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THE KOPPERS-TOTZEK POWDERED COAL GASIFICATION*

The classical gasification technique depends very largely on the physical makeup of the fuel, so that essentially only lumps and non-baking fuels can be gasified.

Technical progress demands the development of a universal gasification process, which would permit the complete conversion of fuels of any kind into gas. We must then select a physical state of the fuel in which all solid fuels can be obtained. This leads to powder gasification which, however, can be successfully performed only in suspension. Powdered fuel gasification is as old as the gasification technique. The theoretical processes have been understood and systematized and the experimental work performed. According to the earlier conception, an effective interchange of heat and material is brought about chiefly by the relative motion, convection and diffusion between the gas envelope of the particles of coal dust and the reacting agents, analogously to the gasification processes in quiet bed of the fuel.

*A paper read by Friedrich Totzek, July 2, 1947, in Essen.

These points have been considered in the structural form and the operating conditions of the first experimental generators built, which permitted a maximum relative motion between the coal dust particles and the reaction agent. The reaction consisted at first in combustion with a steam-carbon dioxide mixture at temperatures up to 1600°. The results were disappointing. Only 20-25% of the carbon introduced was gasified. The coarser particles of coal dust precipitated in the generator, the ash was bared and slagged. The finest coal particles were carried out in the gas stream ungasified. The different series of experiments have brought exhaustive proof that no satisfactory gasification by purely endothermally acting reagents could be brought by contact of carbon with carbon dioxide or steam, and that the relative motion was insufficient to bring about a satisfactory gasification.

The following experiments were carried out with an air-steam mixture at a temperature of 1200°C. When strongly reactive fuels, like brown coal dust and brown coal l.t. coke dust were used, the gasification results changed suddenly. The slag still was produced in the liquid form. The gas outlet temperature was 1500°C.

These results lead to the realization that the principal importance was not in the relative motion of the fuel but in the kinetic energy of the gasification reaction, (i.e. the material and heat exchange). These, however, received complete play only when the particle of the dust was very finely ground and the coal dust and the reagent were perfectly mixed. This will make the gasification process almost independent of time, and the melting of the ash will be prevented by the reformation of carbon monoxide and hydrogen.

The final form of the generator took into consideration these facts based on natural laws. The results of the tests furnished a proof of the accuracy of the theory and construction.

In the different experimental series, brown coal dust, brown coal l.t. coke dust, and bituminous coal dust from the gas flame coal to the lean coal and even to coke dust have been gasified perfectly. The degree of gasification $\left(\frac{\text{gasified C}}{\text{C introduced}}\right)$ amounted to about 95%. The ash was carried out dry with the gas stream.

The gasifying means were air-steam and oxygen-steam with a preheating temperature of around 1200°C. The gas outlet temperature was between 900 and 1200°C depending on the reactivity of the fuel.

The gasification process and the gas obtained are characterized by the following data: a high concentration of $CO + H_2$; regulable proportion of $CO:H_2$, depending on the preheater temperature and the steam addition; simple sulfur compounds; no gum formers; a practically complete gasification of the fuel introduced; a possibility of gasifying any solid fuels; relatively small consumption of energy or oxygen.

When oxygen is used, a fuel of any kind, including waste fuel, can be used for the production of gas for the following industries: The Fischer-Tropsch synthesis, high pressure synthesis, ammonia synthesis, city gas production, fuel gas of every kind. All these industries can now be built around any desired fuel and operated with it.

The above properties of the gases, and in particular the concentration of CO + H_2 of up to 95%, the regulable ratio of CO:H_2, and the temperature at which the gas leaves the producer, and finally a BTU heating value of 2,000 to 2,400 k calories/cbm permit application of the process for the iron works:

The blast furnaces follow the rules of gasification of solid fuels by producing a gas of the highest carbon monoxide concentration. This gas is the reduction agent of the ore. The "blast furnace curve" gives information about the concentrations in the different temperature zones of the blast furnace shaft. It is further known, that the reducing ability of the gas is considerably increased in the presence of a certain proportion of hydrogen, e.g. 75% CO and 25% H_2. The gas produced in powdered fuel gasifiers is ideally suited with respect to temperature and concentration to meet these requirements and may be used for the reduction of ores, e.g. for the production of sponge iron. The gas escaping from the blast furnace after the reduction of the ore will have a heating value of around 2,000 k calories/cbm and can be used as a fuel gas for the hearth furnaces, if necessary, with carburization.

The powdered fuel gasifier offers a further possibility to produce a gas of the higher carbon monoxide and hydrogen concentration at such a high temperature to permit smelting operations in suitable equipment, and to reduce countercurrently the ore with the off-gases from the first unit.

The design shows that coke in the iron smelting processes could be replaced by other fuels, which follows from the above considerations. Experiments and proposals to eliminate coke from blast furnaces have been known (Wiberg et al).

The opinions of F. Wuest* on the Basset process are based on the above. Their principal points consist in that, were it possible to gasify coal dust at high temperature with a production of a gas of high concentration, the possibility would be offered to utilize completely the heat of the reaction of the combustion of carbon in purely metallurgical processes.

*Stahl und Eisen, Volume 41 (1921), Pages 1841/48.