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PROTOTYPE PILOT PLANT OPERATION
SYNTHANE PROCESS

CONTRACTOR MONTHLY ACTIVITY REPORT NO. 38
FOR THE PERIOD
OCT. 1 — OCT. 31, 1977

THE LUMMUS COMPANY
BLOOMFIELD, N.J. 07003
LUMMUS JOB NO. 7849

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November 30, 1977
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Mr. Harold N. Miller, Director
Contracts Management Office
U. S. Department of Energy
9800 South Cass Avenue
Chicago, Illinois 60439

Dear Mr. Miller:

SUBJECT: CONTRACTOR MONTHLY ACTIVITY REPORT NO. 38
for the period covering October 1-31, 1977

Report No. C00-0003-15 covers activities conducted by The Lummus Company at the Synthane Prototype Pilot Plant in Bruceton, Pa., under DOE Contract No. EY-76-C-02-0003.*000.

Very truly yours,

S. E. Carson
S. E. Carson
Plant Manager

/ce

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PROTOTYPE PILOT PLANT OPERATION
SYNTHANE PROCESS

MONTHLY ACTIVITY REPORT NO. 38
FOR THE PERIOD
OCTOBER 1-31, 1977

COO-0003-15

I. ABSTRACT

Three attempts were made to operate the pretreater continuously in October using Illinois No. 6 coal, but each ended after a short operating period with coal agglomerating in the vessel. Procedures were varied during these tests in an attempt to achieve operability. The first two attempts were made using carbon dioxide to transport the coal from the Petrocarb System to the pretreater, and the third attempt was made using high pressure steam. The use of steam as the transport medium was the most successful. The run was terminated when the coal feed stopped due to condensation of the steam in the line. When the pretreater was opened after this run, the vessel contained some agglomerated coal but most of the pretreater bed was free flowing and pretreated.

Plans are underway to fabricate a temporary superheater and acquire a permanent steam superheater for coal transport with steam. Additional tests with carbon dioxide as the transport medium will continue until a superheater is installed.

II. INTRODUCTION, PROJECT OBJECTIVE, AND ACTIVITY SUMMARY

This report is a presentation of the work accomplished during October 1977 at the Synthane Prototype Research Pilot Plant. The Plant is operated by The Lummus Company for the U. S. Department of Energy which was initiated under Contract H036030 by the U. S. Department of Interior, U. S. Bureau of Mines, and was transferred to DOE as Contract (36-2)-0003 and subsequently renumbered to Contract EY-76-C-02-0003.*000. This report represents the 38th month of progress.

The objective of this Contract is to obtain definitive process information sufficient for commercial design purposes on the conversion of coal to pipeline quality gas. This objective is to be accomplished through the execution of experimental and developmental operation programs in the Government-owned Synthane Pilot Plant, located in South Park Township, Allegheny County, Pennsylvania.

The following is a summary of activities during October:

1. The pretreater was operated using Illinois No. 6 coal on October 25, 29 and 31. The runs conducted on October 25th and 29th were made using carbon dioxide as the coal transport medium. The runs were stopped after approximately one hour of operation due to agglomeration in the pretreater. The run conducted on October 31 used steam as the coal transport medium and was the most successful to date. This run was curtailed after nearly two hours of operation because

the outlet of the Petrocarb System plugged with wet coal. The pretreater when opened contained some agglomerated coal, but in general, the bed was free flowing and pretreated. The steam which is available, is only 720°F and does not have enough superheat when combined with coal feed to prevent condensation in the feed line. A major effort is now being undertaken to fabricate a temporary steam superheater and purchase a permanent superheater in order to transport the coal with steam. It is also planned to inject oxygen with the steam in order to achieve some pretreatment in the line before the coal enters the pretreater.

2. Enclosing of the structure is presently requiring a major effort. This project is estimated to be 60% completed. The structure will be enclosed from the second through the seventh floors, and from the 11th to the 13th floors in an effort to provide more operability during the winter months.
3. The Benfield and Stretford Units are currently in circulation and are ready for operation.

III. ACTIVITIES DURING THE MONTH

OPERATIONS

1. The gasifier, pretreater and gas scrubbing area were shut down and opened for inspection on October 1. The Plant then remained down for 21 days in order to remove obstructions in piping that were interfering with enclosing the structure, and to install an oxygen line into the coal transport line such that oxygen can be injected into the coal transport line with the transport gas. Modifications also included extending the cyclone dip leg to the cone line and replacement of check valves in the Petrocarb System.

The gasifier and the pretreater were closed and heatup was started on October 22. Steam and CO₂ circulation were started on October 24. A coal bed was established in the pretreater on October 25 and the bed heated to 800°F. Feed was then restarted per the procedure using carbon dioxide as the transport medium. Shutdown was necessary after 1-1/2 hours due to agglomeration in the pretreater.

A decision was then made to try to transport coal with steam rather than carbon dioxide even though the pretreater was plugged. Coal was then transported with steam successfully for two hours after which the pretreater was shut down and opened for cleaning. Gasifier was also depressured in order to repair a packing gland leak on the char cooler slot valve. When the slot valve repairs were completed, the system was repressured and steam circulation was established.

The pretreater when opened, was found to be half full of soft agglomerated coal. The feed pipe was then modified by lowering the feed line to the bottom of the cone. A splash plate was installed below the feed line to divert the feed. The pretreater was closed and pressure tested on October 27. A leak developed in the steam side of the CO₂ heater which then delayed the next pretreater run.

The next run was conducted on October 29. During this run, it was decided to modify the procedure by slowly introducing oxygen. With this procedure, the initial bed temperature was heated at 5 to 7°F per minute to 800°F and then held for 15 minutes before reintroducing feed. Carbon dioxide was again used for coal transport. Shortly after restarting coal and oxygen feed, a high differential pressure between the gasifier and char cooler tripped coal and oxygen feed to the pretreater. Even though the pretreater operation was resumed within a minute, the interruption in oxygen feed may have helped cause the agglomeration which shortly thereafter occurred in the pretreater, and resulted in the termination of the run.

On October 31, another pretreater run was attempted. However, this time steam was used to transport the coal to the pretreater. During this run, the pretreater was heated to 800°F with oxygen and carbon dioxide at which time the carbon dioxide transport gas was changed to steam. Oxygen was then started to the transport line immediately followed by coal. Operation continued for 2 hours when coal feed was lost due to plugging of the transport line with wet coal under the primary injector of the Petrocarb system. The pretreater was opened and was found to contain some small pieces of agglomerated coal and mostly free-flowing coal which was pretreated by FSI analysis.

2. Initial charging of chemicals to the Stretford Unit began on October 9, and was completed on October 14. The Stretford Unit is presently circulating at desired solution strength ready for operation.
3. Benfield Unit circulation started on October 20 and continues to circulate through the end of the month with no operating problems.

TECHNICAL

1. Calculations show that the equilibrium temperature in the coal transport line of a mixture of 6000 SCFH CO₂ at 550°F and 4000 lbs/hour of coal at 150°F as presently operated will be about 200°F. If hot CO₂ is also used to the primary injector, the maximum temperature of the feed will be about 250°F. As it is our understanding that the ignition temperature of coal with oxygen is between 350°F and 450°F, the use of oxygen in the lift line with carbon dioxide transport should have no advantage. The low feed temperature, caused by using carbon dioxide as the transport medium, is believed to be causing agglomeration in the pretreater.

It has therefore been decided to design a steam superheater for 1100°F steam for the transport of coal from the Petrocarb System. It was agreed that the design basis for the superheater shall be for 1000 psig and 600 psig gasifier operations with some overdesign. The design requirements have been issued to the Plant Engineering Group for detailing and purchasing.

2. A kinetic model for the gasifier has been written. This model takes into account the properties of fluidized beds, rates of

various reactions, etc. We are presently reviewing literature to obtain rate constants for the various reactions. We have been able to obtain expressions to determine various reaction rate constants for the gasifier kinetic model. Some form of expressing the reaction rate for methane producing reactions is yet to be obtained.

3. A graph of steam decomposition versus gasifier bed temperature has been plotted using the steam to coal ratio as a parameter. The plot indicates that the steam decomposition increases with increasing temperature. A temperature of about 1800°F is estimated to be required to obtain the 25% to 30% steam conversion assumed in the original gasifier design.

The study of the effect of total oxidant, defined as oxygen in steam plus elemental oxygen, on carbon conversion, and gas yields has once again confirmed our earlier conclusions. This study indicates the relative unimportance of the residence time on conversions and gas yields. A memorandum on this subject is being prepared.

4. The overall and elemental material balance calculations for the gasifier have been completed, and these calculations will be completed by the computer. A preliminary format for reporting the balances has been prepared.
5. As a result of a study of the Benfield System, we have concluded that the 2-inch Intalox saddles used as packing in the tower may be overloaded when processing Illinois No. 6 coal. A memorandum discussing our recommendations has been released.
6. Representatives of the Pennsylvania Department of Environmental Resources were on site for a meeting in which we were seeking modifications to our NPDES permit. We have requested to allow the blowdown water from the high pressure boiler to be a pH of 10 as opposed to the original NPDES permit wherein we specified that this blowdown would have a pH of 9. Operating experience with our boilers dictates that the boiler water must be maintained at a pH of 10 for correct phosphate control.

ENGINEERING

1. The preliminary design for the gasifier overhead sampling system was released for consideration.
2. Final design has been completed for the installation of the CO Monitoring System in the structure.
3. The design for the Willis Choke Valve modifications was released to Maintenance. A choke was modified using the newly designed double orifice. Preliminary tests were run on October 21 to check the flow rate and controllability of the new trim.
4. The final design for the modifications to the pretreater feed line was released to Maintenance.

5. Preliminary design for fabrication of a 3-inch slot valve was released for consideration. The proposed design of the 3-inch slot valve makes use of a sash weight to maintain closure of the slot valve flapper.
6. The final design for the installation of double block and bleed valves for the low pressure boiler pilots was released to Maintenance.
7. The final design to convert the gasifier startup heater from fuel oil to propane has been completed.
8. The preliminary design for caustic injection to the 48-inch storm sewer was released for consideration. This project has been prepared because acid mine water is destroying the main sewer line through the Plant.
9. A review meeting was held to consider modifications to the shower and locker facilities. It has been proposed to supply all clothing including jackets, work suits, thermal underwear, socks and shoes and to provide a clean and dirty room.
10. The final design to redirect the char cooler outlet steam to thermal oxidizer water guns was released for approval.
11. A review meeting was held with the Technical Department to discuss the design and scope for installation of a superheater for utilizing steam rather than carbon dioxide as the medium for coal transport to the pretreater. The initial scope considers installation of an electrical steam superheater to provide 1100°F steam. The modification also required that the existing transport line be increased from one to two inches.
12. All drawings have been completed for the routing of a fire alarm indicator in the Control Room from the sprinkler systems in the Warehouse and the Modular Building. The final design will be issued during November. This is one of the projects requested by the DOE Fire and Safety Audit.

MAINTENANCE

1. During the month of October, 337 work orders were completed. A backlog of 141 work orders was carried through to November.
2. Major jobs worked during the month were as follows:
 - a. The Stretford Desulfurization Unit was prepared for operation.
 - b. The pretreater was opened, cleaned and closed three times. The gasifier and char cooler were opened, cleaned and closed once during October. Two modifications were made to the pretreater coal feed inlet.
 - c. The thermal oxidizer experienced a refractory failure above

the manway. The arch partially collapsed and required extensive repairs using C-E refractories.

- d. Considerable effort and time were spent on relocating electrical conduit, high pressure steam lines, and process piping in order to provide clearances for the structure enclosure project.
- e. A concentrated effort is being made to complete the steam condensate return system before cold weather arrives. This effort is required as a result of the Benfield and the Stratford Units being operational and their increased use of steam.
- f. An oxygen line was connected into the coal transport line to the pretreater. This modification will allow oxygen to be injected with the transport gas to the pretreater.
- g. The electric tracing on the coal transport line from the ground floor to the tenth floor failed. The heat transfer cement appears to have deteriorated causing inadequate heat transfer resulting in a hot spot. A 3-circuit system was installed in place of the single circuit system.

SAFETY

1. There were no reportable injuries for Lummus employees in October. Lummus personnel have now worked 41 months without any lost-time accidents.
2. Safety data sheets are being prepared for all chemicals used in the Chemical Laboratory.

PLANT VISITORS DURING THE MONTH

Representatives from C. F. Braun, Alhambra, California.
Fossil Energy Senior Staff Members from the Department of Energy.
Representatives from Office of Management and Budget, President's Domestic Policy Staff, Department of Interior, Office of Science and Technology Policy of the White House, Environmental Protection Agency, and the Council of Environmental Quality.
Mr. Brian Robson from the National Coal Board, England.
Mr. Jim McGee from Gilbert Associates, Morgantown, West Virginia.
Representatives from the Department of Environmental Resources.
Mr. Carlos Martinez from Colombia Oil and Gas.
Visitors from Yugoslavia.
Dr. R. Yamamura from Coal Mining Research Center, Japan.
Mr. H. Komatsu from Japan Coal Association.
Mr. A. Kamono from Matsushima Coal Mining Co., Ltd.
Representatives from International Gas Technology.
Dr. Langhoff from Ruhrkohle Ag, Essen, Germany.
Dr. Wolowski from GVV, Bottrop, Germany.
Mr. Schlupp from Steag, Essen, Germany.
Dr. Wien from Steag, Essen, Germany.

IV. PROBLEMS

Six attempts have been made thus far to operate the pretreater. In all cases, the operation had to be curtailed after only a few hours of operation because of agglomeration in the pretreater. In five runs, carbon dioxide has been utilized for coal transport and during one run, steam was utilized.

Procedures require partial loading of the pretreater with coal and then heating with oxygen to 700°F and in later tests, to 800°F before reintroducing coal feed. Each time coal feed is reintroduced using carbon dioxide as the transport gas, the bed temperatures dropped and the bed immediately thereafter agglomerated.

During the last test, high pressure steam was used to transport the coal. After 2 hours, the feed line eventually plugged with wet coal because the steam used does not contain enough superheat to prevent condensation in the line. Following this run, the pretreater was opened and although there was some pieces of agglomerated coal in the vessel, most of the material was free flowing and was pretreated by PSI analysis.

It appears that if superheated steam were available for coal transport, the pretreater would operate satisfactorily. A superheater, therefore, is being designed on a priority basis. A temporary superheater will be fabricated until a permanent unit can be acquired. Until such time that the temporary superheater is completed, tests will continue with carbon dioxide as the transport medium in order to investigate other operating possibilities.

V. PLANS

1. Continue to operate the pretreater and attempt to resolve the agglomeration problems.
2. On a priority basis, design and purchase a superheater to provide high pressure steam at 1000°F for transporting the coal from the Petrocarb System to the pretreater.
3. Continue Laboratory studies of agglomeration in an attempt to obtain more information on conditions that promote agglomeration.