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PEATGAS™ PILOT PLANT OPERATING RESULTS

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Abstract

The Institute of Gas Technology has been developing the PEATGAS™ process for the conversion of peat to synthetic fuels. A program has recently been completed for the pilot-plant-scale testing of the process. In this scheme, peat is gasified in a two-stage reactor system, which operates at temperatures up to 1750°F and pressures up to 500 psig. The process can be controlled to maximize the production of either substitute natural gas (SNG) or liquid hydrocarbons. The technical feasibility of the process was demonstrated in a series of five gasification tests. Highlights of this operating program are presented in this paper.

BACKGROUND

North America has significant peat deposits, which are estimated to contain an equivalent of over 380 billion barrels of oil. These deposits are generally located in areas that have no other significant fossil fuel resources. The Institute of Gas Technology (IGT) has been conducting research on peat utilization since 1974. Its goal has been to develop a process for the production of synthetic fuels.

This work was first initiated by Minnesota Gas Co. (Minnegasco). Since 1974 sponsorship has expanded to include the U.S. Department of Energy (DOE), Gas Research Institute (GRI), and InterNorth (a parent company of Northern Natural Gas Co.). Hundreds of laboratory and process development unit (PDU) tests were performed (1-9) during the last 7 years to evaluate peat as a feedstock for synthetic fuel production. Not only has this work shown that on the basis of its chemistry and kinetics peat is an excellent raw material for the production of substitute natural gas, but it has also resulted in the development of the PEATGAS process (Figure 1).

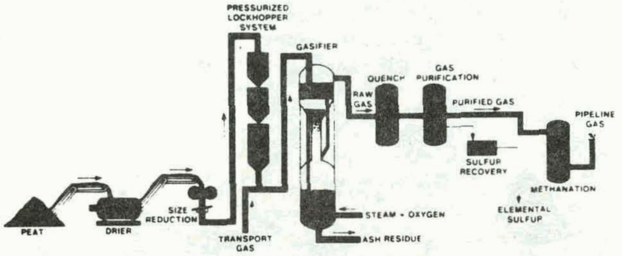

Figure 1. SIMPLIFIED FLOW DIAGRAM OF THE PEATGAS PROCESS

PROCESS DESCRIPTION

To further advance the PEATGAS process concept, large-scale pilot plant studies were started last year in an existing coal gasification facility (Figure 2) at IGT's Energy Development Center (EDC) in Chicago. Only minor modifications of the gasifier were required to provide the necessary configuration for the PEATGAS processing scheme. New drying, screening and crushing equipment was also installed because peat required more drying and screening capacity and less grinding capacity than was available in the existing plant. A slurrying method was used to inject peat into the gasifier for the initial tests. However, when the lockhoppers were installed for the later tests, more

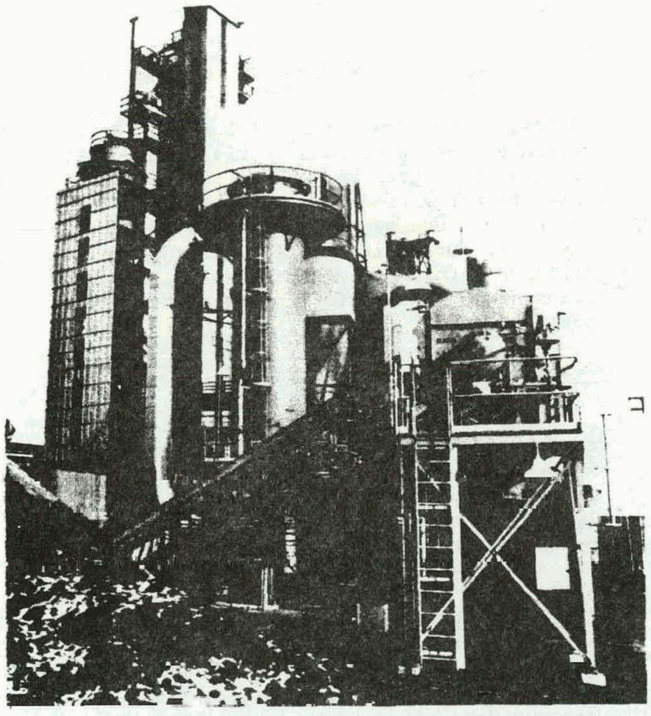

Figure 2. PEATGAS PILOT PLANT FACILITY AT THE IGT ENERGY DEVELOPMENT CENTER IN CHICAGO

variability was achieved in some of the key gasifier operating parameters, resulting in more economically favorable operating conditions.

The modified plant is capable of converting a nominal 50 tons of dry peat into 0.5 million standard cubic feet of substitute natural gas daily. The basic features of the pilot plant are —

Peat Preparation

In the newly installed peat preparation section (Figure 3), as-received peat containing 60 to 75 weight percent water is dried in a natural-gas-fired, triple-pass rotary drum dryer. Up to

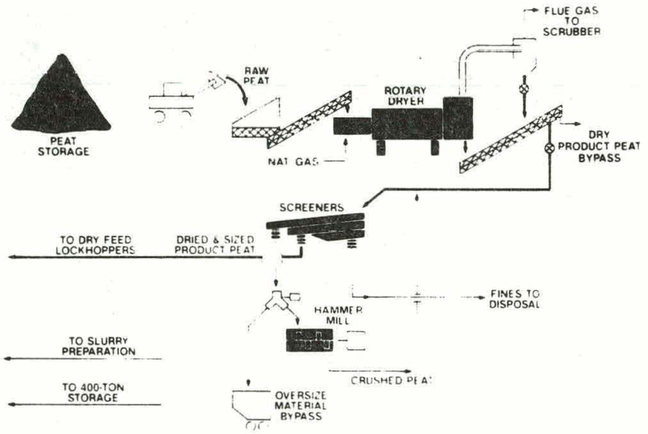

Figure 3. PEAT PREPARATION SECTION

16 tons of wet, raw peat per hour can be dried to a moisture level as low as 10 weight percent. The dried peat is then screened to a -20+80 U.S.S. mesh size product. Product peat is conveyed to the lockhopper feed system for injection into the gasifier. Oversize material is crushed in a hammer mill and returned to the screeners. Two 200-ton silos are available for intermediate storage of prepared peat.

Peat Lockhopper Feed Injection

The new lockhopper feed system (Figure 4) is capable of providing a continuous, measured flow of 1 to 4 tons of dry peat per hour to the gasifier at pressures up to 500 psig. The system includes a 17-ton bin that provides surge capacity during operation, a scalping screen that prevents foreign objects from entering the lockhoppers and possible bridging in the injectors or lodging in the critical lockhopper valves, a storage injector that cycles in pressure and adds a known quantity of peat at regular intervals to the primary injector and the primary injector that is always at system pressure and meters out a constant feed rate of peat. Both injector vessels rest on load cells, which are separated by a balanced pressure expansion joint in order to accurately measure the peat fed to the gasifier.

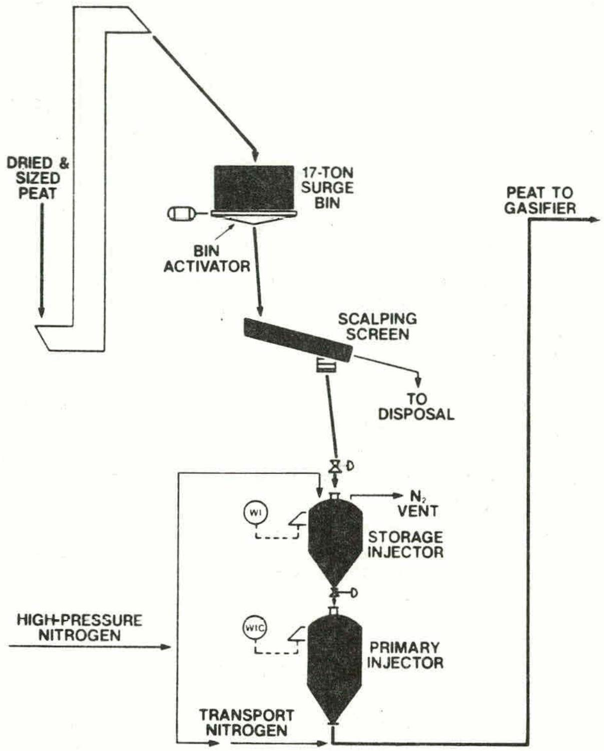

Figure 4. PEAT LOCKHOPPER FEED INJECTION

Gasification

Solids are injected at the top of the PEATGAS reactor (Figure 5) where the transport nitrogen is disengaged and hot gases rising through a fluidized bed from the lower sections of the reactor vaporize the moisture in the peat and preheat the solids to 450°F. The peat solids then overflow by gravity from this drying zone into the first reaction stage, the hydrogasifier (HG).

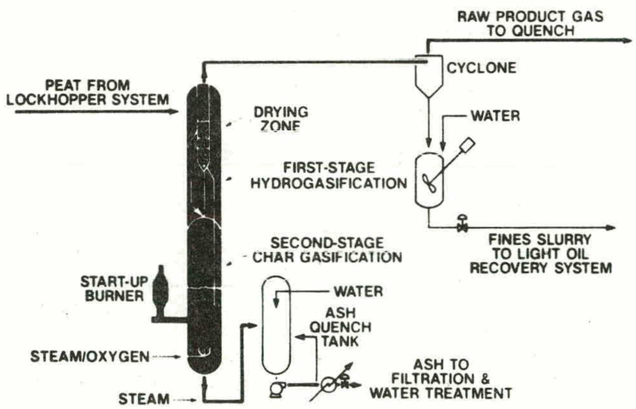

Figure 5. GASIFICATION SECTION

In the HG, which operates at 1000° to 1400°F, both the volatile matter and the more reactive part of the peat are converted to methane and other light hydrocarbons in a short residence time zone by reaction with the hydrogen-rich gas produced in the lower stage of the reactor. Oils released in this gasification stage account for 10% to 30% of the carbon gasified depending on the temperature in the HG. Solids from the hydrogasifier overflow by gravity to the next stage, the char gasifier (CG).

In the CG, the unreacted char is exposed to a temperature of about 1700°F in a dense-phase fluidized bed. Steam and oxygen are injected into the bottom through a three-nozzle distributor. These gases serve as the fluidizing medium for the char and provide reactants for combustion and steam/carbon reactions. The char residue, now over 90% gasified, is discharged from the reactor, quenched, slurried with water and depressurized. The char residue is recovered in downstream filtration and separation equipment.

Product Gas Quench and Oil Recovery

In the product gas quench and oil recovery section of the plant (Figure 6), the product gas leaving the gasifier at 450°F is cooled to 100°F by direct water quench, which condenses the steam and light oil. After an oil-water separation, the light oil is withdrawn, depressurized and stored. The water is reused in the quench system.

The pilot plant facility also contains gas purification and methanation sections where CO_2 and H_2S are removed before catalytic methanation of the remaining carbon monoxide and hydrogen. These units remained on standby during the peat gasification tests.

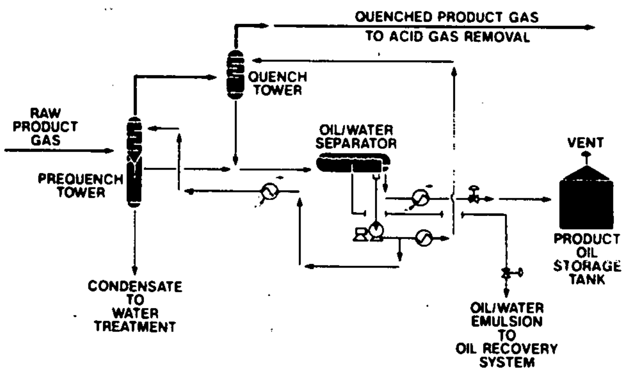

Figure 6. PRODUCT GAS QUENCH AND OIL RECOVERY

GASIFICATION TEST PROGRAM

The overall program had two main objectives: first, to modify the existing pilot plant for peat processing including installation of the drying, screening, grinding and lockhopper feed systems and second, to conduct peat gasification tests. These tasks were successfully completed during a 2-year program period. Key program dates were —

Contract Awarded - Initiated Design of Feed Preparation And Lockhopper System	April 1980
Installation of Feed Preparation Equipment	Sept. 1980 - Feb. 1981
Equipment Shakedown	March 1981
Reactor Flow Test	April 1981
Three Gasification Tests - Slurry Feed (PT-1, PT-2 and PT-3)	June - Aug. 1981
Received Approval to Install Lockhoppers	August 1981
Lockhopper Installation	Sept. - Nov. 1981
Equipment Shakedown	Dec. 1981
Two Gasification Tests - Lockhopper Feed (PT-4 and PT-5)	Jan. - March 1982

After completing the shakedown of the new feed preparation equipment (drying, screening and crushing) in March 1981, testing was begun in the pilot plant. The existing slurry system was used to inject peat into the gasifier because the lockhopper system was scheduled to be installed later in the year. The first test, completed in April 1981, was conducted mainly to obtain solids flow data with the PEATGAS gasifier configuration during integrated operation of the test facility. Oxygen was not added to the char gasification zone.

After successfully completing the solids flow test, a series of three gasification tests (PT-1, -2 and -3) were conducted in June, July and August 1981. The main objectives of the gasification tests were to obtain operating experience with Minnesota peat and to study the effect of gasifier steam partial pressure, temperature and peat feed rate on product yields and composition. The lockhopper system was erected after this series of tests. The construction period was accelerated in order to devote the remaining operating program to tests using the dry feed mechanism. Two successful gasification tests (PT-4 and -5) were then conducted, expanding the data base to lower steam-to-feed carbon ratios in the gasifier and higher peat feed moisture contents. These represent more economically favorable operating conditions. Table 1 highlights test conditions for the five gasification tests.

A typical peat screen and chemical analysis is given in Table 2.

Typical gas composition and oil boiling point distribution for a hydrogasifier temperature of ∿1000°F, a char gasifier temperature of 1650°F and a steam-to-carbon ratio of 1.1 are given in Tables 3 and 4, respectively.

Table 1. GASIFICATION TEST OVERVIEW

Test	PT-1	PT-2	PT-3	PT-4*	PT-5*
Month	June	July	August	Jan.	March
Pressure, psig	500	500	500	300	500
Peat Fed to Gasifier, tons	30	100	100	150	200
Peat Feed Rate Dry, tons/hr	0.5-1.0	1.0-1.5	0.5-1.75	1.0-2.0	1.0-2.0
Moisture, wt %	5-10	5-10	5-10	10-20	15-30
Hydrogasifier Temp (Max), °F	910-960	1060-1140	1060-1190	940-1080	910-990
Char Gasifier Temp (Max), °F	1050-1200	1450-1550	1500-1650	1650-1725	1550-1675
Steam/Carbon Ratio, molar	3.9-5.9	2.6-6.2	1.8-5.4	1.0-2.1	1.4-2.7
Oxygen/Carbon Ratio, molar	--	0.13-0.21	0.17-0.30	0.12-0.18	0.11-0.18
Peat Conversion (MAF), %	73-74	89-98	91-99	92-98	85-94

* Preliminary data.

Table 2. TYPICAL MINNESOTA PEAT SCREEN AND CHEMICAL ANALYSIS

Screen Analysis, U.S.S., wt%	
+10	0.0
+20	3.2
+30	37.1
+40	27.8
+60	22.3
+80	6.9
+100	0.9
+200	0.6
-200	1.2
Total	100
Bulk Density, lb/ft^3	28.6
Moisture, wt %	23.0
Chemical Analysis	
Proximate, wt %	
Moisture	23.0
Volatile Matter	45.8
Fixed Carbon	17.8
Ash	13.4
Total	100.0
Ultimate (Dry), wt %	
Carbon	48.2
Hydrogen	5.0
Sulfur	0.3
Nitrogen	2.2
Oxygen (by Difference)	27.0
Ash	17.3
Total	100.0

Table 3. TYPICAL PRODUCT GAS ANALYSIS

Composition (Dry),* mol %	
Hydrogen	38.0
Carbon Monoxide	16.4
Methane	10.4
Carbon Dioxide	34.9
Ethane	0.3
Hydrogen Sulfide	--
Total	100.0

* Nitrogen- and oil-free.

Typical feed carbon distribution is 65-75 wt % to the gas, 20-30 wt % to the light oil and 5 to 10 wt % to the ash. Operation of the hydrogasifier zone at higher temperatures (>1250°F) will result in higher methane production and lower oil yields. The oil composition, however, will shift to lower boiling point fractions, which are a more desirable gasoline blending feedstock.

Table 4. TYPICAL OIL BOILING POINT DISTRIBUTION

	- wt % -
C_5 - 200°F	11.9
200 - 400°F	37.6
+400°F	50.5

CONCLUSION

The successful pilot plant program resulted in an extensive data base. A range of operating conditions were covered to study the effect of major gasifier parameters on product yield and composition. These included —

Char Gasifier Temperature, °F	1450-1725
Hydrogasifier Temperature, °F	910-1190
Steam/Carbon Feed Ratios, molar	1.0-5.9
Peat Feed Rate, tons/hr	0.5-2.0
Peat Moisture Content, wt %	5-30
Peat Conversion, (MAF) %	73-99

The technical feasibility of the PEATGAS process has been demonstrated on a pilot plant scale. The data obtained represent a significant data base for scale-up to commercial operation. Additional data are desirable at steam/carbon ratios of 0.7 and higher hydrogasifier temperatures (up to 1400°F), which will maximize the production of methane in the gasifier and improve oil quality. These data would further improve the economics of the PEATGAS process. The experience gained, to date, has shown that peat is highly reactive and an excellent feed material for hydrogasification to substitute natural gas.

ACKNOWLEDGMENT

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