

Selection of the Gasification Method.

Except for the production of city gas in which gasification under pressure probably will be most economical for non-caking coals, gasification of pulverized coal is the only available method for caking coals for the large-scale production of $\text{CO} + \text{H}_2$ in connection with the production of gasoline by hydrogenation or synthesis.

In both cases, production can be relatively cheap in large plants only, and with a cheap coal. Run-of-mine coal generally will be the material to be used in the production of gasoline and all auxiliary plants included, such as power production, steam production, and fuel consumption for the mine. In case of hydrogenation, the production of hydrogen requires only a small percentage of the coal, especially if the residual gas of hydrogenation is cracked. In a hydrogenation plant, a suitable coal size may be easily found for any gasification method. Gas production in a synthesis plant requires a much higher amount of the total coal consumption; only 20 to 30 percent may be needed for other purposes. Methods needing a selected lump size coal or coke for gasification cannot be used in a synthesis plant because the quantity required cannot be procured without a surplus of lower-grade fuel. Moreover, the costs of such high-grade fuels, such as coke, as the main raw material of the production obviously increase the production costs of the gasoline to an uneconomical level. There may be exceptional cases of highly volatile bituminous coal in which the recovery of more than 10 percent tar suitable for hydrogenation cover the costs of carbonization and procure a lumpy coke at a low price (Utah).

The present slagging methods generally cannot be considered for these same reasons. Even for gasification in a fixed bed under atmospheric pressure, which needs a coke above 1/4-inch, difficulties may arise in order to procure enough of this coke in an independent synthesis plant, without wasting fuel. Conditions are slightly better if carbonization and gasification are combined and an additional disintegration of the coke by transport and screening is avoided.

With gasification under pressure which can be operated with 1/8-inch coal, usually no difficulties exist in utilizing the fuel below 1/8-inch for the mine and for the production of power and steam.

There are no size restrictions for the utilization of the Winkler and the Koppers method.

Composition and purity of the gas also are of great importance.

For hydrogenation, hydrogen only is of interest, and its preparation requires a shift reaction with any gasification method, the compression of the gas, and the removal of carbon dioxide by water wash. A low content of nitrogen and methane is essential; a high content of hydrogen of the primary gas is advantageous. Any method, avoiding CH_4 by using coke or by splitting the hydrocarbons, is suitable. Production of the gas under pressure would be a great advantage, not only for reduced power consumption but also for simplified sulfur removal, and for the reduction of investment and operating costs of compression. All the gasification methods may be used for the production of hydrogen. A high carbon monoxide content in the primary gas can be converted in the unavoidable shift conversion plant with relatively low additional cost.

For synthesis purposes, the situation is not so clear yet. Though the superiority of iron catalysts may be proved, it still is an open question which ratio of $\text{CO}:\text{H}_2$ is most favorable, and also, whether operation under pressure is essential or even profitable for a good efficiency and quality of products. In case the engineering problem of heat transfer and temperature control can be solved satis-

factorily, as in a fluidized or suspended catalyst system, operation under pressure no doubt will be more efficient. It has sometimes been claimed that a 2:1 ratio of $\text{CO}:\text{H}_2$ is desirable for iron-catalyst operation. However, experience shows that a 1.5:1 ratio is quite satisfactory, and even a 1:1 gas can be used very well for an iron catalyst. In a suspension system, such as the ^{Hydrocol}hydrogenation of coal process, even a 1:1.8 ratio can be used with very good results. For the production of Diesel oil, mainly with a cobalt catalyst, a 1:2 ratio of $\text{CO}:\text{H}_2$ is required.

Except for very high carbon monoxide contents which can only be produced in a slagging operation, a 1.5:1 ratio of $\text{CO}:\text{H}_2$ can be produced with all the other methods. Some of them require recycling of carbon dioxide from the water wash of the synthesis gas or the residual gas of the synthesis. A shift reaction can and should be avoided even for a 1:1.8 ratio. The elimination of carbon dioxide from the synthesis gas, however, is unavoidable because with none of the methods in question a primary gas with less than 10 percent carbon dioxide can be produced. Compression of the gas and water wash probably will be required, or will be of advantage in any synthesis plant, even if pressure is not important for the synthesis itself. The product of carbonization (Thiophene and gum formers) would require an additional active carbon equipment if they are not sufficiently cracked in the gasification process itself. Favorable conditions for the complete removal of organic sulfur and gum-forming individuals are a very important economical factor of a gasification method in connection with the synthesis of hydrocarbons.

For a rough estimation, it may be mentioned that according to calculations on the German works, the costs of compressed hydrogen amounted to 5-7 Pfennig per normal cubic meter, based on production costs of 1.5 to 2 Pf. per normal cubic meter of raw gas. Compression, sulfur removal, shift conversion, and removal of carbon dioxide are the causes for very high additional costs.

Besides these facts, the actual production costs per unit of purified synthesis gas, based on the available fuel, are decisive for the selection of the most economical method of gas manufacture.

... (Table 1).