TECHNICAL PROGRESS REPORT

April 1992 - June 1992

DOE/MC/26367--3235

DE93 008070

For:

U.S. Department of Energy
Morgantown Energy Technology Center

Under:

DOE Contract No. DE-AC21-89MC26367

Production of Low-Cost Hydrogen

By:

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PREFACE

This eleventh Quarterly Technical Progress Report presents the results of work accomplished during the period April 1, 1992 through June 30, 1992 under Contract No. DE-AC21-88MC26367 entitled "Production of Low-Cost Hydrogen." The overall objective of this program is to verify the ability of the MTCI indirectly heated fluid-bed gasifier to produce a hydrogen-rich product gas from liquefaction by-product streams and from char produced in mild gasification processes. The initial quarterly technical progress report included a subsection on background that is omitted in these subsequent quarterly reports.

The characterization unit was renovated and another burner/exhaust designed to replace the one that has been in use for several years. Initial shakedown tests for bed calcination indicated that the gasifier should be changed with fresh limestone and kept at temperature, with whatever make-up was required to maintain bed height until calcination was completed as determined by the CO concentration. Char gasification was then initiated and two relatively long-term tests (15.5 and 10.5 hours) were completed at two different temperatures.

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SECTION 1.0

PROJECT OBJECTIVES AND WORK STATUS

1.1 PROGRAM OBJECTIVES

The overall objective of the proposed effort is to verify, at the laboratory scale, the ability of the MTCI indirectly heated fluid-bed gasifier to economically produce a hydrogen-rich product gas from liquefaction by-product streams and from char produced in mild gasification processes. Specifically, the proposed effort is aimed at developing an experimental technology data base by defining the process characteristics that would be required for process integration into an overall liquefaction system. This would result in substantial decreases in the cost of hydrogen for the production of competitively priced coal-derived liquid fuels.

An important objective of the proposed effort is to provide a process data base that can be utilized by the AMOCO Corporation in evaluating the design and economics of an integrated liquefaction process which employs the MTCI gasifier for hydrogen production. The AMOCO Corporation has offered to provide this effort at no cost to MTCI or the government. Their participation in the project is an important element in verifying the economics of an indirectly heated gasifier to meet the overall program objective of reducing the cost of direct liquefaction processes.

1.2 SUMMARY STATUS FOR THE PERIOD

The characterization unit was renovated and another burner/exhaust designed to replace the one that has been in use for several years. Initial shakedown tests for bed calcination indicated that the gasifier should be changed with fresh limestone and kept at temperature, with whatever make-up was required, to maintain bed height until calcination was completed as determined by the CO concentration. Char gasification was then initiated and two relatively long-term tests (15.5 and 10.5 hours) were completed at two different temperatures.

SECTION 2.0

TECHNICAL DISCUSSION OF THE WORK ACCOMPLISHED DURING THE REPORTING PERIOD

The bench-scale test rig was reassembled for char testing. In the previous char gasification tests it was observed that limestone, used as bed material, becomes calcined at the gasification temperature of 1400-1500°F. It was therefore decided to first calcine the limestone and use the resultant lime as the bed material. This would also provide a better material balance.

A calcination test was conducted on May 21st to produce approximately 150 pounds of lime. The calcined bed was removed and weighed and put back for the char gasification test on May 22nd. During this test the injection screw of the feeder was found to be plugged. The feeder was cleaned and put back in operation. However, afterwards the cyclone and venturi scrubber inlet were plugged. It was also observed that the bed fluidization was quite uneven and could not be controlled; the test, therefore, had to be aborted. The plugging at both subsystems occurred because of hydration of lime to form calcium hydroxide which agglomerated due to steam condensation. The uneven fluidization occurred also due to agglomeration of the lime bed.

In order to avoid these problems, it was decided to run the next test in one-shot by first calcining the limestone completely and then feeding char to the bed for gasification. A test was conducted on May 26th with fresh limestone bed. After about 10 hours of heating, it was observed that the bed was not heating properly, the temperature being maintained at around 1300°F. When the firing rate was increased, the exhaust pipe of the pulse heater was observed to be extremely hot and the test had to be aborted. Later inspection of the combustor revealed that over the years the partition plate and the refractory between the combustion chamber and the exhaust chamber yielded and melted during this test. The combustion-cum-exhaust chamber assembly was redesigned and refabricated. Figure 1 shows the schematic of the assembly. The refractory was cured and the system was again reassembled for testing.

FIGURE 1: TWO-TUBE COMBUSTOR CHAMBER - MODIFIED DESIGN

The solids carryover to the scrubber system was found to be well above the norm. Calculations revealed that the velocity at the inlet of the second cyclone was quite small, resulting in inefficient solid removal. The inlet to the cyclone was modified to increase the velocity. A long duration test was conducted on June 2, 1992. Fresh limestone was used as the bed material. The bed was brought up to temperature over a period of 12 hours. It was necessary to heat up the bed slowly since the pulse combustor refractory was not cured fully.

Table 1 provides the ultimate analysis of the AMAX char to be gasified.

TABLE 1:
ULTIMATE ANALYSIS OF AMAX CHAR

	<u>As Rec'd (Wt.%)</u>	<u>Dry (Wt. %)</u>
MOISTURE	1.55	-
C	81.02	82.30
H	2.08	2.11
N	0.95	0.96
S	0.52	0.53
O (by difference)	1.03	1.05
Ash	<u>12.85</u>	<u>13.05</u>
TOTAL	100.00	100.00

Approximately 160 pounds of fresh limestone was loaded into the reactor. The pulse combustor was fired at 0.25 MMBtu/hr. The bed was heated to 1450°F and kept at that temperature until the bed was fully calcined. Air was used as the fluidizing media. During calcination another 16 pounds of additional limestone was added to the reactor to make up the bed. The CO₂ evaluation due to limestone calcination was monitored until CO₂ concentration dropped to less than 0.5% V/V. When all the limestone was calcined to lime, char feed was commenced. A total of 205 pounds of char was fed into the gasifier over a period of 15½ hours. An average feed rate was maintained at 13.2 lbs/hr and an average bed temperature of 1440°F was maintained. Fluidization velocity

ranged from 1.0 to 1.5 ft/s, and the steam mass rate to the reactor ranged from 20 to 25 lbs/hr.

The above test was immediately followed by a second test with char provided by AMAX. During this test, 178 pounds of char were fed into the gasifier over a period of 10½ continuous hours. At this point, all the char depleted. The average feed rate to the gasifier was approximately 16.9 lbs/hr. The steam flow rate ranged from 20 to 25 lbs/hr. The average bed temperature over the test was 1507°F.

Product gas samples were measured by the gas chromatograph and bed and cyclone solid samples and venturi scrubber condensate samples were collected at two-hour intervals.

The solids and condensate samples were sent to an outside laboratory for analysis.

The average gas composition for the two tests is shown in Table 2.

TABLE 2:
TEST SUMMARY

	<u>TEST #1</u>	<u>TEST #2</u>
AVERAGE BED TEMPERATURE (°F)	1400	1507
TOTAL CHAR FED (lb)	205	178
CHAR FEED RATE (lb/hr)	13.2	16.9
STEAM FEED RATE (lb/hr)	20 - 25	20 - 25
TOTAL HOURS FED (hr)	15.4	10.5
PRODUCT GAS COMPOSITION (%V)		
HYDROGEN	54.33	57.50
METHANE	2.10	1.57
CARBON MONOXIDE	27.81	20.28
CARBON DIOXIDE	15.73	20.58
HYDROGEN SULFIDE	<u>0.04</u>	<u>0.15</u>
TOTAL	100	100

SECTION 3.0
PLANS FOR THE NEXT PERIOD

- Upon receiving the solid condensate sample analysis, a complete mass balance will be conducted for the test.
- Finalize the product gas composition.
- Reduce all the data and write a test report for char gasification.
- Setup testing for SRC gasification.

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