DOE/ET/10137--T5

DE83 002488

DOE/ET/10137--T5

Fe-2247-31

Dist. Category UC-90d

GASIFICATION OF RESIDUAL MATERIALS FROM COAL LIQUEFACTION

Type II Preliminary Pilot-Plant Evaluation Of A Coal-Liquefaction Residue-Water Slurry Using Vacuum-Tower Bottoms From The H-Coal Liquefaction Process

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Date Published -September 1982

PREPARED FOR THE UNITED STATES
DEPARTMENT OF ENERGY

Under Contract No. DEAC 01-76-ET10137 (EX-76-C-01-2247)

Delivery Order No. 7

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Printed in the United States of America

Available From

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

Price: Printed Copy $4.00; Microfiche $3.00

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ABSTRACT

About 6.7 tons of vacuum tower bottoms (residue) which were obtained during the liquefaction of Illinois No. 6 coal from the H-Coal liquefaction process pilot plant at Catlettsburg, Kentucky were successfully gasified at Texaco's Montebello Research Laboratory on January 7, 1982.

The single 9.5-hour run with H-Coal liquefaction residue-water slurry was completed at 750-760 psig gasifier pressure. The run consisted of two test periods, each at a different gasifier temperature.

Over 99.6 percent conversion of carbon in the feed to syngas was achieved yielding 32.9-33.7 standard cubic feet of dry syngas per pound of residue charged. The oxygen requirement was about 1.0 pound of oxygen per pound of residue. The dry syngas contained 78.5-79.7 (vol.) percent carbon monoxide plus hydrogen.

INTRODUCTION

Objective:

The objective of a Type II preliminary pilot plant evaluation is to confirm the operability of the Texaco Gasification Processes on candidate feedstocks selected by DOE from various residual materials from DOE-sponsored coal liquefaction projects.

The short pilot plant evaluation run will permit refining the estimates of preferred processing conditions, product gas yield and composition, and will identify unexpected operating problems.

Background:

Almost all of the coal liquefaction processes, which are being developed to reduce our dependence on expensive imported oil, require hydrogen or synthesis gas (a mixture of hydrogen and carbon monoxide) to solubilize the coal. It is desirable to produce the needed hydrogen or synthesis gas primarily from the non-liquefied fraction of the coal. This material, together with the inorganic ash and some fraction of the unconverted coal, may be recovered in various forms depending on the particular process.

Many of these streams will make excellent feedstocks for gasification using one of the Texaco Gasification processes to produce synthesis gas, which can readily be converted to pure hydrogen.

Texaco developed the non-catalytic partial oxidation process in the late 1940's to convert natural gas to synthesis gas which was then reacted with steam to form additional hydrogen. Further developments enabled the use of light oils, residual oils and asphalts as feedstocks. This process, known as the Texaco Synthesis Gas Generation Process, has been licensed for use in more than 90 plants in over 20 countries throughout the world using a variety of liquid feedstocks.

Since 1975, most of the work performed on coal liquefaction residue involved the gasification of molten residue feedstocks using a modification of the Texaco Syntheisis Gas Generation Process.

Recently, Texaco has carried out extensive work to demonstrate the feasibility of gasifying coal-water slurries. The process, which has been modified to handle slurries of high ash feedstocks such as coal and coal liquefaction residues, has been designated the Texaco Coal Gasification Process.

To determine the suitability of various residual materials from DOE sponsored coal liquefaction projects as feedstocks to the Texaco Gasification Processes, DOE is sponsoring a series of tests to be conducted at Texaco's Montebello Research Laboratory.

SCOPE:

This report covers work performed at Texaco's Montebello Research Laboratory on January 7, 1982 under contract EX-76-C-01-2247 and amendment DEAC-76ET10137 with the United States Department of Energy (DOE).

During a single continuous 9.5 hour run, about 6.7 tons of H-Coal liquefaction residue were successfully gasified. The residue was obtained during the liquefaction of Illinois No. 6 coal from the H-Coal liquefaction process pilot plant at Catlettsburg, Kentucky. The residue was fed to the pilot plant gasifier as a water slurry.

This work was authorized by DOE Delivery Order Number 7.

PILOT PLANT PROCESS FLOW

Introduction:

The Texaco Coal Gasification Process is a non-catalytic partial oxidation process that is based on certain reactions between oxygen and hydrocarbons that take place at high temperature to produce a synthesis gas composed primarily of hydrogen and carbon monoxide.

The high temperature reactions occur when the hydrocarbon and a deficiency of oxygen are introduced under pressure into a refractory-lined gasifier.

The details of the process are outlined below.

Residue Grinding System:

The H-Coal liquefaction residue, as received, was reduced to a nominal half inch top size in a hammer mill. The hammer mill product was then ground and screened. The oversize (plus 14 sieve) material was recycled to the mill for regrinding while the screened residue was augered to plastic tote bags for storage.

Slurry Preparation and Gasifier Feed System:

Figure 1 shows the schematic diagram of the unit as it was used for this work. For the preparation of residue-water slurry, the residue from the tote bags was mixed batchwise with demineralized water in the agitated mix tank. The slurry in the mix tank was then pumped to a stirred holding tank where final slurry concentration adjustments were made. The slurry was then pumped to the run tank. The run tank is mounted on a scale to allow monitoring the slurry charge rate.

H-Coal liquefaction residue-water slurry and oxygen were fed through a proprietary Texaco burner into the top of the pilot plant gasifier.

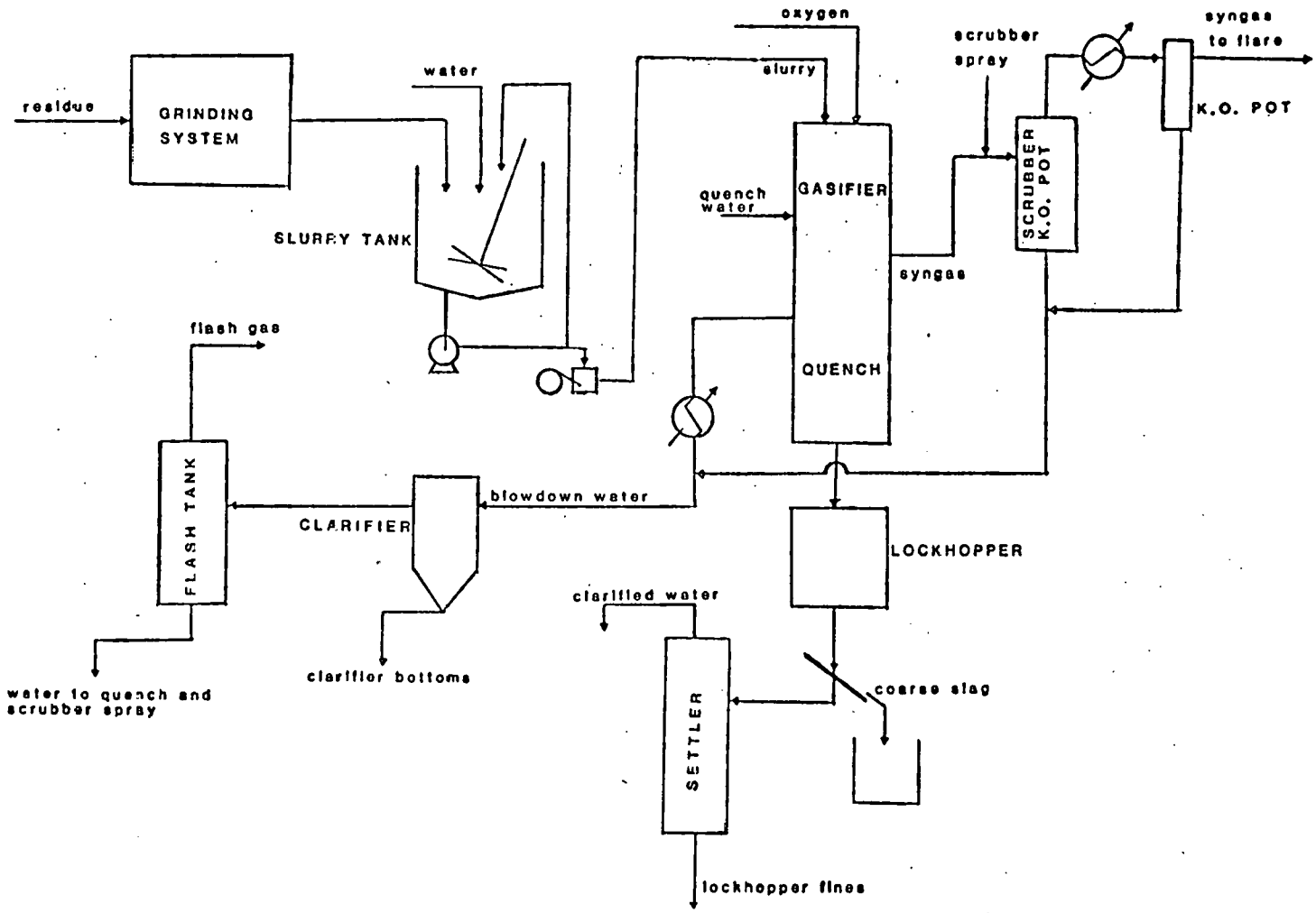
The residue-water slurry was pumped to the burner under pressure at a constant rate.

Pilot Plant Gasifier:

The pilot plant gasifier is a pressure vessel which is divided internally into two sections. The top section, combustion chamber, is lined with a special refractory material designed to withstand severe operating conditions. The mixed feed streams are ignited in this preheated gasifier combustion chamber where the partial oxidation reactions take place.

The lower section, quench chamber, is an uninsulated chamber containing a reservoir of water which is maintained in the bottom at all times. In the quench chamber, the synthesis gas and slag are cooled by direct contact with the quench water. The quenched syngas exits the quench chamber and is water scrubbed to remove residual particulates.

Figure 1 Schematic Diagram of the High Pressure Solids Gasification Pilot Unit



After cooling and removal of water, the raw syngas is metered and then routed to the flare. Water is continuously injected into the quench chamber to replace water lost by evaporation and solids removal.

Slag Removal System:

Upon contacting the quench water, the molten slag solidifies and settles in the quench chamber. It is periodically removed through a lockhopper system. The lockhopper blowdown solids are screened into coarse and fine fractions. The coarse fraction is collected, weighed, sampled and dumped. The fine fraction is periodically transferred to an ore hopper where it is allowed to concentrate for later weighing, sampling, and disposal.

Char Recovery And Water Recycle System:

Quench water, used for cooling the syngas, exits the quench chamber and is combined with the water from the scrubber knock out pot. The combined water streams are cooled and routed to the clarifier where particulate matter (char) settles out and is collected as a sludge from the bottom of the clarifier. This material is weighed, sampled and discarded (no recycle). The clarified water is joined by the water condensed from the syngas (HP knock out pot blowdown). The combined streams are routed to the flash tank where dissolved gases which are evolved from the water when the pressure is reduced are removed as a flash gas stream. The flash gas is metered and sent to the flare. The flash tank water is recycled back to the quench chamber and gas scrubber. Any water not required to maintain the flash tank water level is removed from the system as a waste water stream.

DISCUSSION AND RESULTS OF PILOT PLANT EVALUATION RUN

Raw Material Properties:

The H-Coal liquefaction residue was shipped to the Montebello Research Laboratory in the form of random flakes about one quarter inch thick and less than two inches long.

The properties of the H-Coal liquefaction residue are summarized in Figure 2. Basis the MRL analysis, the H-Coal liquefaction residue contained 69.30 (wt.) percent carbon, 21.91 (wt.) percent ash and 2.10 (wt.) percent sulfur with a gross heating value of 12398 BTU per pound of residue (moisture free basis). The ash fluid temperature in a reducing atmosphere was determined to be 2270°F.

Pilot Plant Operations:

A total of ten tons of H-Coal liquefaction residue were ground and stored in one ton capacity tote bags to be used for this residue-water slurry test. During slurry preparation, while the residue was being added to a pre-calculated fixed amount of water, hard lumps of residue were discovered in the mix tank. An investigation revealed that part of the ground residue had overheated during storage and had fused into hard lumps. As a result, part of the remaining ground residue had to be discarded and that prevented us from achieving a higher solids concentration in the slurry. The residue-water slurry was screened several times to remove the lumps that had been found in it prior to charging it to the gasifier.

A brief description of the H-Coal liquefaction residue-water slurry test run with two test periods follows: The run was made at a constant pressure of 760 psig and the gasifier temperature was controlled within the range 2300°F-2600°F.

Test Period A (Computer Balanced Data)

The high pressure gasifier was charged with a slurry of residue in water at a rate of 2382 lbs/hr. Oxygen was charged to the gasifier at a rate of 1456 lbs/hr. The gasifier was operated for 6.5 hours under steady conditions.

The overall performance of the unit during this test period was smooth and satisfactory.

Test Period B (Computer Balanced Data)

The oxygen feed rate was reduced to 1344 lbs/hr while the slurry feed rate was held constant at 2348 lbs/hr. The gasifier temperature was lower than in test period A, however all other operating conditions were kept the same as in test period A. The unit ran smoothly. This test period lasted for 3 hours and was shut down automatically when the slurry supply had been consumed.

FIGURE 2

H-Coal Liquefaction Residue Properties

Ultimate Analysis	Dry
Wt.%	
C	69.30
H	4.37
S	2.10
N	1.22
Ash	21.91
O (by difference)	1.10
Higher Heating Value, BTU/lb	12398
Melting Range, °F	255-275
Ash Fusion Temperature °F (Reducing Atmosphere)	
Initial Deformation Temperature	1975
Softening Temperature	2060
Hemispherical Temperature	2140
Fluid Temperature	2270

Discussion of Results:

Figure 3 summarizes the material balance and analytical data obtained during the run. The H-Coal liquefaction residue-water slurry was fed to the gasifier at a rate of 2348-2382 pounds per hour. Over 99.6 percent conversion of carbon in the feed to syngas was achieved at an oxygen feed rate of 0.98-1.03 pounds per pound of residue, producing 32.9-33.7 standard cubic feet of dry syngas per pound of residue gasified. The dry syngas contained 78.6-79.8 (vol.) percent hydrogen plus carbon monoxide. No major operational difficulties were encountered while gasifying the H-Coal liquefaction residue in the water slurry form and the operation of the unit was satisfactory. After 9.5 hours of operation, the unit was shut down when the slurry supply was consumed.

The actual data shown on Figure 3 have been slightly adjusted by computer to yield 100 percent recoveries of the elements C, H, and O, and of ash. Also shown on Figure 3 is the material balance projected on the basis of a previous Type I Laboratory Evaluation of a sample of the residue (DOE Report Fe-2247-28, November, 1981). When the data are adjusted for equal feed residue slurry concentration, the good agreement between actual and projected performance is apparent.

The raw data obtained during the run are shown in Appendix A. The computer balanced data are shown in Appendix B.

A small amount of dissolved gases are flashed off when the pressure of the quench and scrubber blowdown water is lowered to atmospheric. The composition of the flash gas is shown in Appendix A and B. It was released at a rate of about 1.4 (vol.) percent of the syngas produced.

About 8 percent less carbon monoxide plus hydrogen and 19 percent more carbon dioxide than projected was actually produced in the dry syngas. The difference is due to a lower residue slurry concentration compared to the projected data.

Figure 4 is the solid recovery data from the gasification test run. A 92.5-96.2 (wt.) percent recovery of the input ash was achieved in the solids which were removed through the lockhopper system. The coarse slag contained insignificant amount of carbon while the lockhopper fines contained 2.84-4.06 (wt) percent of carbon.

A 3.8-7.5 (wt.) percent recovery of the input ash was achieved in the clarifier bottoms (char) stream. The char removed from the bottom of the clarifier contained only 10.9-11.7 (wt.) percent carbon.

Semiquantitative analyses of the above solid streams are shown in Appendix C.

FIGURE 3

Comparison of Predicted vs. Actual Performance
for Gasification of H-Coal Liquefaction
Residue-Water Slurry

	Predicted Data From DOE Report (Fe-2247-28 Figure 1)	Actual Data Test Period A	Test Period B
Charge to Gasifier			
Residue (Dry, Fresh), Lbs/Hr	1600	1,420	1,379
Water, Lbs/Hr	788	962	969
Pure Oxygen, Lbs/Hr	1,447	1,455	1,343
Total Input:	3,835	3,837	3,691
Output From Gasifier			
Dry Product Syngas, Lbs/Hr	3,009	2,734	2,649
Flash Gas, Lbs/Hr	-	59	49
Char, Lbs/Hr	81	13	23
Coarse Slag, Lbs/Hr	280	249	103
Lockhopper Fines, Lbs/Hr	-	15	19
Missing Ash, Lbs/Hr	-	40	164
Forced Water, Lbs/Hr	462	717	677
Total Output:	3,832	3,827	3,684
Analytical			
Charge Residue Analysis, wt%			
Carbon	68.94	67.93	68.04
Hydrogen	4.57	4.51	4.50
Nitrogen	1.31	1.28	1.28
Sulfur	2.13	2.06	2.05
Oxygen (by difference)	1.10	2.09	2.08
Ash	21.95	22.13	22.05
Higher Heating Value, BTU/Lb	12,770	12,328	12,337
Product Syngas Composition, Mole% (Dry)			
H_2	36.50	35.12	36.50
CO	49.37	43.43	43.26
CO_2	12.83	20.47	19.14
N_2	0.52	0.29	0.27
H_2S	0.68	0.65	0.69
COS	0.05	0	0
CH_4	0.01	0	0.10
A	0.04	0.04	0.03
Carbon on Coarse Slag, wt%	0.5	0.1	0.5
Carbon on Lockhopper Fines, wt%	-	4.1	2.8
Carbon on Char, wt%	13	10.9	11.7
Percent Carbon Conversion	99	99.8	99.6
Gasifier Pressure, psig	1,200	760	750
Dry Product Syngas, SCFH	55,500	46,729	46,497
H_2+CO in Product Syngas, SCFH	47,600	36,709	37,088
SCF Syngas/lb Residue	34.6	32.9	33.7
Percent CO+H_2 in Dry Product Syngas	85.9	78.6	79.8

FIGURE 4

Solids Recovery Data From The Gasification of
H-Coal Liquefaction Residue-Water Slurry

	Coarse Slag		Lockhopper Fines		Clarifier Bottoms(Char)	
Test Period	A	B	A	B	A	B
Pounds/Hr Recovered	286	261	17	22	14	26
Ultimate Anlysis, Wt%						
C	0.07	0.53	4.06	2.84	10.93	11.70
H	0.02	0	0.10	0.15	0.19	0.02
N	0	0	0	0.02	0.17	0.08
S	0.05	0.03	0.26	0.20	1.49	0.83
Ash	99.86	99.44	95.58	96.79	87.22	87.37
% of Total Input Ash	90.9	85.4	5.3	7.1	3.8	7.5
Particle Size Distribution Wt% Solids Retained on U.S. Sieve Number						
8	22.11	5.14	0	0	0	0
14	45.14	26.17	3.95	6.37	0	0
20	26.00	40.65	20.85	8.08	0	0
40	5.11	22.40	26.58	28.28	2.36	0.74
100	1.32	3.55	18.83	24.35	14.80	3.74
200	0.19	0.35	9.30	7.70	7.74	4.08
325	0.05	0.13	4.25	3.38	7.32	4.94
-325	0.08	1.61	16.24	21.87	67.78	86.50

ESTIMATE OF OPERATION FOR TYPE III EXTENDED PILOT PLANT TEST ON H-COAL LIQUEFACTION RESIDUE-WATER SLURRY

Based on the data obtained in this pilot plant run, a revised estimate of operation was prepared for gasifying 1500 pounds per hour of H-Coal liquefaction residue fed as a water slurry, should a Type III Extended pilot plant test be desired. During a Type III test, the oxygen rate would be varied to better define optimum gasification conditions. Figure 5 is our best estimate of optimum operation at this time. These conditions could be used as a centerpoint in a balanced experimental design. The distribution of coarse and fine slag shown on the estimate is somewhat arbitrary as this ratio may vary significantly from run to run. A 99.5 percent conversion of carbon in the feed to syngas is predicted which will yield 34.3 SCF of dry syngas per pound of carbonaceous feed.

FIGURE 5

Texaco Coal Gasification Process
Estimate of Operation For Type III Extended
Pilot Plant Evaluation

For: DOE Contract DEAC-01-76-ET10137 (EX-76-C-01-2247)

Location: Montebello Research Laboratory Pilot Plant

Charge Stock: H-Coal Liquefaction Residue-Water Slurry

Ultimate Product: Hydrogen

Charge to Gasifier	
Residue (Fresh, Dry), Pounds per Hour	1,500
Ultimate Analysis, Weight Percent, Moisture Free	
Carbon	69.30
Hydrogen	4.37
Nitrogen	1.22
Sulfur	2.10
Oxygen	1.10
Ash	21.91
Higher Heating Value, BTU per Pound	12,398
Pure Oxygen, Pounds per Hour	1,409
Water, Pounds per Hour	739
Product Compostion, Mole Percent, Dry	
Carbon Monoxide	49.50
Hydrogen	35.11
Carbon Dioxide	14.02
Methane	0.01
Argon	0.16
Nitrogen	0.48
Hydrogen Sulfide	0.68
Carbonyl Sulfide	0.04
Dry Product Gas, Standard Cubic Feet per Hour	51,400
Hydrogen Plus Carbon Monoxide, Standard Cubic Feet per Hour	43,500
Coarse Slag, Pounds per Hour	247
Carbon Content, Weight Percent	0.5

FIGURE 5 (Cont'd)

Lockhopper Fines, Pounds per Hour	60
Carbon Content, Weight Percent	4
Char Discharge, Pounds per Hour	27
Carbon Content, Weight Percent	8
Unconverted Carbon, Percent of Carbon in Feed	0.5
Gasifier Pressure, PSIG	750

CONCLUSIONS AND RECOMMENDATIONS

H-Coal liquefaction residue from Illinois No. 6 coal is a suitable feedstock for the Texaco Coal Gasification Process when finely ground and fed to the gasifier as a water slurry. About 6.7 tons of H-Coal liquefaction residue were gasified during a 9.5 hour successful run at 760 psig.

Essentially complete conversion of carbon in the feed to syngas was achieved at an oxygen feed rate of about 1.0 lb/lb residue. No operating problems were encountered during the run. A Type III extended pilot plant evaluation is recommended to better define optimum operating conditions.

APPENDIX A

Raw Data

RAW DATA
MONTEBELLO COAL GASIFICATION GENERATOR

RUN NUMBER	RUN PERIOD HOURS
1-A -A	6.50

FUEL TYPE
H-COAL RESIDUE-WATER SLURRY

DRY PRODUCT GAS STREAMS FROM COAL GASIFICATION

COMPONENTS	INTERNAL SYNGAS SCFH	INTERNAL SYNGAS MOLPCT	EXTERNAL SYNGAS SCFH	EXTERNAL SYNGAS MOLPCT	FLASH GAS SCFH	FLASH GAS MOLPCT
C6H6	0.00	0.00	0.00	0.00	0.00	0.00
A	60.90	.13	0.00	0.00	.87	.12
H2	16134.11	34.40	0.00	0.00	151.60	21.02
CO	20223.85	43.12	0.00	0.00	164.58	22.82
CO2	10044.00	21.42	0.00	0.00	390.53	54.15
N2	135.86	.29	0.00	0.00	12.33	1.71
CH4	0.00	0.00	0.00	0.00	.50	.07
H2S	299.82	.64	0.00	0.00	0.00	0.00
COS	0.00	0.00	0.00	0.00	.79	.11
NH3	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	100.00		0.00		100.00	
AVG MOL WT	22.55		0.00		31.25	

RECOVERED SOLIDS DATA

LH SLAG	LB/HR	248.89	
LH FINES	LB/HR	15.22	
SETTLER FINES	LB/HR	12.62	
FINES ANAL	LH	SETTLER	
PCT C	4.06	10.93	
PCT S	.26	1.42	
PCT H	.10	.19	
PCT ASH	95.58	87.39	

DRY FUEL ANALYSIS

	WTPCT
C	68.39
H	4.48
N	1.26
S	2.03
ASH	21.79
O	2.05
CL	0.00
TOT	100.00

O2/AIR ANALYSIS

	MOLPCT
O2	99.90
A	.10
H2	0.00
CO	0.00
CO2	0.00
N2	0.00
TOT	100.00
AMWT	32.01

CHARGE DATA

COAL SLURRY LBS/HR	2480.00
COAL RATE LBS/HR	1488.00
O2/AIR RATE SCFH	16611.52

PRODUCT DATA

INT SYN GAS,SCFH	46898.54
EXT SYN GAS,SCFH	0.00
FLASH GAS,SCFH	721.20
SOLIDS,LBS/HR	276.73
H2O,FORCED,LB/HR	721.63

PERFORMANCE PARAMETERS

	PER LB COAL FEED	PER LB C FEED
SCF SYNGAS	31.518	46.085
SCF FLASH GAS	.485	.709
LBS OXYGEN INPUT	.941	1.376
LBS WATER INPUT	.667	.975

RAW DATA
MONTEBELLO COAL GASIFICATION GENERATOR

RUN NUMBER 1 B-5 | RUN PERIOD HOURS 3.00

FUEL TYPE
H-COAL RESIDUE-WATER SLURRY

DRY PRODUCT GAS STREAMS FROM COAL GASIFICATION

COMPONENTS	INTERNAL SYNGAS SCFH	INTERNAL SYNGAS MOLPCT	EXTERNAL SYNGAS SCFH	EXTERNAL SYNGAS MOLPCT	FLASH GAS SCFH	FLASH GAS MOLPCT
C6H6	0.00	0.00	0.00	0.00	0.00	0.00
A	56.19	.12	0.00	0.00	.73	.12
H2	16745.62	35.76	0.00	0.00	127.08	21.02
CO	20154.68	43.04	0.00	0.00	137.96	22.82
CO2	9379.61	20.03	0.00	0.00	327.36	54.15
N2	126.44	.27	0.00	0.00	10.34	1.71
CH4	46.83	.10	0.00	0.00	.42	.07
H2S	318.43	.68	0.00	0.00	0.00	0.00
COS	0.00	0.00	0.00	0.00	.66	.11
NH3	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL		100.00		0.00		100.00
AVG MOL WT		21.96		0.00		31.25

RECOVERED SOLIDS DATA

LH SLAG LB/HR			102.50
LH FINES LB/HR			18.94
SETTLER FINES LB/HR			22.46
FINES ANAL		LH	SETTLER
PCT	C	2.84	11.70
PCT	S	.20	.83
PCT	H	.15	.02
PCT	ASH	96.81	87.45

DRY FUEL ANALYSIS

	WTPCT
C	68.39
H	4.48
N	1.26
S	2.03
ASH	21.79
O	2.05
CL	0.00
TOT	100.00

O2/AIR ANALYSIS

	MOLPCT
O2	99.90
A	.10
H2	0.00
CO	0.00
CO2	0.00
N2	0.00
TOT	100.00
AMWT	32.01

CHARGE DATA

COAL SLURRY LBS/HR	2425.00
COAL RATE LBS/HR	1430.75
O2/AIR RATE SCFH	15407.15

PRODUCT DATA

INT SYN GAS,SCFH	46827.80
EXT SYN GAS,SCFH	0.00
FLASH GAS,SCFH	604.54
SOLIDS,LBS/HR	143.90
H2O,FORCED,LB/HR	674.89

PERFORMANCE PARAMETERS

	PER LB COAL FEED	PER LB C FEED
SCF SYNGAS	32.730	47.857
SCF FLASH GAS	.423	.618
LBS OXYGEN INPUT	.908	1.328
LBS WATER INPUT	.695	1.016

APPENDIX B

Computer Balanced Data

COMPUTER BALANCED DATA
MONTECELLO COAL GASIFICATION GENERATOR

RUN NUMBER	RUN PERIOD HOURS
1 A	6.50

FUEL TYPE
H-COAL RESIDUE-WATER SLURRY

DRY PRODUCT GAS STREAMS FROM COAL GASIFICATION

COMPONENTS	INTERNAL SYNGAS SCFH	INTERNAL SYNGAS MOLPCT	EXTERNAL SYNGAS SCFH	EXTERNAL SYNGAS MOLPCT	FLASH GAS SCFH	FLASH GAS MOLPCT
C6H6	0.00	0.00	0.00	0.00	0.00	0.00
A	16.41	.04	0.00	0.00	.85	.12
H2	16412.66	35.12	0.00	0.00	149.52	21.02
CO	20296.55	43.43	0.00	0.00	162.32	22.82
CO2	9565.93	20.47	0.00	0.00	385.17	54.15
N2	136.51	.29	0.00	0.00	12.16	1.71
CH4	0.00	0.00	0.00	0.00	.50	.07
H2S	301.26	.64	0.00	0.00	0.00	0.00
COS	0.00	0.00	0.00	0.00	.78	.11
NH3	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL		100.00		0.00		100.00
AVG MOL WT		22.20		0.00		31.25

RECOVERED SOLIDS DATA			DRY FUEL ANALYSIS WTPCT		O2/AIR ANALYSIS MOLPCT	
LH SLAG LB/HR		285.66	C	67.93	O2	99.90
LH FINES LB/HR		17.04	H	4.51	A	.10
SETTLER FINES LB/HR		14.13	N	1.28	H2	0.00
FINES ANAL	LH	SETTLER	S	2.06	CO	0.00
PCT C	4.06	10.93	ASH	22.13	CO2	0.00
PCT S	.26	1.49	O	2.09	N2	0.00
PCT H	.10	.19	CL	0.00	TOT	100.00
PCT ASH	95.58	87.39	TOT	100.00	AMWT	32.01

UNACCOUNTED FOR H2S .110 M/HR
UNACCOUNTED FOR NH3 .514 M/HR

CHARGE DATA	
COAL SLURRY LBS/HR	2381.84
COAL RATE LBS/HR	1420.25
O2/AIR RATE SCFH	17267.66

PRODUCT DATA	
INT SYN GAS,SCFH	46729.30
EXT SYN GAS,SCFH	0.00
FLASH GAS,SCFH	711.30
SOLIDS,LBS/HR	316.83
H2O,FORCED,LB/HR	716.79

METERED TO CALCULATED FLOW RATIOS
O2= .962 SLURRY=1.041 UNC CARBON= .893 TOT SYNGAS=1.004 FLASH GAS=1.014
INT SYNGAS- PCT N2=1.00 PCT H2S=1.00 EXT SYNGAS- PCT N2=1.00 PCT H2S=1.00

PERCENT CARBON CONVERSION 99.764

PERFORMANCE PARAMETERS

	PER LB COAL FEED	PER LB C FEED
SCF SYNGAS	32.902	48.434
SCF FLASH GAS	.501	.737
LBS OXYGEN INPUT	1.025	1.509
LBS WATER INPUT	.677	.997

COMPUTER BALANCED DATA
MONTEBELLO COAL GASIFICATION GENERATOR

RUN NUMBER	RUN PERIOD HOURS
1 B	3.00

FUEL TYPE
H-COAL RESIDUE-WATER SLURRY

DRY PRODUCT GAS STREAMS FROM COAL GASIFICATION

COMPONENTS	INTERNAL SYNGAS SCFH	INTERNAL SYNGAS MOLPCT	EXTERNAL SYNGAS SCFH	EXTERNAL SYNGAS MOLPCT	FLASH GAS SCFH	FLASH GAS MOLPCT
C6H6	0.00	0.00	0.00	0.00	0.00	0.00
A	15.23	.03	0.00	0.00	.72	.12
H2	16971.89	36.50	0.00	0.00	125.34	21.02
CO	20116.21	43.26	0.00	0.00	136.07	22.82
CO2	8900.93	19.14	0.00	0.00	322.88	54.15
N2	126.60	.27	0.00	0.00	10.20	1.71
CH4	46.89	.10	0.00	0.00	.42	.07
H2S	318.85	.69	0.00	0.00	0.00	0.00
COS	0.00	0.00	0.00	0.00	.66	.11
NH3	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL		100.00		0.00		100.00
AVG MOL WT		21.62		0.00		31.25

RECOVERED SOLIDS DATA

LH SLAG LB/HR		260.52
LH FINES LB/HR		21.70
SETTLER FINES LB/HR		25.73
FINES ANAL	LH	SETTLER
PCT C	2.84	11.70
PCT S	.20	.83
PCT H	.15	.02
PCT ASH	96.81	87.45

DRY FUEL ANALYSIS

WTPCT	
C	68.04
H	4.50
N	1.28
S	2.05
ASH	22.05
O	2.08
CL	0.00
TOT	100.00

O2/AIR ANALYSIS

MOLPCT.	
O2	99.90
A	.10
H2	0.00
CO	0.00
CO2	0.00
N2	0.00
TOT	100.00
AMWT	32.01

UNACCOUNTED FOR H2S .034 M/HR
UNACCOUNTED FOR NH3 .534 M/HR

CHARGE DATA

COAL SLURRY LBS/HR	2348.32
COAL RATE LBS/HR	1378.71
O2/AIR RATE SCFH	15941.96

PRODUCT DATA

INT SYN GAS,SCFH	46496.66
EXT SYN GAS,SCFH	0.00
FLASH GAS,SCFH	596.27
SOLIDS,LBS/HR	307.95
H2O,FORCED,LB/HR	676.79

METERED TO CALCULATED FLOW RATIOS
O2= .966 SLURRY=1.033 UNC CARBON= .873 TOT SYNGAS=1.007 FLASH GAS=1.014
INT SYNGAS- PCT N2=1.00 PCT H2S=1.00 EXT SYNGAS- PCT N2=1.00 PCT H2S=1.

PERCENT CARBON CONVERSION 99.611

PERFORMANCE PARAMETERS

	PER LB COAL FEED	PER LB C FEED
SCF SYNGAS	33.725	49.565
SCF FLASH GAS	.432	.636
LBS OXYGEN INPUT	.975	1.433
LBS WATER INPUT	.703	1.034

APPENDIX C

Semiquantitative Analysis of H-Coal Residue-Water Slurry Run Slurry, Clarifier Bottoms, Slag Fines and Coarse Slag

Semiquantitative Analysis of H-Coal Residue Water Slurry Run Slurry, Clarifier Bottoms, Slag Fines and Coarse Slag

Component	Slurry	Clarifier Bottoms	Slag Fines	Coarse Slag
Si	5.9%	24.%	19.%	26.%
Al	1.9	7.8	11.	8.9
Fe	1.9	11.	10.	8.6
Ca	0.49	1.5	4.8	2.8
Mg	0.19	0.78	0.62	0.75
Ti	0.11	0.63	0.48	0.45
B	0.024	0.091	0.060	0.086
Mn	0.014	0.046	0.037	0.069
Na	0.10	TR < 0.10	0.72	0.64
Pb	0.0060	0.073	0.027	ND < 0.01
Cr	0.0024	0.013	0.021	0.031
Ni	0.0027	0.015	0.0099	0.012
Mo	0.0019	0.032	0.0081	0.0091
V	0.0024	0.014	0.010	0.012
Cu	0.0024	0.021	0.0067	0.0098
Ga	0.0014	0.020	0.0065	0.0043
Zr	0.0020	0.015	0.015	0.017
Co	0.00089	0.0078	0.0071	0.0080
Sr	0.0024	0.020	0.021	0.024
Zn	TR < 0.01	0.42	ND < 0.04	ND < 0.04
Ge	0.0016	0.0067	ND < 0.004	ND < 0.004
Other Elements	nil	----------	----------	nil
Loss on ignition (sulf. ash)	77.58%	6.90%	0.81%	0.69%

* The loss or gain of material is related to the procedure used to prepare the sample for analysis and does not reflect any loss or gain of weight in the sample itself.