Unit 3 Fuels and their Types

Contents

Learning Objectives

- To learn the usage and importance of various types of fuels.
- To learn about various solid, liquid and gaseous fuels.

3.0 INTRODUCTION

For a healthy body, we consume solid food, liquid food and pure air. Similarly, for an engine to operate, it requires fuel.The heat energy released during burning the fuel with air, is converted into mechanical energy via a heat engine. This mechanical energy gives the required tractive force to move the vehicle in the forward direction.

Figure 3.1.1 Solid Fuels

3.1 FOSSIL FUELS

Fossils fuels are available as Solid, Liquid and Gaseous state. Figure 3.1 shows Fossil Fuels.

Figure 3.1 Fossil Fuels

3.1.1 Solid Fuels

Solid fuel refers to various types of solid material that are used as fuel to produce energy and provide heating, usually released through combustion. Solid fuels include wood, coalare mining under the earth. Initially solid fuels are used in steam engines and boilers. They release less heat energy and emit more ash and emissions. However, the solid fuels are not used in modern automobiles. Figure 3.1.1 shows Solid Fuel.

3.1.2 Liquid Fuels

Many liquid fuels play a primary role in transportation. Liquid fuels are easy to store, easy to transport, and can be handled with relative ease. They release more heat energy and less emission. Petrol and Diesel fuels are widely used for automobiles. Figure 3.1.2 shows Liquid Fuels.

Figure 3.1.2 Liquid Fuels

PETROLEUM

Robert Chesebrough

Robert Augustus Chesebrough, (January 9, 1837 – September 8, 1933) was an American chemist.

He discovered petroleum jelly which he marketed as Vaseline and he founded the Chesebrough Manufacturing Company.

Chesebrough began his career as a chemist clarifying kerosene from the oil of sperm whales.

The discovery of petroleum in Titusville, Pennsylvania, rendered his job obsolete, so he traveled to Titusville to research what new materials might be created from the new fuel.

This led to his discovery of petroleum jelly, which he trade-named as Vaseline.

In 1875, he founded the Chesebrough Manufacturing Company that in 1955 became Chesebrough-Ponds, a leading manufacturer of personal-care products. Chesebrough patented the process of making petroleum jelly (U.S. Patent 127,568) in 1872.

3.1.2.1 Petrol and Its Properties

Most liquid fuels are derived from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust.From the crude oil, by distillation process, various components like Liquid Petroleum Gas (at 40°C), petrol (40°C to 200°C), Diesel (250°C to 300°C) and residue tar (above 350°C) are extracted. Figure 3.1.2.1 shows the distilation process of various components useages.

Petrol, also known as Gasoline, is a transparent fuel derived from crude oil and is used as fuel in internal combustion engines. Petrol is separated from crude oil from 40°C to 200°C. Petrol is usually a blend of paraffin's, naphthenic, aromatics and olefins. Figure 3.1.2.1(a) shown the Line Diagram of Distilation Process of Various Components.

Table: Chemical composition of petrol by weight

Element	Percentage by weight
Carbon	79.5 – 87.1
Hydrogen	11.5 – 14.8
Sulphur	0.1 – 3.5
Oxygen	0.1 – 0.3
Nitrogen	0.1 – 2.0

The following are the properties of petrol:

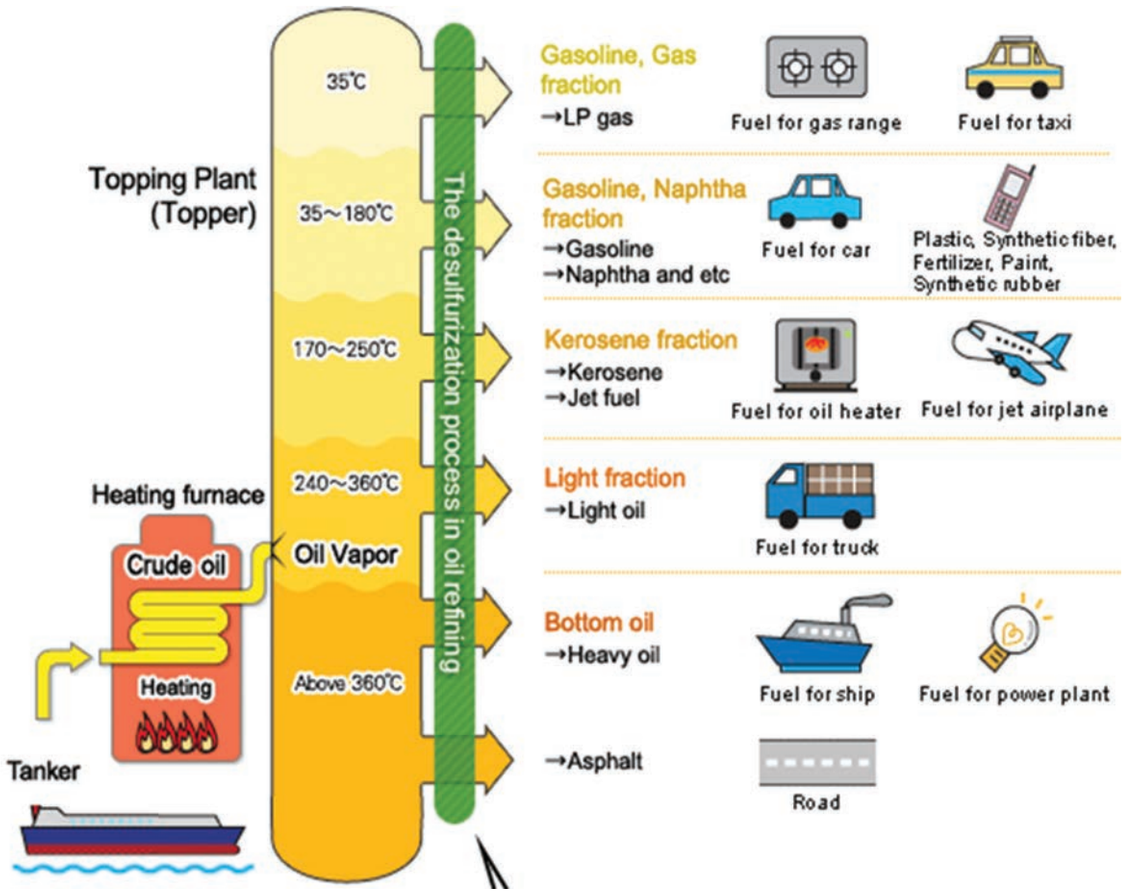


Figure 3.1.2.1 Distilation Process of Various Components Useages

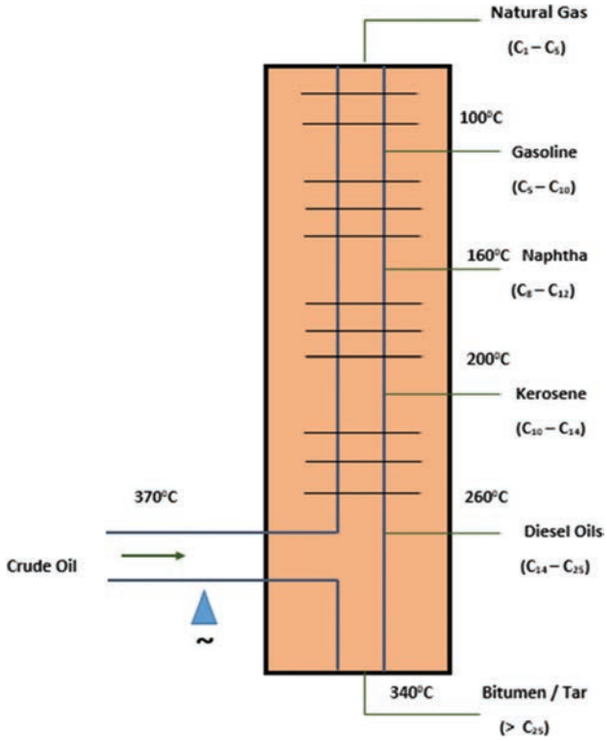


Figure 3.1.2.1(a) Line Diagram of Distilation Process of Various Components.

In petrol have Carbon 79.5% to 87.1%, Hydrogen 11.5% to 14.8%, Sulphur 0.1% to 3.5%, Oxygen and Nitrogen 0.1% to 0.3% and the following special properties are must be in petrol.

1. **Volatility:** Volatility refers to the tendency of fuel to vaporize from liquid state to gaseous state. Boiling Point is an indicator of volatility. Higher the boiling point, the less volatile the fuel. A highly volatile fuel is more likely to form a flammable. Petrol should be sufficiently volatile to form combustible vapor. Petrol must be sufficiently volatile to evaporate at low temperature, for easy starting of the engine, but not so volatile as to evaporate in fuel lines, causing vapor lock and thus preventing flow of liquid fuel.

2. **Specific Gravity:** Specific gravity is the ratio of the density of a substance to the density of a reference substance (usually water). Specific gravity of petrol should be 0.70 to 0.78
3. **Calorific Value:** The amount of heat energy produced by the complete combustion when burning 1 kg of a fuel. The calorific value of petrol is 45.8 MJ/kg.
4. **Flash and Fire Point:** The fire point of a fuel is the lowest temperature at which the vapor of that fuel will continue to burn for at least 5 seconds after ignition by an open flame. Generally flash point should be high for the fuel. The fire point of a fuel is the temperature at which the vapor produced by that given fuel will continue to burn for at least 5 seconds after ignition by an open flame. In general the fire points can be assumed to be about 15°C - 20°C higher than the flash points. For petrol, at least 10% of fuel should be burn instantly and rest in staged phase.
5. **Viscosity:** Resistance to the flow is called as Viscosity and it should be low.
6. **Sulphur Content:** Sulphur will corrode and damage the metal parts. During engine operation, Sulphur combines with oxygen to form Sulphur-di-oxide and in presence of water, it forms sulphurous acid. Hence, Sulphur content should be less than 0.1%
7. **Moisture and Sediment Content:** Petrol fuel should be free from Moisture and Sediment Content.
8. **Octane Number:** This is a measure of auto Ignition resistance in a spark-ignition engine. It represents the volume percentage of iso-octane (C_8H_{18}) in a iso-octane (C_8H_{18}) / n-heptane (C_7H_{16}) mixture. Higher the rating, higher the resistance to knock.A higher rating does not indicate more power but fuel can be used in higher compression ratio. The value of Octane number for the available fuel is between 85 to 90.

3.1.2.2 Diesel and Its Properties

Diesel fuel is the light oil and is obtain from crude oil by the distillation process at a temperature of 250°C – 300°C. Diesel consists of 85% carbon, 12% Hydrogen and 3 % others by weight. These have a boiling point between 250°C and 350°C. Diesel contains more energy than petrol. A diesel engine can be up to 40% more efficient than a spark-ignited petrol engine with the same power output and hence it is widely used in cars, trucks, buses, railway engines etc., The following are the required properties of diesel.

1. **Volatility:** The volatility of diesel is less than petrol. The volatility of diesel fuel influences density, auto ignition temperature, flash point, viscosity and cetane number. High volatility promotes vapor lock and low volatility component may not burn completely, thereby increasing smoke deposits.
2. **Specific Gravity:** Specific gravity of diesel is higher than petrol and the value should be 0.82 to 0.92
3. **Calorific Value:** The amount of heat energy produced by the complete combustion when burning 1 kg of a fuel. The calorific value of diesel is slightly lesser than petrol and the value is 45.5 MJ/kg
4. **Viscosity:** The viscosity is a measure of the resistance to flow of the fuel.

It will decrease as the temperature increases. A high viscosity fuel may cause extreme pressures in the injection systems and will cause reduced atomization and vaporization of the fuel spray. The viscosity of diesel fuel must be low enough to flow freely at its lowest operational temperature, yet high enough to provide lubrication to the moving parts of the finely machined injectors. The fuel must also be sufficiently viscous so that leakage at the pump plungers and dribbling at the injectors will not occur. Viscosity also will determine the size of the fuel droplets, which, in turn, govern the atomization and penetration qualities of the fuel injector spray.

5. **Sulphur Content:** The sulphur in fuel will cause wear of the internal components of the engine, such as piston ring, pistons, valves, and cylinder liners. In addition, a high sulphur content fuel requires that the engine oil and filter be changed more often. This is because of formation of acids when sulphur-di-oxide formed during combustion combines with water vapor. The Sulphur content should be less than 0.5%
6. **Moisture and Sediment Content:** Cleanliness is an important characteristic of diesel fuel. Fuel should not contain any foreign substances, otherwise, fuel pump and injectors will have poor performance moisturizer. Moisture in the fuel can also damage or cause seizure of injector parts when corrosion occurs.
7. **Cetane Number:** The principal measure of diesel fuel quality is its cetane number. A cetane number is a measure of the delay of ignition of a diesel fuel. Higher the cetane rating, the easier the engine will start and the combustion process will be smoother within the ratings specified by the engine manufacturer. It denotes the percentage by volume of cetane (chemical name Hexadecane) in a combustible mixture containing cetane and 1-methylnapthalene. Current diesel fuels have a cetane rating between 45 and 50.

3.2 ALTERNATIVE FUELS

The sources of fossils fuels are depleting and they are not renewable. At the same time the market requirements of this fuels are increasing day by day. Hence, alternative fuels are highly essential. Alternative fuels, known as non-conventional fuel, there are many materials or substances that can be used as fuels, other than fossil fuels like petrol, diesel. Some well-known alternative fuels include biodiesel, bioalcohol (methanol, ethanol, butanol), chemically stored electricity (batteries and fuel cells), hydrogen, non-fossil methane, non-fossil natural gas, vegetable oil, propane etc.,

3.2.1 Alternative Liquid Fuels

3.2.1.1 Alcohol

In recent days, Alcohols can be considered as the best alternative fuels. Methanol and ethanol are of high interest as fuels can be produced chemically or biologically. And they have characteristics which allow them to be used in internal combustion engines. The octane ratings are higher leads to less hydrocarbon emission. Also Sulphur content is less. Figure 3.2.1.1 shown Alcohol chemical bond.

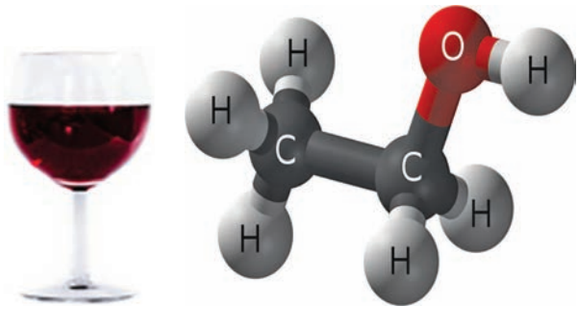
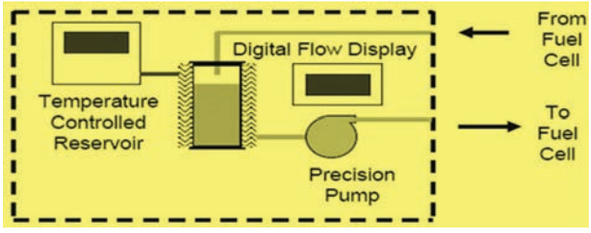


Figure 3.2.1.1 Alcohol Chemical Bond

3.2.1.2 Methanol

Methanol, also known as wood alcohol, can be used as an alternative fuel. M85 (a blend of 85 % methanol and 15 % gasoline) and M10 (a blend of 10% methanol and 90% gasoline) are used as fuel and emissions are lower than conventional vehicles. It has high octane number. Methanol is cheap to produce and has a lower risk of flammability when compared to petrol. The cost of fuel is low. However, methanol is corrosive. Fig 3.2.1.2, 3.2.1.2(a) shows Storage of Methanol and Methanol Unit respectively.

Figure 3.2.1.2 Storage of Methanol



Methanol-unit

Figure 3.2.1.2(a) Methanol Unit

3.2.1.3 Ethanol

Ethanol is also called as Ethyl alcohol. Ethanol can be produced by fermenting and distilling crops such as corn, barley or wheat. In India, Ethanol is extracted from molasses of sugarcane. It can be blended with gasoline to increase octane levels and improve emissions quality. E85 (a blend of 85 % ethanol and 15 % gasoline) and E10 (a blend of 10% ethanol and 90% gasoline) are used as fuel. Fig 3.2.1.3 shows the Carbon Cycle.

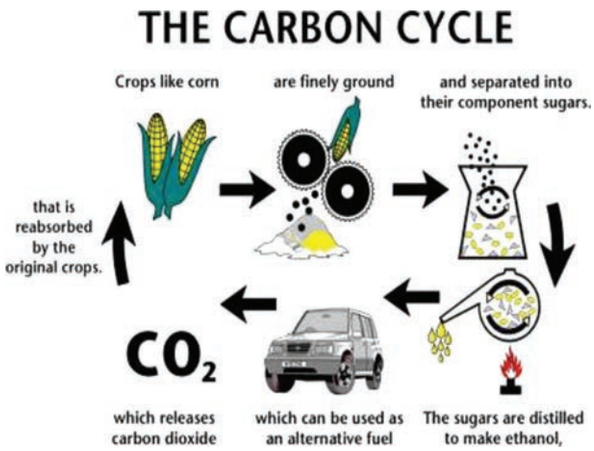


Figure 3.2.1.3 The Carbon Cycle

3.2.1.4 Bio Diesel

Bio diesel is a domestically produced, renewable fuel that can be manufactured from vegetable oils, animal fats, for use in diesel vehicles. Biodiesel can also be blended with diesel and used in unmodified engines. B20 (i.e 20% biodiesel blended with diesel) is a most common biodiesel blend. B20 has good balance of cost, emissions, cold-weather performance, materials compatibility, and ability to act as a solvent. Biodiesel is safe, biodegradable, reduces air pollutants associated with vehicle emissions, such as particulate matter, carbon monoxide and hydrocarbons. Fig 3.2.1.4 shown Bio Diesel Production Process Cycle.

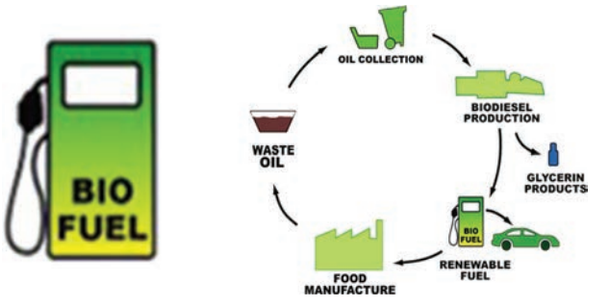


Figure 3.2.1.4 Bio Diesel Production Process

3.2.2 Gaseous Fuels

The gaseous fuels are readily mix with atmospheric air without delay and it is inducted in engine. The following gaseous fuels are presently in use.

3.2.2.1 Liquified Petroleum Gas (LPG)

Liquified petroleum gas (LPG) also called as Propane is a by product of natural gas processing and crude oil refining. LPG is widely used as a fuel for domestic cooking and heating and now it is also a popular alternative fuel for vehicles. It is stored under pressure (100psi or 680 atm) inside a special tank and is a colorless, odorless liquid. As pressure is released, the liquid propane vaporizes and turns into gas that is used in combustion.An odorant, ethyl mercaptan, is added for leak detection.Propane has a high-octane rating, making it an excellent choice for spark-ignited internal combustion engines. It provides uniform homogenous mixture for all cylinders. The carbon content in LPG is less than petrol and hence, LPG vehicles can produce lower amounts of harmful air pollutants and greenhouse gases, CO_2. The operating cost of the vehicle is reduced by 50%. The use of LPG enhances engine life. Refer Figure 3.2.2.1.

Figure 3.2.2.1 Liquified Petroleum Gas

3.2.2.2 Liquified Natural Gas (LNG)

Liquified natural gas (LNG), is natural gas in its liquid form. LNG is produced by purifying natural gas and super-cooling it to -161°C to turn it into a liquid. During the process known as liquefication, natural gas is cooled below its boiling point, removing most of the extraneous compounds found in the fuel. The remaining natural gas is primarily methane (98%) with small amounts of other hydrocarbons.

The specific gravity of LNG is higher than CNG. The calorific value of LNG is 48MJ/kg and its octane value are 110. Because of LNG's relatively high production cost as well as the need to store it in expensive cryogenic tanks, the commercial applications of LNG has been limited. Refer Figure 3.2.2.2.

3.2.2.3 Compressed Natural Gas (CNG)

Natural gas is primarily extracted from gas and oil wells. Natural gas is an odorless and it is a mixture of hydrocarbon, mainly 95% of methane and 5% of other components like butane, propane, ethane,

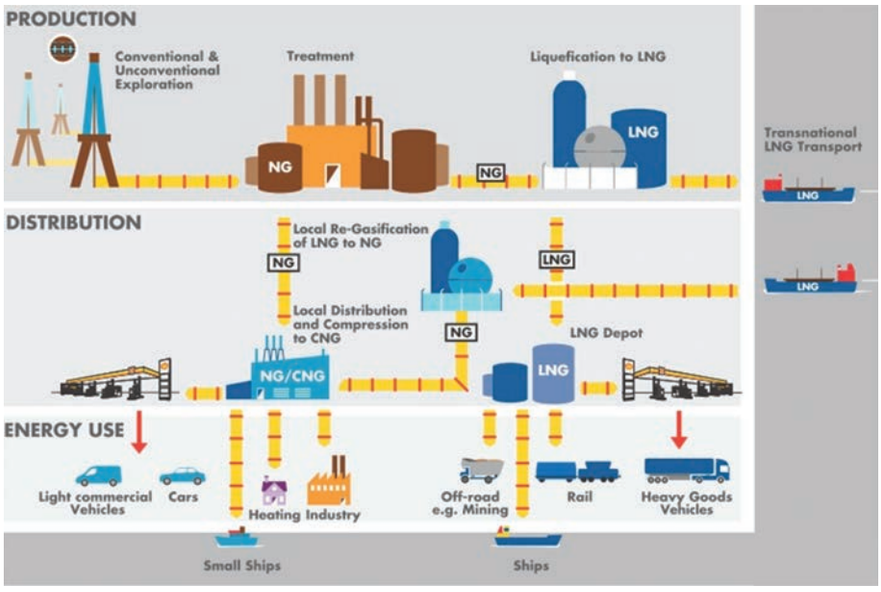


Figure 3.2.2.2 Liquified Natural Gas Plant

water vapor etc., Natural gas are stored in tanks under pressure and hence it is called as compressed natural gas. Octane rating is high. Cars and trucks with specially designed engines produce fewer harmful emissions than gasoline or diesel. CNG fuel systems are completely sealed, the vehicles produce no evaporative emissions. Operating cost of the vehicle is low. Figure 3.2.2.3 shown Compressed Natural Gas Filling Station.

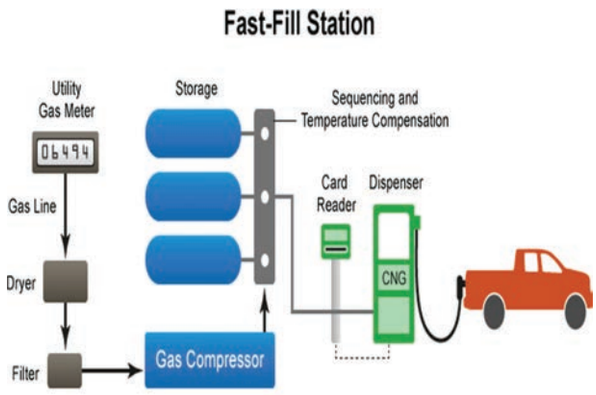


Figure 3.2.2.3 Compressed Natural Gas Filling Station

3.2.2.4 HYDROGEN

Many test engines have been developed to use Hydrogen as an alternative fuel. Hydrogen can be produced from diverse domestic resources. Hydrogen is abundant in our environment. It's stored in water

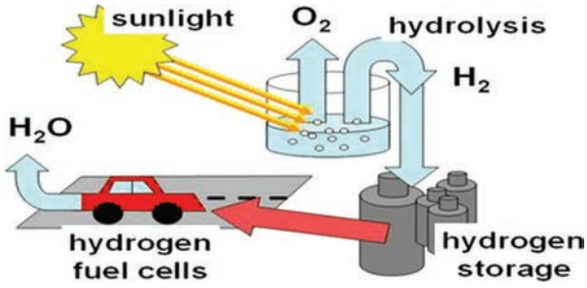


Figure 3.2.2.4 Hydrogen Preparing and Filling Process

(H_2O), hydrocarbons (such as methane, CH4), and other organic matter. One of the challenges of using hydrogen as a fuel comes from being able to efficiently extract it from these compounds. Hydrogen is also used in zero-emission electric vehicles that run on electricity generated by fuel-cell by the petrochemical reaction. Hydrogen is environmental freely. Figure 3.2.2.4 shown Hydrogen Preparing and Filling Process.

3.3 COMPARISON OF VARIOUS FUELS

Commercially fuels are available in different grades like Unleaded Petrol, Speed Petrol, White Petrol, Diesel, Speed Diesel or Premium Diesel etc., Previously, Tetra Ethyl Lead (TEL) is mixed with petrol to increase the octane rating (for antiknocking). However, the lead emission emit from the vehicle is polluting the atmosphere and lead is also poisonous. Hence addition of TEL in petrol is banned and this petrol is called as Unleaded petrol. Various additives are added with fuel to enhance the properties. Such petrol will have high octane rating and called as Speed petrol or premium petrol. Similarly, additives are added with diesel to enhance the cetane rating and such diesel is called as Speed Diesel or Premium Diesel.

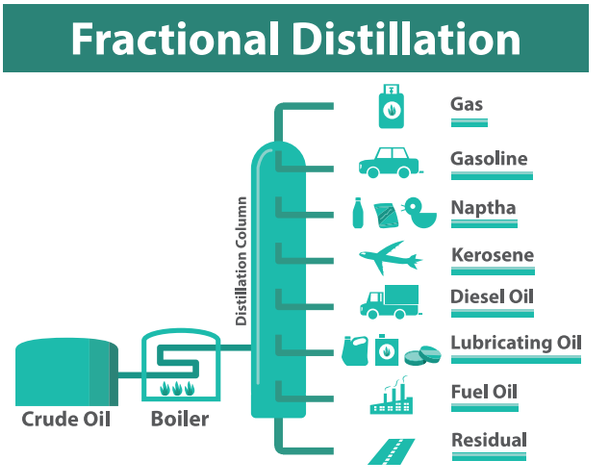


Figure 3.4 Fractional Distillation Process.

3.4 DISTILLATION CURVE

From the above curve, it is understood that the most volatile parts of the gasoline evaporate at lower temperature. This petrol vapor is mixes with air and makes the engine to start easy at cold condition. As the working temperature increases, the less volatile parts evaporate and mixes with air. Based on the distillation graph, the required additives during summer and winter season, can be added with fuel to ensure smooth operation of engine. Fig 3.4, 3.4(a) shows Distillation Curve and Fractional Distillation Process.

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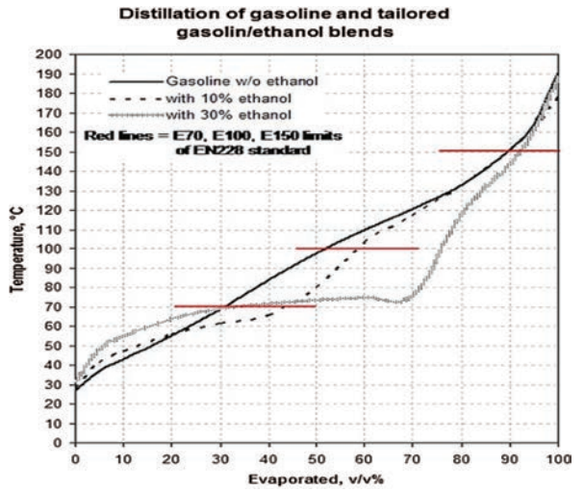

Figure 3.4(a) Distillation Curve-(% of Evaporation Vs Temperature °C)

Student Activity

1. Students should visit the nearby petrol bunks to study the usage and applications of gaseous and liquid fuels and should submit a report on it.
2. Students should visit the nearby petrol bunk and should note down the change in cost of petrol, diesel and coolant oil per litre respectively for seven days from the start of the task and should submit a report on it.
3. Students should learn the importance of octane and cetane number.

Glossary

Colorific Value	-	வெப்பமதிப்பு
Cryogenic	-	கடுங் குளிர்வியல்
Flash Point	-	வெடிப்பு நிலை
Fire Point	-	எரிநிலை
Viscosity	-	பிசுபிசுப்புத்தன்மை
Moisture	-	ஈரப்பதம்
Sediment	-	வீழ்படிவு
Crude Oil	-	கச்சா எண்ணெய்
Unleaded Petrol	-	ஈயம் கலக்கப் படாத பெட்ரோல்
Distillation Curve Diagram	-	வடிகட்டி பிரித்தல் நிலையின் வளைவு வரைபடம்

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SAMPLE QUESTIONS

Choose the correct answer:

1. Why the Solid fuels are not used in Automobile Engines?
   a) Scarcity of Fuel
   b) Higher fuel cost
   c) Low heat energy and more ash and smoke
2. What type of liquid fuel used in Automobile Engines?
   a) Mineral Oil
   b) Vegetable Oil
   c) Animal Oil

3. The quality of which fuel is known by Octane number.
   a) Petrol
   b) Diesel
   c) LPG
4. The quality of which fuel is known by Cetane number
   a) Petrol
   b) Diesel
   c) LPG
5. Which is the another name of Gasoline
   a) Petrol
   b) Diesel
   c) LPG

Answer the following questions:

1. Define Fuels.
2. Write any five properties of Petrol.
3. Define Octane Number.
4. Write any five properties of Diesel.
5. Define Cetane Number.
6. What is meant by LPG?
7. What are the properties of LPG?
8. What is meant by CNG? Mention the advantages of CNG.
9. What are the two different types of Heat Engines?
10. Define Clearance Volume.
11. Define Swept Volume.
12. What is Volumetric Efficiency?
13. What is Heat Efficiency?