a) Coal does not produce as much strength and porosity as coke.
b) During the process of coking undesirable sulphur is removed.
c) Coal burns with a long flame, which is suitable only for reverbatory furnaces.

1.6.4 CARBONIZATION OF COAL

Conversion of coal into coke in the absence of air is known as carbonization. Carbonization of coal can be carried out at low temperature or high temperature.

Low temperature carbonization (450-750°C): Low temperature carbonization is done at a lower temperature and the coal obtained is widely used as domestic fuel.

High temperature carbonization (above 900°C): In high temperature carbonization, coal is heated to a high temperature to 900-1200 °C, and the coke obtained has desired porosity, strength, purity and hardness. This coke is generally used for metallurgical purposes.

Comparison of High Temperature and Low temperature carbonization

Characteristics		Low temperature carbonization	High temperature carbonization
1	Heating temperature	450-750°C	900-1200°C
2	Yield of coke	75-80%	65−75%
3.	Volatile matter content	5−15%	1−3%
4.	Coke produced	Soft	Hard
5.	Calorific value	6500−9500 kcal/kg	5400−6000 kcal/kg
6.	Mechanical strength	Poor	Good
7.	Smoke produced	Smokeless	Smoky
8.	Uses	Domestic	Metallurgy

1.6.5 MANUFACTURE OF METALLURGICAL COKE

Metallurgical coke can be manufactured by two methods. They are

1. Beehive's oven method and
2. Otto-Hoffmann's by-product oven method.

1.6.5.1 BEEHIVE'S OVEN METHOD

This is the earliest and cheapest method for the manufacture of metallurgical coke.

Construction: The oven has a dome shaped brick structure about 4m wide and 2.5 m high. It has two openings which can be opened and closed as desired. Coal is charged from the top opening, while the coke produced is removed from the side door. The side door, also act as air inlet.

Process: Through the top opening coal is charged and evenly leveled to form a 0.6-0.7 m thick layer. Some air is supplied through the side door and coal is ignited. Volatile matter present in the coal escapes and burns inside. Thus, heat for carbonization is supplied by the burning of volatile matter and partly by coal itself. Combustion is allowed to proceed gradually by in a limited supply of air. Complete carbonization takes place in 3-4 days. After complete carbonization, hot coke is quenched with water and taken out through the side opening, leaving the oven hot to begin the next batch of carbonization. The yield of coke is about 75% of charged coal. Many such ovens are arranged in series and average 5-6 tones of coke are produced per oven. By products are not recovered in this method.

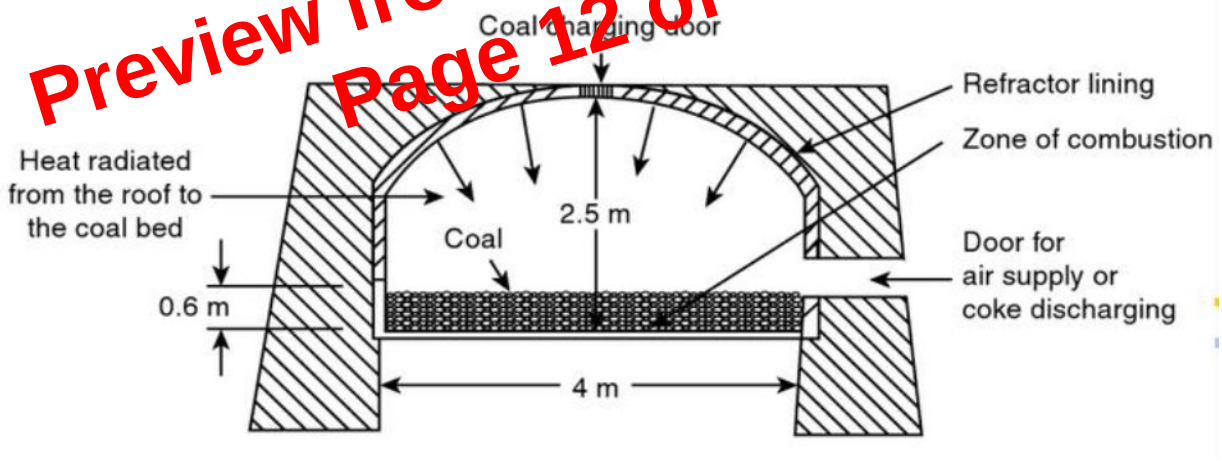


Figure 1.1 Beehive's oven

Disadvantages:

- Useful by-products are not recovered.
- Cause significant air pollution.
- Yield of coke is lower due to partial combustion

The amount and quality of gasoline largely depends upon the temperature of the furnace. With increase in temperature of the furnace, octane number of the gasoline increases but yeild decreases. The octane number of gasoline achieved by thermal refining process is only 65-80. Thermal reforming is less effective to obtain gasoline of high octane number.

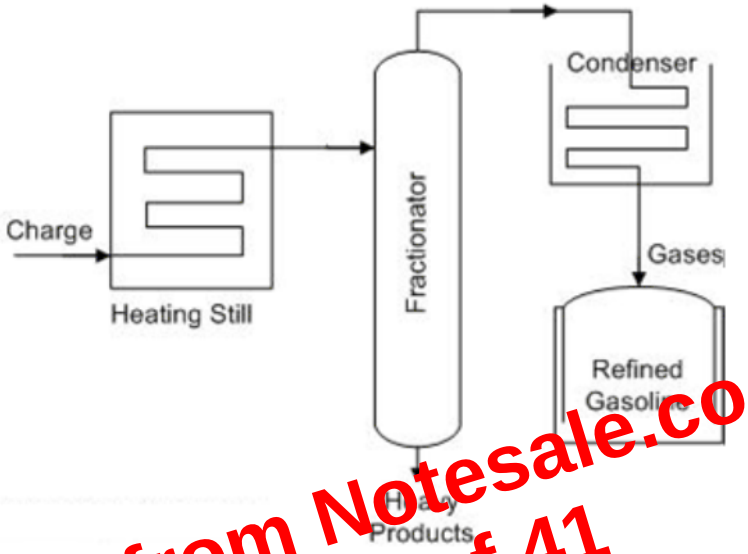


Figure 1.7 Thermal reforming process

1.7.8.2 CATALYTIC REFORMING

Catalytic reforming refers to conversion of low octane gasoline to high octane gasoline in the presence of a catalyst. Catalyst used is platinum supported on alumina. Increase in octane number of gasoline occurs through structural modifications where straight chain hydrocarbons are converted into branched chain, cyclic and aromatic hydrocarbons. Octane number as high as 90-95 can be achieved by this method.

This process can be carried out in a fixed bed or a moving bed reactor. The process of carrying out reforming using platinum is called **platiforming**.

In this process, straight run naphtha is fractionated to remove the low boiling fractions. Then the fraction having boiling range of 100-200°C is chosen for reforming. This fraction is preheated and compressed with hydrogen and heated to about 500°C before it comes into contact with catalyst in the reactor. The products are obtained in both liquid (petrol) and gaseous phases (H_2 and H_2S). Gases are passed through an

• Knocking causes sound pollution.

• Driving and travelling becomes unpleasant.

1.8.1 MECHANISM OF KNOCKING

Mechanism of knocking is quite complicated. It involves the formation of free radicals, peroxy compounds etc.

Under ideal conditions

$$CH_3(CH_2)_5CH_3 + 11\ O_2 \rightarrow 7\ CO_2 + 8\ H_2O$$

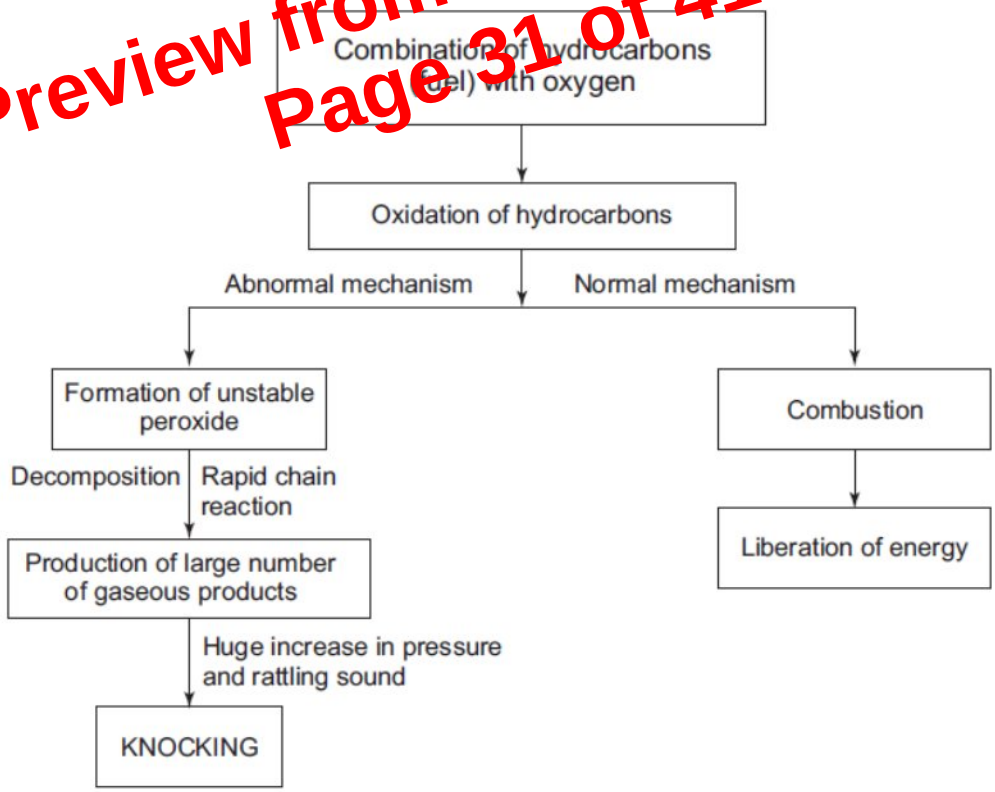
Under knocking conditions

$$CH_3(CH_2)_5CH_3 \rightarrow CH_3(CH_2)_3CH_2^{\bullet} + CH_3CH_2^{\bullet}$$

$$CH_3(CH_2)_5CH_3 + O_2 \rightarrow CH_3(CH_2)_4CH_2 - O{-}O{-}CH_3$$

(Peroxide, explosive)

In presence of oxygen, peroxy compounds are also formed which contributes to free radical reactions. The accumulated peroxides decompose suddenly and burst into flames producing shock waves. The shock wave hits the walls of the engine and the piston with a rattling sound (knocking).



c) Gaseous fuels are expensive when compared to solid and liquid fuels.

Important gaseous fuel are natural gas, producer gas, water gas, coal gas, biogas etc. Except natural gas all other gaseous fuels are artificially prepared.

1.9.1 COAL GAS

Coal gas is obtained by heating good quality of coal in the absence of air. It is colorless and has a characteristic odor. It is lighter than air and slightly soluble in water. Its calorific value is about 4900 Kcal/m^3.

Average composition of coal gas is

Constituent	H_2	CH_4	CO	C_2H_4
Percentage %	50	35	10	5

1.9.1.1 MANUFACTURE OF COAL GAS

Coal gas is obtained by carbonization of coal (heated in absence of air) at about 1300°C in coke ovens or gas retorts. The scheme is shown below.

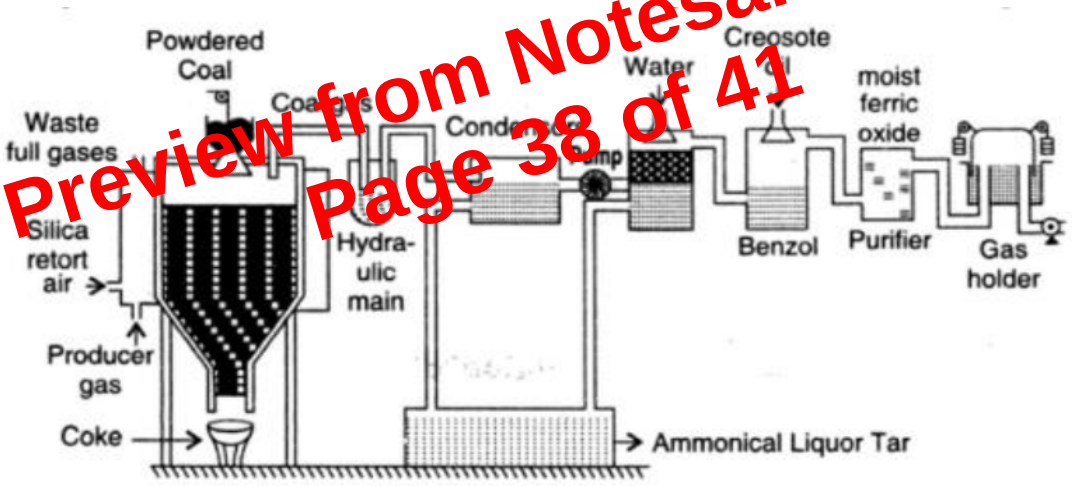


Figure 1.11 Manufacture of coal gas

Powdered coal added from the top of retort. It is heated by producer gas to a temperature of 1300°C. The gas which is coming out from the retort, is first scrubbed by passing through a hydraulic main which acts as a water seal. Tar is removed by cooling the gas in a big water cooling heat exchanger called condenser. Ammonia and any other remaining tar present in the gas are removed by scrubbing with water in a scrubber. Benzol, naphthalene etc are removed by scrubbing with creosote oil. Sulphur compounds like H2S is removed by passing the gas over moist ferric oxide (Fe_2O_3).

4. Write note on refining of petroleum crude

   Refer Section 1.7.4

5. Write notes on the following:

   (iii) Synthetic petrol [R.T.U.2007,2015] **(Refer Section 1.7.10)**

   (iv) Cracking [R.T.U. 2012, 2015] **(Refer Section 1.7.6)**

6. Write note on oil gas

   Refer Section 1.9.2

7. Differentiate the characteristic of solid, liquid and gaseous fuels.

   Refer Section 1.2

8. What is synthetic petrol? Explain, with the help of figure, Fischer-Tropsch process of making synthetic petrol.

   Refer Section 1.7.10.2

9. What is knocking in IC engine? How it is related to the structure of constituent hydrocarbons? Define octane number

   Refer Section 1.8