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COAL-FEEDER DEVELOPMENT

Second Quarterly Technical Progress Report January - March, 1980

Dilip K. Mistry

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INGERSOLL-RAND RESEARCH, INC.
Box 301, Princeton, N. J. 08540

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1.0 CONCLUSIONS

The pilot scale piston feeder development is progressing satisfactorily and should proceed as planned. The bench scale testing of components, sub-system and critical areas continued to provide very useful information in support of the development of the complete feeder. The K30M seals and polyurethane scrapers are showing very promising results. The components development facility is being upgraded and testing at the bench scale level should be vigorously pursued. The upgrading of the pilot scale feeder and its system will be emphasized during next quarter to perform feeder capabilities and limitations testing.

No progress on the 5.5" diameter pilot scale screw feeder has been made because IRRI is waiting decision from METC as to when the feeder can be installed on the 42" gas producer.

2.0 CONTRACT OBJECTIVES

The overall objectives of the coal feeder program are (1) to develop the pilot scale piston feeder to a point of readiness for evaluation at a DOE selected pilot plant, and, (2) to provide technical support in the evaluation of the pilot scale screw feeder at the METC gas producer.

2.1 COAL PISTON FEEDER

The piston feeder development program is composed of two phases. The objective of phase I, proof of concept, is to upgrade the existing pilot scale feeder and its test systems to perform the capability and limitations testing. Bench scale testing of feeder components, subsystems and critical areas will be performed in order to upgrade the feeder. Feeder capabilities and limitations with respect to coal types, sizes, moistures and additives will be determined. Feeder performance with the selected feed mixtures at maximum pressure and throughput will be demonstrated. Feeder turn down and start/stop capabilities will be determined. The objective of phase II, verification testing, is to perform 500 hours of noncontinuous long term verification and reliability testing consistent with the targeted process operating parameters.

2.2 COAL SCREW FEEDER

The objective of the coal screw feeder program is to provide technical support during evaluation of the 5.5" diameter screw feeder at the METC 42" diameter gas producer pilot plant. The technical support will consist primarily of "on site" assistance during installation, shakedown, and performance evaluation testing.

COAL PISTON FEEDER DEVELOPMENT

Ident. No.	REPORTING CATEGORY	FY '81												FY '82											
		S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
1.0	PROOF OF CONCEPT (PHASE I)																								
1.1	Program Planning, Test Plan																								
1.2	Component, Subsystem & Feeder Upgrading & Development																								
1.3	Test System Upgrading																								
1.4	Capability & Limitation Testing																								
1.5	Operating Manual																								
1.6	Phase Ending Report																								
2.0	VERIFICATION TESTING (PHASE II)																								
2.1	Program Planning, Parameter Selections & Test Plans																								
2.2	Feeder Non-Continuous Testing																								
2.3	Feeder Teardown, Inspection																								
2.4	Feeder Retrofit & Delivery																								
2.5	Upgrade Operating Manual																								
2.6	Final Report																								

COAL SCREW FEEDER DEVELOPMENT

Ident. No.	REPORTING CATEGORY	FY '81												FY '82											
		S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A
1.0	PILOT PLANT EVALUATION																								
1.1	Installation & Shakedown																								
1.2	Training Program																								
1.3	Technical Support																								
1.3.1	Development Activities																								
1.3.2	Verification Testing Test Plan																								
1.3.3	Verification Testing																								
1.4	Upgrading Operating Manual																								
1.5	Final Report																								

*Program activities delayed due to changes in plan by DOE-METC.

3.0 SUMMARY OF PROGRESS

3.1 COAL PISTON FEEDER

Upgrading of the design of the pilot scale piston feeder, and component development facility, as well as bench scale testing of the gas exclusion piston, the transport piston and its liner, continued. The K30M seals continued to show good performance. Several polyurethane seals and scrapers are being evaluated at bench scale level with encouraging results. The procurement activities on liners, new 9" bench scale tester, hydraulic power pack is progressing satisfactorily.

3.2 COAL SCREW FEEDER

METC continues to review the gasifier program schedule and will advise IRRI when the 5.5" diameter screw feeder will be installed and evaluated on the pilot plant.

4.0 DETAILED DESCRIPTION OF TECHNICAL PROGRESS DURING THIS QUARTER

4.1 COAL PISTON FEEDER DEVELOPMENT

Test evaluation of transport and gas piston seals and scraper continued during the quarter with encouraging results. In addition the upgrading of the feeder and the bench scale testers continued in selected areas. The progress made during this quarter is described below.

4.1.1 Transport Piston and Liner Testing

Testing was performed on the transport piston which utilizes a pair of bronze-filled teflon (K30M) buffered ring seals. Two different designs with the buffered seals were tested and are shown in Figure 1 and Figure 2. In Figure 1, the piston assembly uses an externally energized, UHMW polyethylene labyrinth-type scraper assembly on both sides of the seals and a ramp scraper to clean the transport liner exit ramp so that the gas exclusion piston enters a clean ramp. The piston assembly in Figure 2 uses a Disogrin scraper as the primary scraper. A summary of the results of the testing are shown in Table 1. The tests were carried out at an average speed of approximately 0.65 feet per second and buffer pressure of 200 psig.

After a total of 34,170 cycles, the transport piston shown in Figure 1 was removed for inspection. It was observed (Figure 3) that coal had packed in the UHMW scraper grooves and on both sides of the K30M buffered seals. Particle sizes were in the range of 5 micron size. Even though coal had packed around and under the seals, the leakage rates were still satisfactory. The seals

Figure 1: Transport Piston Assembly

FIGURE 2: TRANSPORT PISTON

UHMW POLYETHYLENE
SELF ENERGIZED SCRAPERS

K30M RIDER RINGS

K30M BUFFERED SEALS

TRANSPORT PISTON
AFTER 34,176 CYCLES

FIGURE 3

showed no damage due to port passing. During inspection, a maximum of 0.006 inch radial wear of the seals was measured.

At this time the K30M buffered seals, riders, etc., were disassembled, cleaned, and assembled back on the piston with a Disogrin scraper in place of the UHMW labyrinth type scraper. This piston was reinstalled and tests were then continued on the feeder. It was found that the seal leakage rate increased by two times compared to the one established prior to the disassembly and cleaning. It appears that the K30M seals digested some coal particles and that coal particles also became packed on sides of seals. Both of these factors assisted in sealing and the removal of these particles resulted in increased leakage. It should be noted, however, that, even with this increase in leakage rate, the seal performance was satisfactory. A total of 54,682 cycles have been accumulated on this seal with a leakage rate less than 0.5 SCFM.

During the testing, it was found that the leakage rates were dependent on seal temperature. The bronze filled teflon seals have no memory and during the cold start up period, leakage rates are unacceptable. Once the seals are warmed up and have thermally expanded to provide more contact force against the bore, acceptable leakage rates would be obtained.

During the testing with the Disogrin scraper, (not pressure balanced), it was found that the buffer gas leaking through the front seal would pick up small coal particles (5 microns) that has passed the scraper

and carry them out through the piston as shown in Figure 2. A total of 5.6 grams of coal was collected during the 4000 cycle testing. Other methods are being investigated to exploit this observation which will help keep the seals clean. No apparent damage was observed on the scraper due to port passing.

4.1.2. 9" BENCH SCALE TESTING

The 9" bench scale tester was utilized to test and evaluate the gas exclusion seals, the UHMW labyrinth self-energized scraper and the Disogrin scraper/seal. A summary of the results of the testing is shown in Table 2.

Testing of the gas exclusion seal was performed to find the capability of the retained seal in going in and out of the bore, coal particle side sealing as well as gas sealing. The configuration of the test piston is shown in Figure 4. The set up utilizes two glass filled teflon seals with an omni scraper and two K30M rider rings on one side of the coal charge cavity and a self-energized UHMW polyethylene scraper, K30M rider ring and the retained K30M seal with "O" ring sealing under the seal on the other side.

The test procedure was to operate the seal in and out of the bore with 100 psig gas applied under the retained seal and then periodically checking the static leakage rates at 500 psig in the coal cavity and 600 psig under the seal. A total of 58,553 cycles were performed. The maximum static leakage rate during the testing was 0.0159 SCFM at 500 psig. This low leakage rate indicates excellent sealing capability.

Figure 4: 9" Bench Scale Tester Assembly for Gas Exclusion Piston Seals

After testing, the piston was removed from the tester for examination. It was found that coal was packed in and over the energized UHMW polyethylene labyrinth type scraper and had gotten beyond the seals. Examination of the seal showed that some coal had gotten past the side sealing and was found packed on the shoulder designed for retaining the seal. This condition, however, had not caused difficulty in sealing. Measurements on the seal showed approximately 0.001 to 0.002 inch taper on the seal caused by entering the bore. A maximum of 0.018" radial wear on the seal was measured. A majority of this wear probably occurred during the initial operation when the "O" rings under the seal were installed improperly causing very high contact loading and consequently high wear.

It should be noted that this test was an extreme test for the gas exclusion seals. In the normal feeder operation the gas exclusion piston will never push the coal as it was required to do in the 9" tester and in all probability will not see as much coal as it did in this test.

In addition to the testing of the gas exclusion seals, two Disogrin seals were evaluated on the 9" bench scale tester for its inlet port passing, sealing and scraping ability. Tests were performed at no gas pressure. A total of 18,736 cycles were performed out of which 16,728 cycles were with coal. Some coal particles passed the scraper, although the quantity was less compared to what passed through UHMW labyrinth scraper in earlier tests.

No apparent damage was noticed due to port passing. An average of 0.080" wear on diameter was measured after 17,736 cycles. The initial O.D. was 9.197".

During the tests, the condition of the scraper as a seal was examined by periodically measuring the static leakage rate at 500 psig. This leakage rate was negligible and independent of barrel temperature. Although the Disogrin seal showed excellent sealing capability during this test, based on the observation made on 3" bench scale test, the wear would be excessive when used as a seal, due to pressure loading, and consequently a short seal life would be anticipated.

During this quarter, the decision was made to upgrade the 9" bench scale tester in the area of water cooling the liner. The tester was disassembled, components modified and reassembly completed (Figure 5).

4.1.3 NEW ENERGIZED TRANSPORT SEAL

From the testing to date, it is apparent that the gas energized seals used in the gas exclusion piston showed better performance with respect to leakage rates and cold start up compared to the buffered seals used in the transport piston. Therefore, new K30M energized transport seals and associated carriers were designed and fabricated and will be tested during the next month. The transport piston assembly utilizing the new energized transport seals is depicted in Figure 6.

In the transport piston, there is no need to retain the seals as is necessary in the gas exclusion piston. Therefore, the retained lip was eliminated. The sealing

Figure 5: 9" Bench Scale Tester After Reassembly

FIGURE 6 : TRANSPORT PISTON

of the energized gas is performed by "O" rings sealing the side of the seal. These "O" rings will also help to minimize coal build-up underneath the seal.

The piston assembly will have two K30M energized seals, a Poly seal type scraper in the front, Disogrin scraper in the rear, and two K30M rider rings. There is a gas supply line between the two energized seals for static seal leakage testing and buffered operation. The procedure will be to apply 600 psig energizer gas and 500 psig gas between the seals when measuring the static seal leakage.

In this piston assembly, the port passing capability of the Poly scraper and Disogrin scraper will be compared during the testing.

4.1.4 LINER

The liner, consisting of AISI 4140 material heat treated to a hardness of RC 40-43, has been procured and meets our specifications. The port relief was machined by electrical discharge machining (EDM). The outside diameter of the liner was flash chromed to prevent any scale buildup during water cooling. The liner will be placed in the 9" bench scale tester and the bore coated with teflon prior to qualification testing with seals.

Due to satisfactory results on the 4140 liner, the Xaloy 800 liner has been released for EDM machining of the port relief. This liner will also be flash chromed on the outside diameter.

4.1.5 NEW 9" BENCH SCALE TESTER

The design and the detailing of all the critical long lead items were completed and the parts are being

fabricated by a local vendor with an expected delivery during the second week of April. The order was placed for a 50 HP hydraulic power supply unit as well as a valve bank and their associated controls. The valve bank will be used with the pilot scale feeder power pack to operate a bench scale tester. It is anticipated that towards the end of April the new 9" bench scale tester will be operational.

4.1.6 UPGRADING OF PILOT SCALE FEEDER

In addition to the upgrading of the piston's seal and scraper design, gas exclusion piston alignment it was necessary to upgrade the feeder in the area of maintaining low seal and scraper temperature by water cooling the liner. Provisions for the inlet and discharge of the water in the housing were made and a temperature controller and solenoid valve were purchased and installed to automatically maintain the desired liner temperature. A new water jacket insert for sealing the port area was designed, fabricated and installed into the housing. With the water cooling of the liner, higher piston speeds can now be achieved without damage to seals and scrapers due to elevated temperatures.

4.1.7 3" BENCH SCALE TESTING

The upgrading of the 3" bench scale tester for continuous, unattended overnight operation was completed. Timers were installed to shut the unit down if a stroke was not completed in the desired time. Thus, if the piston stalled during the testing, the unit would shutdown. Thermo switches were installed to discontinue operation if oil or sleeve temperatures were excessive. Also, temperature controllers were utilized to operate a solenoid

valve to regulate cooling water flow to the liner.

Several seal manufacturers have recommended that seals and/or scrapers of polyurethane material, which has excellent resistance to abrasive wear, may perform adequately in the piston feeder application. Two types of seals (Poly-Pac Seal and Disogrin) made of polyurethane material were obtained for evaluation. The poly seal has a rubber (nitrile) ring to energize the lips and the Disogrin seal has a chamfered lip to provide the radial load. Both have U-cap configuration.

Initial tests on the polyurethane seals were performed to determine how well they function as scrapers with -200 mesh coal. A total of 101,203 cycles were performed with the Poly seal and 91,298 cycles were accumulated with the Disogrin seal. Examination after testing showed that some wear had occurred on both seals and some coal had passed beyond both seals. The maximum size of the particles passing the seals was in the order of 10 microns.

Testing of Poly-Pac and Disogrin as seal and scraper with -200 mesh coal continued. The following tests were performed:

- o Disogrin seal and scraper with 250 psig gas back pressure for 91,743 cycles. This is in additions to 91,298 cycles accumulated as scraper only.
- o Poly-Pac scraper with additional 280,188 cycles (total of 381,981 cycles).
- o Poly-Pac scraper with and without the energizer.
- o Poly-Pac seal with 250 psig gas back pressure.

Several observations were made during the testing. They are:

- o Coal particles of about 10 micron size passed through both Poly-Pac & Disogrin scraper.
- o Both seals, under gas pressure loading, wear considerably and their application as seals is questionable.
- o The Poly-Pac scraper with energizer, performs better than the Disogrin scraper
- o Initially, the Poly-Pac scraper shows very good scraping ability. However, it also shows higher wear than the original Disogrin design.

Based on the above observations and looking for better scraping performance as well as wear resistance, a new Disogrin design, suggested by the manufacturer, has been tested. The new seal design has more interference and less radial contact force with the bore. This is achieved by increasing the diameter and thinning out the lip.

The new Disogrin design has been tested up to 867,125 cycles (equivalent to 110 miles) under -200 mesh coal. At this stage the scraper showed a coal leakage rate of .315 gm/100,000 cycle; the interference with the bore decreased from 0.185" to 0.056" approximately.

Continuing the tests on Poly-Pac scraper, a total of 741,051 cycles (94 miles) has been accumulated. Coal leakage rate of 0.825 gm/100,000 cycle was measured; and the interference decreased from 0.1103" to 0.103" approximately.

Figures 7 and 8 show the history of interference and weight loss, which is an index of wear, of the Disogrin and Poly-Pac scrapers respectively. It's observed that the interference decreases very slightly after 200,000 cycles for both types of scrapers. The Disogrin wear rate appeared to have increased after 600,000 cycles. This will be further investigated.

At this stage of the Polyurethane scrapers testings, it seems that the Disogrin is scraping at least twice better than the Poly-Pac. Further tests are going to be continued to find out their scraping limitations.

Another approach, under consideration for scraper & seal design, is the use of the packing ability of small coal particles. As it was observed during previous tests, the very small particles (5 or less) have the tendency to accumulate on the rim of seals and carriers. If the accumulation is significant, the particles start packing all around the seals. From early tests it was observed that packed coal can hold the back pressure and lower the gas leakage rate. Layouts of devices that can collect and pack coal particles are being carried out.

Figure 7: New Disogrin Design Scraper Weight Loss and Interference History

Figure 8: Poly-Pac Scraper Weight Loss and Interference History

4.2 COAL SCREW FEEDER

METC is still reviewing future scheduling of the gasifier program and will advise IRRI when the 5.5" diameter screw feeder will be installed, interfaced and evaluated on the pilot plant gasifier.

A meeting was held on March 5, 1980 to review their plan. Efforts were made to clarify the issue. However, no progress has been made to date on this matter.

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