DR. 2920

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FOSSIL ENERGY

PIPELINE GAS FROM COAL—HYDROGENATION (IGT HYDROGASIFICATION PROCESS)

Project 9000 Quarterly Report No. 9 for July 1—September 30, 1978

MASTER

March 1979
Date Published

Work Performed Under Contract No. EX-76-C-01-2434

Institute of Gas Technology
IIT Center
Chicago, Illinois

U. S. DEPARTMENT OF ENERGY

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Prepared by
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IIT Center, 3424 S. State Street
Chicago, Illinois 60616

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SUMMARY

The objective of this project is to perform the necessary pilot plant operations and related support studies to acquire data for a commercial/ demonstration plant design based on the HYGAS® Process. To this end, tests are being conducted with Illinois bituminous coal to acquire data for optimizing the process. This quarterly covers the work conducted between July 1 and September 30, 1978.

Pilot Plant Operations

The entire HYGAS plant was shut down and the plant operating personnel took their annual vacations during the first 2 weeks of July. Annual plant maintenance, repairs, and cleanup were carried out, as were repairs made necessary by the June 22 fire in Chem Systems' liquid-phase methanation unit.

Modifications made in the pilot plant prior to Test 74 include —

- A new perforated baffle plate installed beneath the pretreater grid distributor to improve gas distribution and dampen pulsating gas flows in the pretreater reactor
- A new high-level alarm installed to aid in the operation of the slurry mix tank
- A new sonic flowmeter device installed to measure the char/oil slurry flow to the HYGAS reactor
- Changes in the steam-oxygen gasifier to test alternative gas distribution systems
- New thermowells installed in the superheated steam feed lines to the reactor.

Test 74 was conducted during this reporting period. The new steam-oxygen gas distributor and the fluidizing steam distributor were tested in the steam-oxygen gasifier for their effects on its operation. Temperature measurements below the steam-oxygen distributor indicate that at higher steam feeds to the fluidizing steam distributor, solids mixing was significantly improved. Twenty-one days of continuous self-sustained operation were logged, breaking all previous records and accumulating over 200 hours of steady-state operation.

The entire HYGAS pilot plant was inspected following Test 74. Immediately after Test 74, the reactor and related piping and vessels were successfully pressure-tested at 1000 pounds as a preliminary procedure for Test 75

high-pressure operations. Routine maintenance and turnaround activities were completed, and Test 75 light-off occurred at 0130 hours, September 24. A leak on the prequench tower manway forced the reduction of reactor temperature and pressure; and, at the same time, line valve 321 became uncontrollable. Both these problems were solved, and the reactor was relighted at 1200 hours on September 29.

Additional data, included in this report, were supplied to Procon, Inc., to aid in its design of a commercial/demonstration HYGAS plant. Work continued on the cold-flow model of the upper stage of the HYGAS reactor, details of which are presented in this report. Pretreater and gasifier material balances and engineering data from Test 70 are also included.

INTRODUCTION

This report covers work done between July 1 and September 30, 1978, under United States Department of Energy (DOE) Contract No. EF-77-C-01-2434.

Tasks 1 through 6, which concerned demonstrating the feasibility of using lignite, bituminous, and subbituminous coal feedstocks in the HYGAS pilot plant, were completed between July 1, 1976, and June 30, 1977, and are reported in Project 9000 Interim Report No. 1 (DOE Report No. FE-2434-23). Work done since July 1, 1977, has involved Tasks 7 through 9, which are detailed in this report.

Data supporting the demonstration plant program were supplied to Procon, Inc., and to DOE during this quarter. These data are presented in this report.

ACHIEVEMENTS

Task 7. Pilot Plant Experimental Operations

Material and energy balances for Test 70 are presented in Tables 1 through 3 and in Figures 1 through 11. For the pretreater, char was calculated by ash balance and quench water effluent was calculated by oxygen balance. During Test 70, the reactor consistently achieved char conversions of over 90% for 39 hours under smooth operating conditions. Three hundred twenty-one tons of bituminous coal were processed through the pretreater, and 279 tons of pretreated char were fed to the reactor.

The entire HYGAS plant was shut down, and the HYGAS plant operating personnel took their annual vacations during the first 2 weeks of July. Annual maintenance, modifications, repairs, and cleanup were carried out.

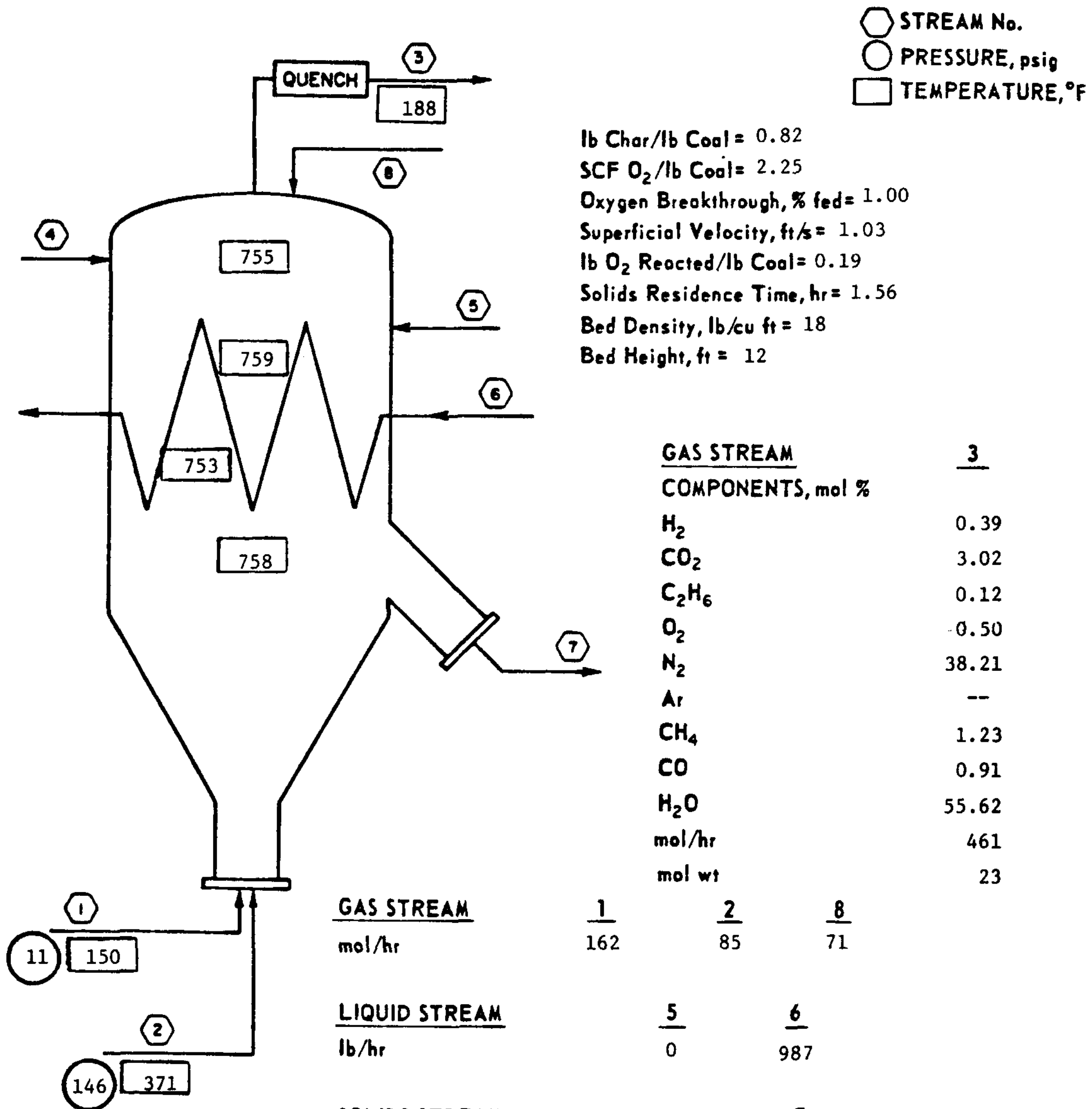
The coal preparation section was given routine maintenance, was cleaned, and put on standby. The pretreater section was cleaned after Test 73. A new perforated baffle plate was installed beneath the pretreater grid distributor to improve gas distribution and dampen pulsating gas flows in the pretreater reactor. The baffle plate was then tested and showed improved gas distribution in the pretreater; the pretreater was put on standby and readied for operation. The slurry system was also cleaned. Slurry mix tank 3.06-41 was drained and cleaned out, and a new high-level alarm was installed to aid its operation. Slurry piping in the slurry section was X-rayed. Four fittings had eroded and were replaced. A new sonic flowmeter device was installed in this section to measure the char/oil slurry flow to the HYGAS reactor. Routine maintenance was performed on the slurry pump and the slurry mix tank agitators.

The reactor was cleaned and readied for maintenance. The sealing surface of manway 0 on top of the reactor and the start-up burner were reclad and resurfaced by Grayserv technicians during this plant turnaround period. The steam-oxygen gasifier is being modified to test alternative gas distribution systems. The new steam-oxygen gas distributor is a six-nozzle pipe distributor without cones (Figure 12); each pipe nozzle is beveled at the output end to an angle of 30 degrees from the vertical. The stripping steam distributor was also modified and relocated directly below the steam-oxygen distributor in the 24-inch section instead of in the 12-inch section (Figure 13). These changes were made to improve fluidization around the steam-oxygen gas distributor, thus

Table 1. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 70 FROM 2/23/78 (2000 Hours) TO 2/24/78 (0500 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.09	4.98	9.64	1.04	4.20		10.05	100
	Coal (Dry)	4015	285	552	60	241		576	5729
	Moisture		46	367					413
Streams to Pretreater	Air			1087	3540		61		4688
	Steam		171	1355					1526
Air From Purges				9	29				38
H_2O to Venturi Scrubber			746	5923					6669
H_2O to Quench Tower			318	2522					2840
Nitrogen from Purges					377				377
Nitrogen to Char Cooler					422				422
Cooling Water to Char Cooler			112	890					1002
TOTAL INPUT		4015	1678	12,705	4428	241	61	576	23,704
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	70.42	3.61	8.60	1.26	4.09		12.02	100
	Char (Dry)	2945	151	360	53	171		503	4183
	Moisture		7	53					60
Slurry Waste From Quench	Wt % (Dry)	68.50	3.48	10.55	1.08	3.65		12.74	100
	Solids (Dry)	392	20	60	6	21		73	572
	Tars & Oils	118	12	9	1	4			144
	H_2O & Disc Materials	26	958	7599	1	13			8597
Quench Tower Off-Gas	Total	299	546	4624	4930		61		10,460
	Components:								
	H_2		4						4
	CO_2	167		445					612
	C_2H_6	13	3						16
	N_2				4930				4930
	CH_4	68	23						91
	CO	51		67					118
	O_2			13					13
	Ar						61		61
	H_2O		516	4099					4615
TOTAL OUTPUT		3780	1694	12,705	4991	209	61	576	24,016
Net (Output − Input)		−235	16	0	563	−32	0	0	312
% Balance (Output/Input)		94	101	100	113	87	100	100	101



lb Char/lb Coal = 0.82
SCF O_2/lb Coal = 2.25
Oxygen Breakthrough, % fed = 1.00
Superficial Velocity, ft/s = 1.03
lb O_2 Reacted/lb Coal = 0.19
Solids Residence Time, hr = 1.56
Bed Density, lb/cu ft = 18
Bed Height, ft = 12

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.39
CO_2	3.02
C_2H_6	0.12
O_2	0.50
N_2	38.21
Ar	--
CH_4	1.23
CO	0.91
H_2O	55.62
mol/hr	461
mol wt	23

GAS STREAM	1	2	8
mol/hr	162	85	71

LIQUID STREAM	5	6
lb/hr	0	987

SOLIDS STREAM	4	7
lb/hr	5729	4183

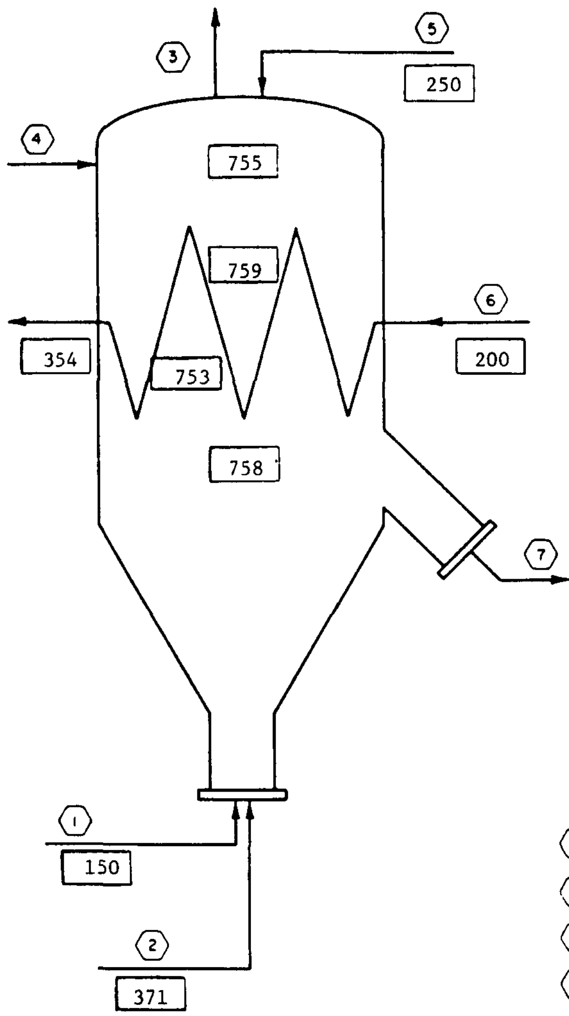
1. AIR TO PRETREATER
2. STEAM TO PRETREATER
3. PRETREATER OFF-GAS AFTER QUENCH
4. RAW COAL TO PRETREATER
5. DIRECT WATER QUENCH
6. COOLING WATER TO COOLING COIL IN PRETREATER
7. PRETREATER CHAR TO CHAR COOLER
8. GAS FROM CHAR COOLER

Figure 1. PRETREATMENT DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/23/78 (2000 Hours) TO 2/24/78 (0500 Hours)

◯ Stream No. ▭ Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.



INPUT	Btu
Sensible Heat (Streams 1, 2, 4, 5, 6)	488,977
Heat of Combustion (Stream 4)	72,283,709
Steam Enthalpy (Streams 2 & 5)	2,807,000
Total	75,579,686
OUTPUT	
Sensible Heat (Streams 3 & 7)	4,444,087
Heat of Combustion (Streams 3 & 7)	62,750,479
Steam Enthalpy (Streams 3 & 6)	5,996,641
Total	73,191,207
% Balance	97

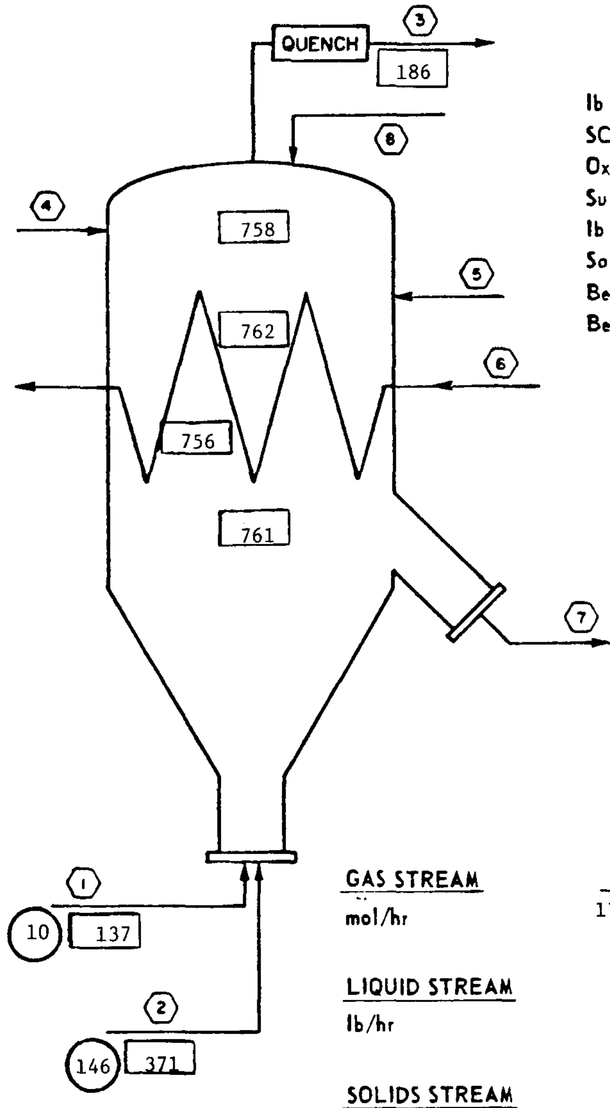
1. Air to Pretreater
2. Steam to Pretreater
3. Pretreater Overhead
4. Raw Coal to Pretreater
5. Gas From Char Cooler
6. Cooling Water to Cooling Coil in Pretreater
7. Pretreated Char to Char Cooler

Figure 2. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 70 FOR STEADY PERIOD FROM 2/23/78 (2000 Hours) TO 2/24/78 (0500 Hours)

Table 2. MATERIAL BALANCE SUMMARY FOR PRETREATER SECTION FOR TEST 70 FROM 2/22/78 (1800 Hours) TO 2/23/78 (0230 Hours)

BASIS: 1 hr. All units in pounds unless otherwise noted.

INPUT		C	H	O	N	S	Ar	ASH	TOTAL
Coal Feed	Wt % (Dry)	69.86	4.90	9.49	1.09	4.30		10.36	100
	Coal (Dry)	3610	253	491	56	222		535	5167
	Moisture		42	337					379
Streams to Pretreater	Air			1161	3783		65		5009
	Steam		190	1509					1699
Air From Purges				9	29				38
H_2O to Venturi Scrubber			920	7302					8222
H_2O to Quench Tower			373	2958					3331
Nitrogen from Purges					406				406
Nitrogen to Char Cooler					423				423
Cooling Water to Char Cooler			85	674					759
TOTAL INPUT		3610	1863	14,441	4697	222	65	535	25,433
OUTPUT									
Pretreated Char to Gasifier	Wt % (Dry)	70.20	3.44	8.89	1.04	3.91		12.52	100
	Char (Dry)	2641	129	334	39	147		471	3761
	Moisture		8	65					73
Slurry Waste From Quench	Wt % (Dry)	68.88	3.32	10.41	1.21	3.59		12.59	100
	Solids (Dry)	352	17	53	6	18		64	510
	Tars & Oils	119	12	11	1	4			147
	H_2O & Disc Materials	36	1173	9305	1	11			10,526
Quench Tower Off-Gas	Total	336	516	4673	5231		65		10,821
	Components:								
	H_2		6						6
	CO_2	220		588					808
	C_2H_6	10	3						13
	N_2				5231				5231
	CH_4	33	11						44
	CO	73		98					171
	O_2			50					50
	Ar						65		65
	H_2O		496	3937					4433
TOTAL OUTPUT		3484	1855	14,441	5278	180	65	535	25,838
Net (Output — Input)		−126	−8	0	581	−42	0	0	405
% Balance (Output/Input)		97	100	100	112	81	100	100	102



STREAM No.
PRESSURE, psig
TEMPERATURE, °F

lb Char/lb Coal = 0.81
SCF O_2/lb Coal = 2.66
Oxygen Breakthrough, % fed = 4.00
Superficial Velocity, ft/s = 1.12
lb O_2 Reacted/lb Coal = 0.22
Solids Residence Time, hr = 1.70
Bed Density, lb/cu ft = 18
Bed Height, ft = 12

GAS STREAM	3
COMPONENTS, mol %	
H_2	0.62
CO_2	3.93
C_2H_6	0.09
O_2	0.77
N_2	39.99
Ar	--
CH_4	0.59
CO	1.31
H_2O	52.70
mol/hr	467
mol wt	23

GAS STREAM	1	2	8
mol/hr	173	94	57

LIQUID STREAM	5	6
lb/hr	0	1968

SOLIDS STREAM	4	7
lb/hr	5167	3761

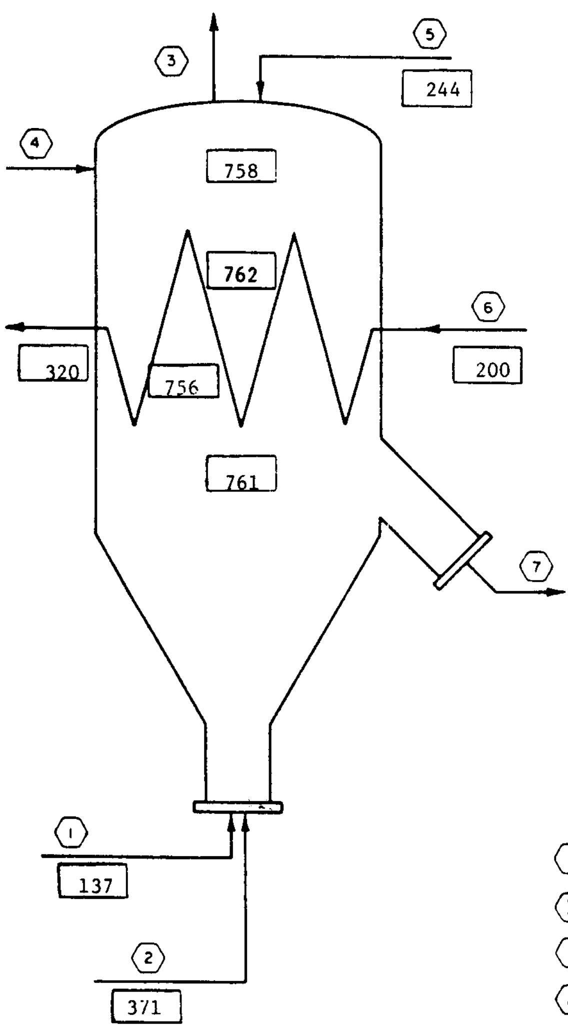
1. AIR TO PRETREATER
2. STEAM TO PRETREATER
3. PRETREATER OFF-GAS AFTER QUENCH
4. RAW COAL TO PRETREATER
5. DIRECT WATER QUENCH
6. COOLING WATER TO COOLING COIL IN PRETREATER
7. PRETREATER CHAR TO CHAR COOLER
8. GAS FROM CHAR COOLER

Figure 3. PRETREATMENT DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/22/78 (1800 Hours) TO 2/23/78 (0230 Hours)

Stream No. Temperature, °F

Basis: 1 hour

Datum Condition: 77°F, 1 atm, material in standard state.



INPUT	Btu
Sensible Heat (Streams 1, 2, 4, 5, 6)	545,453
Heat of Combustion (Stream 4)	64,817,021
Steam Enthalpy (Streams 2 & 5)	2,750,800
Total	68,113,274
OUTPUT	
Sensible Heat (Streams 3 & 7)	4,297,750
Heat of Combustion (Streams 3 & 7)	55,610,066
Steam Enthalpy (Streams 3 & 6)	6,654,462
Total	66,562,278
% Balance	98

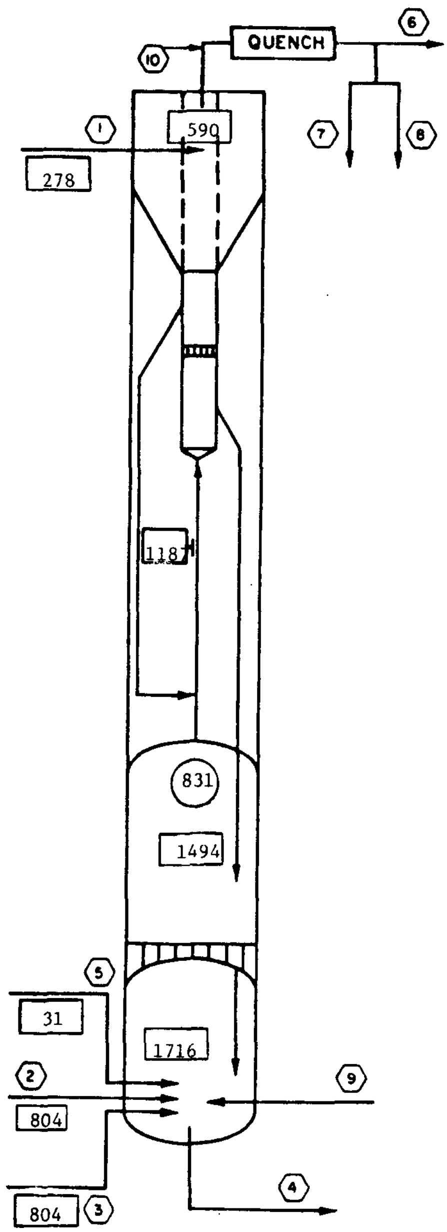
1. Air to Pretreater
2. Steam to Pretreater
3. Pretreater Overhead
4. Raw Coal to Pretreater
5. Gas From Char Cooler
6. Cooling Water to Cooling Coil in Pretreater
7. Pretreated Char to Char Cooler

Figure 4. PRETREATER HEAT BALANCE DATA SHEET FOR TEST 70 FOR STEADY PERIOD FROM 2/22/78 (1800 Hours) TO 2/23/78 (0230 Hours)

Table 3. MATERIAL BALANCE SUMMARY FOR HYGAS GASIFIER FOR TEST 70 FROM 2/23/78 (1800 Hours) TO 2/24/78 (0500 Hours)

Basis = 1 hour. All units in pounds unless noted otherwise.

INPUT		C	H	O	N	S	ASH	TOTAL
Coal Feed	Wt % (Dry)	70.77	3.58	8.89	1.26	3.92	11.58	100
	Coal (Dry)	4260	215	535	76	236	697	6019
	Moisture		10	80				90
Sparger	Oxygen			1094				1094
	Steam		910	7220				8130
Burner	Oxygen			0				0
	Steam		0	0				0
	Hydrogen		0					0
Stripping Ring	Steam		121	964				1085
Nitrogen From Purges					629			629
Pump Seal Flush			74	593				667
Water to Cyclone Pot			667	5293				5960
Light Oil In		13,658	1288					14,946
TOTAL INPUT		17,918	3285	15,779	705	236	697	38,620
OUTPUT								
Reactor Overhead	Wt % (Dry)	74.33	2.80	4.65	1.10	2.91	14.21	100
	Dust (Dry)	1454	55	91	21	57	278	1956
Spent Char	Wt % (Dry)	25.36	0.42	0	0.34	0.27	73.61	100
	Char (Dry)	145	2	0	2	2	419	570
Product Gas After Quench	Total (Dry)	1508	293	2473	595	50		4919
	Components H_2		148					148
	CO_2	777		2072				2849
	C_2H_6	16	4					20
	H_2S		3			50		53
	N_2				595			595
	CH_4	414	138					552
	CO	301		401				702
Water Out + Dissolved Materials		52	1556	12,273	40	36		13,957
Toluene Storage Tank Vent Gases		215	16	446	42	12		751
Stripper Vent Gas		58	5	92	9	3		167
Light-Oil Out		14,118	1332					15,450
Estimated Oil Losses		--	--					--
TOTAL OUTPUT		17,550	3259	15,395	709	160	697	37,770
Net (Output - Input)		–368	–26	–384	4	–76	0	–850
% Balance (Output/Input)		98	99	98	101	68	100	98



STREAM No.
PRESSURE, psig
TEMPERATURE, °F

MATERIAL BALANCE, %

C	98
H	99
O	98
ASH	100

	GAS STREAMS	
	6	10
mol % (dry)		
H_2	33.40	30.83
CO_2	29.18	33.06
C_2H_6	0.30	0.36
N_2	9.58	9.32
H_2S	0.70	0.82
CH_4	15.53	15.14
CO	11.31	10.46
mol/hr (dry)	222	247

	SOLIDS STREAMS		
	1	10	4
wt % (dry)			
C	70.77	74.33	25.36
H	3.58	2.80	0.42
N	1.26	1.10	0.34
S	3.92	2.91	0.27
ASH	11.58	14.21	73.61
O	8.89	4.65	0
lb/hr (dry)	6019	1956	570

FEED MOISTURE, wt % 1.5

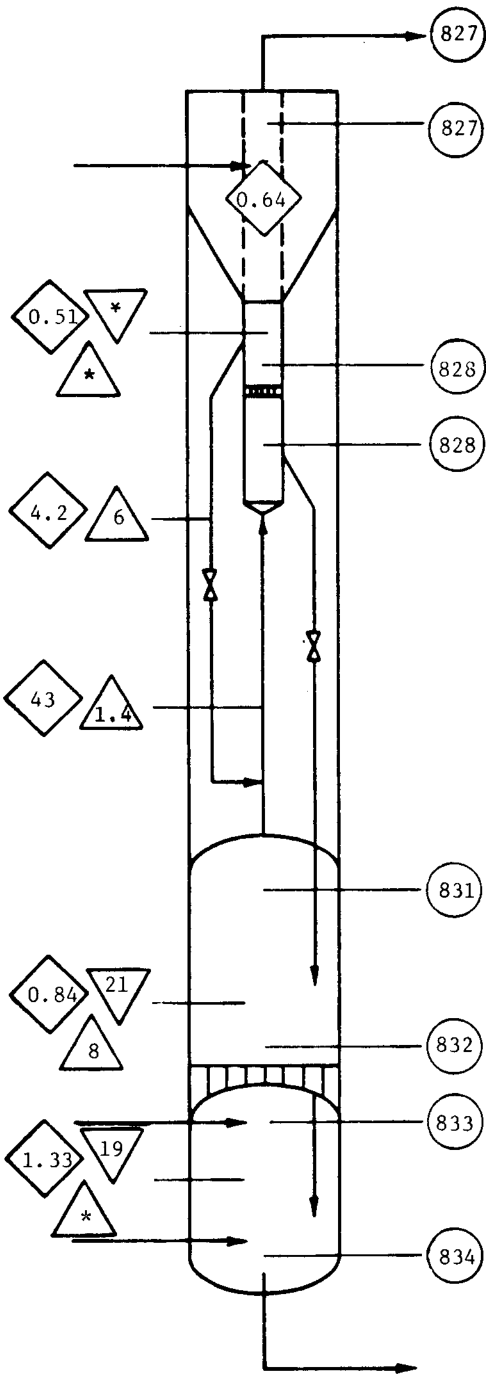
FEED SLURRY CONCN, wt % 29

	LIQUID STREAMS		
	7	8	1
	lb/hr		
H_2O	7330	--	--
LIGHT OIL	--	15,450	14,946

GAS FEED STREAMS			
2	3	5	9
mol/hr			
452	60	34	0

(1) FEED SLURRY
(2) HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
(3) HIGH-PRESSURE STEAM TO STRIPPING RING
(4) SPENT CHAR
(5) HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
(6) GASIFIER EFFLUENT AFTER QUENCH
(7) WATER MADE
(8) LIGHT OIL TO RECYCLE
(9) GASES FROM EXTERNAL HEATER
(10) REACTOR OVERHEAD

Figure 5. HYGAS REACTOR DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/23/78 (1800 Hours) TO 2/24/78 (0500 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/lb CARBON (net) = 0.39
lb STEAM/lb CARBON (net) = 3.28
lb OXYGEN/lb COAL FED = 0.18
lb STEAM/lb COAL FED = 1.53
lb COAL FED/1000 SCF REACTOR PRODUCT GAS = 113

BY ASH BALANCE

MAF† COAL GASIFIED, % = 95
CARBON GASIFIED, % = 94

METHANE YIELD, SCF/lb COAL FED = 2.36

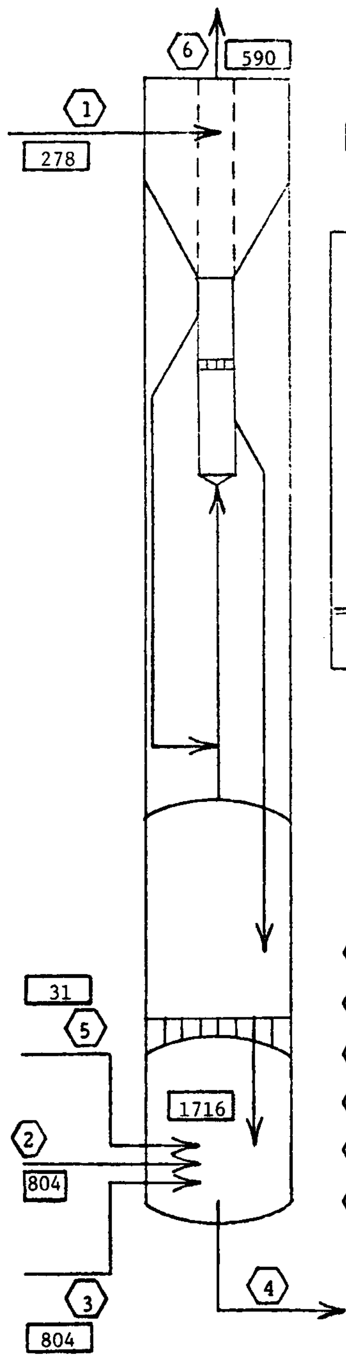
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.06

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 13
SOG = *

†MOISTURE ASH FREE.

Figure 6. HYGAS REACTOR ENGINEERING DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/23/78 (1800 Hours) TO 2/24/78 (0500 Hours)



⬡ Stream No.

▭ Temperature, °F

Basis: 1 hour; Datum condition: **77°F, 1 atm, material in standard state.**

INPUT	Btu
Sensible Heat (Streams 1 & 5)	1,833,734
Heat of Combustion* (Stream 1)	347,016,720
Steam Enthalpy (Streams 2 & 3)	12,518,193
Total	361,368,647
OUTPUT	
Sensible Heat (Streams 4 & 6)	5,674,422
Heat of Combustion* (Streams 4 & 6)	339,720,267
Steam Enthalpy + Light Oil Latent Heat (Stream 6)	11,442,220
Total	356,836,909
% Balance	99

(1) **Feed Slurry**

(2) **High-Pressure Steam to Steam-Oxygen Sparger**

(3) **High-Pressure Steam to Stripping Ring**

(4) **Spent Char**

(5) **High-Pressure Oxygen to Steam-Oxygen Sparger**

(6) **Reactor Overhead**

*** High heating value.**

Figure 7. HYGAS REACTOR HEAT BALANCE DATA SHEET FOR TEST 70 FOR STEADY PERIOD FROM 2/23/78 (1800 Hours) TO 2/24/78 (0500 Hours)

MATERIAL BALANCE, %

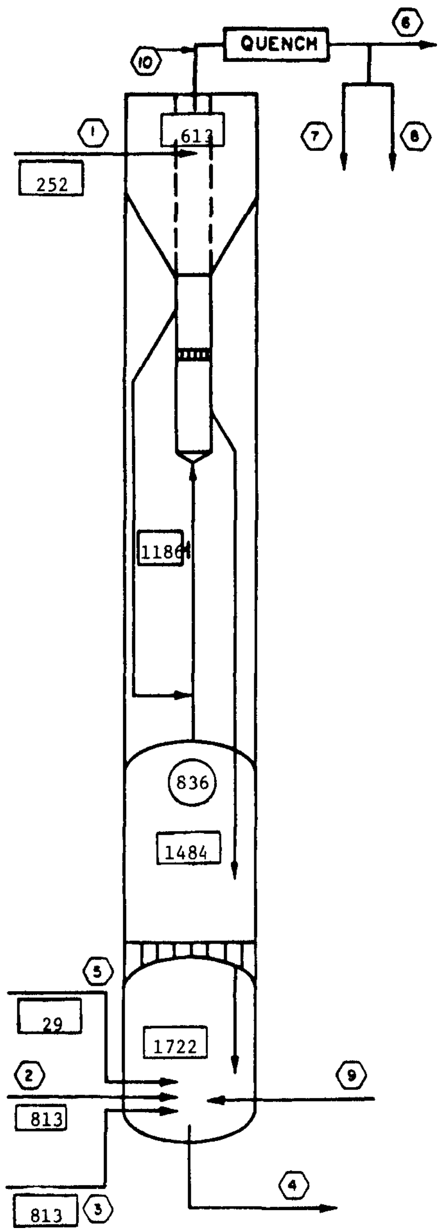
C

H

O

ASH

○ STREAM No.
○ PRESSURE, psig
□ TEMPERATURE, °F



GAS STREAMS	6	10
mol % (dry)		
H_2	33.37	30.39
CO_2	31.18	35.83
C_2H_6	0.29	0.35
N_2	6.56	6.24
H_2S	0.77	0.73
CH_4	16.46	16.04
CO	11.37	10.42
mol/hr (dry)	220	251

SOLIDS STREAMS	1	10	4
wt % (dry)			
C	70.30	73.95	32.31
H	3.26	2.78	0.53
N	1.28	1.05	0.11
S	3.98	2.79	0.27
ASH	12.46	14.63	66.78
O	8.72	4.80	0
lb/hr (dry)	5973		

FEED MOISTURE, wt % 1.9

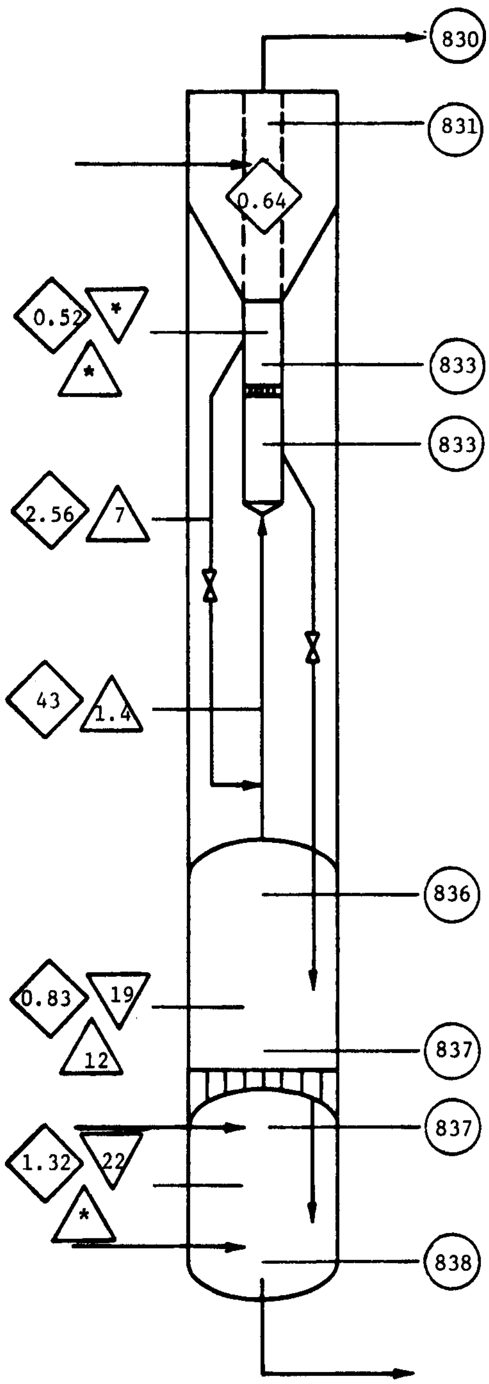
FEED SLURRY CONCN, wt % 30

LIQUID STREAMS	7	8	1
	lb/hr		
H_2O	7330	--	--
LIGHT OIL	--	12,867	13,684

GAS FEED STREAMS			
2	3	5	9
mol/hr			
421	88	35	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure 8. HYGAS REACTOR DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/22/78 (1400 Hours) TO 2/23/78 (0900 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/ lb CARBON (net) = 0.58
lb STEAM/ lb CARBON (net) = 4.77
lb OXYGEN / lb COAL FED = 0.19
lb STEAM / lb COAL FED = 1.54
lb COAL FED / 1000 SCF REACTOR PRODUCT GAS = 109

BY ASH BALANCE

MAF† COAL GASIFIED, % = 93
CARBON GASIFIED, % = 91

METHANE YIELD, SCF/lb COAL FED = 2.56

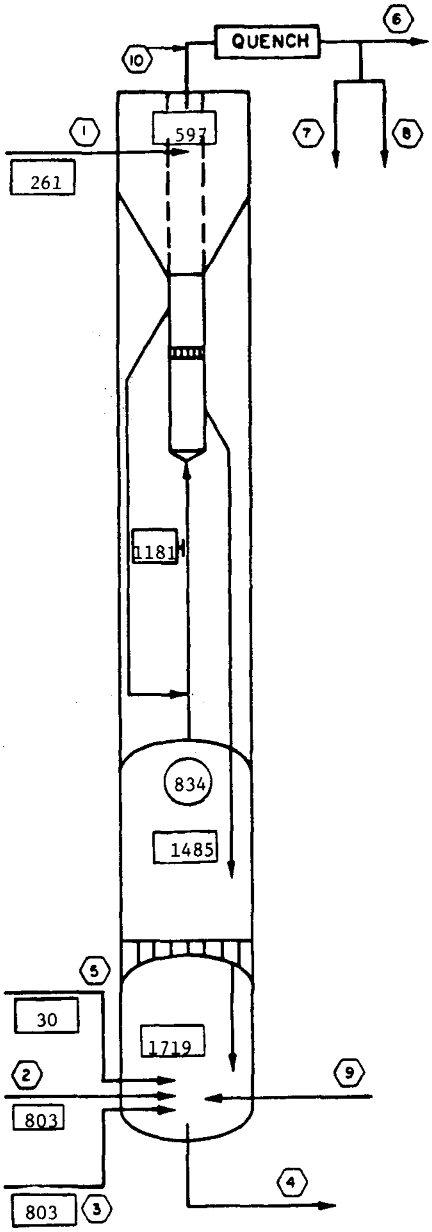
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.28

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 11
SOG = *

†MOISTURE ASH FREE.

Figure 9. HYGAS REACTOR ENGINEERING DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/22/78 (1400 Hours) TO 2/23/78 (0900 Hours)



MATERIAL BALANCE, %

C
H
O
ASH

STREAM No. (circle)
PRESSURE, psig (circle)
TEMPERATURE, °F (box)

	GAS STREAMS	
	6	10
mol % (dry)		
H_2	33.48	30.57
CO_2	30.44	35.22
C_2H_6	0.28	0.35
N_2	7.65	6.96
H_2S	0.74	0.80
CH_4	16.11	15.73
CO	11.30	10.37
mol/hr (dry)	218	248

	SOLIDS STREAMS		
	1	10	4
wt % (dry)			
C	70.48	74.17	29.59
H	3.46	2.77	0.47
N	1.27	1.10	0.10
S	4.00	2.86	0.28
ASH	12.01	14.43	69.56
O	8.78	4.67	0
lb/hr (dry)	6001		

FEED MOISTURE, wt % 1.5

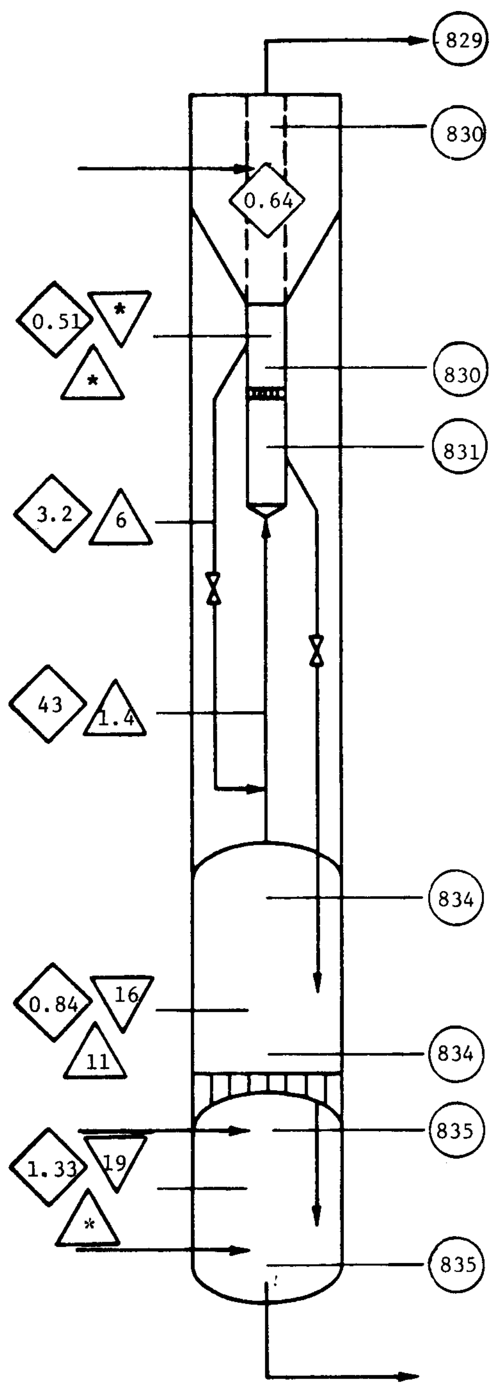
FEED SLURRY CONCN, wt % 30

	LIQUID STREAMS		
	7	8	1
	lb/hr		
H_2O	7330	--	--
LIGHT OIL	--	14,203	14,150

GAS FEED STREAMS			
2	3	5	9
mol/hr			
437	74	35	0

1. FEED SLURRY
2. HIGH-PRESSURE STEAM TO STEAM-OXYGEN SPARGER
3. HIGH-PRESSURE STEAM TO STRIPPING RING
4. SPENT CHAR
5. HIGH-PRESSURE OXYGEN TO STEAM-OXYGEN SPARGER
6. GASIFIER EFFLUENT AFTER QUENCH
7. WATER MADE
8. LIGHT OIL TO RECYCLE
9. GASES FROM EXTERNAL HEATER
10. REACTOR OVERHEAD

Figure 10. HYGAS REACTOR DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/22/78 (1400 Hours) TO 2/24/78 (0500 Hours)



○ PRESSURE, psig
△ DENSITY, lb/cu ft
◇ VELOCITY, ft/s
▽ MEAN RESIDENCE TIME, min
* NOT AVAILABLE

REACTOR PRODUCT GAS - dry, nitrogen- and acid-gas-free basis
COAL FED - dry basis
CARBON (net) = total carbon in char feed - carbon in overhead solids

lb OXYGEN/ lb CARBON (net) = 0.48
lb STEAM/ lb CARBON (net) = 3.98
lb OXYGEN / lb COAL FED = 0.18
lb STEAM / lb COAL FED = 1.54
lb COAL FED / 1000 SCF REACTOR PRODUCT GAS = 111

BY ASH BALANCE

MAF† COAL GASIFIED, % = 94
CARBON GASIFIED, % = 93

METHANE YIELD, SCF/lb COAL FED = 2.46

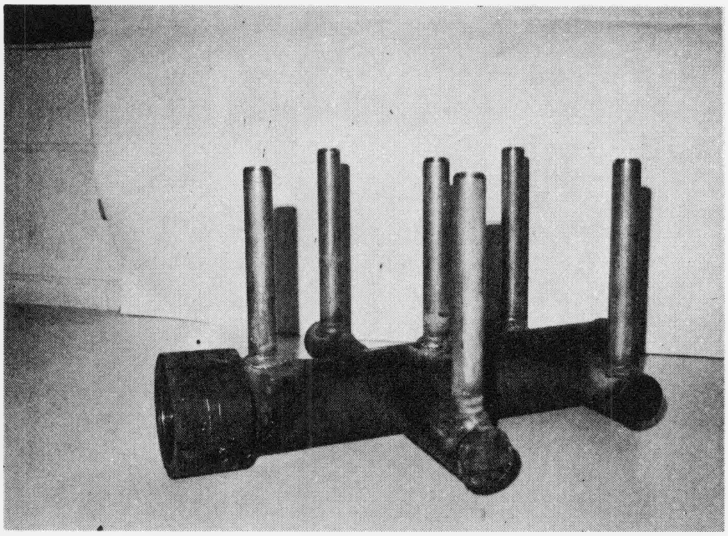
EQUILVALENT METHANE YIELD, SCF/lb COAL FED = 4.16

BED HEIGHT, ft

SLURRY DRYER = *
HTR = 12
SOG = *

†MOISTURE ASH FREE.

Figure 11. HYGAS REACTOR ENGINEERING DATA FOR TEST 70 FOR STEADY PERIOD FROM 2/22/78 (1400 Hours) TO 2/24/78 (0500 Hours)



P78061857
Figure 12. SIX-NOZZLE STEAM-OXYGEN DISTRIBUTOR

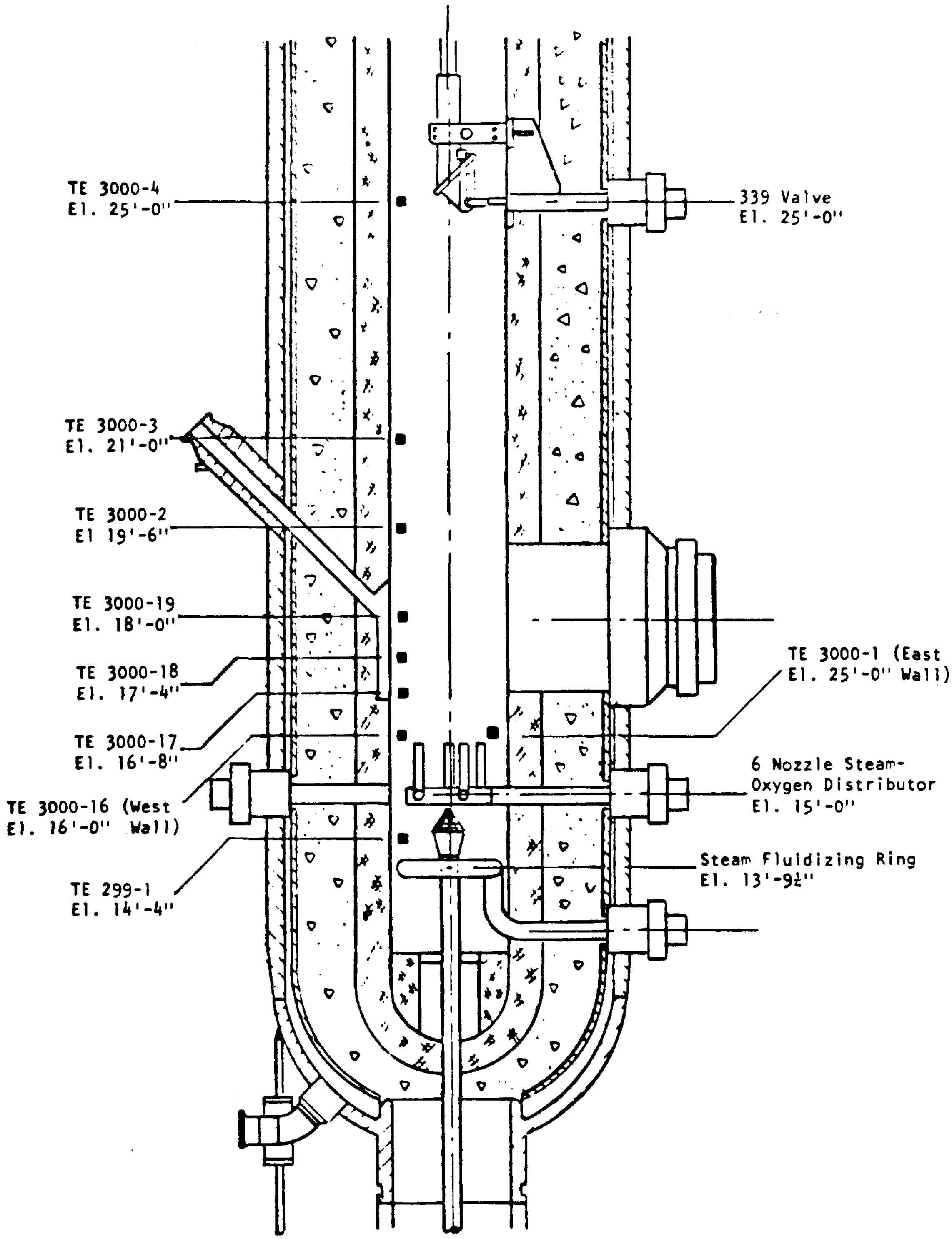


Figure 13. SIX-NOZZLE STEAM-OXYGEN GASIFIER CONFIGURATION

allowing sinter-free operation in the steam-oxygen gasifier. A new hot-gas sampler was installed in the low-temperature reactor to permit continuous product gas sampling from this section. The thermocouples in the steam-oxygen gasifier were also reworked in such a way that no thermocouple will be in the path of a gas jet issuing from the nozzles in the steam-oxygen distributor. New thermowells were installed in the superheater steam lines. The rest of the reactor was inspected and given routine maintenance.

The quench section was completely cleaned after Test 73 and was ready for operation. IGT's maintenance crew repaired the purification section amine circulation pump. The IGT fixed-bed catalyst methanation section was cleaned for fire damage assessment. The fire damage from the hot-oil fire at the Chem System's liquid-phase methanation unit on June 22 included significant damage to the instrument and electrical conduits of the HYGAS plant to and from the control room. The damage was quickly assessed, and subcontractors were hired to repair the instrumentation, electrical system, and construction. The repairs progressed smoothly and did not significantly delay the HYGAS operational program. The repaired instruments and electrical lines were checked for proper operation in preparation for Test 74.

The utility section was shut down completely for its annual inspection. The tubes in both boilers were in good condition, but the high-pressure boiler tubes had a buildup of calcium phosphate sludge. This was removed, and the boiler tubes were then rechecked. Minor patches were made on the refractory of both fire boxes. Other routine maintenance was performed in this section. The hydrogen plant was inspected after Test 73. The reformer stack refractory was in good condition, and two reformer heat exchangers were cleaned.

Test 74

The HYGAS plant was ready for Test 74 following the completion of the modifications in the steam-oxygen gasifier gas distributors. The reactor was pressure-tested to 500 psig prior to light-off on August 6 at 0430 hours. When a routine reactor check revealed a leak on the water jacket piping system, the reactor was depressurized and the burner shut off. The leak was fixed and the reactor was relighted on August 8 at 0330 hours. Oil slurry circulation was begun on August 8 at 2130 hours, and char was fed to the reactor at 0200 hours on August 9. After initial problems with the pretreater char vibrating feeder and the operation of valve 339 were solved, solids flow throughout the reactor was established. Self-sustained operation was achieved on August 9 at 1500 hours. The new steam-oxygen gas distributor and the fluidizing steam distributor in the steam-oxygen gasifier were tested for their effects on the steam-oxygen gasifier operation. These tests involved different combinations of steam to the two distributors ranging from 4000 pounds of steam per hour to the steam-oxygen distributor and 1000 pounds of steam per hour to the fluidizing steam distributor to 2500 pounds of steam per hour to each of the distributors. Results from this series of tests show that the bulk bed temperature profiles in the steam-oxygen gasifier were similar, but temperature measurements below the steam-oxygen distributor indicate that solids mixing was significantly improved at higher steam feeds to the fluidizing steam distributor. Operations in the steam-oxygen gasifier were then set for optimum solids-mixing conditions, with 1500 pounds of steam per hour to the fluidizing distributor and 3500 pounds of steam per hour to the steam-oxygen distributor. Under these conditions, with 740 pounds of oxygen per hour to the steam-oxygen gasifier, char conversions (obtained by quick ash analysis) ranged from 70% to 80%. Based on calculations from the feed gases and the averaged maximum steam-oxygen gasifier temperature of about 1750°F, the superficial gas velocity was 1.15 ft/s. The reactor operated very well during all of Test 74, attaining 21 days of continuous self-sustained operation and breaking all previous records by accumulating over 200 hours of steady-state operation. Test 74 was voluntarily terminated on August 30 at 1500 hours. Over 900 tons of caking Illinois No. 6 seam bituminous coal from Peabody No. 10 Mine were processed through the plant during Test 74.

An upset occurred in the reactor on August 17 when the spent-char slurry discharge valve stuck in the closed position. This caused the spent-char vessel to overflow, resulting in water backing into the steam-oxygen gasifier, some temperature drops, and interrupted solids flow out of the steam-oxygen gasifier. This situation was corrected within 1 hour, and the reactor recovered. Early in the test, reactor solids flow from the high-temperature reactor bed to the steam-oxygen gasifier bed was sluggish. Valve 339 was not sealing properly; however, after the valve stroke on the valve 339 actuator was adjusted, and the high-temperature reactor bed density improved, solids flow through the reactor became very smooth. Toward the end of the test, valve 321 malfunctioned, interrupting the feed to the reactor lower stages.

The controlboard valve-position indicator gave a false signal that valve 321 was in the closed position. The problem was finally diagnosed as a faulty instrument readout, but some time was spent in determining that valve 321 was actually in the open position.

The slurry preparation section operated satisfactorily during Test 74, although there were some initial problems with the vibrating feeder under the 15-ton storage hopper and calibration problems with the weighbelt system, which measures pretreater char to the char slurry tanks. Thick slurries, high-pressure slurry pump switches, and lost suction to the low-pressure slurry pump also interrupted solids feed to the reactor.

The quench section operated very well during Test 74, and there were no problems with oil-water separation. The purification section operated for 230 hours with one interruption on August 19: The condenser in the regenerator lost its cooling water flow, resulting in a loss of significant amounts of digylcolamine. This situation was corrected on August 22 at 0022 hours, and the purification system was put back in service until the termination of Test 74. Foaming problems in the absorber tower during Test 74 were mild and were controlled by the addition of Dow-Corning HB-10, an antifoaming agent. In two instances, the addition of the antifoaming agent to the absorber caused some gas flow surges in the reactor, and upsets in solids flow in the reactor resulted. Operating procedures are being prepared to avoid these sudden surges in the tubing. The effluent cleanup section and the utilities both operated well during Test 74.

Pretreater operations began with coal feed to the pretreater on August 18 at 2300 hours. Coal feed to the pretreater was interrupted several times. The oversize and fines waste bins and the 15-ton pretreater char storage hopper overflowed. The oversized coal screw feeder and the bucket elevator overloaded. Cooling water to the wet scrubber was lost, the weighbelt system had to be calibrated, and the char cooler discharge valve malfunctioned. Despite all of these interruptions, the pretreater was able to supply properly pretreated char as feed to the reactor for all of Test 74. The pretreater operated at nominal conditions of 775°F and a 1.0 ft/s superficial velocity.

The plant was voluntarily shut down on August 30 and a postrun plant inspection was immediately begun.

The coal mill was in good condition and was cleaned of dust accumulations. Even through operation of the wet scrubber was interrupted when it lost its scrubbing water flow, it was in good condition with only a normal amount of accumulated dust. A support plate on the restriction cone of one of the two gas inlet ducts was broken and was replaced. The Sweco fines screener was clean and intact. Two of the screener middle screens tore from fatigue failure and were replaced during the test. Some caked coal, which had accumulated near the bottom of the wall of the 60-ton raw coal storage hopper during the past four tests, was removed.

The pretreater section was inspected. A few small pieces of soft sintered coal, the largest of which was 6 by 6 inches, were lying on the pretreater grid. The rest of the pretreater was clean. Two small leaks on the pretreater internal cooling coils were discovered and repaired. Downstream of the pretreater, the char cooler, the venturi scrubber, and the quench tower were clean. Solids transfer lines and gas flow lines were clear. The pressure-equalizing line between the pretreater and the char cooler, which developed a pinhole leak during the test and was temporarily patched, was replaced. Twelve guide rods were dislodged from the pretreater grid nozzles following pretreater cleanup. The Dustex system which removes coal dust from the Sweco screener and the weighbelt areas was heavily loaded with solids. More water flow through the system is planned for the next test to provide a better flush for dust removal.

The vibrating feeder from the 15-ton storage hopper, which presented some operational problems during the test, was inspected. One of the two stationary counterweights was 30 degrees off its set point. Some of the mercury remained in the inner reservoir, reducing the weighed eccentricity, and the electric motor, which had been rewound, was 300 rpm higher than specifications. All of these problems contributed to reducing the vibration of this feeder and will be corrected before starting Test 75. The seal flush lines to the flowmeters in the low-pressure slurry loop were plugged with fines and were cleaned. The high-pressure slurry pump valve seats showed excessive wear and were replaced.

The reactor was inspected. The slurry dryer bed area, the spouting bed, line 322, the lift line, and line 339 were clear. Some solids were left in line 321, and a pinhole leak was found on this line's expansion joint and was replaced. Some spalled refractory pieces were lying on top of the second-stage refractory grid. The steam-oxygen gasifier bed was clean, with no clinker formations, and the two gas distributors were in good condition. However, both lines 339 and 340 were slightly damaged. Line 339 had a kink in the pipe as a result of the valve 339 actuator pushing too hard on the pipe. Line 340 was dislodged from the exit socket. However, these conditions did not interfere with the solids flow control in the reactor during the test. Valve 340 was inspected with a television camera, and some wear was found on the leading edges of the valve plug. The rotation of the valve was reversed to obtain a longer valve life. Line 339 was straightened and the force on the valve 339 actuator limited to prevent overstressing the line in the future. The reactor high-pressure cyclone, dipleg, and cyclone solids slurry pot were all in good condition.

The quench system vessels and transfer lines were hydraulically cleaned following Test 74. The light-oil recovery unit was clean, and only a small amount of solids had accumulated in the oil-water separator. The stripper-tower recycle pump impeller was replaced because it was excessively worn. A larger magnetic flowmeter was installed in place of the 1-inch unit to reduce the overall pressure drop on the stripper tower bottom discharge piping. The high-pressure boiler in the utility section was inspected, and phosphate powder deposits were again observed; therefore, the frequency of this boiler blowdown was increased to reduce the deposit on the boiler tubes.

Immediately following Test 74, the reactor was prepared for high-pressure operations. The reactor and related piping and vessels were successfully pressure-tested at 1000 pounds. Test 75 is designed to run with a low steam-to-char ratio, similar to that of the commercial/demonstration plant design conditions. Dilution with nitrogen is planned to achieve the desired superficial gas velocity in the steam-oxygen gasifier. A new nitrogen feeding system was installed to allow the addition of the necessary amount of preheated nitrogen into the reactor.

Test 75

Routine maintenance and turnaround activities were completed, and the plant was readied for Test 75. The reactor internals were pressure-tested and leaks were fixed. Test 75 light-off occurred at 0130 hours on September 24. Reactor pressure and temperature were brought down when a leak occurred on the prequench tower manway; and at the same time, operation of the line 321 valve became uncontrollable. Both of these problems were solved, and the reactor was relighted for Test 75 at 1200 hours on September 29.

Task 8. Demonstration Plant Support

One of the major activities under this task has been the transfer of data to Procon, Inc., for its design of a HYGAS demonstration plant. During this reporting period, data were supplied for oil make, phenolics, and low-temperature steam feed.

Estimate of Oil Make

The breakdown of oil components by type has been estimated for Test 64 and is presented in Table 4. The number of significant figures is not meant to imply that degree of accuracy; rather, the numbers reflect a relative quantity of each constituent in the oil make.

In the current pilot plant configuration, the low-temperature reactor does not operate adiabatically but operates at somewhat lower temperatures than would be expected in the demonstration plant design. An assessment of the rates of hydrodealkylation indicate that only the simplest of the ring compounds should be present in the demonstration plant design system. Table 5 is based on this premise. In addition, significant hydrodehydroxylation and further splitting of oxygen, nitrogen, and sulfur containing ring systems, as well as continued reduction in the amount of polycyclic aromatics can be expected; however, there is no good basis for estimating these effects. Table 5, therefore, is conservative.

The oil make estimated from pilot plant data is 90 pounds of oil for each ton of moisture- and ash-free (MAF) coal. This is approximately 35.5 pounds of oil per 1000 pounds of pretreated char fed to the gasifier. The initial design basis was 55 pounds of oil per 1000 pounds of char fed to the gasifier based primarily upon process development unit data. The new assessment of the pilot plant data, however, appears to be more valid.

Phenolics Data

In Test 64, 10 pounds of phenolic material per ton of MAF coal was recovered in the water stream and an additional 7.6 pounds of phenolics

Table 4. OIL COMPOSITION — DIRECT ESTIMATE FROM TEST 64

COMPOSITION BY TYPE*	lb/ton MAF coal
Alkane	0.85
Alkene	0.85
Aromatic Hydrocarbons	76.36
Oxygen-Containing	18.73
Nitrogen-Containing	0.36
Sulfur-Containing	1.88
Unidentified	0.97
Total	100.00

DETAILED COMPOSITION:

	Base Compound	C_1	C_2	C_3	C_4	C_5	C_6	Total
	lb/ton MAF Coal							
Benzene	46.9	14.01	4.23	1.22	0.37	0.11	0.03	66.87
Styrene	0.006	0.002						0.008
Idene	0.115	0.063	0.020					0.198
Indan	0.235	0.265	0.057					0.556
Naphthalene	3.55	1.20	0.72	0.21	0.13	0.003		5.82
Biphenyl	0.46	0.40	0.046	0.092				0.997
Acenaphthene	0.025	0.016						0.041
Acenaphthylene	--							--
Diphenylethane	0.012							0.012
Phenyl Naphthylene								
Benzo-acenapthene	0.085	0.063						0.146
Fluorene	0.40	0.22	0.071	0.031				0.725
Phenanthrene	0.40	0.166	0.057					0.741
Anthracine	0.12							
4-Ring								0.234
5-Ring								0.016
Total Aromatic Hydrocarbons								76.36
Phenol	12.11	2.78	1.66	0.60	0.46			17.61
Benzofuran	0.049	0.057	0.057					0.143
Dibenzofurans	0.46	0.40	0.057	0.060				0.977
Total Oxygen-Containing Compounds								18.73
Pyridine								--
Pyrrole								--
Quinolines								0.043
Indoles								0.22
Acridenes								0.019
Carbazoles								0.046
Anilines								< 0.01
Benzonitrile								< 0.02
Total Nitrogen-Containing Compounds								0.36
Thiophene	0.25	0.31	0.066	0.008				0.638
Benzothiophene	0.69	0.31	0.092	0.046				1.14
Dibenzothiophene	0.080	0.027						0.107
Total Sulfur-Containing Compounds								1.88
Unidentified								
Boiling Below Naphthalene								0.174
Boiling Between Naphthalene and Phenanthrene								0.544
Boiling Above Phenanthrene								0.255
Total Unidentified Compounds								0.97

*Basis: 1 ton MAF Coal.

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Table 5. PROJECTED COMPOSITION OF MAKE OIL ESTIMATED AT DESIGN TEMPERATURE OF LOW-TEMPERATURE REACTOR (1419°F)

	lb/ton MAF Coal
Benzene	67
Indan and Indene	0.7
Naphthalene	5.8
Biphenyl	1.0
Fluorene	0.7
Phenanthrene + Anthracene	0.7
Other 3-Ring	0.2
4-Ring	0.2
Total Aromatic Hydrocarbons	76.3
Aliphatic	1.7
Oxygen Containing	18.7
Nitrogen Containing	0.4
Sulfur Containing	1.8
Unidentified	1.1
Total	23.7
Total Hydrocarbons	100

estimated make was recovered in the oil. The breakdown of the phenolics in the oil was as follows:

Phenol	2.11
C_1-Phenol	2.78
C_2-Phenol	1.66
C_3-Phenol	0.6
C_4-Phenol	0.46

The breakdown of the phenolics in the wastewater has not yet been determined analytically because of difficulities in the extraction step.

Revised Gasification Balances for Low-Temperature Steam Feed

Procon had requested a revised gasifier material and energy balance using less superheating in the steam feed. Computer printouts for the gasifier yield estimates at 500 psi, a 750°F steam temperature, a 300°F oxygen temperature, and H_2O-to-carbon ratios of 1.0 (Table 6, commercial design cost basis) and 1.234 (Table 7, demonstration design basis) were supplied to Procon.

Under these conditions, gasifier efficiency dropped about 2% from that estimated for the previous design, because additional carbon and oxygen had to be burned to superheat the steam and more coal had to be consumed to achieve the required plant output. The gasifier temperature, pressures, and coal feed were held constant, relative to the earlier design. The oil make per unit of coal was constant, but the gas make decreased. The residence times also decreased from 105 to 95 and from 40 to 35 minutes, because less gasification and more combustion occurred within the unit. The data in Tables 6 and 7 imply that superheated steam at a higher temperature is the more desirable alternative because it improves overall efficiency and probably lowers gas cost.

Revised Gasifier Balance for 1200 psig

Revised estimates of the light-oil production and composition for the 1200-psig designs of the HYGAS demonstration plant cause a new balance around the gasifier. The balance for the commercial design at 1200 psig, modified for the new oil and light-hydrocarbon production estimates, is shown in Figure 14 and Tables 8 and 9. The steam-to-carbon mole ratio is 1:1. Relative to the earlier balance, this design requires less coal to make the same quantity of gas (because less coal is converted to oil), which is significantly

Table 6. GASIFIER YIELD ESTIMATES FOR COMMERCIAL DESIGN COST BASIS

Pressure = 34 atm
Steam/C = 1.0

TYPE OF COAL - COMMERCIAL DESIGN USING ILLINOIS BITUMIOUS COAL NOV. 4,1977

LOW TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	CHAR PRODUCT	OIL PRODUCT
C	52.4813	42.3083	4.1985
H(2)	21.5278	2.9275	2.3541
O	4.3750	0.0000	0.0000
N(2)	0.4212	0.0842	0.0000
S	1.0667	0.2067	0.0000
ASH*	210.3000	210.3000	0.0000
TEMPERATURE, DEGREE F	600.	1348.	1348.

GAS FLOW RATE,MOLE/HR	FEED	PRODUCT
CO	17.4989	16.8792
CO(2)	14.6197	16.5520
H(2)	20.2505	24.8848
H(2)O	24.1584	25.2491
CH(4)	4.9501	9.0007
C(2)H(6)	0.0000	0.2624
C(6)H(6)	0.0000	0.0000
NH(3)	0.0000	0.5247
H(2)S	0.1001	0.9217
N(2)	0.0000	0.0505
TEMPERATURE, DEGREE F	1680.	1348.

ADDITIONAL PRODUCT GAS : COS =0.0384 HCN =0.0481 ALSO BENZENE = 0.10500 TOLUENE = 0.50978 (MOLES)

HIGH TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT
C	42.3083	35.4951
H(2)	2.9275	2.4561
O	0.0000	0.0000
N(2)	0.0842	0.0842
S	0.2067	0.2067
ASH*	210.3000	210.3000
TEMPERATURE, DEGREE F	1348.	1680.

SOLIDS RESIDENCE TIME = 84.7783 MINUTES (95.1687 MINUTES)

GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
CO	15.7575	0.0000	17.4989
CO(2)	12.6076	0.0000	14.6197
H(2)	20.1331	0.0000	20.2505
H(2)O	29.9239	0.0000	24.1584
CH(4)	1.8903	0.0000	4.9501
H(2)S	0.1001	0.0000	0.1001
N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	1850.	0.	1680.

OXYGEN GASIFIER

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT
C	35.4951	5.2396
H(2)	2.4561	0.9997
O	0.0000	0.0000
N(2)	0.0842	0.0842
S	0.2067	0.1067
ASH*	210.3000	210.3000
TEMPERATURE, DEGREE F	1680.	1850.

SOLIDS RESIDENCE TIME = 20.2448 MINUTES (35.2465 MINUTES)

GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
CO	0.0000	0.0000	15.7575
CO(2)	0.0000	0.0000	12.6076
H(2)	0.0000	0.0000	20.1331
H(2)O	0.0000	52.4813	29.9239
CH(4)	0.0000	0.0000	1.8903
O(2)	9.2077	0.0000	0.0000
H(2)S	0.0000	0.0000	0.1001
N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	300.	750.	1850.

* FLOW RATE OF ASH IS IN LBS/HR

Table 7. GASIFIER YIELD ESTIMATES FOR DEMONSTRATION DESIGN BASIS

Pressure = 34atm
Steam/c = 1.9338

TYPE OF COAL - COMMERCIAL DESIGN USING ILLINOIS BITUMIOUS COAL NOV. 4,1977

LOW TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	CHAR PRODUCT	OIL PRODUCT
C	52.4813	42.3980	4.1985
H(2)	21.5278	2.9337	2.3541
O	4.3750	0.0000	0.0000
N(2)	0.4212	0.0842	0.0000
S	1.0667	0.1978	0.0000
ASH*	210.3000	210.3000	0.0000
TEMPERATURE, DEGREE F	600.	1348.	1348.

GAS FLOW RATE,MOLE/HR	FEED	PRODUCT
CO	14.6486	14.3268
CO(2)	17.1645	18.7989
H(2)	21.7080	26.2087
H(2)O	34.1940	35.5828
CH(4)	5.3453	9.3062
C(2)H(6)	0.0000	0.2624
C(6)H(6)	0.0000	0.0000
NH(3)	0.0000	0.5247
H(2)S	0.0912	0.9217
N(2)	0.0000	0.0505
TEMPERATURE, DEGREE F	1644.	1348.

ADDITIONAL PRODUCT GAS : COS =0.0384 HCN =0.0481 ALSO BENZENE = 0.10500 TOLUENE = 0.50978 (MOLES)

HIGH TEMPERATURE REACTOR

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT
C	42.3980	34.8243
H(2)	2.9337	2.4097
O	0.0000	0.0000
N(2)	0.0842	0.0842
S	0.1978	0.1978
ASH*	210.3000	210.3000
TEMPERATURE, DEGREE F	1348.	1644.

SOLIDS RESIDENCE TIME = 98.9527 MINUTES (112.5880 MINUTES)

GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
CO	12.7869	0.0000	14.6486
CO(2)	14.6603	0.0000	17.1645
H(2)	20.7295	0.0000	21.7080
H(2)O	41.0641	0.0000	34.1940
CH(4)	2.1375	0.0000	5.3453
H(2)S	0.0912	0.0000	0.0912
N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	1800.	0.	1644.

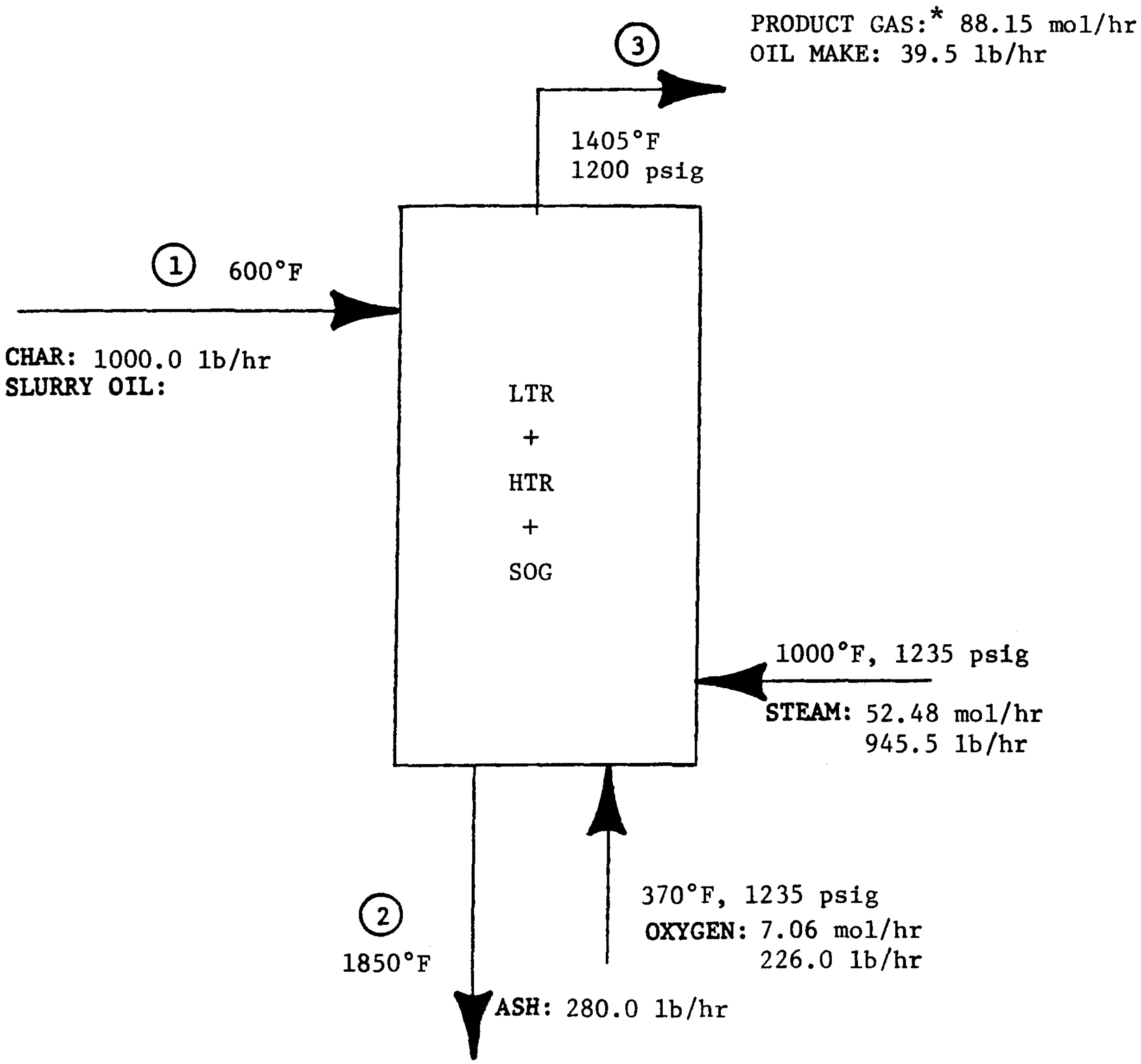
OXYGEN GASIFIER

SOLIDS FLOW RATE,MOLE/HR	FEED	PRODUCT
C	34.8243	5.2396
H(2)	2.4097	0.9999
O	0.0000	0.0000
N(2)	0.0842	0.0842
S	0.1978	0.1067
ASH*	210.3000	210.3000
TEMPERATURE, DEGREE F	1644.	1800.

SOLIDS RESIDENCE TIME = 23.4771 MINUTES (40.4200 MINUTES)

GAS FLOW RATE,MOLE/HR	FEED 1	FEED 2	PRODUCT
CO	0.0000	0.0000	12.7869
CO(2)	0.0000	0.0000	14.6603
H(2)	0.0000	0.0000	20.7295
H(2)O	0.0000	64.7500	41.0641
CH(4)	0.0000	0.0000	2.1375
O(2)	9.2108	0.0000	0.0000
H(2)S	0.0000	0.0000	0.0912
N(2)	0.0000	0.0000	0.0000
TEMPERATURE, DEGREE F	300.	750.	1800.

* FLOW RATE OF ASH IS IN LBS/HR
===> SFR 6



* Oil free.

Figure 14. GASIFIER BALANCE FOR THE COMMERCIAL DESIGN OF THE HYGAS PLANT AT 1200 psig

Table 8. GASIFIER BALANCE FOR COMMERCIAL DESIGN HYGAS PLANT AT 1200 psig, STREAMS 1 AND 2

Stream No.	1			2		
Description	Coal Feed			Ash Residue		
Temperature, °F	600			1850		
Components	lb/hr	wt %	mol/hr	lb/hr	wt %	mol/hr
C	630.3	63.03	52.48	63.1	22.54	5.26
H_2	43.4	4.34	21.53	1.7	0.61	0.85
O	70.0	7.00	4.37	--	--	--
N_2	11.8	1.18	0.42	2.4	0.84	0.08
S	34.2	3.42	1.07	3.4	1.22	0.10
Cl	0.9	0.09	0.02	--	--	--
Ash	209.4	20.94	--	209.4	74.79	--
Total	1000.0	100.00		280.0	100.00	

Table 9. GASIFIER BALANCE FOR COMMERCIAL DESIGN HYGAS PLANTS AT 1200 psig, STREAM 3

Stream No.	3	
Description	Raw Product Gas	
Temperature, °F	1405	
Components	mol/hr	mol %
CO	13.7084	15.55
CO_2	16.6711	18.91
H_2	18.9234	21.47
H_2O	23.8119	27.01
CH_4	13.1004	14.86
C_2H_6	0.2580	0.29
C_2H_4	0.0097	0.01
C_2H_2	0.0043	0.00
C_3H_8	0.0422	0.05
C_3H_6	0.0136	0.02
C_4H_{10}	0.0072	0.01
C_6H_6	0.0000	0.00
NH_3	0.5247	0.60
N_2	0.0496	0.06
HCN	0.0481	0.05
H_2S	0.9132	1.04
COS	0.0384	0.04
HCl	0.0244	0.03
Total (Oil-Free Gas)	88.1486	100.0

Oil Make*

C	2.9180
H_2	1.4408
O	0.0798
N_2	0.0010
S	0.0084
	4.4480

* Basis: 100 pounds of oil make per ton of MAF char. Obtained from pilot plant data.

richer in direct methane. The difference in the heat of formation of the various species slightly reduces the temperature of the low-temperature reactor.

The balance shown in Figure 14 is for the low-temperature and high-temperature reactors and the steam-oxygen gasifier only. It does not include the heat balance around the slurry dryer bed, which specifies the quantity and temperature of the incoming slurry oil. These data will be used to estimate gas costs in the commercial testing facility and also to incorporate sufficient flexibility in the demonstration plant design.

Cold-Flow Model

A cold-flow model of the upper stage of the gasification reactor is being constructed. This stage is the only section of the unit that is not a direct mechanical transfer of technology from the pilot plant reactor. The model is being constructed to determine gas-solids behavior, on a large scale and at elevated pressure, in systems similar to the proposed demonstration plant design.

The procurement status of the various elements of this model is —

a. Compressor: received and set in place.

b. Instrumentation: received and partially installed.

c. Building Foundation: completed.

d. Building Structural Steel: Nearly complete. Cannot be finished until the last vessel is delivered.

e. Vessels: The test vessel and the cyclone receiver vessel have been received and erected. Delivery of the solids receiver vessel is now projected for October 30.

f. Cyclone: received and installed.

g. Pipeline Filters: received and installed.

h. Control Valves: received.

The starter for the compressor has been installed and wired. The compressor motor and control panel is being wired.

Task 9. Support Studies

Plant Effluent Processing

The plant effluent processing section was cleaned after Test 73, and the malfunctioning drive chain on the Edens separator was replaced. The section operated well for Test 74 with a minimal number of problems and recovered oil satisfactorily. This increase in efficiency is a result of the reduction of fines in the reactor overhead. Following Test 74, the section was again in good condition. Repair of the light-oil stripper tower circulation pump and impeller was completed. A new, larger, 2-inch, magnetic flowmeter was installed in place of the 1-inch meter used earlier. This was done to reduce the flow restriction in the stripper tower bottoms effluent piping system. Routine cleanup and maintenance were performed on this section, and it was readied for Test 75 operations.

Test Methanation Systems and Catalysts

The IGT fixed-bed catalyst methanation section was cleaned after the June 22 oil fire. A fire damage assessment is being made of this section. The Chem Systems' liquid-phase methanation unit was inspected, and a fire investigation committee, organized to study the cause of the fire, inspected the plant area.

Hot-Oil Quench Systems

No work was done on this section.

Materials Testing

MPC corrosion/erosion coupons were tested during Test 74.

Engineering Services

The study of pretreatment minimization on Illinois No. 6 seam, Peabody No. 10 Mine bituminous coal was continued in a small-scale bench unit. Engineering services were also provided for HYGAS reactor modifications, including the design and installation of a nitrogen-addition system required for Test 75 and the design and installation of a gas sampler for the first-stage lift reactor. This sampler will be tested. Other routine services were also provided.

FUTURE WORK

Test 75 was started by the end of this quarter. Its primary objective is to approach the steam-to-char ratios in the reactor specified by Procon's commercial/demonstration plant design.

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