MWK-MPR-7

RESEARCH AND DEVELOPMENT DEPARTMENT

DEVELOPMENT OF KELLOGG COAL GASIFICATION PROCESS

Contract No. 14-01-0001-380

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Progress Report No. 7

APPROVED:

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CONTENTS

# I. INTRODUCTION

The evaluation of gas purification processes was continued. Preliminary process designs were prepared for plants to produce pipeline gas or hydrogen from raw materials other than bituminous coal.

The rate of gasification for anthracite at 1700°F appears to be independent of coal size, bed height, steam pressure, steam feed rate and superficial gas velocity.

An initial gasification experiment on lignite indicates that it is 50% to 100% more reactive than anthracite.

The second environmental test with refractory samples has begun. To date 114 hours have been logged.

## II. PROCESS DEVELOPMENT

### A. Accomplishments

The evaluation of gas purification processes was continued. Information from Lurgi on the Rectisol process is still being awaited, but process designs and cost estimates have been finished for the other systems being considered.

Preliminary process designs were prepared for plants to produce pipeline gas or hydrogen from raw materials other than bituminous coal, on which all studies to date have been based. Specifically, the Pennsylvania anthracite, Wyoming sub-bituminous coal, and North Dakota lignite listed in Progress Report No. 1 were considered. Approximate cost estimates are being made to permit a very rough estimate of economic attractiveness for these other raw materials.

A study of the recovery of secondary products, particularly sulfur and ash minerals, has been started. This effort will have two objectives at this stage:

1. To determine the magnitude of credits that could be obtained from sale of these secondary products, assuming that they can be recovered at no additional cost to the process.

2. To compare the quantities of secondary products recovered from a 250MM SCFD pipeline gas plant with the total U. S. consumption of these materials to determine whether the market is large enough to yield the credits calculated in #1.

### B. Projections

Evaluations of gas purification schemes and secondary product recovery will be continued. The effect of experimental results to date on process design assumptions, economics, and the future direction of the development program will be reviewed.

## III. PROCESS RESEARCH

### A. Accomplishments

#### 1. Physical Property Data

Melt composition, temperature, viscosity relationships have been completed for all coal ashes except sub-bituminous. Viscosities equilibrate in 4 hours or less. Table 1 gives the equilibrium values of the melt in the presence of steam and $CO_2$. The data for 30% bituminous ash has been corrected from previously reported viscosity since this particular composition is susceptible to ash settling.

#### 2. Gasification Studies

Work on the rate of gasification of coal in a molten sodium carbonate medium is continuing. The kinetic response to changing operation parameters is being investigated. A summary of recent runs is compiled in Table 2. The data indicate that anthracite gasification rate apparently does not respond to increase in steam pressure, bed height, coal/melt mixing (superficial gas velocity) or particle size of coal charged. The effect of particle size is however obscured by the fact that the coal is thermally shocked and definite conclusions as to whether particle size affects the rate cannot be made. Lignite appears to be about 50-100% more reactive than anthracite.

Possible mechanisms of steam gasification in molten salt appear to be (1) the rate limiting reaction is the rate of the $Na_2CO_3 + C \xrightarrow{slow} Na_2O + 2CO$ reaction or (2) the gasification rate is limited to mass transfer of catalyst to the coal or heat transfer to the coal.

TABLE 1

COAL ASH - $Na_2CO_3$ VISCOSITIES

| Test [illegible] | Wt. % $Na_2CO_3$ | Temp. °F | Atmosphere CO₂/Steam | Viscosity, CPS. |
|---|---|---|---|---|
| Anthracite (2) | 15 | 1650 | 1/ | 1000 |
| " | 30 | " | S/1, 1/1 | 8000 |
| " | 15 | 1800 | 1/1 | 300 |
| " | 30 | " | S/1, 1/1 | 7000 |
| Bituminous (3) | 15 | 1650 | S/1, 1/1 | 1000 |
| " | 30 | " | S/1 | 18,000 |
| " | 15 | 1800 | S/1, 1/1 | 800 |
| " | 30 | " | S/1 | 17,000 |
| Lignite (4) | 15 | 1650 | S/1 | 200 |
| " | 30 | " | S/1 | 1600 |
| " | 15 | 1800 | S/1 | 100 |
| " | 30 | " | S/1 | 1000 |

(1) All coal ashes prepared by burning in air

(2) Greenwood anthracite

(3) #27 Island Creek Bituminous

(4) South Beulah lignite

Table 2

ANTHRACITE AND LIGNITE GASIFICATION

Rate of Coal Gasification, 1700°F

| Run No. | Coal Charge | Quiescent Bed Hght. (Inches) | (1) $P_{H_2O}$ psia | Sup. Gas Vel. Ft/Sec. (2) | Reaction Rate Constant, k, $hr^{-1}$ (7) |
|---|---|---|---|---|---|
| J-9654 | 20 g. < 60 mesh (loose pellets) Anthracite (5) | 4 | 7.8 | 0.074 | 0.19 |
| J-9655 | 20 g. < 10 mesh anthracite (5) | 4 | 7.6 | 0.080 | 0.23 |
| J-9656 | 40 g. < 10 mesh anthracite (5) | 8 | 11.4 | 0.30 | 0.17 (4) |
| J-9657 | 38 g. < 10 mesh anthracite (5) | 8 | 13.6 | 0.26 | 0.23 |
| J-9658 | 7.5 g. (3) 12/20 mesh lignite (6) | 4 | 13.5 | 0.51 | .31-.45 |

(1) Balance of inlet pressure is nitrogen (Total Pressure = 14.7 psia)
(2) $N_2$ + $H_2O$ Feed (Moles/Hr) x 0.0441
(3) 3.5 g. of fixed carbon
(4) Approx. value. Due to reactor plugging and possible gas leakage this value may be low.
(5) Greenwood anthracite
(6) South Beulah lignite
(7) Reaction rate constant for first order reaction with respect to coal

F. Projections

Experimentation using preimpregnated ($Na_2CO_3$) coal (or coke) will be performed in an attempt to discover the mechanism of gasification.

## IV. MECHANICAL DEVELOPMENT

### A. Accomplishments

#### 1. Environmental Testing of High Temperature Materials

Test #2 got underway during this report period. The objective of this test is to subject refractory samples to an endurance of 250 hours. To date 114 hours have been logged. The refractory samples undergoing the test were as listed in the last report, namely:

| Carborundum | Harbison-Walker |
|---|---|
| Mullfrax H | Chromex B |
| Mullfrax W | Varnon BF |
| Herbide | Harklase |
| Zircofrax | Korundal XD |
| KT Silicon Carbide | |

General Refractories

Ritex CB

### B. Projections

#### 1. Environmental Testing of High Temperature Materials

Quantitative corrosion rate data of the metal alloys (100 hours exposure in Test #1) are expected from The International Nickel Company in the very near future. The selection of metal alloys for Test #3 will be made after results from Test #1 are known. In addition to running those alloys which showed promise in Test #1 it is planned to test additional cast metal alloys which have good corrosion

...service records as fired furnace tubing (centrifugally cast alloy). Among these are two alloys produced by the Electro-Alloys Division of American Brake Shoe Company, having chrome-nickel compositions of 25-20 and 15-35.

## V. MANPOWER AND COST ESTIMATES

Figure 1 shows the projected manpower breakdown for Phase I for 1965 as well as the actual effort that was made. It can be seen that a nine-man effort was made during February.

Figure 2 shows the expenditures during February. For the month $14,270 was expended not including fee and G & A. The total expenditures through February were $112,124. Including fee and G & S the total expenditures were $132,700.

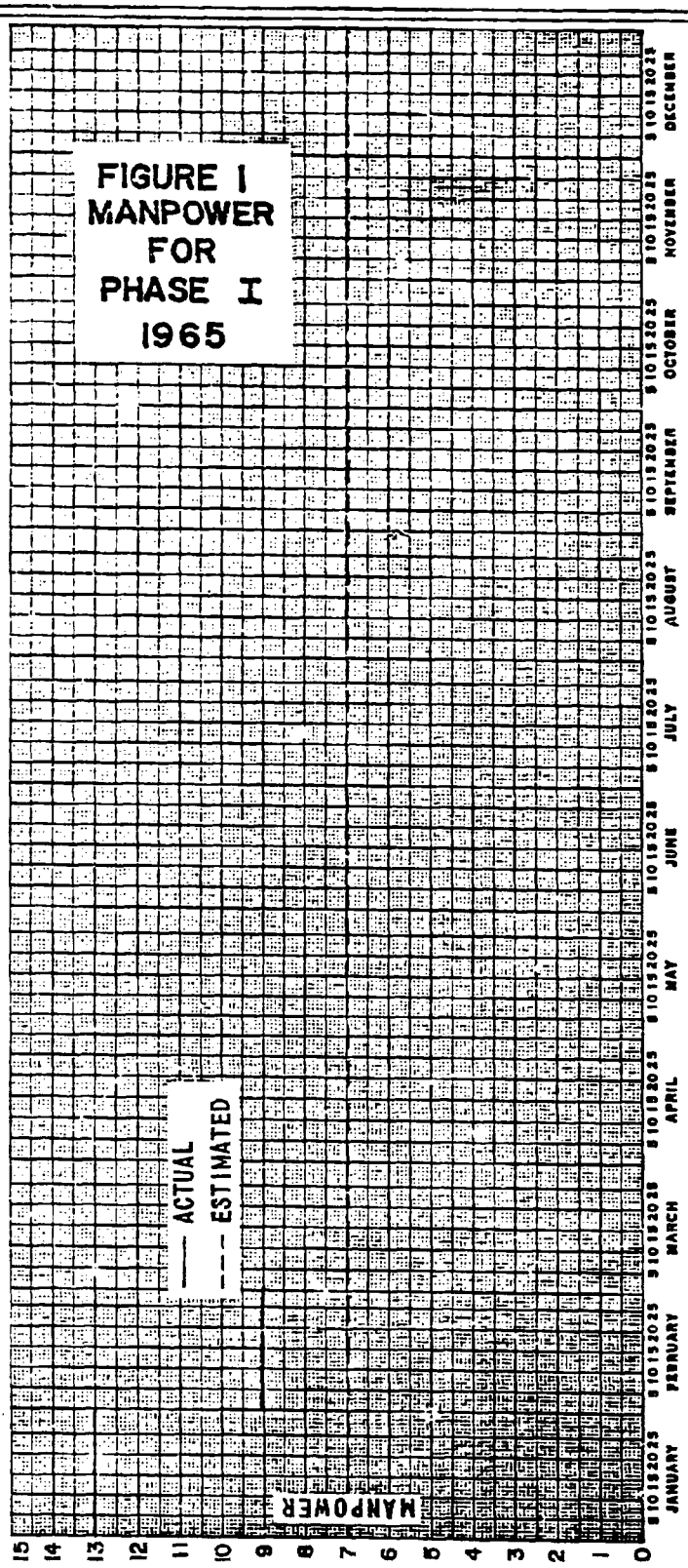
FIGURE 1
MANPOWER
FOR
PHASE I
1965
MANPOWER
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
ACTUAL
ESTIMATED
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER

# FIGURE 2
# COST ESTIMATE FOR PHASE I
# 1965