MASTER

FOSTER-MILLER ASSOCIATES, INC.

ENGINEERS
350 SECOND AVE.
WALTHAM, MA 02154
617 890-3200/TWX 710-324-1468

APPROVED FOR RELEASE OR
PUBLICATION - O.R. PATENT GROUP
BY *E. Parker* DATE *5/19/81*

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

COAL MATERIALS HANDLING
COAL FEEDER DEVELOPMENT
PHASE I
1ST QUARTERLY TECHNICAL
PROGRESS REPORT
OCTOBER - DECEMBER 1980
CONTRACT NO. DE-AC21-80MC 14601

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

Submitted by:
Foster-Miller Associates, Inc.
350 Second Avenue
Waltham, Massachusetts 02154

January 20, 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 x 0 in., 1/2 x 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 x 0 in. and 1/4 x 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

Task 2.1 Upgrading of the LPF

1. The drop-out and gas-water transfer pressure vessels which were designed for 500 psi service and released for fabrication were redesigned for 1000 psi rating in order to upgrade the LPF to 100 psi operation. Delivery anticipated by the first of February 1981 has slipped to the end of February.
2. Automatic water level control system has been added to the existing water station and tested. The operation is satisfactory. The pH control system is fabricated and should be installed by the end of January. New pump seals have been received and will be installed at an opportune time. The leaking seals do not present any problems for operation at this time.
3. We were not able to locate a vendor willing to provide a system for chain drying, therefore, we have started our effort to accomplish this. Several standard types of air nozzles were purchased and a small amount of testing was done to determine optimum locations and air pressures.
4. More and different nozzles were added to the machine to blow water from the chain. Also all the openings on the front of the chain, such as those for spanner wrenches and set screws have been plugged to eliminate the entrapment of water, but water still drips down so that a drop remains at the bottom of the piston most times before the piston enters the loading station. Also a wiper was added before the loading station to

flick this drop off as much as possible. This does not do the complete job. Another drop sometimes forms within the next six inches. Elimination of this modification represents significant improvement over that which existed in the previous phase of the program. Further work is continuing.

5. An alternative chain link design has been developed which features a "hidden pin" that will be out of the coal area. The sprocket for the "hidden pin" chain design is being designed and material has been ordered to fabricate a number of links for test in the bench tester.
6. A positive inlet seal assembly has been fabricated. This seal fits between the loading tube and the sealing tube. It consists of a ultra-high molecular weight polyethelene sleeve inside a steel housing which is pressurized with hydraulic fluid. It has been assembled and pressure tested. It has more than enough shrinkage to be useable over a period of time as it wears. We will attempt as soon as possible to put this in the machine and try to attempt some wear testing and some power measurements.
7. An improved chain and tube alignment system using a laser and optical and LED targets is in the process of being fabricated. Most of the materials have been received. The system will be assembled on the machine during the next quarter and used to check the alignment of the present tubes and sprockets.
8. Improved materials for tubes, chain links and pin joints continue to be investigated.

9. The layout of the chain breakage safety system is scheduled to begin during January based on a conceptual design which has been completed.

Task 2.2: Upgrading of the FMA Test Facility

1. A demonstration of the test loop operation both feeding and recycling pulverized coal was run for our material handling sub-contractor, Taunton Engineering Company. The purpose of this run was to demonstrate the problems in coal handling, metering, and dust collection which exist and to discuss proposed solutions. Taunton was the original vendor on the program for this equipment and appears to be the logical choice to implement the modifications.

A proposal has been received from Taunton to provide modifications to the test loop mainly those required to handle pulverized coal but also modifications to speed up the machine in general on the recycle portion of the cycle.

Their quotation consists of the following recommendations:

- a. Modifying the screw feeder to take the material from the feed bin to the inlet to the LPF. These changes will consist of shrouding the screw, reinforcing and reclamping the covers to make it more dust tight, and adding triple flights to the screw at the outlet section to prevent the material from flushing by the screw.

- b. Several dampers will be added to the duct work to control and balance air flow.
 - c. Bridge breakers will be added inside the feed bin. These items will essentially deaerate the coal and provide a uniform and predictable density. Also, they will eliminate bridging in the bin which has been a problem in the past.
 - d. Rotary airlock feeder will be installed below the outlet ball valve on the reactor vessel. The reason for this is that in the recycle loop if the ball valve is opened with a load of coal in the receiver vessel, the gravity drop out of the coal is at such a rate that the rest of the recycle equipment cannot keep up and overflows result.
 - e. New plumbing and diversion valves will be added to facilitate dump out of the system.
 - f. The bucket elevators will be modified to change the recycle rate from five tons an hour to twelve tons an hour. This will require changing the present buckets to a larger size and changing horsepower along the motors. Several changes in the structure will be made to permit easier access and working space.
2. Instrumentation on the loop is being looked at at the moment and vendors are being solicited for prices on what we feel we require as far as added instrumentation.

Task 2.3: Critical Component Development and Testing

1. A bench test fixture has been designed which will test link pin joints and link fatigue life under conditions that exist on the actual machine. The unit has four stations, each of which operates in a low load condition while a link is rotated 30° in relation to the succeeding link to simulate sprocket loads. The links are then stressed at a high load to simulate passage through the drop-out area. This test is run with coal applied to the joints and at a rate which accumulates cycles at approximately ten times actual machine rate.

All materials for the conveyor joint link tester are in house at the moment. Assembly will start the third week in January. We expect this to take two to three weeks.

2. A full scale model for use in studying coal flows into and out of the LPF has been designed. This model will be constructed from obsolete chain, sprockets and other parts with tubes, loading and unloading stations made of transparent material. To allow observation of coal flows, particularly pulverized coal, in order to optimize the flow to and through the LPF.

Task 2.4: Effect of Moisture on LPF Performance

No progress to date. This will be started during the next quarter.

Task 2.5: Performance Testing

1. A proposal has been received to supply us with the coal we will require for the extensive test program. The total amount of coal required is in the vicinity of 150 to 160 tons and the actual coal price is approximately \$4,200 to \$4,300. The major portion of the cost is in transportation and grinding of the 200 mesh coal. If all these things are taken together, they come out to a total of \$48,925. We have contacted the other contractors on this feeder program, and have been unable to find a way to combine with them in order to reduce this price, mainly because the transportation is the large part of the cost. We will purchase this coal now to be sure we have it in time for the program.

PLANS FOR THE NEXT REPORTING PERIOD

Task 1.1 Upgrading of the LPF

1. Further work will be done on chain drying using air nozzles and absorbent material.
2. The inlet seal assembly and a plain steel tube with pressure transducers inserted will be incorporated into the LPF. The purpose of the plain steel tube is to measure pressure distribution versus wear.
3. A decision will be made as to what tube materials will be used in this phase as tubes are the longest lead time items on the machine.
5. The chain breakage safety containment system layout will be started.
6. Preliminary tests will be run with pulverized coal to determine operational characteristics.

Task 1.2 Upgrading of the FMA Test Facility

1. The contract for test loop improvements will be let to Taunton Engineering.
2. Water filtering equipment will be ordered and pH control will be installed and tested. A 1000 psi pump will be ordered.
3. Instrumentation will be selected and ordered.

Task 1.3 Critical Component Development and Testing

1. The link fatigue and joint tester will be assembled and possibly a test will be started on the present chain links.
2. The fabrication drawings will be released for quotation and probably parts will be ordered for the infeed-outfeed modelling machine.

Task 1.4 Effect of Moisture on LPF Performance

1. Equipment will be assembled to test flow characteristics of coal at various moisture contents. We will utilize bins and feeders available from past phases of this program.

Task 1.5 Performance Testing

1. Orders for various coal types and sizes will be placed.

PAUL O
PUBLISHED WEEKLY
CHAS. E. SMITH, JR., EDITOR

[illegible]

11. Homework

1.2 Signature of Contractor's Project Manager and Date

13. Signature of Government Technical Representative and Date

RECEIVED BY TIC

JAN 30 1980

FOSTER-MILLER ASSOCIATES, INC.
ENGINEERS
850 SECOND AVE.
WALTHAM, MA 02154
617 890-3200/TWX 710-324-1468

AN EQUAL OPPORTUNITY EMPLOYER.