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# GASIFICATION - AN OVERVIEW

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# - I N T R O D U C T I O N -

More than ever, the developing countries need to create a new philosophy in the implementation of indigenous technology, to protect the national security and economy of the particular country, and also to improve the quality of life of its citizens.

In order to eliminate the uncertainties of the politically unstable Middle East, we would have to reduce a significant amount of our overal consumption of petroleum energy, because the exporting nations are able to manipulate the market of fosil fuels to ther a advantage.

Because of the long lead times required for building and operating a technology, an appropiate technology that have a real impact on national needs, we have to begin a program NOW, to be effective when we have the most need of it.

Petroleum and natural gas are the most attractive energy resources in the world, and it is very important to find a substitute, at least for some of it uses, through the rational use of our natural resources.

The greatest problems are not in the technical areas. There are many serious non technical constraints to the establishment of new technologies. These non technical constraints are enviromental, social, political and legal in nature. But the largest problem may be the delaying government policies in order to decide adapt and/or create new technologies for the solution of our greatest energy problems.

There are alternative energies and technologies that may offer solutions for some of our energy problems, also it can improve the quality of life, specially in small decentralized communities in the country, and at the same time, can represent a solution for the emigration of the people to the city, which only contributes to the increase of unemploiment and deliquence.

In this overview I am attempting to present a sketch of one of the alternative technologies for biomass conversion, which can represent a very good solution for many energetic needs, where gasoline, natural gas or some other combustibles are used. - These applications may be transportation, drier, irrigation and power generation, and many other industrial applications. The technology that can do that is GASIFICATION.

# - O V E R V I E W -

The promise of the gasifier is to produce a fuel alternative to oil, or at least to reduce its consumption, which is ever increasing in price and difficult to obtain. For this reason most of the technologically advanced countries are developing a very strong technology for the production of alternative fuels.

Should the technology for synthetic fuel production be sufficiently attractive to eliminate the usual economic constraints that often cause delays, there are still the constraints that has been mentioned, that is, non-technical in nature. The constraints may be environmental, (the requirement for an acceptable Environmental Impact Statement), social (fitting in with the existing infrastructure of the community, or developing an infrastructure for a new community, political (meeting the complicated state and local regulatory policies and procedures, some of which are not adequately specified or subject to change), and legal (chandling the court challenges that so often are encountered in these large projects). All of these constraints make it very difficult to estimate the time in which a synthetic fuel industry can be formed.

Coal can be gasified to syngas, by known methods. There are expected projects in the United States that will total 500 million standard cubic feed per day - (SCF/D), from coal gasification by the year 1990, which is the equivalent of 85,000 barrels of oil per day.

At the same time, they also have plans for liquefaction, a more difficult process; but it is possible that 60,000 barrels a day be available by 1990, making a total of 145,000 barrels per day of oil equivalent from coal. If the growth rate is predicted, capacity would increase to 400,000 barrels a day of oil equivalent by the year 2000. In this case the total synfuels production would be about 1.2 million barrels per day crude oil equivalent.

I have included those dates here, showing the great promise of the synfuels for the future and, at the same time, the promise of the appropiate technology for the conversion. Because of the very large capital expenditures estimated for a synthetic fuels industry and the lack of experience in most of the developing countries making and opperating this technology, it may be better or may be necessary to beging transferring and adapting the new technology, creating a good experience to a very large number of technicians, making smaller gasifier for smaller needs, and prepare to intoduce this new technology in the society through a rational education system. There are advantages for a country and every person that accepts this new technology, because of an economic gain.

The succes of underground coal and, also, the biomass gasification process, depends upon the efficient and economic utilization of the resource.

To accomplish this, a large percentage of the available coal must be converted to gas, but also, we can obtain the gas by the same method from wood, charcoal, ricehull, saw dust and other crop wastes which can be used for power generation. The gasifying equipment must be manufactured according to the matirial intended to be gasified.

Extensive evaluation programs have shown that the perfomance depends on the process involved. Typical coal or any biomass gasification plant subsystems include the following:

- Feed preparation: crushing, screening and (in some cases) mild oxidation to prevent caking.

- Gasification: reacting the feed with steam and air/oxigen in one or more vessels.

- Gas quenching and purification: cooling and cleaning of raw product gas.

- Spent char or ash collection: collection os solids remaining from the gasification step for disposal or further use.

Gasifier subsystem presents different material exposure conditions, and enviroments habe to perform under conditions which often involve temperatures and partial pressures that fluctuate between oxidizing, reduzing and sulfidizing conditions. This variety of conditions have to be considered in selecting the material for the construction of the gasification reactor components.

Like most of the data at hand, they only refer to coal gasification, I will see myself compelled to refer this report to some references, but gasification of any biomass or combustible waste have to follow the same process, perhaps with some modification for the material to be gasified.

Coal gasification is an old technology that is now undergoing modernization. In the early part of this century, a large number of coal gasifiers were commercially operated in the United States and other nations, to produce industrial and residential fuel gas, but the availability of abundant and inexpensive natural gas and crude oil led to the abandonment of most coal gasification units by the mid-1950 s. However, since 1973, OPEC has dramatically increased oil prices and, in effect, decoupled oil prices from oil supply capacity. Natural gas also moved forward with crude oil. This

situation significantly increases the attractiveness of coal gasification and reduces its economic risk.

Coal or biomass gasification is an adaptation of coal or biomass combustion, where the combustion process is limited by insuficient oxygen suministration. A combination of combustion and pyrolysis reaction produce a combustible raw gas. Depending on process conditions, the raw gas is a complex mixture of steam, hydrogen, carbon monoxide, carbon dioxide, hydrocarbons, hydrogen sulfide and also particulates consisting of ash and unconsumed coal. In addition, the gas may contain sulfur compounds, amonia, nitrogen compounds and inert gases, and trace elements compounds. Fortunately, these gaseous mixtures can be treated by low-temperature liquid absorption system to remove the bulk of undesirable compounds, and leave a premium gaseous fuel.

Although direct coal firing is a well established practice and sulfur dioxide emission control via fluegas desulfurization has been widely applied comercially, and also, although coal gasification is more expensive, inefficient, and technically difficult, there are very good reasons for the use of coal or biomass gasification. For many uses, solid coal is not the most desirable form of the fuel. Most plans for the shift from oil and

gas to coal, assume that a large portion will be converted to either a liquid or a gas form. The reasons for conversion are that the synthetic fuel can be made into a cleaner product, and that solid coal is not suitable for automotive use. Even for the generation of primary electricity, solid coal is more costly to transport over great distances to the point of consumption, than a gas or a liquid. Also, there are countries where a natural-gas pipeline exist, like in U.S.

In addition, these facts can be included:

- Almost total control of toxic emission from combustion.

- Production of synthesis gas, liquid fuels, or chemicals from coal.

- Reduce the utilization of products in existing natural gas or fuel-oil-fired equipment.

The various gasification processes which have benn developed or which are in the developing stage, vary with respect to the reactor design. In fact, to a large degree, the mechanical and engineering variations of the gasification step in each gasification process, particulary the features designed for sup-

plying the heat for the endothermic reaction, ($C + H_2O$), and for handling solids in the gasifier, characterize the proces ses, but, in nearly all of the processes, the chemistry of the high-temperature gasification is the same.

Fig. 1 shows a schematic represntation of the processing steps, and Fig. 2 shows the basic reactions in coal gaswficat ion processes.

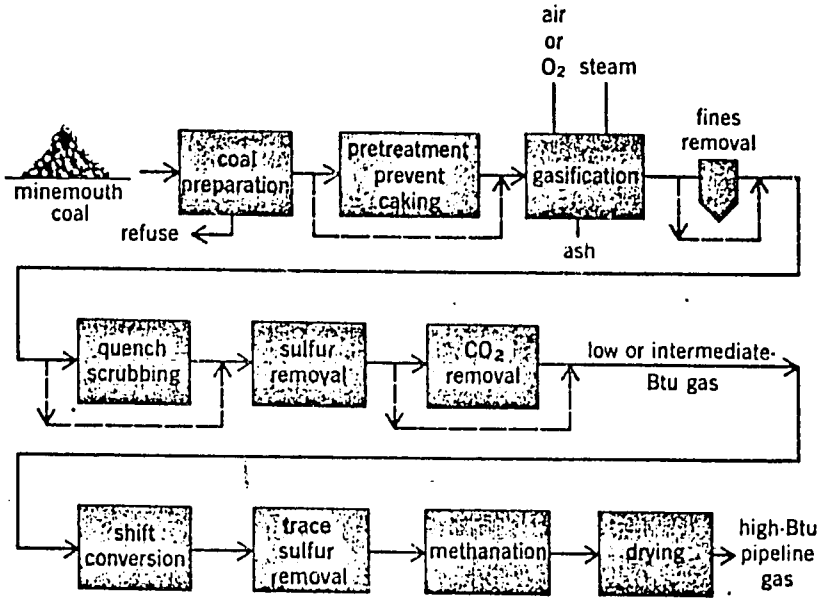



Fig. 1. Schematic representation of the processing steps in coal gasification.

Coal reactions

$$\text{Coal} \xrightarrow{\text{Heat}} \text{gases } (CO, CO_2, CH_4, H_2) + \text{liquids} + \text{char} \quad (1)$$

$$\text{Coal} + H_2 \xrightarrow{\text{Catalyst}} \text{liquids} + (\text{char}) \quad (2)$$

$$\text{Coal} + H_2 \text{ (from a hydrogen donor)} \rightarrow \text{liquids} + (\text{char}) \quad (3)$$

$$\text{Coal} + H_2 \xrightarrow[\text{destruction}]{\text{Noncatalytic}} CH_4 + \text{char} \quad (4)$$

Char reactions

$$C\,(\text{char}) + 2H_2 \rightarrow CH_4 \quad \text{exothermic} \quad (5)$$

$$C\,(\text{char}) + H_2O \rightarrow CO + H_2 \quad \text{endothermic} \quad (6)$$

$$C\,(\text{char}) + CO_2 \rightarrow 2CO \quad \text{endothermic} \quad (7)$$

$$C\,(\text{char}) + O_2 \rightarrow CO_2 \quad \text{exothermic} \quad (8)$$

Gaseous reactions

$$CO + H_2O \xrightarrow{\text{Catalyst}} H_2 + CO_2 \quad \text{exothermic} \quad (9)$$

$$CO + 3H_2 \xrightarrow{\text{Ni}} CH_4 + H_2O \quad \text{exothermic} \quad (10)$$

$$CO_2 + 4H_2 \xrightarrow{\text{Ni}} CH_4 + 2H_2O \quad \text{exothermic} \quad (11)$$

$$xCO + yH_2 \xrightarrow{\text{Fe}} \text{hydrocarbon gases and/or liquids} + zCO_2 \quad \text{exothermic} \quad (12)$$

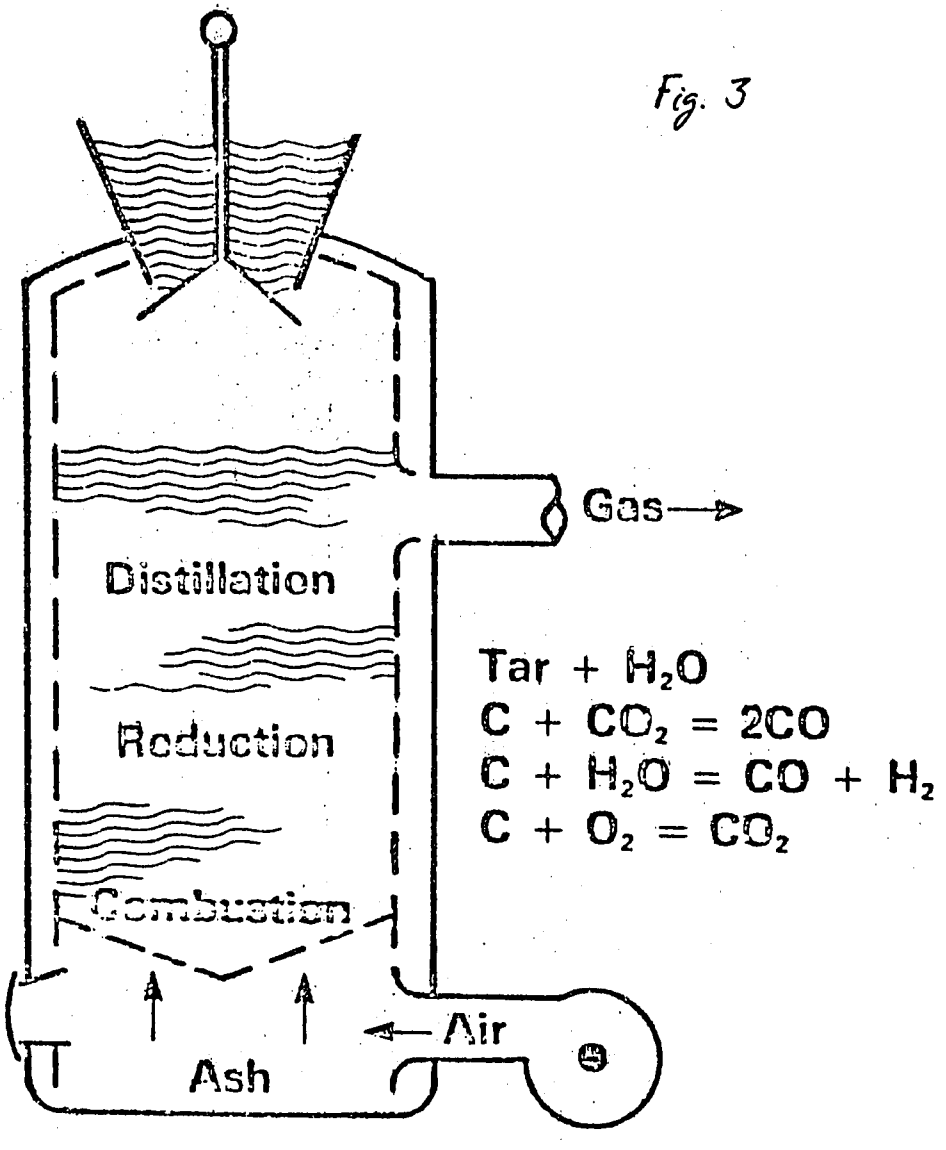
Fig. 2

The conversion of coal, coke, char or any combustible biomass to gaseous products can be done with air, oxigen, steam, carbon dioxide, or a mixture of these (see Fig. 2). Products consist of carbon dioxide, carbon monoxide, hydrogen, methane, and some other chemicals in a ratio -ependent upon the particular reactants employed and the temperatures and pressures within the reactors, as well as upon the type of treatment which the gases from the gasifier undergo sub-sequently after leaving the gasifier.

Gas producers were the first gasifiers to be comercially developed, dating from the 19$^{th}$ century. These system were air blown, using a fixed-bed or gravitating-bed gasifier, and operating at near atmospheric pressure. Sized coal enters the top of the vessel, while ash is withdrawn from the botton of the vessel through a water tight seal. Air saturated with steam enters at the base of the vessel through the blast hood, and reacts with the coal in countercorrent flow. The producer gas leaves the top of the vessel with a heating value of about 150 BTU/SCF, containing tars, oils, entrained fines, and water vapor (Fig. 3).

There is a modified version of the gas producer that has two gas tope- offs, one at the top and the other in the mid-section. This is also sometimes called a two-stage gas producer. The top gas contains tars and oils, whereas the mid-section gas is free of condensables.

The capacity of a typical gas producer may be about 70 tons of sized coal per day, this means about 50 million BTU of raw gas per hour.




The cost of producer gas appears very high, if environmental laws or the fuel gas applications require sulfur removal, tar separation, and water purification. Producer gas does appear to be more economical for applications where the gas can be used hot and raw, such as firing kilns or wood dryer. It must be noted however, that many of these applications can also utilize coal directly, which is less expensive.

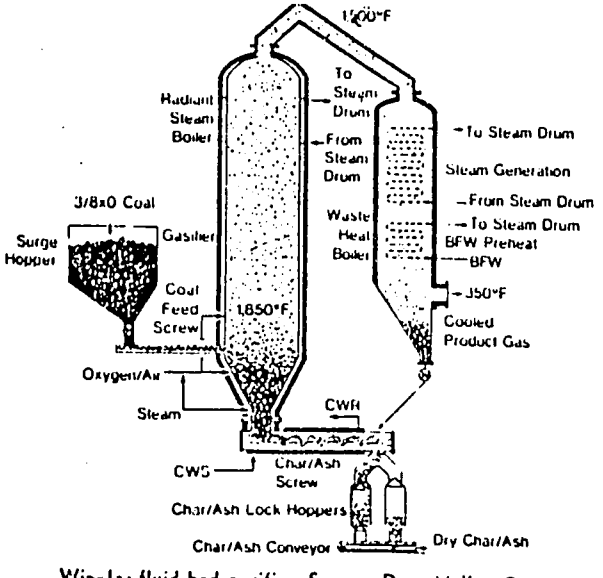
# -WINKLER PROCESS-

The Winkler coal gasification process was one of the first applications of fluidized beds. The process was developed by Dr. Fritz Winkler in 1922. The first large-scale unit was built in 1927 at Leuna, East Germany. Since that time, 36 gasifiers of this type has been built. The primary application for Winkler gasifiers has been producing synthesis gas for ammonia production.

The recent experience for Winkler gasifiers is very limited. The last Winkler gasifier was built over twenty years ago in India, and that plant has now been dismantled. Presently there are only two operating Winkler plants, one in Yugoslavia and the other in Turkey, which chose Kopper-Totzek gasifiers when the capacity of that plant was tripled in 1967.

The Winkler coal gasification process is shown in Fig. 4, which use a fluidixed bed operated at near atmospheric pressure. The fluidizing gas is usually a mixture of steam and oxygen; however, several of the early Winklers used air and steam. The fluidized bed is maintained at a temperature of about 1000 $^{o}$C (1850 F) since the bed temperature must be below the ash-fusion temperature to avoid formation of clinkers. The hot gas leaving the gasifier is cooled in a waste-heat boiler, producing about one pound of high-pressure steam per pound of moisture an ash-free coal gasified in the reactor.

The carbon conversion of the Winkler process is poor because of entraiment of particles before complete gasification and the required low temperatures. The unreacted char is usually burned along with additional coal in conventional boilers to supply the plant utilities.




Winkler fluid-bed gasifier. Source: Davy McKee Corp. Reproduced by permission of Davy McKee Corp.

Fig. 4

# - L U R G I  G A S I F I E R -

The Lurgi gasifier was developed woon after the winkler process, but over fifty years ago, the concept of complete gasification of coal with oxigen under pressure was put into practice by the pioneering work Drawe, Danulat, and Hubmann, which ultimately let to the current Lurgi process for coal gasification.

The Lurgi process was developed in 1930 by Lurgi and A. G. Sachsische Werke, but the first commercial plant was built in 1936 in Hirschferlde, Germany. Since then, Lurgi has built 140 gasifiers, and the principal phases in the development of the gasifier are shown in Fig. 5.

Fig. 5.

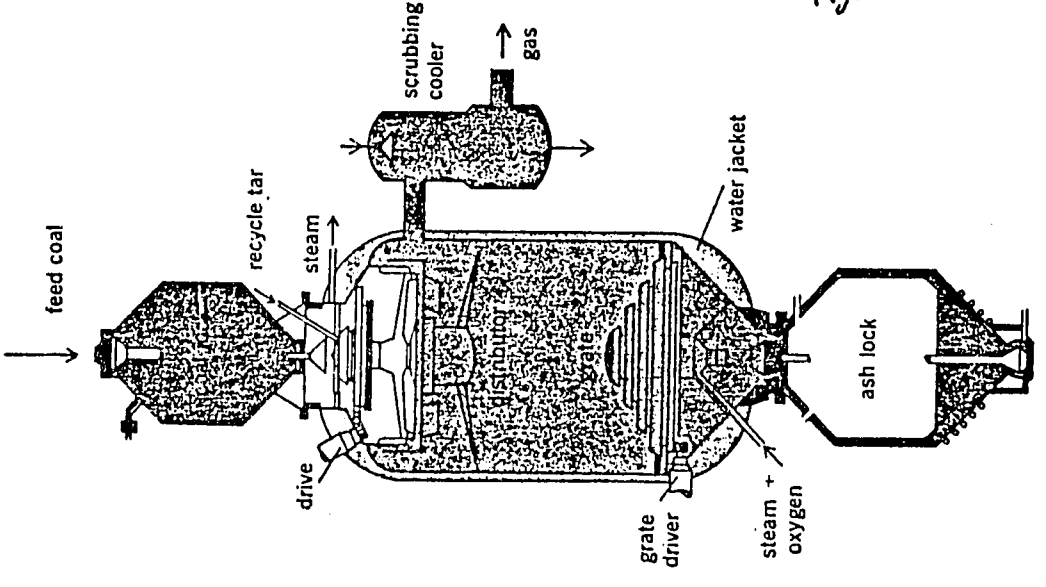



Diagram of a Lurgi pressure gasifier.

Because, when the gas production by coal gasification was initiated in Germany, the processes available for coal upgranding were pyrolysis, the low-pressure air-blown gas producer, and the oxigen-glown atmospheric pressure Winkler gasifier, which are all poor process,

the task was to produce substitute town gas from low-grade coal by complete gasification in a high-duty-gasifier. This task was solved by ussing oxigen under pressure. Although the air blow gas producer , representing the countercurrent principle, was taken as a model, many parallel developments in various engineering disciplines had to be made to create the current Lurgi gasifier.

In many ways, the Lurgi gasifier es an improved version of the old gas producer. May be descrived as a reactor for the performance of countercurrent gasification of coal in a moving bed. Also may be descrived as an oxygen/steam-blown pressurized gravitating-bed, or often called fixed-bed, gasifier.

The principal mechanically operated devices include:

1. The automated coal-lock chamber for feeding coal from coal bin to the pressurized reactor.

2. The coal distributor through which the coal is introduced into the reactor chaft in such a manner that uniform distribution of the coal across the shaft area is achieved (when processing caking coals, blades are mounted to the distributor which rotate within the fuel bed).

3. The revolving grate introduces the gasification agent and extracts the ash.

4. The ash-lock chamber for discharging the ash from the pressure reactor to an ash bin from where the ash may be transported either hydraulically or mechanically.

5. The scrubber in which the hot crude gas is quenched and washed before it is passed to the waste heat boiler.

The performance of the gasification process and temperature distribution is show in Figure 6. It is a countercurrent operation in which the operating conditions are optimized for the various reactions.

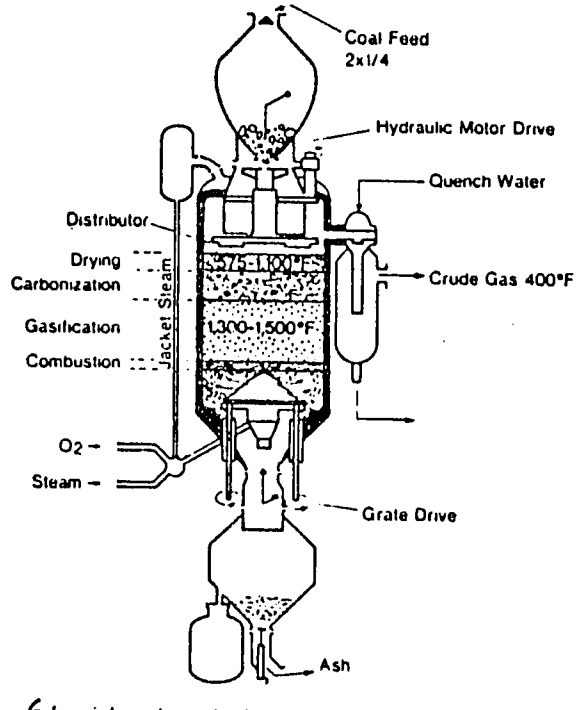



Figure 6 Lurgi dry-ash gravitating-bed gasifier. Source: Lurgi Kohle and Mineralöltechnik GmbH. Reproduced by permission of Lurgi Corp.

The first step is preheating and drying of the coal. As the coal gravitates downward and is heated up, devolatilization commences, and from a temperature of 1150 to 1400 ºF (621 to 760 ºC) onward devolatilization is accomplished by gasification of the resulting char. The interaction between devolatilization and gasification is a determining factor for the kinetic of the complete gasification process.

Although gasification in this process should be performed under pressure, the pressure level that is most economic must be studied. There are several influencing factors. There is the influence of the operating pressure on the methane yield. Figure 7 illustrates the formation of methane in a steam-oxigen-operated pressured gasifier as a funtion of pressure. The figures up to 400 psi are based upon actual plant experience and include all losses which must be considered as, for example, hydrogen in $H_2S$ and $NH_3$ losk gas of the coal lock chambers, and so on. Furthermore, the tar in this case had not been processed to gas, but was disposed of as valuable by-product

On another coal, the absolute figures will differ, but general tendency will be the same. In terms of present technology, for the factor that influence the economics, a pressure range of 350 to 450 psi appears to be most economical.

The combustion zone is the most critical area, since the coal ash must be kept below its fusion point to avoid formation of clinkers, which would plug

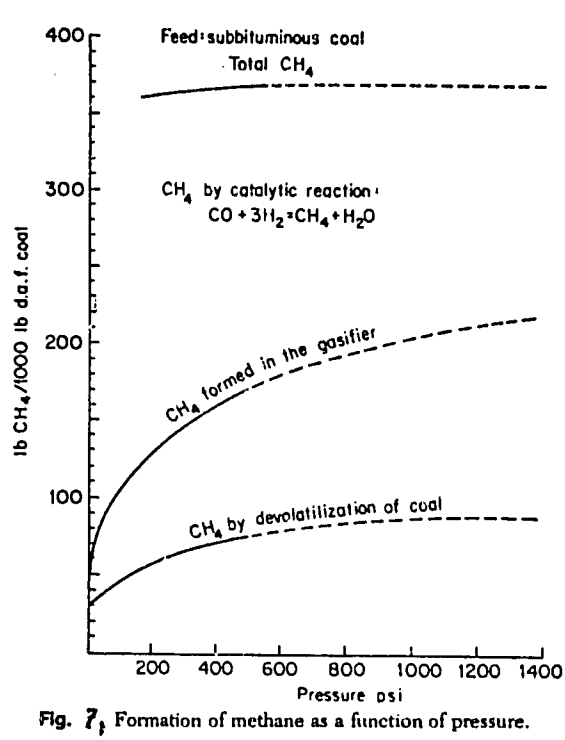



Fig. 7. Formation of methane as a function of pressure.

the gasifier, and, a the same time, has to be sufficiently high to ensure complete gasification of the coal. The combustion-zone temperature is controlle by using large amounts of excess steam (approximately two pounds of steam per pound of MAF coal). About 70% of the steam together with all the moisture in the feed coal becomes waste condensate, which must be purified.

The crude gas leave the gasifier at temperatures between 700 and 1100 ºF (371 and 593 ºC), depending of the type of coal used. The crude gas contains carbonization products, such as tar, oil, naphtha, phenols, and ammonia, and traces of coal and ash dust. This crude gas is passed through a acrubber where it is washed by circulating gas liquor and then cooled to a temperature at which the gas is saturate with steam. As higher-boiling tar fractions are condensed, the wash water contains tar to which the coal and ash dust is bonded.

The steam-saturated gas is passed to a waste-heat boiler in which waste heat at a temperature of 320 to 360 ºF (160 to 182 ºC) is recovered. The gas liquor condensed in this boiler is pumped to the scrubber, and surplus gas liquor is routed to a tar-gas-liquor separator. The mixtured of tar and dust is returned to the gasifier for cracking and gasification.

The basic concept of what has been referred to as a "clean-fuel-gas process" combines the gasification process just described with additional elements. The gas leaving the gasifier at a temperature of about 800 ºF (427 ºC) is cleaned in a attached scrubber to a degree of purity that makes it usable for gas turbines. The gas is saturated with steam at a temperature of 320 ºF (160 ºC). The ash is extracted in granular form which minimizes disposal problems.

Purification of gas from coal gasification to a degree of purity required for synthesis processes is difficult because of the large quantities of impurities and the variety of these impurities. The "Rectisol" process was developed for these conditions and is a physical gas absorption process which uses organic solvent, preferentially methanol, at low temperatures between 30 and -80 ºF (-1 and -62 ºC). The process involves contacting the crude gas countercurrently with the solvent in a trayed absorption column and regenerating the spent solvent ba flashing and subsequent stripping or reboiling in a desorption colum, from which it is recycled to the top of the absorber.

The thermal efficiency of the gasification process is high. More than 90 percent of the latent heat of the coal is recovered. During gasification and by quenching the resulting gas, an increase of volume under conctant presure occurs. This effect is utilized in the subsequent gas-turbine process.

The process scheme just described must be supplemented by an oxygen plant, and the process units must be sopported by a steam and power plant and by other utility plants. A thermal efficiency of 68 to 70 percent can be obtained for a fully self-supporting plant. This depends, however, very much on the properties of the coal, on the overal design of the plant, and on how far an approach to a highly spphisticated steam-power integration can be justified by the economics. The means of processing the by-products and the requirements of environmental protection are influential and vary from case to case.

# -KOPPERS-TOTZEK GASIFIER-

The Koppers-Totzek (K-T) gasifier is the most recent of the commercially proven coal gasifier to be developed. Work began on this process in about 1940 by Dr. Friedrick Totzek of Heinrich Koppers GmbH (now Krupp-Koppers) in Essen, Germany. A pilot plant was built by Koppers Company (U.S.A.) in 1948 for the U.S. Bureau of Mines at its coal-conversion demonstration plant at Louisiana, Missouri. The first commercial plant was built in Finland about 1952 by Heinrich Koppers; since that time 48 K-T gasifiers has been built. In addiction, actually there are four plant, including 27 gasifiers utilizing this technology, in advanced engineering or early construction stage.

Since 1980, Krupp-Koppers has been marketing the K-T technology under the name GKT, while Koppers Company (U.S.A.) has joined with Babcock and Wilcox to market the conventional K-T technology and their own entrained technology. Koppers (U.S.A.) and Babcock and Wilcox have developed and improved design of the K-T called the KBW which they have recently licensed to Hitachi Kabushiki Kaisha. The primary application of the gasifier has been synthesis gas for ammonia production.

Figure 8 is an artist's sketch of the K-T gasifier, which is an oxygen-blown, entrained-flow gasifier operating at near atmospheric pressure.

Pulverized coal is blown into the gasifier with large amounts of oxigen and only a small amount of steam. Partial oxidation of the coal takes place at very high temperatures, over 1400 ºC (2600 ºF). The coal ash becomes molten slag. The hot gas is cooled in a large waste-heat boiler which produces about two pounds of high-pressure steam per pound of MAF coal feed.

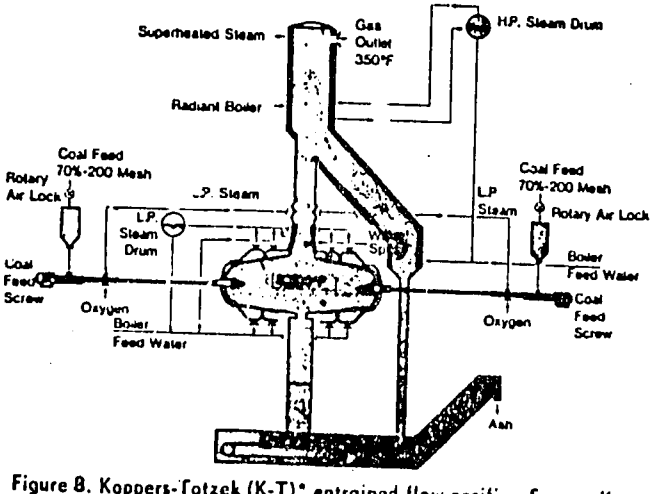



Figure 8. Koppers-Totzek (K-T)* entrained-flow gasifier. Source: Krupp-Koppers GmbH. Reproduced by permission of Krupp International Inc.

Table 1 lists world capacity of the large-scale gasifiers built in the last 20 years. Lurgi dominates the world capacity; however, this is due primarily to only one customer, Sasol. K-T is a distant second in terms of capacity; however, over the last 20 years Koppers has gad a larger customers than Lurgi. Winkler is a very distant third and is at a disadvantage because two of the three most recent plants has been dismentled.

TABLE 1. COMMERCIALLY PROVEN COAL GASIFICATION INSTALLED SINCE 1960 (ONLY PROJECTS ACTUALLY BUILT OR CURRENTLY UNDER CONSTRUCTION, EXCLUDES THOSE IN EAST BLOC COUNTRIES)

| Process | Customers | Operating/ Spares | $10^6$ nM³/D | Percent |
|---|---|---|---|---|
| Lurgi | 5 | 100/14 | 150 | 90 |
| Koppers-Totzek | 7 | 28/2 | 15 | 9 |
| Winkler | 3 | 5/1 | 2 | 1 |

Source: Synthetic Fuels Associates, Inc.

Table 2 shows the capacity and utility requirements of the large-scale commercially proven gasifiers side-by-side based on 1,000 ton per day of MAF coal. Lurgi gasification has a high steam and low oxygen demand, whereas K-T requires the opposite, low steam and high oxygen demand. The near atmos-

pheric pressure operation of the K-T and Winkler gasifiers greatly reduces their coal capacity per gasifier, relative to Lurgi.

TABLE 2. COMMERCIALLY PROVEN GASIFIER CAPACITY FACTORS (BASIS: LIGNITE)

| | Lurgi | K-T | Winkler |
|---|---|---|---|
| MAF* Coal t/d | 1000 | 1000 | 1000 |
| Steam t/d | 2000 | 150 | 350 |
| Oxygen t/d | 400 | 900 | 600 |
| Gasifiers per 1000 t/d MAF coal | 2 | 2 to 3 | 4 |
| Gasifier Size | 4.0 meter dia. (Mark 4) | 7.9 meter dia. (4 headed) | 4.2 meter dia. |
| Dry Gas Production per Gasifier 1,000 $NM^3/HR$ | 55 | 35 | 17 |
| Pressure Atm. | 30 | 1 | 1. |

*MAF—Moisture and Ash Free
Source; Synthetic Fuels Associates, Inc.

The choice of coal gasification technology is complex. It depends more on coal characteristics and by-product utilization than on projected economic comparisons. For example, the projected cost of synthetic fuels by the Lurgi gasifier is generally less than by the K-T or Winkler gasifiers because of pressure operation (30 atmospheres) and the lower oxygen consumption of the Lurgi gasifier. It should be note, however, that all six of the currently operated commercial coal-based ammonia plants (which require $H_2$ at 150 atmospheres pressure) utilize the near atmospheric pressure K-T or Winkler gasifiers.

The use of the Lurgi gasifier is greatly influenced by the coal characteristic and utilization of the coal fines, methane, and liquid by-products. Key coal characteristics for the Lurgi gasifier are coal reactivity, ash softening temperature, friability, caking behavior, and moisture content.

The use of Lurgi gasifiers by Sasol reflects requirements dictated by the feed-coal characteristics more than by the products desired. The Sasol coal characteristics favor the Lurgi technology in that the coal has a high ash-fusion point, allowing high-temperature operation and relatively low steam usage. In addition, the high content of the Sasol coal, a problem for any gasifier, would be specially disadvantageous for entrined gasification. In terms of by-products, the Lurgi gasifiers produce large amounts of methane and hydrocarbon liquids. They cannot utilize coal fines, which become another by-product. These by-product considerations and the feed-coal characteristics have motivated Sasol to invest in the development of the Westinghouse gasifier, which is one of near-commercial gasifiers.

Synthetic Fuels Associates, Inc. (U.S.A.) defines near-commercial gasifiers as those that have been successfully operated in large pilot plants and, more importantly, will be operated at near commercial scale in demonstration plants. Near-commercial gasifiers should not be considered commercially proven be-

fore successful operations of the demonstration plant, however. The following gasification processes can be considered to be near-commercial , with their pilot plants and demonstration plants listed in Table 3.

- Bristish Gas Corporation (BGC)/Lurgi Slagger
- High Temperature Winkler (HTW)
- Shell
- Texaco
- Westinghouse

Economic analysis of these near-commercial gasifiers liste in Table 3 shows major advantages over the commercially proven gasifiers for many applications. This is to be expected when comparing optimistic designs of commercially unproven technology to realistic designs of proven technologies. Demonstration plants are urgently needed to verify the actual advantages of near-commercial gasifiers.

The principal improvement of the near-commercial gasifiers over the commercially proven gasifiers are reduced overall plant utilities and higher gasifier unit capacity. The BGC/Lurgi slagger, as the name implies, is similar to the conventional Lurgi, but slags the ash. This enables a reduction in the gasifier steam demand to only

TABLE 3. NEAR-COMMERCIAL COAL GASIFICATION PROCESSES

| | | Pilot Plant | | | Demonstration Plant | | | |
|---|---|---|---|---|---|---|---|---|
| Process | Developer | Location | Size (mt/d dry) | Start-up | Location | Size (mt/d dry) | Start-up | Product |
| British Gas Corporation (BCC)/Lurgi Slagger | British Gas Corporation Lurgi GmbH | Westfield, Scotland | 300 | 1976 | Westfield, Scotland | 600 | 1982 | Fuel gas |
| High Temperature Winkler (HTW) | Rheinbraun | near Cologne, West Germany | 30 | 1978 | near Wessling, West Germany | 500 | 1984 | Methanol |
| Shell | Shell International Krupp-Koppers GmbH* | Harburg, West Germany | 150 | 1978 | Wilhelmshaven, West Germany | 1,000 | 1986 | Methanol + Chemical |
| Krupp-Koppers | Krupp-Koppers GmbH | — | — | — | Ruhr Valley, West Germany | 1,000 | 1988 | Fuel gas |
| Texaco | Texaco Corporation | Oberhausen-Holten, West Germany | 150 | 1978 | Kingsport, TN U.S.A. | 750 | 1983 | Methanol + Chemical |
| | | Plaquemine, LA U.S.A. | 100 | 1978 | near Barstow, CA U.S.A. | 900 | 1984 | Electricity |
| | | Muscle Shoals, AL U.S.A. | 170 | 1981 | Oberhausen-Holten, West Germany | 750 | 1986 | Chemical |
| Westinghouse | Westinghouse Electric | near Pittsburgh, PA U.S.A. | 30 | 1975 | Sasol II, South Africa | 1,000 | 1984 | Gasoline + Diesel |

*Since 6/81 Krupp-Koppers is no longer involved
Source: Synthetic Fuels Associates, Inc.

20% of that required for the conventional Lurgi gasifier and also increases the unit capacity by a factor of 2.5. The other near-commercial gasifiers are basically pressurized versions of the K-T and Winkler. Pressurization increases the unit capacity and greatly reduces the overall plant utility requirements since most applications for coal gasification are at pressure.

The Shell gasifier is very similar to a pressurized K-T. The Texaco gasifier is also based on pressurized entrained flow' however, the coal is fed into the gasifier as a coal/water slurry to a downflow reactor. This is an important disadvantage for the Texaco process for low rank coals as the inherent moisture of such coal leads to a high water content in the coal feed slurry.

The HTW is the equivalent of a 10-atmosphere pressurized Winkler and is being developed by Rheinische Braunkohlenwerke AG (Rheinbraun). It should be noted that Davy McKee indicates that they are prepared to build a Winkler gasifier to operate at four atmospheres pressure; however, this is unrelated to the Theinbraun HTW pilot plant or demonstration development.

The Westinghouse gasifier differs from the pressurized Winkler in that the Westinghouse system is a pressurized fluidized bed with a hotter ash-agglomerating zone in the middle of the bed.

The Westinghouse has an advantage over the pressurized Winkler in attaining higher carbon conversion by recycling entrained char to the hot ash-agglomerating zones. Coal cost, coal reactivity, char utilization, and operability are the key considerations when comparing pressurized Winkler to Westinghouse.

There are also a large number of advanced coal - gasification processes. Table 4 lists some of them . Several of these systems have unique mechanical, thermodynamic, or kinetic features that give them potential advantages over commercially proven gasifiers.

TABLE 4. CURRENTLY ACTIVE ADVANCED COAL GASIFICATION PROCESSES

| Gravitating Flow | Fluid Bed |
|---|---|
| High Pressure Lurgi | Exxon Catalytic |
| Gegas | Enrecon |
| Kilngas | Cogas |
| Underground (UCG) | U-Gas |
| KGN | Hygas |
| BGC's Composite | Synthane |
| BKV | Tri-Gas |
| PCV | N.C.B. |
| Toscodyne | CMRC (Japan) |
| | Tosco |

| Entrained Flow | Molten Bath |
|---|---|
| KBW | KHD |
| Chevron | Rockgas |
| Saarberg/Otto | Sumitomo |
| Bigas | |
| Rockwell/Cities Service | |
| C.E. | |
| MFR/Eyring | |
| Bell Aerospace | |
| AVCO | |
| VEW | |

Source: Synthetic Fuels Associates, Inc.

Most of these advanced coal-gasification processes have been developed only in laboratories or small pilot plants. The developers of several of these gasifiers are presently attempting to obtain support and funging to build large-scale gasifiers that could propel their large-scale demonstration into the same time frame as the near-commercial gasifiers. However, many of the advanced gasifiers may never be developed commercially since the complexity of many of these systems have made their operability questionable. Also, there is little potential economic advantage for most of these gasifiers compared with near-commercial gasifiers. Nonetheless, a few of the advanced gasifiers do have attractive economics relative to near-commercial gasifiers and reasonable operability. Therefore, good potential for commercialization exists for a sellect few.

Many information exist about these systems, but it is not of the interest of this report to describe these gasification process here, because they have been not proven commercially, or at list in a demonstration plant, and many tecnic and economic uncertanties exist about the most of these systems.

# - C O N C L U S I O N -

Consideration about coal gasification will be influenced by the end need. Like in many processes, direct coal combustion is not desirable or useful, coal gasification constitutes an alternative; also to fossil fuels.

Introducing this technology with an overview can be considered necessary, because in this way one can undestand the advantages and disadvantages involved in wach method; and understanding those processes, one can be able to initiate the adoption and transference of coal gasification technology for any small or large scale needs, in which this technology may be a solution.

Although in this report has been presented some data about the most important methods for coal gasificatior, it does not mean that they are enough for making decisions. It pretends only to initiate technicians in understanding this alternative technology.

# - B I B L I O G R A F Y -


- Energy Progress (Vol. 2, No. 1)
  Coal Gasification - an Overview.
  March, 1982.

- Energy Technology Handbook
  Considine
  Mc Graw-Hill.

- Oil and Gas Journal
  SNG from Coal: By-Product Considerations,
  March 1979.

- Encyclopedia of Energy
  Second Edition,
  Mc Graw-Hill