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THE TEXACO COAL GASIFICATION PROCESS
FOR
MANUFACTURE OF MEDIUM BTU GAS

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ABSTRACT

The development of the Texaco Coal Gasification Process is discussed with particular emphasis on its close relationship to the fully commercialized Texaco Synthesis Gas Generation Process for residual oil gasification. The end uses of the product gas are covered, with special attention to electric power generation via combined cycle technology. Control of SO₂, NO_x and particulate emissions in the power generating mode is also covered. The application of this technology in a proposed Texaco-Southern California Edison demonstration project is mentioned. Investment information released by EPRI for a 1000-megawatt advanced combined cycle gasification facility, is also reviewed.

and carbon monoxide along with lesser amounts of carbon dioxide and methane. The reactants are introduced through a special burner into a refractory lined pressure vessel or generator and the auto-thermal non-catalytic reactions occur at temperatures ranging from 2,000-3,000°F. Small amounts of unconverted fuel or soot are recycled to extinction. The basic exothermic and endothermic chemical reactions are shown in Figure 1. Sulfur present in the fuel is converted to H₂S and small amounts of COS, and organic nitrogen is reduced to elemental nitrogen and ammonia. The hot exiting gases are cooled through appropriate heat recovery equipment and treated as necessary to produce the desired product.

I. INTRODUCTION

Medium BTU gas is usually considered to be a fuel composed primarily of hydrogen and carbon monoxide, with varying amounts of methane and inert components and a specific heat of combustion ranging from 250-500 BTU/SCF. This gas, particularly when produced at elevated pressure, can be processed by means of a variety of commercially proven technologies to remove sulfur compounds and produce a clean burning fuel or gas for use in many applications in which natural gas has been formerly employed. Some of these uses include fired process heaters, chemicals manufacture (ammonia, methanol, oxo-synthesis products), and gas turbine fuel.

II. RESIDUAL OIL GASIFICATION

For many years, Texaco offered the Texaco Synthesis Gas Generation Process^{1,2} throughout the free world as an efficient technology for converting high sulfur residual petroleum fuels and tars to synthesis gas, approximately a 50-50 mixture of hydrogen and carbon monoxide. Some seventy plus plants have been built in the past twenty-five years. Most of these plants have been associated with manufacture of ammonia, methanol and oxo-chemicals.

In a nut-shell, the process involves reacting the residual fuel with a controlled amount of high-purity oxygen and steam at pressures ranging from 300-1,200 psi with the net production of hydrogen

III. COAL GASIFICATION

It was recognized nearly 30 years ago that fuel for the process could just as well be coal, and work on process development for production of synthesis gas from coal was then started at Texaco's Montebello Research Laboratory where Texaco operates a variety of large scale pilot plant units and gasifiers capable of processing 15-20 tons per day of coal. Economic incentives for using coal in place of petroleum products at that time were not very strong, and the process development proceeded on a low priority basis.

In the late sixties, the solids gasification process finally evolved to its present form, and the energy crisis brought on by the 1973 Arab oil embargo greatly accelerated the development of the process based on coal as the fuel.

Basically, the process involves a slagging entrained downflow gasifier fed with oxygen and a concentrated slurry of ground coal in water. The same type of refractory lined gasifier is employed as in the earlier oil gasification process, except provision is made to remove solidified slag through a lock-hopper system. Optionally, the gasifier may be fed with a slurry of coal in oil and a controlled amount of reaction temperature moderator such as steam. Facilities for recycle of unconverted coal or char are also provided. A schematic flow diagram of the process is shown in Figure 2.

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The process is capable of efficiently gasifying a wide variety of caking and non-caking bituminous and sub-bituminous coals as well as lignites or brown coals and petroleum coke. In addition, the process has been used to demonstrate the gasification of a variety of residues from emerging coal liquefaction processes.

Due to the high gasification temperature, by-product tars, phenols, and hydrocarbons heavier than methane are not produced.

Slag removed from the screen below the lockhoppers consists of fused particles generally less than one-fourth to one-half inch in diameter. This inert material containing less than 0.5 percent carbon can be easily handled and removed to slag disposal sites. Typical slag removed from the pilot unit at Montebello is shown in Figure 3.

A. GAS PURIFICATION

The crude raw synthesis gas is first contacted with water at gasifier pressure to remove entrained particulates. Water removed from the scrubbing system is recovered through a settler where the particulate matter is extracted and recycled to the gasifier. After water contacting, the particulate loading in the raw gas is typically on the order of 1 Mg/Nm³. This washed gas is further cooled and treated for removal of undesirable acid gas components. The type of technology used in this step will be dictated by the final or end use of the synthesis gas. For example, if the gas is to be used as a gas turbine fuel, it is in the interest of overall process efficiency to remove only the H₂S and COS, leaving the CO₂ in the fuel gas to recover energy by expansion through the gas turbine. On the other hand, if synthesis gas for methanol, Fisher Tropsch synthesis or oxo-products is desired, sulfur compounds in the gas must be reduced to less than 1 ppm and all or substantial portions of the CO₂ will also need to be removed. Gas purified in this manner can also be used for manufacture of SNG.

Alternately, it may be desirable to reduce the ratio of CO to H₂ in the gas. This step can easily be done through the well-known water gas shift reaction. Generally, the shifting is carried out before the acid gas removal step using the sensible heat in the gasifier exit gases to reach the necessary steam content by direct water injection or quenching. This alternate makes it possible to produce high purity hydrogen for ammonia manufacture or use in coal liquefaction plants.

Various commercially proven acid gas removal processes are available for purifying the gas to the desired degree.

Typical compositions of some feed coals and coke and the raw synthesis gas from them are shown in Figure 4 and 5.

IV. POWER GENERATION

The above technology is particularly well suited to generation of electric power via coal gasification in the combined cycle system. Since sulfur is removed from the fuel gas before combustion in the turbine, SO₂ emissions can easily be maintained at or below mandated levels. The primary source of NO_x emission in fossil fuel-fired power plants is the organic nitrogen in the fuel. Since all organic nitrogen in the coal has been converted to elemental nitrogen and a small amount of ammonia which is removed in the water wash and subsequent processing, NO_x emissions are greatly reduced and are comparable to natural gas fueled-systems.

Furthermore, it has been shown that specially designed burners or nozzles in the gas turbine can reduce NO_x emissions even further. Work in this area is presently underway at the Montebello Research Laboratory, as well as other installations.

V. DEMONSTRATION UNITS

In addition to the 15-ton per day pilot unit at Montebello, a 150-T/D unit is presently in the start-up phase in West Germany and the Tennessee Valley Authority is in the process of designing a 150-T/D unit for installation at Muscle Shoals, Alabama. Last March, Texaco and Southern California Edison jointly announced their intention to obtain partial support and to construct a 1,000-ton/day coal gasification combined cycle demonstration plant near Barstow in the high desert northeast of Los Angeles. Fuel gas from the coal gasifier will initially be used to fire an existing 65 MW boiler and eventually, when the combined cycle facilities are installed, the gas will be employed as turbine fuel producing a total of approximately 90 MW through steam and gas turbines. Preliminary engineering on this project is presently underway.

VI. ECONOMICS

The Electric Power Research Institute has recently published results of a study conducted by Fluor Engineers & Constructors, Inc. indicating that, with advanced turbine technology (2400°F expander inlet) the combined cycle system potentially offers one of the most attractive means yet available for gen-

erating electricity from coal in an environmentally acceptable manner. Heat rates are predicted to be below 9000 BTU/KWH and plant investment and other capital charges are estimated to be about \$800/KWH of capacity for a 1000 MW stand alone power plant. The study was based on mid-1976 dollars.

It is obvious that we have some interesting and difficult challenges ahead to merge the various technologies and to produce an efficient, smoothly running, environmentally acceptable power plant. This goal can be achieved.

Literature Cited

1. Child, E. T., "Texaco Heavy Oil Gasification," the University of Pittsburgh School of Engineering, Symposium on Coal Gasification and Liquefaction: Best Prospects for Commercialization, Pittsburgh, Penn., August 6-8, 1974.
2. Child, E. T., & Marion, C. P., "Recent Developments in the Texaco Synthesis Gas Generation Process," The Fertilizer Association of India National Seminar, New Delhi, India, December 14-15, 1973.
3. "Economic Studies of Coal Gasification Combined Cycle Systems," Fluor Engineers and Constructors, Inc., EPRI AF-642, January, 1978.

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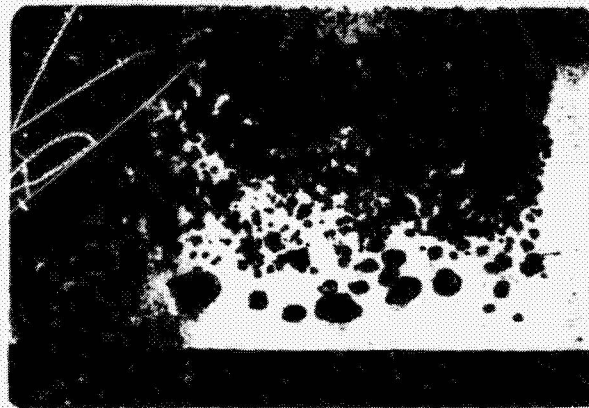
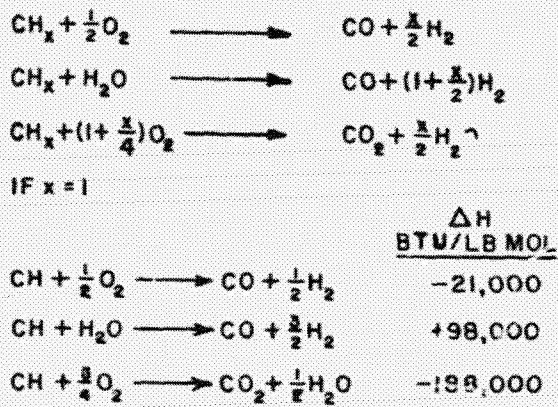


FIGURE 1. GASIFICATION: REACTION

FIGURE 3. SLAG REMOVED FROM GASIFIER

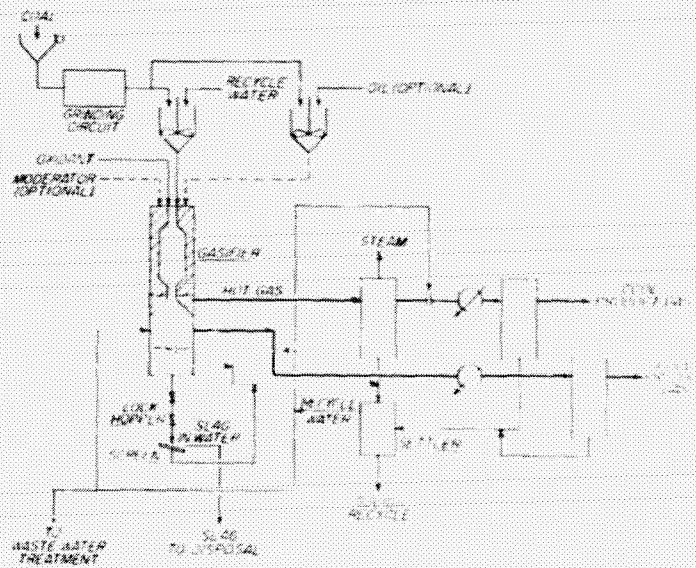


FIGURE 2. PILOT PLANT FLOW SHEET

<u>WEIGHT %</u>	<u>WESTERN BITUMINOUS COAL</u>	<u>DELAYED PETROLEUM COKE</u>	<u>EASTERN BITUMINOUS COAL</u>
C	74.56	89.47	67.62
H	5.31	3.71	5.16
S	0.46	1.44	3.26
N	0.99	2.69	1.00
O	11.47	2.37	11.17
ASH	7.20	0.31	11.76
HEAT OF COMBUSTION BTU/LB DRY	13,134	13,515	12,250

FIGURE 4. TYPICAL COAL AND COKE ANALYSES

<u>FEEDSTOCK</u>		<u>WESTERN BIT. COAL</u>	<u>DELAYED PET. COKE</u>	<u>EASTERN BIT. COAL</u>
OXIDANT SLURRY MEDIUM		OXYGEN WATER	OXYGEN WATER	OXYGEN WATER
PRODUCT GAS COMPOSITION, % VOL (DRY GAS BASIS):	H ₂	35.79	34.50	35.78
	CO	50.71	45.22	44.62
	CO ₂	13.14	19.38	17.97
	N ₂ -A	0.24	0.72	0.48
	CH ₄	0.09	—	0.08
	H ₂ S	0.02	0.13	1.02
	COS	0.01	—	0.05
HIGH HEATING VALUE, BTU/SCF (CO ₂ -H ₂ S- COS FREE BASIS)		321	319	320

FIGURE 5. TYPICAL GASIFICATION PERFORMANCE SUMMARIES