EXPERIMENTAL PROGRAM FOR THE DEVELOPMENT OF PEAT GASIFICATION

Project 65003

Monthly Status Report

For the Period February 1 Through February 28, 1981

Submitted by
MINNESOTA GAS COMPANY
733 Marquette Avenue
Minneapolis, Minnesota 55402

Prepared by
Institute of Gas Technology
IIT Center, 3424 S. State Street
Chicago, Illinois 60616

Prepared for the

UNITED STATES DEPARTMENT OF ENERGY

Under Contract No. EX-76-C-01-2469

DISCLAIMER

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The work described in this report was conducted by the Institute of Gas Technology under subcontract to Minnesota Gas Company.

ABSTRACT

In Task 1 (Single-Stage Fluidized-Bed Gasification Tests), we conducted one test with Minnesota peat in the process development unit (PDU), using steam and oxygen. The test was conducted at a pressure of 268 psia, a fluidization velocity of 1.0 ft/s, and an average bed temperature of 1680°F. The objective of this test was to determine the effects of high feed moisture content (22-weight-percent moisture) and low gasification pressure on the gasification characteristics of peat. Most of the previous tests had been conducted at a nominal pressure of 500 psia. The test was successful; about 1 hour of steady-state operation was achieved before sintering began and the test was ended.

The results of one test conducted previously with Minnesota peat containing about 8-weight-percent moisture were analyzed and are presented this month. The test was conducted at an average bed temperature of 1700°F, a pressure of 522 psia, and a steam-to-carbon feed ratio of 1.1 mol/mol; it achieved a carbon conversion of about 84%.

In Task 2 (Wet-Carbonization PDU-Scale Tests), we continued placing orders for long-lead-time equipment for the PDU. The design and specifications for the slurry heater/cooler system and the shell-and-tube heat exchangers have been finalized. The installation of the instrumentation and the control panel for the PDU is continuing.

In Task 3 (Kinetic Data on Alaska and Florida Peats), we continued efforts to obtain representative samples of peats from Alaska and Florida. A sample of Florida reed-sedge peat has been obtained and is being analyzed. Samples of Alaskan peat have been taken by the company conducting the U.S. Department of Energy (DOE) peat resource assessment work; however, they have not yet been received.

In Task 4 (Effect of Dewatering Methodology on Peat Gasification), we continued efforts to obtain peat dewatered by various methods.

OPEN ITEMS

No critical technical or management problems occurred during February.

ACHIEVEMENT OF PROJECT OBJECTIVES

The overall objective of the program is to conduct laboratory and PDU-scale research on converting peat to substitute natural gas (SNG).

Under the joint sponsorship of the U.S. Department of Energy, Gas Research Institute, Minnesota Gas Company, and Northern Natural Gas Company, work is being conducted on four tasks: Single-Stage Fluidized-Bed Gasification (Task 1), Wet-Carbonization PDU-Scale Tests (Task 2), Kinetic Data on Alaska and Florida Peats (Task 3), and Effect of Dewatering Methodology on Peat Gasification (Task 4).

The objectives of Task 1 initiated on August 15, 1980, are to conduct experiments to determine the kinetic parameters necessary for designing a large-scale, single-stage fluidized-bed gasifier that uses steam and oxygen, and to estimate the economics of converting peat to synthesis gas and SNG by this method.

Achievements in this task include the following. Nine tests have been conducted in a fluidized-bed PDU with Minnesota peat in the following parameter ranges: average bed temperatures from 1570° to 1765°F, pressures from 268 to 544 psia, steam/carbon feed ratios from 0.6 to 3.6 mol/mol, and moisture contents from 7 to 25 weight percent.

The objectives of Task 2 of the current program initiated on September 30, 1980, are to —

- Design, construct, and operate a continuous wet-carbonization PDU to obtain the kinetic data necessary to design a system for the wet carbonization of peat
- Conduct experiments to determine the effects of operating conditions during wet carbonization on mechanical dewatering and on the hydrogasification characteristics of wet-carbonized peat
- Estimate the economics of using wet carbonization to produce peat containing 50-weight-percent moisture, and the economics of converting the peat to SNG by the PEATGAS™ process.*

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* The Institute of Gas Technology (IGT) offers PEATGAS research and development, engineering, and technical services relating to the PEATGAS process.

Achievements in this task include the following. The design of a continuous wet-carbonization PDU is proceeding on schedule. Site preparation and the construction of the support framework for the heat exchangers and wet-carbonization reactors have been completed.

The objective of Task 3 initiated on January 1, 1981, is to conduct tests with peats from Alaska and Florida to generate the kinetic data necessary for designing large-scale reactors for hydrogasification and char gasification. Peat samples are being obtained for analyses in order that a representative peat from Alaska and Florida can be selected.

The objective of Task 4 initiated on January 1, 1981, is to determine the effect of dewatering methodology on the gasification characteristics of peat. The sources of dewatered peat include the following:

- Wet Minnesota peat mechanically dewatered in a Sulzer belt press, then thermally dried at 300°F in a Sulzer fluidized-bed dryer
- Wet Minnesota peat mechanically dewatered in a Sulzer belt press, then thermally dried at 250°F in a tray dryer
- Sod-harvested, air-dried North Carolina peat from First Colony Farms
- Minnesota peat dewatered by IGT's solvent extraction process using two preferred solvents at the preferred operating conditions of each.

The North Carolina sod peat has been obtained for testing.

DETAILED MONTHLY TECHNICAL PROGRESS REPORT

Task 1. Single-Stage Fluidized-Bed Gasification Tests

This month we conducted one test, Run BF-9, using steam and oxygen in the 6-inch-diameter PDU with Minnesota peat containing about 22-weight-percent moisture. The test was conducted at a pressure of 268 psia, an average bed temperature of 1680°F, a steam-to-carbon feed ratio of 0.6 mol/mol, and a fluidization velocity of 1.02 ft/s. The objective of this test was to determine the effects of high feed moisture content and lower pressure on the gasification characteristics of Minnesota peat. Most of the previous tests had been conducted at pressures of about 500 psia.

The test was operationally successful. Sintering began, however, after about 1 hour of steady-state operation had been achieved and so the test was ended. Sintering began when pieces of refractory from the reactor shell-top

closure settled on top of the feed gas distributor and obstructed the feed gas flow. A total of 210 pounds of dry peat was fed at an average rate of 56 lb/hr during the 4-hour duration of Run BF-9.

A summary of the key operating conditions and some preliminary results of this test are shown in Table 1. More detailed information on the operating conditions and the results of Run BF-9 will be presented when analyses of the test solids, liquids, and gas samples are completed. The complete results of Run BF-6, conducted previously, are presented in Table 2; the chemical and screen analyses of the feed and residue from this test are presented in Table 3.

The results of Run BF-6 show that, with an average bed temperature of 1700°F, pressure of 522 psia, steam-to-carbon feed ratio of 1.1 mol/mol, and fluidization velocity of 0.77 ft/s, the total carbon conversion achieved was 83.8% of the feed carbon. The yield of carbon monoxide was 13.8% of the feed carbon; the yield of hydrocarbon gases was 4.9% of the feed carbon. The hydrocarbon liquids product accounted for 1.1% of the feed carbon.

Next month we will conduct tests to determine the effect of decreasing the amount of steam fed to the reactor on the gasification characteristics of Minnesota peat.

Task 2. Wet-Carbonization PDU-Scale Tests

We continued preparing the design of the peat wet-carbonization PDU. The design and specifications for the slurry heater/cooler system and the shell-and-tube heat exchangers have been finalized. We have begun placing orders for the short-lead-time equipment. Work on installing the instrumentation and control panel for the PDU is continuing.

Task 3. Kinetic Data on Alaska and Florida Peats

Samples of peats from Alaska and Florida are being obtained for analysis before being ordered in bulk quantity for PDU tests. Two samples of Alaskan peat are in transit to IGT. They were obtained from near Nancy Lake and from Rogers Creek by Nortec, Inc., the company conducting the DOE peat resource assessment work in Alaska.

Table 1. PRELIMINARY RESULTS OF FLUIDIZED-BED GASIFICATION OF MINNESOTA PEAT WITH STEAM AND OXYGEN

Run No.	BF-9
Feed Moisture Content, wt %	22
Peat Sieve Size, U.S.S.	−10+100
Steady-State Operating Period, min	60
Operating Conditions	
Pressure, psia	268
Average Temperature, °F	
Whole Bed	1680
Bottom of Bed (6 in. above distributor)	1705
Bed Height (Standpipe), in.	34
Superficial Fluidization Velocity, ft/s	
Reactor Bed	1.02
Peat Feed Inlet	1.19
Peat Feed (Dry) Rate, lb/hr	56
Gas Feed Rate, SCF/hr	
Nitrogen	2475
Oxygen	374
Steam	500
Gas/Carbon Feed Ratios, mol/mol	
Oxygen	0.43
Steam	0.6
Sinter Formation	Yes

Table 2. OPERATING CONDITIONS AND RESULTS OF MINNESOTA PEAT STEAM-OXYGEN GASIFICATION TESTS PERFORMED IN A 6-INCH REACTOR

Run No.	BF-6
Feed Material	Minnesota Peat
Feed Source	Dried by MEC Co.
Sieve Size, U.S.S.	−20+100
Duration of Test, hr	5
Steady-State Operating Period, min	125
Operating Conditions	
Standpipe and Peat Bed Height, in.	34
Standpipe OD, in.	1-1/2
Reactor Pressure, psia	522
Reactor Temperature, °F	
Internal, Distance From Tube Bottom, in.	
10	1680
14	1730
20	1700
26	--
34	1695
40	1685
55	1620
73	1605
Average Bed Temperature, °F	1700
Feed Gas Distributor,[a] no. of feed ports	6
Fluidizing Gas Distributor,[b] no. of feed ports	6
Peat Feed Rate,[c] lb/hr	37.1
Nitrogen Rate (Feed Gas), SCF/hr	2280
Oxygen Rate, SCF/hr	312
Oxygen Concentration in Feed Gas, mol %	6.4
Oxygen/Peat Ratio, SCF/lb	8.4
Oxygen/Carbon Ratio, mol/mol	0.56
Steam Rate, lb/hr	29.1
Steam/Peat Ratio, lb/lb	0.8
Steam/Carbon Ratio, mol/mol	1.1
Nitrogen Rate, SCF/hr	
Fluidizing Gas	1230
Feed Screw	238
Feed Hopper Extension	232
Purge (Shell)	213
Fluidized-Bed Density, lb/ft^3	7.8
Peat Residence Time,[e] min	25.1
Superficial Fluidization Velocity, ft/s	
Reactor Bed[f]	0.77
Peat Feed Inlet[g]	0.67
Operating Results	
Product Gas Rate[h] (Shell Purge Nitrogen-Free), SCF/hr	4530
Product Gas Yield (Nitrogen-Free), SCF/lb dry peat	14.8
Hydrogen Yield, SCF/lb dry peat	2.6
Carbon Monoxide Yield, % of feed carbon	13.8
Carbon Dioxide Yield, % of feed carbon	64.0
Hydrocarbon Gas Yield, % of feed carbon	4.9
Residue Char Rate,[i] lb/hr	9.3
Bayonet Filter Fines Rate, lb/hr	1.9
Sintered Ash (Total), lb	Nil
Sintered Ash Rate,[j] lb/hr	--
Condensed Liquid Rate,[k] lb/hr	
Water	36.7
Oils	0.3
Net Peat Gasified (MAF), % of feed	83.5
Carbon Gasified, % of feed carbon	82.7
Total Carbon Conversion, % of feed carbon	83.8
Steam Reacted, % of steam fed	Nil
Steam Concentration in Product Gas, mol %	14.5

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Table 2, Cont. OPERATING CONDITIONS AND RESULTS OF MINNESOTA PEAT STEAM-OXYGEN GASIFICATION TESTS PERFORMED IN A 6-INCH REACTOR

	BF-6
Material Balances, %	
Overall	100.8
Carbon	102.1
Hydrogen	92.3
Oxygen	103.0
Product Gas Composition (Shell Purge Nitrogen-Free), mol %	
Nitrogen	81.9
Carbon Monoxide	1.7
Carbon Dioxide	7.9
Hydrogen	2.1
Methane	0.4
Ethane Plus Ethylene	Trace
Propane Plus Propylene	0.0
Butanes Plus Pentanes	0.0
Benzene	Trace
Total	100.0
Heating Value,[m] Btu/SCF	24.6
Specific Gravity, (air = 1.000)	0.992

[a] Consists of a 4-3/8-inch-diameter torus made of 1/2-inch-diameter tubing. Each port diameter is 1/8 inch. Located 6-3/4 inches above the reactor tube bottom.

[b] Consists of a 3-inch-diameter torus made of 3/8-inch-diameter tubing. Each port diameter is 0.0995 inch. Located 22 inches below the feed gas distributor.

[c] Operating conditions and results are based on weight of dry feed.

[d] To convey peat from the feed screw discharge up into the reactor bottom.

[e] (Fluidized-bed density)(peat bed volume)/(residue char plus bayonet filter fines rate from reactor).

[f] Based on feed gas flow rates: (CF/s at reactor temperature and pressure)/(reactor annulus cross-sectional area).

[g] Based on fluidizing nitrogen plus feed screw and feed hopper extension nitrogen.

[h] Dry gas volume in SCF at 60°F, 30-inch Hg pressure.

[i] By ash balance.

[j] Not included in steady-state material balance calculations.

[k] Based on weight of liquid recovered.

[m] Gross: Gas saturated at 60°F, 30-inch Hg pressure.

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Table 3. CHEMICAL AND SCREEN ANALYSIS OF THE FEED AND RESIDUE FROM A MINNESOTA PEAT STEAM-OXYGEN GASIFICATION TEST PERFORMED IN A 6-INCH REACTOR

Run No.	BF-6		
	Peat Feed	Residue	Filter Fines
Proximate Analysis, wt %			
Moisture	7.7	0.7	2.7
Volatile Matter	54.4	21.3	22.1
Fixed Carbon	21.4	18.6	18.5
Ash	16.5	59.4	56.7
Total	100.0	100.0	100.0
Ultimate Analysis (dry), wt %			
Carbon	47.80	29.20	28.80
Hydrogen	5.05	1.95	2.02
Nitrogen	2.23	1.05	1.34
Oxygen	26.78	7.87	9.18
Sulfur	0.26	0.15	0.37
Ash	17.88	59.78	58.29
Total	100.00	100.00	100.00
Screen Analysis, U.S.S., wt %			
+12	0.0	0.0	0.2
+20	0.2	0.3	0.7
+30	4.0	2.6	0.5
+40	9.7	7.2	0.7
+60	26.6	19.2	1.6
+80	16.6	17.3	1.8
+100	12.2	15.9	2.8
+200	17.6	16.1	13.3
+325	7.4	4.8	30.3
−325	5.7	16.6	48.1
Total	100.0	100.0	100.0
Bulk Density, lb/ft^3	22.0	39.0	28.9
Gross Heating Value, Btu/lb	8019	4852	4745

Task 4. Effect of Dewatering Methodology on Peat Gasification

The North Carolina sod peat has been obtained for testing. We plan to begin PDU-scale hydrogasification and laboratory-scale char-gasification tests with North Carolina sod peat next month.

PATENT STATUS

The work conducted during February is not considered patentable.

TIME SCHEDULE

Figure 1 shows the schedule for the overall program. We are behind schedule in Tasks 3 and 4, because securing representative bulk samples of Alaska and Florida peats and peats dewatered by various methods has taken more time than anticipated. The overall cost or schedule of the program will not be affected by the delay.

Signed W. W. Bodle

W. W. Bodle, Director
Process Analysis

Signed D V Punwani

D. V. Punwani, Assoc. Director
Chemical Processing Research

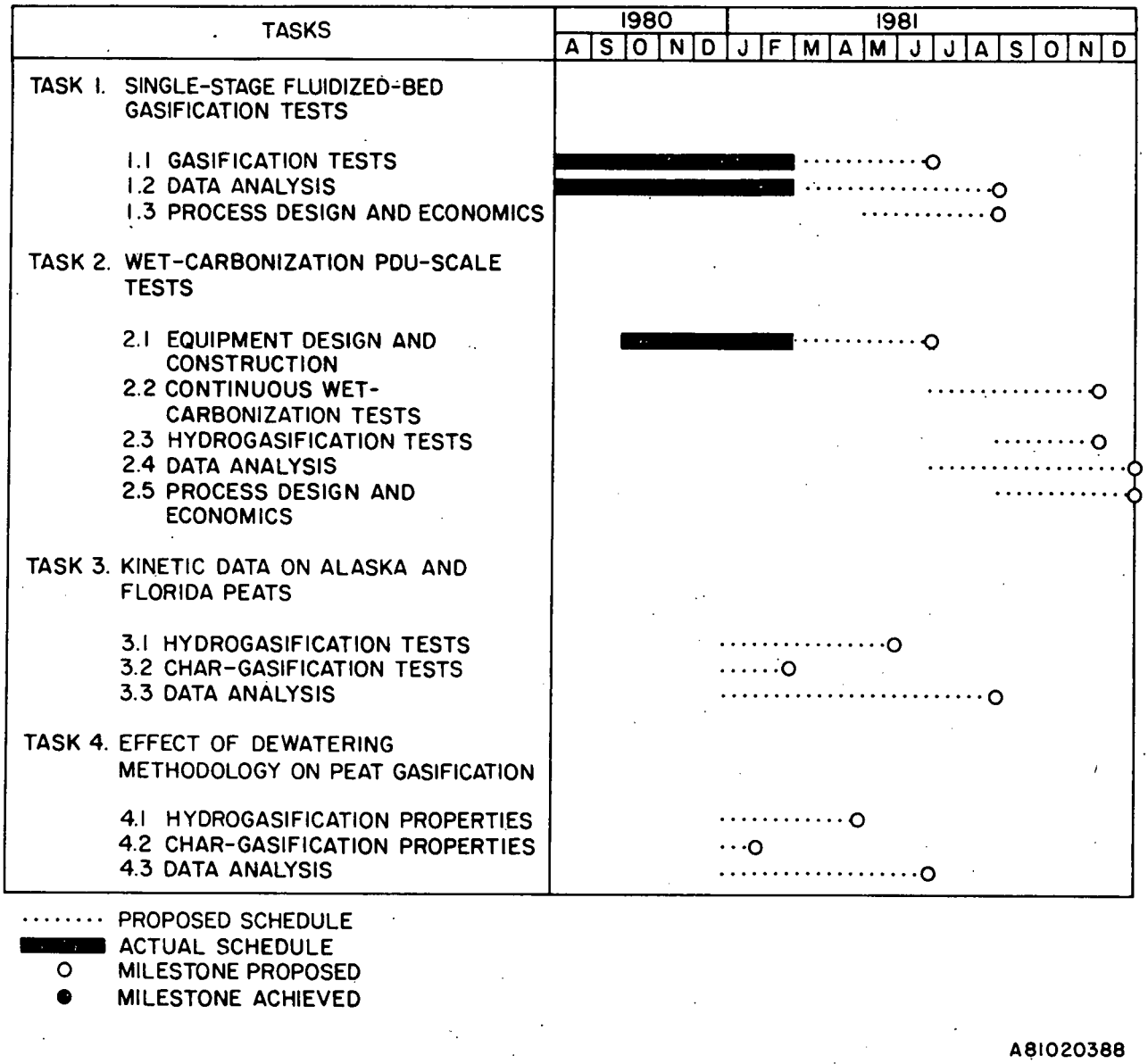

Figure 1. MILESTONE CHART FOR THE PEAT GASIFICATION PROGRAM

LS/MM/wpc