



SNS COLLEGE OF TECHNOLOGY

AN AUTONOMOUS INSTITUTION



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DEPARTMENT OF AGRICULTURE ENGINEERING

COURSE CODE & NAME: 16AGT301 & HEAT POWER ENGINEERING

III YEAR / V SEMESTER

UNIT : 1 FUELS AND COMBUSTION

TOPIC 3 : Solid Fuels



METALLURGICAL COKE

Good coke for metallurgy should possess the following *requisites*



- **(1) Purity:** It should have moisture, ash, sulphur and phosphorus contents as low as possible. A low percentage of moisture helps in keeping down the heating expenses. Excess of ash hinders the heating and also helps in slag formation, which is not desirable in fuels. According to Dr. Mott, 2% of excess coke is required for the removal of 1 % ash. Presence of S and P gives on burning, undesirable products like SO₂ P₂O₃ and P₂O₅, which adversely affect the quality of the metal being produced. Moreover, presence of sulphur makes the coke brittle.
- **(2) Porosity :** Coal should be porous, so that oxygen can easily come in contact with the carbon of coke, thereby helping in complete combustion at a high rate.
- **(3) Strength:** The coke should be quite compact, hard, strong to withstand dropping abrasion as well as the pressure of the over-burden (ore + fuel + flux) in the furnaces. It would be useless to employ weak coke in blast furnaces, as the weight of ore, etc., would crush the coke to breeze and thus prevent the essential passage of gases up the furnace.
- **(4) Size:** The size of metallurgical coke should be neither too big nor too small. In case the size is too big, the uniformity of heating is never maintained, but on the other hand, if the coke size is too small, choking will result.



- **(5) Cost:** Coke should be cheap and easily available near the site of the metallurgical plant, so that the transportation cost is low.
- **(6) Combustibility:** Coke should burn easily. The combustibility of coke depends upon the nature of the coal, carbonization temperature and reaction temperature. Cokes obtained from strongly coking coals are not as combustible as those derived from weakly caking and non-caking coals. At a given temperature, cokes obtained by high-temperature carbonization process are less combustible compared to those obtained by low-temperature carbonization. However, at high combustion temperatures (800° - 900°C), all cokes appears to be equally reactive. At about $1,000^{\circ}\text{C}$, it appears that the rate of combustion depends only on the rate of oxygen/air supply.
- **(7) Calorific value:** The calorific value of coke should be high.
- **(8) Low ash, S and P contents** to avoid the incorporation of these in the metal to be extracted.
- **(9) Reactivity to steam:** Reactivity towards steam increases with the reaction temperature and varies inversely with carbonizing temperature at which the coke was produces. Moreover, coke derived from non-caking coals are more reactive to steam than those derived from taking coals.



Coal versus coke in metallurgical processes



- (1) Coal does not possess as much strength and porosity as coke.
- (2) By coking, much of undesirable sulphur is removed.
- (3) Coke burns with short flame, due to expulsion of much of its volatile matter during carbonization.
- Because of these reasons, "*coke is preferred to coal for metallurgical purposes*", particularly in blast furnaces. On the other hand, coal burns with a long flame, which is suitable only for reverberatory furnaces.
- Coking quality: The coals which on heating, in the absence of air, becomes soft, plastic and fuse together to large coherent masses, are called **caking coals**. Consequently, such coals are difficult to be oxidized. If the residue (i.e.: coke) obtained after heating is porous, hard, strong and usable for metallurgical purpose, the original coal, is known as coking coal.



TYPES OF CARBONIZATION OF COAL



- These are *two* types of carbonization of coal:
- (1) **Low-temperature carbonization**: In this process, the heating of coal is carried out at 500 - 700°C. The yield of coke is about 75-80% and it contains about 5-15% volatile matter. *It is not mechanically strong, so it cannot be used as a metallurgical coke.* However, it burns easily giving practically a smokeless, hot and radiant fire. Hence, it is suitable for domestic purposes. The by-product gas produced (about 130-150 m³/tonne) by this process is richer in heating value (about 6,500-9,500 kcal/m³) and is, therefore, a more valuable gaseous fuel.
- (2) **High-temperature carbonization** is carried out at 900 - 1,200°C with the object of producing coke of the right porosity, hardness, purity, strength, etc., so that it can be used in metallurgy. Nearly all the volatile matter of coal is driven off and the yield of coke is about 65-75%, containing only 1-3% volatile matter. The by-product gas produced is high in volume (about 300-390 m³/tonne), but its calorific value is low (about 5,400-6,000 kcal/m³).



MANUFACTURE OF METALLURGICAL COKE



- **Otto Hoffman's by-product oven:**
- In order to: (1) *increase the thermal efficiency* of the carbonization process, and (ii) *recover valuable by-product* (like coal gas, ammonia, benzol oil, tar, etc.), Otto Hoffman developed modern by-product coke oven which, unlike beehive oven, is *heated externally* by a portion of coal gas produced during the process itself or by producer gas or by blast furnace gas. Moreover, the heating is done on the basis of "*regenerative system of heat economy*", *i.e.*, utilizing the waste flue gases for heating the checker-work of bricks.
- The by-product coke oven consists of number of narrow *silica chambers* (each about 10 to 12 m long, 3 to 4 m high and 0.40 to 0.45 m wide) erected side-by-side with *vertical flues* in-between them to form a sort of battery. Each chamber is provided with *a charging hole at the top, a gas off-take and a refractory-lined cast iron door* at each ends for discharging coke.



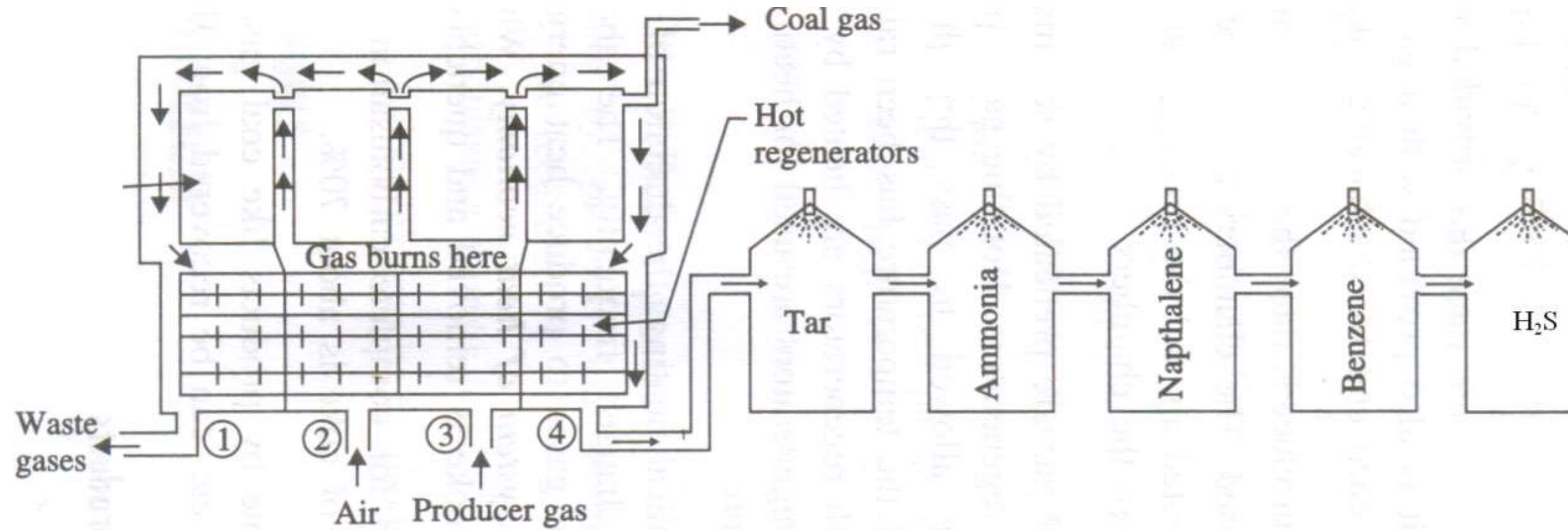
- A charge consisting of *finely crushed coal* is introduced through the charging holes at the top of chambers, which are then closed tightly at both ends to prevent any access of air. The coke ovens are heated to $1,200^{\circ}\text{C}$ by burning gaseous fuel (like producer gas) and usually employing a regenerative principle to achieve as economical heating as possible.
- The flue gases produced during combustion, before escaping to chimney, pass on their *sensible heat* to one of the two sets of checker brick-work, until this brick-work has been raised to a temperature of about $1,000^{\circ}\text{C}$. The flow of heating gases is then *reversed* and the inlet gases are passed through the heated checker brick-work, which thus serves to preheat the inlet gases.
- The flue gases are then allowed to pass through the second set of checker bricks to heat it. This checker-work then serves to preheat the inlet gases. Thus, this cycle goes on. The heating is actually continued, till the evolution of volatile matter *ceases* completely. Carbonization of a charge of coal takes about between 11 to 18 hours.



- When carbonization is completed, a massive *ram* pushes the red hot coke into a truck. It is subsequently quenched by a water spray ('*wet quenching*'). In place of wet quenching, "dry quenching" offers advantages, because the coke produced is more strong, dense, graphitized and non-reactive.
- In this method, the red hot coke is placed in a chamber and cooled by passing inert gases from boilers (like nitrogen). The heated inert gases are then circulated to boilers, where they generate steam.
- The coke produced by 'dry quenching' is cheaper, drier and contains lesser dust than 'wet-quenched' coke.



Otto Hoffman's by-product oven





Recovery of By-products



- (i) Recovery of tar :** The gas is first passed through a tower in which liquor ammonia is sprayed. Here dust and tar get collected in a tank below, which is heated by steam coils to recover back ammonia sprayed. The ammonia is used again.
- (ii) Recovery of ammonia:** The gases from the chamber are then passed through a tower in which water is sprayed. Here ammonia goes into solution as NH_4OH .
 - (iii) Recovery of naphthalene:** The gases are then passed through another tower in which water at very low temperature is sprayed. Here naphthalene gets condensed.
 - (iv) Recovery of benzene:** The gases are then sprayed with petroleum, when benzene and its homologues are removed.
 - (v) Recovery of H_2S :** The gases are then passed through a purifier, packed with moist Fe_2O_3 . Here H_2S is retained.



- After some time, when all Fe_2S_3 is changed into Fe_2O_3 , the purifier is exposed to atmosphere, when Fe_2O_3 is regenerated,





THANK YOU..!!