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CLEAN AUTOMOTIVE FUEL. LABORATORY-SCALE OPERATION OF THE SYNTHANE PROCESS

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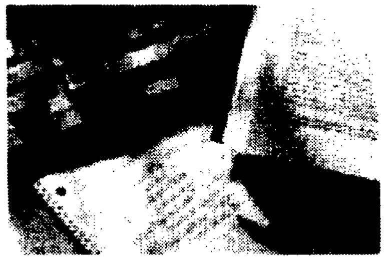

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CLEAN AUTOMOTIVE FUEL

Laboratory-Scale Operation of the Synthane Process

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CLEAN AUTOMOTIVE FUEL

Laboratory-Scale Operation of the Synthane Process

by

A. J. Forney, W. P. Haynes, J. J. Elliott,
and R. F. Kenny

Pittsburgh Energy Research Center, Pittsburgh, Pa.

Bureau of Mines Automotive Exhaust Emissions Program

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CLEAN AUTOMOTIVE FUEL

Laboratory-Scale Operation of the Synthane Process

by

A. J. Forney,[1] W. P. Haynes,[2] J. J. Elliott,[3] and R. F. Kenny[4]

ABSTRACT

A high-Btu gas was made at the Bruceton, Pa., laboratories of the Bureau of Mines to demonstrate the feasibility of using the gas as a nonpolluting fuel for automobiles. The pilot plants at Bruceton were revised to combine the processes of coal gasification, gas purification, and catalytic methanation in one overall system. Tests in the Bureau's test automobiles at Bartlesville, Okla., showed the Synthane gas was less polluting than natural gas.

INTRODUCTION

This paper discusses the production of a high-Btu gas made from coal using the Synthane process including gasification, purification, and methanation. The gas was bottled for testing as a fuel for automobiles in the Bureau of Mines laboratories at Bartlesville, Okla.

The Synthane process is a coal-to-gas process developed at the Bruceton, Pa., laboratories of the Pittsburgh Energy Research Center (4, 6).[5] In the process coal is converted to a synthesis gas by steam-oxygen gasification in a fluid bed. If the coal is a caking coal, it is rendered nonagglomerating by pretreatment in a fluid bed with steam (or CO_2) plus oxygen. Thus any coal found in the United States can be gasified in the process; an added advantage is that the gases made in pretreatment become part of the overall product gas from the gasifier.

The synthesis gas, consisting of H_2, CO, CH_4, and CO_2, plus minor quantities of H_2S, C_2H_6, and C_3H_8, is passed through a shift converter to change the H_2/CO ratio from about 1.5 to the $3H_2$/1CO required for methanation. Prior to methanation the gas is purified by the hot carbonate process (2) to reduce the

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[1] Research supervisor.
[2] Supervisory research chemical engineer.
[3] Chemical research engineer.
[4] Chemical engineering technician.
[5] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

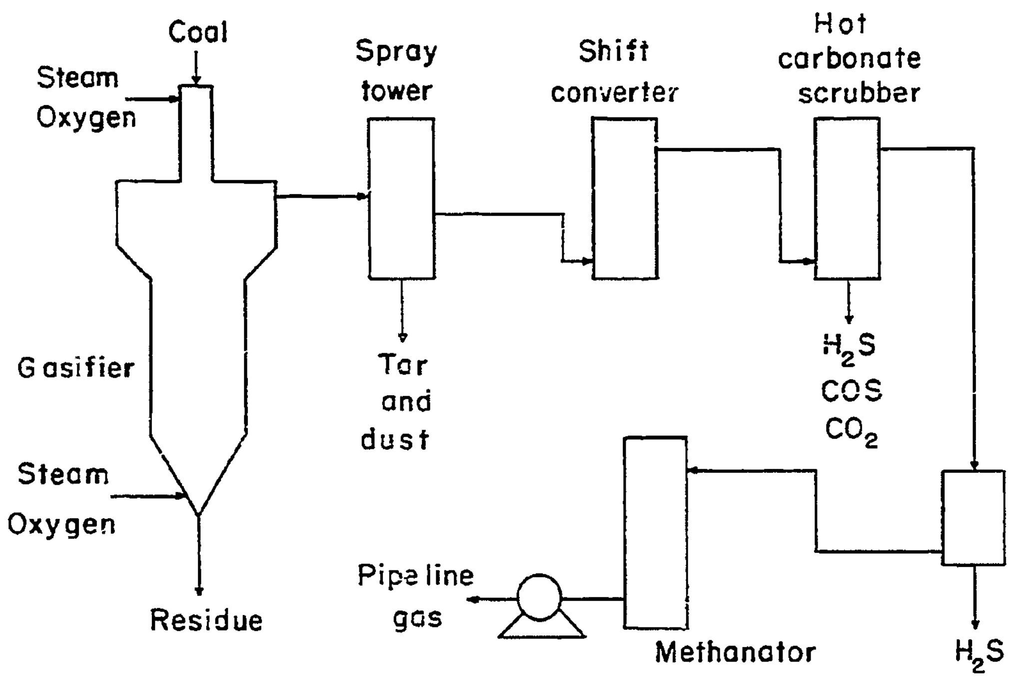


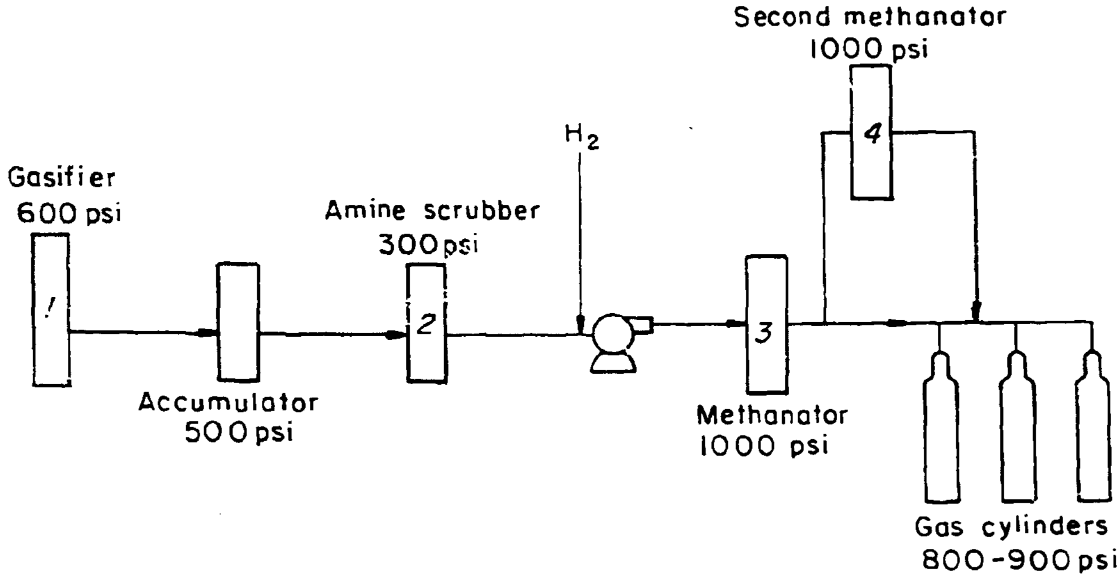
FIGURE 1. - Overall Synthane Plant.

CO_2 to about 2 percent and the H_2S content to about 5 ppm. Final purification with iron oxide boxes and activated charcoal or zinc oxide reduces the sulfur level to below 0.1 ppm. The purified gas then is methanated in the tubewall-reactor system (5) or the hot-gas-recycle system (3). The purified gas enters the methanator with a heating value between 500 to 600 Btu/cu ft and is upgraded to a heating value exceeding 900 Btu/cu ft, thus becoming a satisfactory substitute for natural gas.

EXPERIMENTAL PROCEDURE

Figure 1 shows the overall Synthane process and is essentially the plant being designed by the Lummus Co. for gasifying 75 tons of coal per day. The objective was to make a high-Btu gas derived from coal using existing gasification, purification, and methanation pilot-plant units at Bruceton which had been operating independently or were on standby status. This objective was achieved by connecting together the units shown in figure 2. In the gasifier system shown in figure 3, caking coals (Pittsburgh seam and Illinois No. 6) were gasified at 600 psig. The gas analysis shown in figure 2 is typical of the gas made in the gasifier for these runs. The CO_2 should be about 30 percent; it is high because CO_2 was used in place of N_2 as a bleed gas for the pressure taps; CO_2 was used because it could be removed in the amine scrubber, whereas N_2 could not. A more typical gas would be (adjusting the CO_2):

H_2 - 28.7 percent	CO - 22.7 percent	H_2S - 0.3 percent
N_2 - 0.4 percent	C_2H_6 - 0.7 percent	HV - 342 Btu/cu ft
CH_4 - 17.2 percent	CO_2 - 30.0 percent	



Laboratory-scale Synthane plant

	1	2	3a	3b	4
H_2	20%	40%	10%	15.9%	7.9%
N_2	0.3	0.6	.9	1.1	1.0
CH_4	12	24	88.3	80.7	91.1
CO	16	32	0.2	0.4	0
C_2H_6	0.5	1	0.2	0.9	0
CO_2	51	1	0.4	1.0	0
H_2S	0.2	0[1]	0[1]	0[1]	0[1]
H.V.	246 $\frac{\text{Btu}}{\text{cu ft}}$	492	930	886	950

1 Less than 30 ppb

FIGURE 2. - Pilot Synthane Plant.

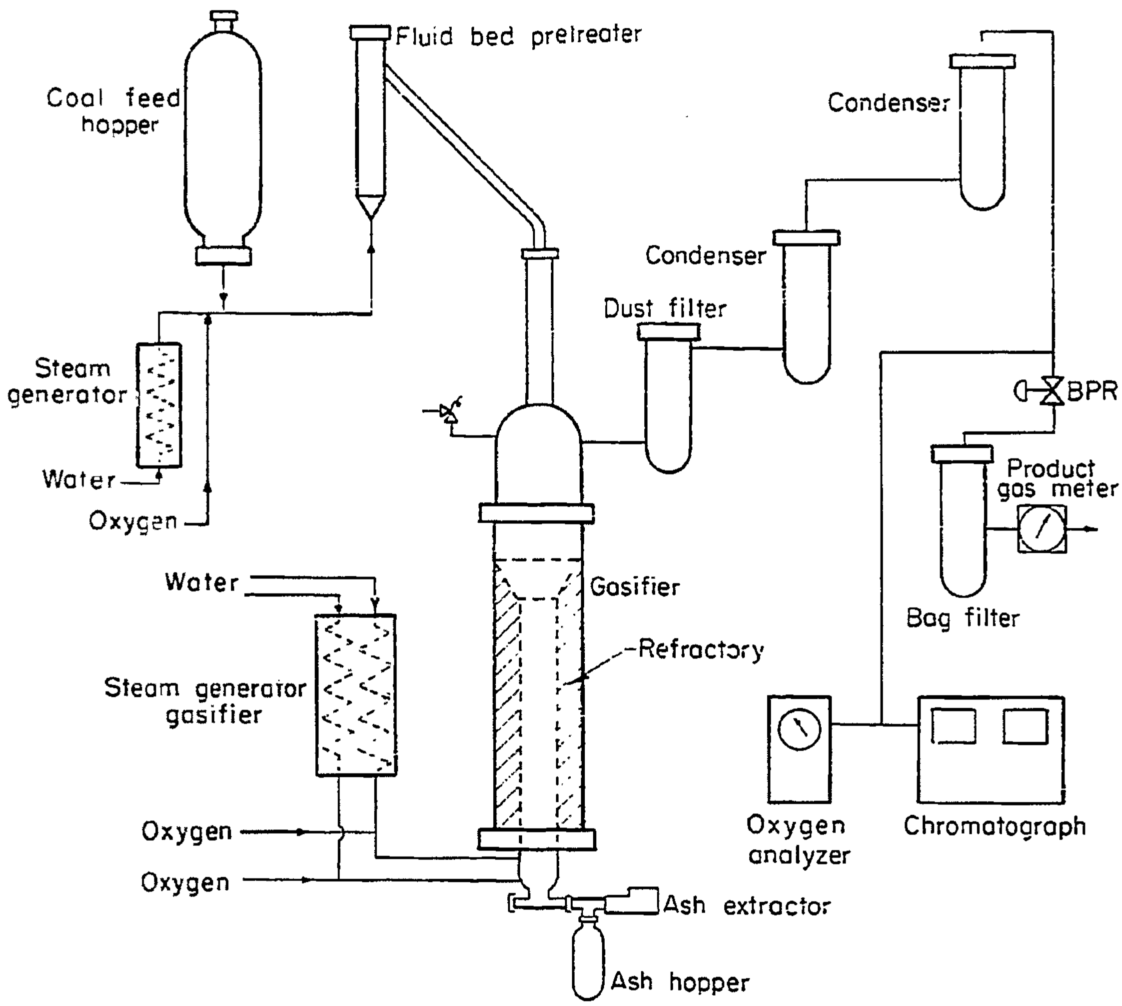


FIGURE 3. - Bruceton Experimental Gasifier System.

The gas from the gasifier (fig. 2) was passed to high-pressure accumulators for storage. The gasifier operated intermittently (about 6 hours per day), but the methanator operated continuously (24 hours per day) so the accumulators were used to store about 8,000 cu ft of gas at 500 psig. The gas was then fed at a constant rate into a pilot-plant-sized amine scrubber system (no hot carbonate system was available), where about 40 scfh of gasifier gas was scrubbed of CO_2 and H_2S. Gas analysis had shown the sulfur in the gasifier gas is about 92 percent H_2S, the balance being COS with traces of thiophenes. The purified gas, typically, was of the analysis shown in figure 2, column 2. The gas had a H_2/CO ratio of only 1.25; as we had no shift-converter pilot plant, hydrogen was added to give an H_2/CO ratio slightly above 3 to 1. This gas was compressed to 1,000 psi and methanated over a small tubewall reactor. This reactor was 3/4 inch in OD by 6 inches long with Raney nickel

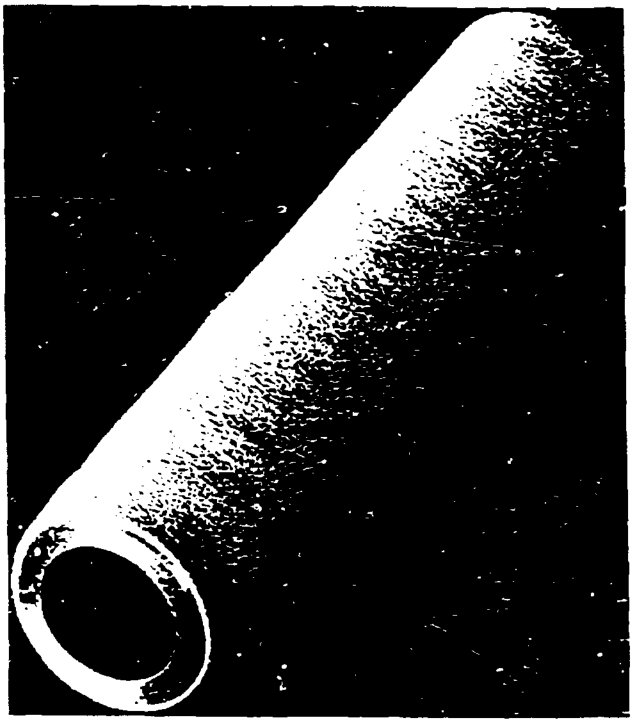


FIGURE 4. - Bench-Scale Tubewall Methanator.

catalyst (58 percent aluminum, 42 percent nickel) sprayed on the outside surface to a depth of 0.20 inch; a section is shown in figure 4. The unit had been used for several months previously for other testing; at first it made a satisfactory gas of 930 Btu/cu ft (fig. 2, column 3a), but as the catalyst deteriorated because of age the heating value decreased to 886. A second methanator using a packed bed of a Chemetron G-65[6] catalyst was added to the train, operating at the same temperature and pressure as the tubewall reactor. As shown in figure 2, column 4, this methanator completely reacted the remaining CO, CO_2, and C_2H_6. The gas passed from the methanator to cylinders and was shipped to Bartlesville for testing. Results of these tests are described by Eccleston and Fleming in a companion publication (1).

CONCLUSIONS

1. The level of sulfur from the amine scrubbing system, about 40 ppm, was much lower than believed possible from such a regenerating purification scheme; however, the amine system was greatly oversized for the amount of gas handled.

2. The idea of using a cleanup methanator has been incorporated into the prototype plant design. A second methanator has been added to the pilot-plant tubewall reactor at Bruceton, Pa., and has demonstrated satisfactory operation at a space velocity of 10,000 scfh/cu ft of catalyst volume.

3. The test demonstrated there were no impurities such as chlorine or sulfur compounds in the coal that could affect the methanation operation when the gas was purified by standard procedures.

4. The tests at Bartlesville (1) demonstrated that Synthane has all the advantages of natural gas and produces an automobile exhaust that is significantly less reactive in causing smog compared with the exhaust from natural gas.

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[6]Reference to trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

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