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DOE/MC/14601--T3

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COAL MATERIALS HANDLING
COAL FEEDER DEVELOPMENT
PHASE I
2ND QUARTERLY TECHNICAL
PROGRESS REPORT
JANUARY - MARCH 1981
CONTRACT NO. DE-AC21-80MC 14601

Submitted to:
U.S. Department of Energy
Morgantown Energy Technical Center

Submitted by:
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April 27, 1981

1. Objectives and Scope of Work

The FMA Linear Pocket Feeder (LPF) is a positive displacement feed system in which the pressure seal is developed by a set of mechanical labyrinth seals between the piston rings and the sealing tube. The pressure seal is completely independent of the type and size of coal used. The LPF can maintain a pressure difference with no coal in the system and can achieve steady state operation in less than a minute after startup. Coal flow rate can be changed while the LPF is operating at design speed and operating pressure with no effect on the LPF's performance. A test program has been developed using these inherent features of the LPF which demonstrates its capability to meet the specified acceptability criteria.

The LPF has the potential for operating on all types and sizes of coal as long as they are free flowing. The test program will verify performance of the LPF on all three sizes of coal, 3/4 x 0 in., 1/4 x 0 in., and 70 percent minus 200 mesh, all four types of coal specified in the RFP and varying moisture content.

Phase I - Proof of Concept

The scope of work includes:

- Upgrading of the existing prototype LPF
- Upgrading the FMA test facility
- Critical component development and testing
- Effect of moisture on LPF performance
- Test verification of operational limits of the LPF for conditions specified in the RFP

- Verification of operational controls and safety under various failure modes
- Documentation.

1.1 Upgrading of the Existing LPF

The existing LPF will be upgraded utilizing the knowledge gained during the previous 330 hours of operation.

The major areas which are targetted for redesign and a brief description of the intended changes are listed below.

1.1.1 Loading Station

The loading station will be redesigned to allow the infeed of coarse coal in such a manner that minimum degradation occurs during entry into the pockets of the feeder and feed of pulverized coal in a way that minimizes entrapment of air under the coal charge to allow quicker settling.

1.1.2 Unloading Station

Unloading of the coal from the pockets has been accomplished by gravity dropout to this point. This is generally satisfactory for coarse coal but a small amount, which sits on horizontal chain surfaces, does escape the reactor vessel and reaches the gas water transfer station to eventually end up in the water tank. In the case of pulverized coal, a much larger amount bypasses the unloading station and contaminates the water supply.

It is our intention to provide a flow of gas from the reactor, past the chain at the unloading station and return into the reactor in order to provide a gas velocity to clean this coal from the chain.

1.1.3 Improved Gas--Water Transfer Station

The gas--water station and the water supply system will be revised in order to provide an automatic control system for water level, improved filtration of the water, and control of pH to eliminate corrosive effects of the acid produced from the reaction between the water and the coal carried past the dropout point and into the water system. The previously mentioned redesign of the unloading station will, of course, minimize this problem by reducing coal carryover.

1.1.4 Improved Chain Drying

The drying of the chain will be improved by redesigning the present system, purchase of a commercial air stripping system, coating of the chain to reduce surface tension and possible mechanical "blotting" by use of felt or other materials. As the chain drying at this time is the major user of power in the operation of the LPF, even greater than the power used to drive the chain; a major consideration in the drying system is to minimize the power required.

1.1.5 Improved Chain Design

The major problem source in the existing chain is the wear generated in the pinned joint. While this will be attacked from the point of view of using the existing chain configuration but changing wear materials, a complete new chain will be designed featuring a sealed "hidden" pin which is not in the normal coal area. The new pin joint material pairs and the new chain configuration will be tested in the wear test unit to be described in the following section before a complete change of hardware is attempted.

1.1.6 Positive Inlet Seal

Gas leakage from the reactor to atmosphere by way of the LPF seals is a subject of discussion by all potential gasifier operators. Collection of this leakage and piping to an off-gas treatment system or flaring is not favorably looked upon. A positive seal arrangement by which the reduced pressure gas is prevented from leaving the sealing tube will be developed.

1.1.7 Automatic Control System

The control system which is presently in use on the LPF requires manual start-up in a number of steps all of which are initiated in sequence by the operator. This system will be redesigned to allow a simplified, possibly one button, start-up of the unit.

1.1.8 Improved Safety System

Chain breakage in the unloading area is the major safety problem on the LPF. Should this occur, the chain can be propelled from the tubes in two directions toward each sprocket causing the hazard of flying metal and also allowing blow down of the reactor. The existing LPF has structural steel guards wrapped around each of the sprockets to trap the chain in such a manner that buckling and jamming occur to stop chain motion. Additional safety equipment will be added in this phase which will be in the form of devices which capture the chain should it move at a rate which is not synchronous with the sprocket. These devices will provide a switch closure which will be utilized to close the reactor valve, shut down the LPF, provide interlocking with the process, etc.

1.2 Upgrading of the FMA Test Facility

The 5 ton/hr, 1000 lb/in² coal feeder test facility will be upgraded in order to facilitate the conduct of the extensive test program and to insure acquisition of meaningful data.

The planned changes will include, but not be limited, to the following areas.

1.2.1 Pulverized Coal Handling

A pneumatic pulverized coal handling system will be added to the test facility to transport the coal from the ground level in-feed area to the upper level bin, which feeds to the LPF input metering device. The actual metering of the coal into the LPF will require equipment designed for accuracy and reliability.

1.2.2 Improved Material Handling Equipment

The introduction of both coarse and pulverized coal into the test loop requires improvement with the major emphasis being required in the feeding of pulverized coal. If our supply of -200 mesh is obtained in bags, we would purchase a bag opening machine to automatically separate the bag from the contents and feed the coal into the pulverized coal transport system. If the coal is shipped to us in drums, an unloading system which handles these drums would be fabricated.

Other improvements will be made to facilitate disposal of degraded material and for better storage facilities.

1.2.3 Leakage Measurements

Instrumentation will be added so that all gas flows to, from, and through the LPF can be monitored.

1.2.4 Solids Flow Measurements

A solids flow rate measuring system will be added to provide indication of instantaneous solids flow rates.

1.2.5 Improved Instrumentation and Monitoring Equipment

Transducers will be added at several points to allow recording of pressures, speeds, etc. beyond those which are presently recorded. Also, improved communications among various work areas will be provided.

1.2.6 Water Handling System

The water handling system suffers from inadequate filtration of carry over coal particles and a lack of pH control to neutralize acidification caused by the interaction of coal and water. These deficiencies will be corrected.

1.2.7 General Facility Upgrading

Improvements will be made to provide safer working conditions for personnel including increased dust ducting.

1.3 Critical Component Development and Testing

An accelerated failure test program will be conducted to determine the operational life and reliability of the key components of the LPF. Bench scale fixtures for this testing will be fabricated and tests run under simulated feeder environments.

These tests will be conducted in parallel with the performance tests of Task 4. Results obtained will be used to

upgrade components, where necessary, for the LPF used in Phase II - Verification Testing.

Following is a description of the particular testing planned.

1.3.1 Conveyor Joint Testing

Bench testing of conveyor joint configurations and material pairs will be conducted by cycling under load in the presence of coal.

1.3.2 Link Fatigue Testing

Conveyor links will be cycled under maximum load conditions in order to verify calculated fatigue life.

1.3.3 Positive Seal Configurations

Absolute seal configurations will be bench tested with coal present in order to test sealing over a number of cycles and to evaluate materials chosen for the application.

1.3.4 Modelling of Infeed and Outfeed Stations to Accommodate Pulverized Coal

Using obsolete sprockets, chains, and other parts, we intend to model the LPF in a zero-pressure form using substitutes made of transparent materials for the loading and unloading stations in order to provide the information on which to base the design of the actual LPF parts.

1.4 Effect of Moisture on LPF Performance

Bench tests for flow characteristics versus moisture content for various coal types and sizes will be conducted to determine the maximum moisture content of coal to be metered into the LPF. If the coal can be reliably metered into the LPF, it will feed through.

The specified four types of coal: Eastern Bituminous, Western Bituminous, Lignite, and Subbituminous will be tested, each ground to three sizes: $3/4 \times 0$ in., $1/2 \times 0$ in., and 70 percent -200 mesh with moisture content varied in three steps to 14 percent or the maximum usable. Three series of tests will be run for the above combinations of variables for a total of 108 tests.

The apparatus used would consist of a feed hopper supplying a screw or belt feeder. Moisture measurements will be taken with an Ohaus moisture tester and rate will be measured on a weight scale with respect to time.

1.5 Performance Testing

A series of performance tests will be conducted on the LPF with coarse coal ($3/4 \times 0$ in. and $1/4 \times 0$ in.) for fluidized bed combustors and pulverized coal 70 percent thru 200 mesh. Insofar as possible, the four coal types specified on the RFP will be tested. Preliminary information tends to show that fire hazards inherent in lignite handling and high rate of material degradation will not allow the full spectrum of testing specified with lignite. Due to a lack of adequate, safe storage facilities for a large quantity of lignite, testing would be limited to a small number of tests in which the lignite is fed at a size and moisture content which is consistent with that

required on an actual process. Based on our knowledge of these processes, we will assume that 70 percent -200 mesh with a high moisture content will be required. The first moisture content to be used in these tests will be less than 5%; the second will be at or near the maximum determined from the testing specified in Task 1.4.

A series of tests will be conducted and the following operating parameters will be measured and recorded:

- Gas Leakage Rate
- Chain Pull
- Power Requirements for Drive Chain, Water Pump, and Chain Drying
- Water Leakage With No Coal
- Particle Size Distribution into and out of the LPF to Determine Size Degradation Attributable to the LPF.

2. TECHNICAL PROGRESS ACHIEVED DURING THIS QUARTER

Introduction and Summary

The essential objective of Phase I of our program is to demonstrate extended capabilities for the Linear Pocket Feeder (LPF). This requires extensive modification of both our test facility and the LPF. At this time we estimate that delays in modifications will prevent our testing the LPF until at least mid-May, a month and a half later than originally scheduled. However, we have reviewed our test plan and facility operation in detail and conclude that testing can probably be completed by the end of August as originally proposed, and that the program is not jeopardized in any other way. In fact, our projected delay in specified testing is due in part to our initial testing--crude but recently successful, with pulverized coal (PC).

On the strength of this success, we are attempting to go immediately to an LPF and feed system that is fully modified for PC. Following is a status report task by task from the program plan.

We see no operational problems that might jeopardize the program.

2.1 Upgrading of the LPF

2.1.1 Loading Station

Two alternatives are designed and will be purchased as hardenable steel with optional hard coating later.

2.1.2 Unloading Station

The final design of the vessel with recent mounting mods is complete and being fabricated, with delivery expected in April. The dropout tube and coal stripping gas circulating system is being designed.

2.1.3 Gas-Water Transfer Station

The pressure vessel is being fabricated and expected in April. A short sample of one of our two hard-cast water tubes in stock has been machined and heat treated, but the results were growth instead of expected shrinkage, traced by the vendor (Abex) to a mismarking. The other tube stock will be sent out for testing and if satisfactory, for fabrication.

2.1.4 Chain Drying

No effort in this period; recent PC testing indicates drying may be less critical than previously thought, and low-pressure air stripping may suffice.

2.1.5 Chain Design

Little effort this period; a rough design awaits detailing and quotes.

2.1.6 Positive Inlet Seal (also see 2.3.3)

The metal elastic seal preliminary design is complete.

2.1.7 Automatic Control System

The design is being combined with the test facility electrical mods.

2.1.8 Improved Safety System

Preliminary design of a synchronous chain entrapment is complete; detail design is in progress in combination with tube and mounting mods. The system will be installed before we operate above our previous test limit of 500 psi.

2.2 Upgrading of the Facility

Essentially all designs and equipment are in hand for facility modifications. This month we recognized several mundane but important (to code) inadequacies in our facility and are making corrections in combination with the rewiring of the overall control system. Taunton Engineering Co. has completed their subcontract engineering and will begin actual installation work April first. Facility work will be complete before, and will not delay rebuilding of the LPF proper.

2.3 Critical Component Development

2.3.1 and 2.3.2 Conveyor Link Testing

The link test machine is assembled but has not been cycled. Links will be tested before we exceed our previous test limit of 500 psi on the LPF machine.

2.3.3 Positive Seals

The soft "sphincter" seal (made of UHMWPE) exists, has been bench tested, and will be installed first on the LPF for testing. The detail designs of the two metal-elastic sphincters are nearly complete; two tubes, one axially split at one place, and one helically (45°) split in two halves are interchangeable in the same housing and end fittings. Both the split clamp and spiral clamp have apparent pros and cons; only LPF testing will indicate the better.

2.3.4 Flow Modeling of PC

The basic atmospheric pressure full size flow model test LPF is assembled and running without solids flow. Test methods have been planned basically, but the construction of the input and output methods has not begun. Program personnel should be available to arrange simulated PC flow tests in April.

2.4 Moisture Testing

No work has been done on the effect of moisture on coal feeding except to test our standard Ohaus moisture measurement instrument. It is not suitable because of its radiant heat source and consequent high coal surface temperature that result in devolatilizing as well as drying. We will use our low temperature (<100°C) oven instead. Quantitative work will begin in April to provide knowledge for flow modeling (Task 1.3.4).

2.5 Performance Testing

All coal and other supplies for performance testing have been ordered and are satisfactorily scheduled. Preliminary testing on PC of the "old" LPF and facility was completed in early March. We found that jamming of the LPF did not occur while using solid piston rings that had an axially short (.2 inch) sealing land followed by a length (.3 inch) of somewhat greater clearance. Reversing these rings always resulted in jamming after a few feet of travel. These results are entirely consistent with the theory of coal dust caking and wedging between ring and tube and show at least one simple way to avoid jamming on PC. In addition, pressure sealing with PC seemed to be excellent (up to about 150 psi, limited by our original unsafe pressure vessels). Now it remains only to complete as soon as possible the machine and facility modifications, which are largely for PC, so that testing can begin.

PLANS FOR THE NEXT REPORTING PERIOD

Task 1.1 Upgrading of the LPF

1. Detail design will be completed.
2. Parts procurement will continue.
3. Assembly and checkout will begin.

Task 1.2 Upgrading of the FMA Test Facility

1. Major modifications will be completed.
2. Wiring and installation of some system components will continue.

Task 1.3 Critical Component Development and Testing

1. Link testing will begin.
2. Effort will be concentrated on the in-out feed modelling machine.

Task 1.4 Effect of Moisture on LPF Performance

1. Effect of moisture will be tested in small samples and in the feed modelling machine, above.

Task 1.5 Performance Testing

1. No expected effort.

U.S. DEPARTMENT OF ENERGY
MILESTONE SCHEDULE AND STATUS REPORT

PAGE OF

FORM APPROVED
DOE NO. 50-10-01-02

1. Contract Identification Coal Materials Handling/Coal Feeder Development Phase I		2. Reporting Period 1/1/81 through 3/31/81		3. Contract Number DE-AC21-80MC 14601															
4. Contractor (name, address) Foster-Miller Associates, Inc 350 Second Avenue Waltham, MA 02154		5. Contract Start Date 5 September 1980		6. Contract Completion Date 5 September 1981															
7. Identification Number	8. Reporting Category (e.g., Contract line item or work breakdown structure element)	9. Fiscal Years and Months FY 80 S O N D J F M A M J J A																10. Percent Complete	
																		a) Planned	b) Actual
1	Proof of Concept																		
1.1	Upgrading of LPF																		
1.2	Upgrading of Test Facility																		
1.3	Critical Component Development & Test																		
1.4	Effects of Moisture on Performance																		
1.5	Performance Testing																		
1.6	Verification of Controls & Safeties																		
1.7	Documentation																		
11. Remarks																			
12. Signature of Contractor's Project Manager and Date Aldi R. Gnadar 4/27/81										13. Signature of Government Technical Representative and Date									

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