UNIT V

FUELS AND COMBUSTION

5.3. Carbonization,

5.3.1-Manufacture of metallurgical coke

5.3 Carbonization

Carbonization is the process in which coal is strongly heated in the absence of air and is converted into coke.

Complexity in carbonization:

Carbonization is a pyrolytic reaction, therefore, is considered a complex process in which many reactions take place concurrently such as dehydrogenation, condensation, hydrogen transfer and isomerization.

Carbonization differs from coalification in that it occurs much faster, due to its reaction rate being faster by many orders of magnitude. For the final pyrolysis temperature, the amount of heat applied controls the degree of carbonization and the residual content of foreign elements. For example, at T ~ 1200 K the carbon content of the residue exceeds a mass fraction of 90 wt.%, whereas at T ~ 1600 K more than 99 wt.% carbon is found.

Carbonization is often exothermic, which means that it could in principle be made self- sustaining and be used as a source of energy that does not produce carbon dioxide. (See. In the case of glucose, the reaction releases about 237 calories per gram. When biomaterial is exposed to sudden searing heat (as in the case of a nuclear explosion or pyroclastic flow from a volcano, for instance), it can be carbonized extremely quickly, turning it into solid carbon. In the destruction of Herculaneum by a volcano, many organic objects such as furniture were carbonized by the intense heat.

How wood is transformed in to charcoal:

The carbonization of wood in an industrial setting usually requires a temperature above 280°C, which liberates energy and hence this reaction is said to be exothermic.

This carbonization, which can also be seen as a spontaneous breakdown of the wood, continues until only the carbonized residue called charcoal remains. Unless further external heat is provided, the process stops and the temperature reach a maximum of about 400 °C.

Using heat efficiently in carbonization:

In carbonization there are substantial flows of heat into and out of the wood being carbonized. Correct control of them affects the efficiency and quality of charcoal production. The heat flows can be calculated and shown on a heat balance diagram of the process. This needs knowledge of heat engineering but the basic principles are not hard to understand. A heat input must come from the burning of a fuel of some kind which will usually mean wood in the case of charcoal making. Even if we use the exothermic heat from carbonization or the heat liberated by burning the off-gas from the retort any additional heat will come from burning some wood and hence represents a loss. Wood which is burned cannot be turned into charcoal.

The three main stages requiring heat inputs in charcoal making are:
- The drying of the wood.
- Raising the temperature of the oven dry wood to 270°C to start spontaneous pyrolysis which itself liberates heat.
- Final heating to around 500-550°C to drive off tar and increase the fixed carbon to an acceptable figure for good commercial charcoal.

An ideal carbonizing process would be one which required no external heat to carry out the carbonization. The exothermic heat of the process would be captured together with the heat produced by burning off-gas and liquid by-products and this in total would be sufficient to dry out the residual moisture in the wood, raise it to spontaneous pyrolysis temperature and then heat it to a temperature sufficient to drive-off residual tars. In practice due to losses of heat through the walls of the carboniser and poor drying of the feedstock it is almost impossible to achieve this aim. However, some systems particularly the large hot rinsing gas retorts come close to the ideal where the climate of the locality permits proper drying of the wood raw material.

No wood will carbonize until it is practically bone dry. The water in green wood however is typically about 50% of the green weight of the wood and this must all be evaporated before the wood will start to pyrolysis to form charcoal.

Types of carbonization

- Low-temperature carbonization - heating coal at 500 – 700^{0}C.
- High-temperature carbonization - heating coal at 900 – 1200^{0}C.

Differences between low-temperature & high-temperature carbonization

Low-temperature carbonization	High-temperature carbonization
Heating coal at 500 – 700^{0}C.	Heating coal at 900 – 1200^{0}C
Yield of coke is 75-80%	Yield of coke is 65-75%
The coke is used for domestic purpose.	The coke is used for metallurgical purpose.
Soft coke is obtained.	Hard coke is obtained.
No smoke is produced.	Smoke is produced.

Coke

Lustrous, dense, porous and coherent mass obtained by strong heating of coal in the absence of air is called coke.

Metallurgical coke

When bituminous coal is heated strongly in the absence of air, it loses volatile matter and becomes lustrous, dense, porous and coherent mass called metallurgical coke. This process of conversion of coal into coke is called carbonization.

5.3.1 Manufacture of metallurgical coke by Otto - Hoffman's method-

Importance of Otto - Hoffman's method:

Otto – Hoffman's modern by-product method is considered the best method because,

Heating is done on the basis of 'regenerative system of heat economy' by using heat energy of the waste flue gases.

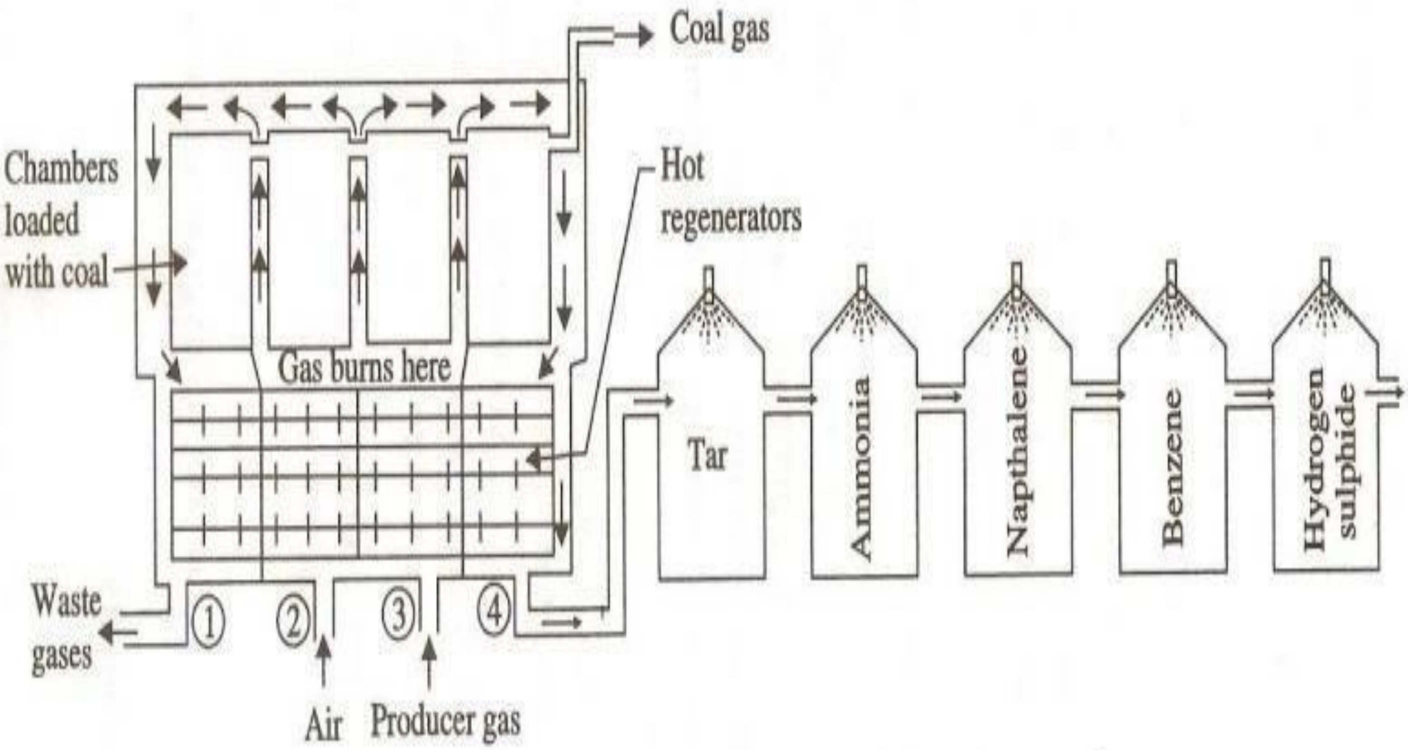
It is possible to recover the various by –products.

Description of the oven:

The oven consists of number of silica chambers.

The chambers are about 10 – 12 m long, 3 – 4 m height and 0.42 –0.45 m wide.

Each chamber has a charging hole (top), gas off- take valve and irondoor (end) for discharging coke.The air required for the combustion of coal is preheated in regenerators.



Working:

Coal is introduced into the silica chambers and the chambers are closed.

The chambers are heated to 1200˚C by burning of gaseous fuels (air and producer gas) by passing them through 2ndand 3rd hot regenerators.

Hot flue gases produced during carbonization come out through 1st and 4thregenerators raising the temperature to 1000^{0}C.

The fuel gas is now passed through the 1stand 4th regenerators (preheating).

Flue gases come out through the 2ndand 3rd regenerators raise the temperature to 1000^{0}C. This cycle goes on. This process is known as 'regenerative system of heat economy

The time taken for the carbonization process is 11 to 18 hours.

When the process is over, coke is removed from oven and cooled by dry quenching.

Recovery of by – Products:

By- products	Recovery procedure
Tar	-spraying liq.NH_3. -NH_3 is got back by heating process.
Ammonia	-spraying water. -Ammonia is converted to NH_4OH.
Naphthalene	-spraying cool water. - naphthalene condenses.
Benzene	-spraying petroleum. - benzene condenses to liquid.
H_2S	-passing remaining gas through purifier packed with moist Fe_2SO_3 -H_2S is retained.
Purified coal gas	-Final product that can be used as a gaseous fuel.

Advantages:

- Time taken (11-18 hours) for carbonization is less compared to other methods.
- Improved thermal efficiency.
- Valuable by- products are obtained. It is a regenerative system.
- The yield of coke is 70%.