Difference between L.T.C &H.T.C

L.T.C:-

- It is carried out at 700^0c.
- It produces semi coke for use as smokeless domestic fuel.
- Content of tar is high i.e., about 10% of the coal used.
- Calorific value of coke oven gas produced in L.T.C is more due to higher % of volatile matter i.e., 600-6500 Kcal/$m^{3.}$
- After carbonization discharging of coke is difficult as it swells a lot, but doesn't Shrink much finally at the end of the coking due to lower temp. of carbonization.
- Due to less Shrinkage coke produced is bigger in size, weaker & more reactive.
- Volatile matter content in coke is more i.e., 5-7%. Hence it is easier to ignite & ignition temp. is 425^0c.

H.T.C:-

- It is carried out at 1000^0c.
- It produces metallurgical coke for use in different metallurgical furnaces.
- The content of the tar here is 3% of the coal used.
- Calorific value of coke oven gas produced is very low i.e., 4200-4400 Kcal/m^3.
- Discharging of coke is easier as it Shrinks finally to a more extent comparatively due to higher temp. of carbonization.
- Coke produced is stronger, smaller in size & less reactive due to higher amount of Shrinks.
- Volatile matter content is very low i.e., 1-2%. Hence it has higher ignition temp. i.e., 605^0C.

Hardness & Strength:-

It is defined as the resistance power of material to breakage by impact. Strength of coke is measured by Shatter index while both hardness & strength of coke is measured by a parameter called Micum Index.

Shatter Index:-

It measures the resistance of coke to breakage by impact. 50lb of 2" size Coke are taken in a rectangular box of dimension 28"x18"x15". This box is placed 6ft above a steel base plate of 1/2". Materials are realised from the box & is dropped on the base plate. Coke is then screened through a series of sieves made up of square stamped sheet. The % of coke retained on 2", 1.5" &1/2" sieves are recorded & called Shatter Index. Desirable value of shatter index for blast furnace coke are 80% on 2" screen, 90% on 1.5" screen & 97% on 0.5" screen.

Micum Index of Coke:-

This gives the hardness & strength of cokes. 50kg coke of 50mm size is rotate in a mecum drum for 4 minutes at the rate of 25 rpm. Micum drum is a cylindrical steel drum of both length & diameter of 1 meter each. Drum is fitted length wise

with four angle irons. After rotating, coke is taken out & screened through 60mm, 40mm, 20mm, & 10mm round hole screens.
The % of coke retained on 40mm screen is called M_{40} index. Whereas the % of coke that passes through 10mm screen is called M_{10} index of coke.
M_{40} gives the resistance of coke to breakage by impact i.e, it gives the strength of coke where as M_{10} gives the resistance of coke to breakage by abrasion. So it measures the hardness of coke. High M_{40} & low M_{10} values are desirable for metallurgical coke.

LIQUID FUEL

Petroleum:-

Petroleum or rock oil is a natural occurring brown to black oil containing mainly of hydrocarbons & found under the crust of the earth. It is obtained from the ground by drilling up to a various depths.

Origin of petroleum can be explained by:

1. Carbide theory
2. Engler theory
3. Modern theory

1. Carbide theory:-

According to this theory inside the earth when Ca,Mg, or Al etc combines with carbon at high temp. & pressures, Carbides of corresponding elements are formed. When these carbides combines with water, hydrocarbons of lower molecular weight are formed which on hydrogenation & polymerization generates different types of hydrocarbons.

Reaction:-

$$Ca + 2C \text{ - } CaC_2$$
$$4Al + 3C \text{ - } Al_4C_3$$
$$Mg + 2C \text{ - } MgC_2$$
$$CaC_2 + 2H_2O \text{ - } Ca(OH)_2 + C_2H_2$$
$$Al_4C_3 + 12\,H_2O \text{ - } 4\,Al(OH)_3 + 3C\,H_4$$
$$C_2H_2 \text{ - } C_2H_4 \text{ - } C_2H_6$$
$$C_2H_2 + C_2H_2 + C_2H_2 \text{ - } C_2H_6$$
$$C_2H_4 + C_2H_4 + C_2H_4 \text{ - } C_6H_{12}$$

As carbide theory failed to explain the presence of N_2, S compounds, chlorophyll, some optically active compounds, other theories are develop to explain the origin of petroleum.

2. Engler Theory:-

According to this theory petroleum is the product of animal origin which is formed by decaying & decomposition of marine animals under high pressure & temp. Sulphur dioxide gas (SO_2) given out of volcanoes besides the sea site kills the marine animals & fishes which go on gathering & after 1000 of years these

animals starts decomposing under high pressure & temp. to give petroleum products. This theory helps in explaining:

1. Presence of brine or sea water in the petroleum.
2. Presence of S & N compound.
3. Presence of optically active compound.
4. **Modern Theory:**

As Engler theory couldn't explain the presence of chlorophyll i.e., green colour of oil, it couldn't explain the presence of coal deposits nearby oil fields, however according to modern theory petroleum is formed by the decay & decomposition of marine animals as well as the plant substances (origin). This theory helps in explaining the presence of brine & coal in the vicinity of petroleum. It also explains the presence of sulphur & nitrogen compound along with some optically active compound.

Composition of petroleum:-

C=84-87%
H_2=11-15%
S=0.1-3%
N_2=0.1-1.5%
O_2=0.3-1.8%

Distillation:-

D- Gasoline or petrol
I- Naphtha
S-Solvent spirit or jet fuel
T-Kerosene
I-Diesel
L-Gas oil
L-Lubricating oil
A-Petrolatum
T- Light Fuel Oil
I- Heavy fuel oil
O-Tar
N-Wax

During refining of petroleum product which have different boiling point are separated by evaporation & condensation process in a distillation column. The products Having low boiling point & molecular weight are separated at the top of the distillation column where as that of high B.P & molecular weight are separated at the bottom of the distillation column.

Here preheated crude oils are heated through a pie in a furnace & their vapours are passed through a tall cylindrical fractionating column which has number of plates inserted inside it. During the process lower boiling point vapours move to higher plates & condensed there. Similarly higher boiling point vapours condensed on the lower plates. This process of condensation & vaporization takes place many times which helps in separating the constituents of petroleum according to their boiling points. Thus the higher boiling point fractions are collected towards the lower part of the column & the lower B.P. products are collected towards the higher part of the distillation column. The liquids having

almost close boiling point are separated according to the difference of their specific gravities.

Properties & Tests of petroleum:-

1. **Viscosity:-**

   Viscosity of petroleum product is important because high viscosity petroleum can't be properly atomized which causes loss of fuel. Highly Viscous fuel is to be preheated first to reduce the Viscosity such that it can be used for different purpose. Highly viscous lubricating oil reduces it's fluidity. In case of lubricants viscosity determine the bearing friction, heat generation & rate of flow under a particular condition.

2. **Flash point:-**

   It is that temp. at which an oil gives out sufficient vapour to form an inflammable mixture with air & catches fire momentarily when flame is applied.

   Flash point gives idea about

   (a) Amount of low boiling point fuel present in liquid fuel.

   (b) Explosion hazards.

   (c) Volatility of liquid fuels.

   In Clevelant apparatus, an open brass cup is filled with oil & is heated at a constant rate. The vapours of the oil are continuously exposed to a flame. The temp. at which the vapour catches fire gives the flash point of the oil.

   In Pensky-Marten closed cup apparatus oil is taken in a closed cup & is heated by a flame, another test flame is introduced in a regular interval of

temp. and the temp. at which the vapours of the oil catches fire is noted to know the flash point.

An oil cup of 5cm deep is filled in oil up to the mark. The lid has 4 openings, one for the passage of thermometer, 2^{nd} for the introducing the test flame, 3^{rd} for stirrering, 4^{th} for the admission of air. Oil under test is filled up to the mark into the oil cup & is heated by heating the air path by burner. Stirrer is used for the stirring of oil. Heat is applied so as to raise the oil temp. by about 5^0 c/min. At every 1^0c rise in temp. , flame is introduced for a moment. The temp. at which a distinct flask appears inside the cup is recorded as flash point.

3. Cloud Point:-

During the cooling of oil at a specified rate, the temp. at which it becomes cloudy or hazy is called the cloud point of oil. This is due to the increase of viscosity at low temperature. Cloud point is important for fuel oils which have to pass through filters of fine mesh in unheated condition.

4. Pour Point:-

The temp. at which the oil doesn't flow is called the pour point of that oil. It is particularly important for lubricants.

Pour point is determined by the help of pour point apparatus. It consists essentially of a flat bottom tube of 3 cm diameter & 12 cm height. It is enclosed in an air jacket. The air jacket is surrounded by a freezing mixture of ice & $CaCl_2$. Half part of tube is filled with oil. A thermometer is introduced to record the temp. of oil. After every degree fall of temp. of oil, tube is taken out & examined for 2-3 seconds. The temp. at which cloudyness is noticed is recorded as the cloud point. After this cooling is continued & the test tube is withdrawn after every 3^0c fall of temp. & tilted to observe the flow of oil. The

temp. at which the oil doesn't flow in the test tube even when kept horizontal for 5 sec. is recorded as the pour point of the oil.

Lubricants used in a machine working at low temp. should posses low pour point. Otherwise solid fiction of lubricant will hamper the normal operation of machine.

5. **Aniline point:-**

It is the lowest temp. at which an oil is completely soluble with an equal volume of aniline. Aromatic compounds have higher tendency to react with aniline more readily than paraffin. The higher the aniline point the lower the aromatic compounds & the higher the paraffin contents & this combination is required for the use of oil in different diesel engines. Aniline point of an oil also gives an indication or possible deterioration of rubber sealing, packing etc in contact with oil. The aromatic have a tendency to dissolve natural rubber. Therefore a low aromatic content in lubricants are required.

6. **Specific Gravity:-**

Gross Calorific Value=12400-2100 P^2

This is one of the important properties of petroleum products. Hydrocarbons of lower specific gravity have maximum thermal energy per unit volume. Whereas hydrocarbons having higher specific gravity (Aromatic compounds) possess maximum thermal energy per unit weight. In the light crude oil, the content of light constituents like gasoline or kerosene is more.

Octane Number:-

When a gasoline engine is made to operate at high load & low speed, a rattling noise may develop from the combustion chamber resulting from unsteady & uncontrolled combustion. This is called as knocking & is harmful to engine as it vibrates the engine parts. Knocking depends on the quality of fuel. It has been found that n-heptanes knocks very badly. So its anti knocking property has arbitrally been taken as zero & Iso-Octane gives very little knocking. So its anti knocking value has been taken as 100. Octane number of fuel is defined as "The percentage by volume of iso-octane in a mixture of n-heptane and iso-octane with the same knocking tendency as the fuel". Higher the octane number better is the fuel. To determine the octane number of a fuel it is burnt in a standard engine for the purpose & the knock is measured by a knock meter Tetra ethyle Led (TEL) is added to improve the octane number of a fuel.

Cetane Number:-

It is a characteristic property of diesel & is used to indicate it's quality & performance in compression ignition engine. In case of diesel engine the fuel should ignite as soon as it is injected into the cylinder. The time lag between the fuel injection & fuel ignition is called ignition delay period. In case of fuel having long ignition period, abnormal combustion takes place resulting in shock waves due to fluctuating pressure rise in the cylinder. With diesel of long ignition delay period, much of the charge is injected into the cylinder before ignition is initiated causing violent combustion increases in pressure. This is called diesel knock. Cetane has a very short ignition period. Hence it gives a cetane number ratting

of 100.α- Methyle napthaline has very high ignition delay period. Hence is given a rating of zero. Cetane number of diesel oil is " The percentage by volume of cetane in a mixture of cetane and α-methyl napthaline that has same ignition delay period & performance that of fuel".
1-1.5% of additives called dopes like ethyl nitrate, acetone etc are added to improve the cetane number.

GASEOUS FUEL

1. **Methane Gas:-**

Methane gas forms in association with coal mines. These gases are formed during the coalification process. Methane gas forms explosive mixture with air. So it should be remove with proper arrangement because it is a source of dangerous explosion in gassy mines. The composition of methane gas from different coal mines varies but a high concentration methane gas has composition.

CH_4=93-92%
C_2H_6=0-3%
CO_2=0-4%
N_2=2-6%

These gases are recovered through a system of boring holes and may be used as a fuel. These gases are generally recovered in UK, FRANCE and GERMANY etc. But it is not developed on a wide scale due to the availability of natural gas on large scale. In INDIA it is not recovered to use as fuel and this is the potential source of fire in mines under the crust of earth.

2. **Water Gas:-**

It generally contains CO and H_2. It is generally produced by passing super saturated steam over hot coke kept above 1000^0c.
Reaction occurs is: $C+H_2O \rightarrow CO+H_2+28$ Kcal/Kmol.

So it is endothermic in nature and the temperature of coke gradually decreases. By passing steam over coke having less than 1000^0c temperature, CO2 & H2 will ivolve instead of water gas.

$$C+2H_2O \text{ ─ } CO_2+2H_2+1900Kcal/Kmol$$

So super saturated steam & air are alternately supplied to the coke to maintain the temperature of coke. During the air blowing reaction occurring are

$$C+O_2 \text{ ─ } CO_2\text{-}97000 \text{ Kcal/Kmol}$$

$$2C+O_2 \text{ ─ } 2CO\text{-}29000 \text{ Kcal/Kmol}$$

By passage of air, temperature of coke is increased & steam is again allowed to produce water gas. The period of steam blow is 4 minutes & the period of air blow is 2 minutes.

Water gas generator is a cylindrical vessel made up of steel. It is about 4.5 meter in height & 2.3 in diameter. Steam &air are blown alternately through the inlet at the bottom. Water gas is collected through the out let provided at the top. During the blowing of air the gaseous products are allowed to escape into the atmosphere.

Compositions:-

H_2=48-51%
CO=40-42%
CH_4=0.1-0.5%
CO_2=3-5%
N_2=3-6%

Uses:-

Water gas by mixing with oil is called carbureted water gas & is used as a fuel in different furnace. It is also used as a source of hydrogen for NH_3 synthesis in fertilizer plant.

Carbureted water gas:-

Water gas has very low calorific value i.e., 2800Kcal/m3. So it is not more effective to use as fuel. To increase its calorific value, fuel oil is added to water gas & the mixture is called carbureted water gas.

Carbureted water gas is made by passing water gas through a hot chamber into which hydrocarbon oil is spread. The oil cracks & produces methane (CH_4), ethane (C_2H_6), acetylene (C_2H_2), propane (C_3H_8) & other hydrocarbon which have very high calorific value. The resultant mixture is a carbureted water gas with the calorific value of 4300Kcal/m^3.

Composition:-

CO_2=5-6% H_2=37%

CmHn=7% CH_4=14%

O_2=0.4% N_2=5.5%

CO=30.5%

Specific gravity=0.63

3. **Coke oven Gas:-**

Composition:-

CO=7.5-9%

H_2=55-57%

CH_4=24-26%

N_2=2-3%

CO_2=2-5%

O_2=0.3-0.6%

CmHn=2-5%

H_2S=0.2-0.3%

NH_3=0.2-0.5

It is produced during high temperature carbonization of cooking coal. It is the most important fuel in steel plants. High sulphur contents are undesirable because it forms crack during mechanical working of steel. About 290m^3 of gas is produced by burning 1 ton of coal. Composition of coke oven gas varies with the temp. of carbonization & rank of coal. With increase of temperature, cracking of hydrocarbon takes place. So the amount of hydrocarbon in gas decreases & the % of hydrogen increases. But calorific value of gas produced decreases. Because the decrease in hydrocarbon content is not compensated by increase in hydrogen.

With increase in time of carbonization at constant temp. the hydrogen & the hydrocarbon decrease resulting in reduction in calorific value.

By the increase of rank of coal, the % of hydrocarbon decreases. So the calorific value decreases.

Properties:-

1-It is not as poisonous as blast furnace gas.

2-Its rate of flame propagation is considerably higher than that of natural gas, producer gas & blast furnace gas.

3-It has low specific gravity.

4-It has a high theoretical flame temp. than that of natural gas.

5-Its explosive range is about twice of natural gas.

Uses:-

Coke oven gas has extended use due to high calorific value & relatively low distribution cost due to low specific gravity. But its use during steel making leads to higher sulphur content in final steel which increases the brittleness of steel. Coke oven gas along with blast furnace gas mixture is used in iron & steel making in different furnaces like blast furnace, sintering machine, reheating furnace, open earth furnace etc.

4. **Blast furnace gas:-**

$$3Fe_2O_3 + CO \rightarrow 2Fe_3O_4 + CO_2$$

$$Fe_3O_4 + CO \rightarrow 3FeO + CO_2$$

$$FeO + CO \rightarrow Fe + CO_2$$

It is a by-product of pig iron blast furnace. During the manufacture of pig iron the air entering at the bottom reacts with the coke, iron ore, lime stone etc present in the furnace & the resultant gaseous products called BF gas escapes out at the top of the furnace. The reaction occurring are as shown above.

Composition:-

CO=23-26%

H_2=2-4.5%

CO_2=12-16%

N_2=51-57%

O_2=0.2-0.5%

Though the calorific value of the BF gas is very low but because of its very large quantity produced in steel plant, it is use in most of the furnaces in steel plants. In modern integrated steel plant about 30-35% total BF gas produced is used in the BF stoves itself for heating the air blast. Because of its low calorific value it is usually pre heated or mixed with coke oven gas to get high flame temp. BF gas leakage in atmospheric air is detected by CO detecting tubes, the chemical yellow coating inside which turns green to blue on exposer to CO depending upon the extent of CO.

BF gas coming out of the BF contains a large amount of dust particles; previously it was use directly but now a days it is cleaned by using dust catcher, wet scrubber & electrostatic precipitator.

Uses:-

Though it has very low calorific value yet because of the large quantity of production, it is one of the most important fuels in integrated steel plant. It may be used in cold states or by pre heating in BF stoves, reheating furnace, foundry ovens, boiler etc. Greater care is taken in its utilization because of its toxic & poisonous nature.

5. **Mixed Gas:-**

It is a mixture of BF gas & coke oven gas in different ratios to have a gaseous fuel of a desired calorific values & combustion characteristics. BF gas has low calorific value, but coke oven gas has very high calorific value. So in each steel plant gas mixing stations are there for mixing of coke oven gas & BF gas. There may be a common mixing station for all application or different mixing stations for the production of different grades of mixed gases for individual applications.

In Rourkela steel plant coke oven is used as a source of H_2 for synthesis of NH_3 fertilizer plant.

6. **Natural Gas:-**

It is a mixture of paraffinic hydrocarbons. It occurs in the gas fields in association crude petroleum in oil field. After recovery natural gas is processed to remove small size solids present in it. It is then treated to recover the liquidous products like gasoline. When natural gas contains less than 15gm/m3 of condensate it is called dry natural gas & when more than 50gm/m3 of condensate are present, it is called Wet Natural Gas. The condensate recovery is done by adsorption on a porous solid.

Sulphur is present in gas as H_2S. H_2S free gas is called as sweet gas. Natural gas is used for cooking, domestic or industrial heating etc. In India natural gas is available in Gujarat, Assam & Maharashtra.

Composition:-

CH_4=77.22-96.91
C_2H_6= 1.33-11.18
C_3H_8=0.19-5.83
C_4H_{10}=0.05-2.34
C_5H_{12}=0.02-1.18
CO_2=0.8-0.82
N_2=0.68-1.39

Calorific value=9000-11200 cal/m3

Specific gravity=0.574-0.74

7. **Producer Gas:-**

*When coal bed reactor heated at 1100^0c in presence of air mixed with mixture producer gas is formed.

*It is a clean gas can be easily prepared & is cheap.

Composition:-

CO=22-30% H_2=8.12%

CO_2=3% N_2=52-55%

It's calorific value is 1300 Kcal/Kg

Uses:-

i. For heating open formation.

ii. For glass & steel manufacturing.

iii. Reducing agent.