%)

Element	Pine Wood	Birch Wood	Oak Wood
C	50.05	48.45	49.8
H	6.04	5.95	5.81
O + N	43.21	45.26	44.00
Ash	0.70	0.34	0.4

Table 3.5 : Average Values of Constituents of Wood

Constituents	Cellular Tissue
C	50.00
H	6.00
O	43.10
N	0.30
Ash	0.60

Calorific Value

Engineer A. Marjhevskee determined the calorific values of different kinds of wood with the help of the samples taken out from the same tree at different distances from centre. The calorific values are given in Table 3.6.

Table 3.6 : Calorific Values of Wood

Kinds of Wood	Lowest Calorific Value (cal/kg)	Highest Calorific Value (cal/kg)
Oak	4729	4750
Birch	4695	4831
Elm	4674	4833
Alder	4745	4839
Pine	4818	5310
Fir	4887	4900
Lrch	4775	4840

Ash

The ash content of wood is negligible. The ash consists of mineral water that is found in the wood itself, with an admixture of some impurities which accure during transportation, etc. The mineral matte is distributed in the tree rather irregularly. The ash consists of mainly potassium carbonate with varying degrees of calcium, magnesium and sodium carbonate, as well as minute quantities of iron oxides, alumina and silica. Pure ash is white in colour.

Moisture

A freshly felled tree anything from 40% to 60% of hygroscopic moisture depending upon the species of the tree as well as the seasons of the year. On exposure to atmospheric air, the moisture dries up and reduces to 15-20% in about 18 months. On the exposure for a longer period, no appreciable change had been observed. When wood is seasoned in water, it absorbs nearly 150% of water by weight.

Characteristics of Flame

The nature of the flame depends on the tar content of wood. Pine and birch contain more tar and hence burn with a thick and bright flame, while aspen and alder burn with a dim, transparent flame. The length of the flame also depends on the tar content.

Combustion Characteristics

The lighter the wood, the more intensely it burns with a long flame. This is because air penetrates easily throughout the whole piece during combustion. If the wood is heavy, i.e. hard, the penetration of air is rendered difficult and a concentrated flame results with the development of more heat at the point of burning.

Ignition Temperature

Wood ignites very easily. That is why it is used for lighting other fuels. The average ignition temperature of different kinds of wood is given in Table 3.7.

Type of Wood	Ignition Temperature (^oC)
Pine	295
Oak	287
Larch	290
Fir	292

3.2. Coals and their Characteristics

It is commonly adopted view that coal is a mineral substance of vegetable origin. The large deposits of coal in India are in Bengal, Bihar and Madhya Pradesh. Most of the

Indian coal is of low grade variety and coal washing to obtain low ash metallurgical coal is unavoidable. Over 30% of coal output is consumed by railways, another similar proportion is used by industry including iron and steel works. This leaves barely 40% of coal mined for use of the power supply undertakings.

Analysis of Coal

To ascertain the commercial value of coal certain tests regarding its burning properties are performed before it is commercially marketed. Two commonly used tests are : Proximate analysis and Ultimate analysis of coal. Calorific value of coal is defined as the quantity of heat given out by burning one unit weight of coal in a calorimeter.

Proximate Analysis of Coal

This analysis of coal gives good indication about heating and burning properties of coal. The test gives the composition of coal in respect of moisture, volatile matter, ash and fixed carbon. The moisture test is performed by heating 1 gm of coal sample at 104^{o}C to 110^{o}C for 1 hour in an oven and finding the loss in weight. The volatile matter is determined by heating 1 gm of coal sample in a covered crucible at 950^{o}C for 7 minutes and determining loss in weight, from which the moisture content as found from moisture test is deducted. Ash content is found by completely burning the sample of coal in a muffled furnace at 700^{o}C to 750^{o}C and weighing the residue. The percentage of fixed carbon is determined by difference when moisture, volatile matter and ash have been accounted for. The results of proximate analysis of most coals indicate the following broad ranges of various constituents by weight :

Moisture	3-30%
Volatile matter	3-50%
Ash	2-30%
Fixed Carbon	16-92%

The importance of volatile matter in coal is due to the fact that it largely governs the combustion which in turn governs the design of grate and combustions space used. High volatile matter is desirable in gas making, while low volatile matter for manufacturing of metallurgical coke.

The Ultimate Analysis of Coal

This analysis of coal is more precise way to find the chemical composition of coal with respect to the elements like carbon, hydrogen, oxygen, nitrogen, sulphur and ash. Sine the content of carbon and hydrogen that is already combined with oxygen to form carbondioxide and water is of no value for combustion, the chemical analysis of coal alone is not enough to predict the suitability of coal for purpose of heating. However, the chemical composition is very useful in combustion calculations and in finding the composition of flue gases. For most purposes the proximate analysis of coal is quite sufficient.

The broad range in which the constituents of coal vary by weight as determined by ultimate analysis are given below :

Carbon	50-95%
Hydrogen	2.5-5%
Oxygen	2-4%
Sulphur	0.5-7%
Nitrogen	0.5-3%
Ash	2-30%

3.3. Manufactured Solid Fuels and their Characteristics

The manufactured solid fuels include, charcoal, coke, briquettes, etc. They are obtained from the natural fuels, like wood, coal, etc.

Charcoal and its Characteristics

Out of the mentioned various manufactured fuels, the charcoal occupies the first place in India. In some parts of the country, for example, Mysore, huge quantities of charcoal are being used till today in blast furnaces for reducing iron ores, etc. and in many homes charcoal is used for cooking purposes. Charcoal is a produce derived from destructive distillation of wood, being left in the shape of solid residue. Charcoal burns rapidly with a clear flame, producing no smoke and developing heat of about 6,050 cal/kg.

Coke and its Characteristics

It is obtained from destructive distillation of coal, being left in the shape of solid residue. Coke can be classified into two categories : soft coke and hard coke. Soft coke is obtained as the solid residue from the destructive distillation of coal in the temperature range of 600-650°C. It contains 5 to 10% volatile matter. It burns without smoke. It is extensively used as domestic fuel. Hard coke is obtained as solid residue from the destructive distillation of coal in the temperature range of 1200-1400°C. It burns with smoke and is a useful fuel for metallurgical process.

Briquettes and their Characteristics

The term briquettes is used in respect of the dust, culm, slack and other small size waste remains of lignite, peat, coke, etc. compressed into different shapes of regular form, with or without binder. Dust and rubble result in considerable percentage during mining, transportation, etc. and the briquetting industry is, therefore, an important step towards the saving of fuel economy.

Good briquettes should be quite hard and as little friable as possible. They must withstand the hazards of weather, and must be suitable for storing and general handling in use. These properties are impart to briquettes by a correctly selected binder, or suitable processing such as pre-heating, pressing, etc. Amongst the binders, asphalt, pitch are most commonly used, giving fine results. The general conclusion is that 5-8% binder should be used to produce high quality briquettes.

Bagasse and its Characteristics

Bagasse is the residue of sugarcane, left as waste in the sugar mill after extraction of sugar juice. In weight, it is about 20% of virgin cane. By nature, it is fibrous fuel which can be compared to wood. It contains 35-45% fibre, 7-10% sucrose and other combustible, and 45-55% moisture, and possesses an average calorific value of 2200 cal/kg. On moisture-fibre basis the average composition is :

$$C = 45\%,\ H_2 = 6\%,\ O_2 = 46\% \text{ and Ash} = 3\%$$

Bagasse is the main fuel satisfying the needs of sugar industries and efforts are being made for decreasing the percent moisture of bagasse with the help of flue-gas waste heat dryers. Bagasse is a quick burning fuel with good efficiency.

4. 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 :

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.

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.

4.1. Petroleum and its Characteristics

Petroleum is a basic natural fuel. It is a dark greenish brown, viscous mineral oil, found deep in earth's crust. It is mainly composed of various hydrocarbons (like straight chain paraffins, cycloparaffins or napthenes, olefins, and aromatics) together with small amount of organic compounds containing oxygen nitrogen and sulphur. The average composition of crude petroleum is : C = 79.5 to 87.1%; H = 11.5 to 14.8%; S = 0.1 to 3.5%, N and O = 0.1 to 0.5%.

Petroleums are graded according to the following phsio-chemical properties :

(a) Specific gravity,

(b) Calorific value,

(c) Fish point or ignition point,

(d) Viscosity,

(e) Sulphur contents,

(f) Moisture and sediment content, and

(g) Specific heat and coefficient of expansion.

Classification of Petroleum

The chemical nature of crude petroleum varies with the part of the world in which it is found. They appear, however, to be three principal verities.

Paraffinic Base Type Crude Petroleum

This type of petroleum is mainly composed of the saturated hydrocarbons from CH_4 to C_{35} H_{72} and a little of the napthenes and aromatics. The hydrocarbons from C_{18} H_{38} to C_{35} H_{72} are sometimes called waxes.

Asphalitc Base Type Crude Petroleum

It contains mainly cycloparaffins or napthenes with smaller amount of parffins and aromatic hydrocarbons.

Mixed Base Type Crude Petroleum

It contains both paraffinic and asphaltic hydrocarbons and are generally rich in semi-solid waxes.

4.2. Manufactured Liquid Fuels and their Characteristics

Manufactured liquid fuels include Gasoline, Diesel oil, Kerosene, Heavy oil, Naptha, Lubricating oils, etc. These are obtained mostly by fractional distillation of crude petroleum or liquefaction of coal.

Gasoline or Petrol and its Characteristics

The straight run gasoline is obtained either from distillation of crude petroleum or by synthesis. It contains some undesirable unsaturated straight chain hydrocarbons and sulphur compounds. It has boiling range of 40-120°C.

The, unsaturated hydrocarbons get oxidized and polymerized, thereby causing gum and sludge formation on storing. On the other hand, sulphur compounds lead to corrosion of internal combustion engine and at the same time they adversely affect tetraethyl lead, which is generally added to gasoline for better ignition properties.

The sulphur compounds from gasoline are generally removed by treating it with an alkaline solution sodium plumbite. Olefins and colouring matter of gasoline are usually removed by percolating through 'Fuller's earth' which absorbs preferentially only the colours and olefine. It is used in air-crafts. It is also used as motor fuel, in dry-cleaning and as a solvent.

Some of the characteristics of an ideal gasoline are the following :

(a) It must be cheap and readily available.

(b) It must burn clean and produce no corrosion, etc. on combustion.

(c) It should mix readily with air and afford uniform manifold distribution, i.e. should easily vaporize.

(d) It must be knock resistant.

(e) It should be pre-ignite easily.

(f) It must have a high calorific value.

Diesel Fuel and its Characteristics

The diesel fuel or gas oil is obtained between 250-320°C during the fractional distillation of crude petroleum. This oil generally contains 85% C. 12% H. Its calorific value is about 11,000 kcal/kg.

The suitability of a diesel fuel is determined by its cetane value. Diesel fuels consist of longer hydrocarbons and have low values of ash, sediment, water and sulphalt contents.

The main characteristics of a diesel fuel is that it should easily ignite below compression temperature. The hydrocarbon molecules in a diesel fuel should be, as far as possible, the straight-chain ones, with a minimum admixture of aromatic and side-chain hydrocarbon molecules.

It is used in diesel engines as heating oil and for cracking to get gasoline.

Kerosene Oil and its Characteristics

Kerosene oil is obtained between 180-250°C during fractional distillation of crude petroleum. It is used as an illuminant, jet engine fuel, tractor fuel, and for

preparing laboratory gas. With the development of jet engine, kerosene has become a material of far greater importance than it is used to be. When kerosene is used in domestic appliances, it is always vaporized before combustion. By using a fair excess of air it burns with a smokeless blue flame.

Heavy Oil and its Characteristics

It is a fraction obtained between 320-400°C during fractional distillation of crude petroleum. This oil on refractionation gives :

(a) Lubricating oils which are used as lubricants.

(b) Petroleum-jelly (Vaseline) which is used as lubricants in medicines and in cosmetics.

(c) Greases which are used as lubricants.

(d) Paraffin wax which is used in candles, boot polishes, wax paper, tarpolin cloth and for electrical insulation purposes.

5. 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 :

(a) 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.

Disadvantages

(a) Very large storage tanks are needed.

(b) They are highly inflammable, so chances of fire hazards in their use is high.

5.1. Natural Gas and its Characteristics

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 :

$$CH_4 = 70.9\%,\ C_2H_6 = 5.10\%,\ H_2 = 3\%,\ CO + CO_2 = 22\%$$

The calorific value varies from 12,000 to 14,000 kcal/m^3. 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.

5.2. Manufactured Gases and their Characteristics

Manufactured gases are obtained form solid and liquid fuels. Some of the important manufactured gaseous fuels whose characteristics are discussed in the following sections are coal gas, blast furnace gas, water gas, producer gas and oil gas.

Coal Gas its Characteristics

Coal gas is obtained when it is carbonized or heated in absence of air at about 1300°C in either coke ovens or gas-making retorts. In gas making retort process coal is fed in closed silica retorts, which are then heated to about 1300°C by burning producer gas and air mixture.

$$C + \frac{1}{2} O_2 \rightarrow CO + 29.5 \text{ kcal}$$

Coal gas is a colourless gas having a characteristic odour. It is lighter than air and burns with a long smoky flame. Its average composition is : H_2 = 47%, CH_4 = 32%, CO = 7%, C_2H_2 = 2%, C_2H_4 = 3%, N_2 = 4%, CO_2 = 1% and rest = 4%. Its calorific value is about 4,900 kcal/m^3.

It is used as (a) illuminant in cities and town, (b) a fuel, and (c) in metallurgical operations for providing reducing atmosphere.

Blast Furnace Gas and its Characteristics

It is a by product flue gas obtained during the reduction of ion ore by coke in the blast furnace. Its calorific value is about 1,000 kcal/m^3. It contains about 20-25% carbon monoxide along with CO_2, N_2, etc. About 1/3 of this gas is used for preheating air used in blast furnace itself; while the remaining 2/3rd is available for use in boilers or after cleaning in gas engines. It is also used for burning in a special type of stoves (called Cowper's stove) where the furnace is preheated.

This gas contains much dust and is usually cleaned before use by dust settlers, cyclones or electrolytic precipitators.

Water Gas and its Characteristics

Water gas is essentially a mixture of combustible gases CO and H_2 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 1000°C in a rector, 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 900-1000°C to form CO and H_2.

$$C + H_2O \rightarrow CO + H_2 - 29 \text{ kcal}$$

$$C + O_2 \rightarrow CO_2 + 97 \text{ kcal}$$

Composition

The average composition of water gas is : H_2 = 51%; CO = 41%; N_2 = 4%; CO_2 = 4%. Its calorific value is about 2,800 kcal/m^3.

Uses

It is used as (a) a source of hydrogen gas, (b) an illuminating gas, and (c) a fuel gas.

Producer Gas and its Characteristics

Producer gas is essentially a mixture of combustible gases carbon monoxide and hydrogen associated with non-combustible gases N_2, CO_2, 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 1100°C 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.

Reactions

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 CO_2. The temperature of this zone is about 1100°C. The following reactions take place.

$$C + O_2 \rightarrow CO_2 + 94 \text{ kcal}$$

$$C + \frac{1}{2} O_2 \rightarrow CO + 29.5 \text{ kcal}$$

Reduction Zone

Here carbon dioxide and steam combines with red hot carbon and liberates free hydrogen and carbon monoxide. The reactions are :

$$CO_2 + C \rightarrow 2CO - 94 \text{ kcal}$$

$$C + H_2O \rightarrow CO + H_2 \rightarrow 29 \text{ kcal}$$

$$C + 2H_2O \rightarrow CO_2 + 2H_2 - 19 \text{ kcal}$$

All these reduction reactions are endothermic, so, the temperature in the reduction zone falls to 1000°C.

Distillation Zone

In this zone (400 – 800°C) 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%, H_2 = 8.12%; N_2 = 52.55%; CO_2 = 3%. Its calorific value is about 1,300 kcal/m^3.

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.

Oil Gas and its Characteristics

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 : CH_4 = 25.30%; H_2 = 50-55%; CO = 10.12%; CO_2 = 3%. Its calorific value is about 6,600 kcal/m^3.

Uses

It is used as laboratory gas.

SAQ 1

(a) What is the difference between natural and manufactured fuels?

(b) What are the merits and demerits of solid fuels?

(c) What are the main constituents of wood?

(d) What is the difference between ultimate analysis and proximate analysis of coal?

(e) Mention the uses of different types of coal.

(f) What are the characteristics of coke and briquette fuels?

(g) Mention the composition of crude petroleum.

(h) Mention the uses of different types of manufactured liquid fuels.

(i) Mention the origin and composition of natural gas.

(j) Mention the characteristics of the following gaseous fuels :

(i) Coal gas,

(ii) Water gas,

(iii) Producer gas, and

(iv) Blast furnace gas.

6. SUMMARY

Let us summarise what we have learnt in this unit. In this unit, we have discussed in detail the types of fuels and their characteristics.

The fuel is a substance which when once raised to its ignition temperature continues to burn if sufficient oxygen or air is available. The main constituents of any fuel are carbon and hydrogen. These constituents are called combustibles. The calorific value of a fuel is amount of heat liberated by its complete combustion. For solid and liquid fuels, calorific value is expressed in kJ/kg, where as for gaseous fuels it is expressed as kJ/m^3. We have learnt various types of fuels and their characteristics.

7. KEY WORDS

Fuel	**:**	A fuel is a substance which when once raised to its ignition temperature continues to burn if sufficient oxygen or air is available.
Calorific Value of Fuel	**:**	The calorific value of a fuel is amount of heat liberated by its complete combustion.
Bagasse	**:**	The residue of sugarcane is called a bagasse.