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**CE IGCC Repowering Project
Use of the Lockheed Kinetic Extruder for Coal Feeding**

**Topical
June 1993**

February 1994

Work Performed Under Contract No.: DE-FC21-⁹¹~~90~~MC26308
1

For
U.S. Department of Energy
Office of Fossil Energy
Morgantown Energy Technology Center
Morgantown, West Virginia

By
Combustion Engineering, Inc
Windsor, Connecticut

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DOE

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Office of Fossil Energy
Morgantown Energy Technology Center
P.O. Box 880
Morgantown, West Virginia 26507-0880**

**By
Combustion Engineering, Inc
1000 Prospect Hill Road
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February 1, 1994

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LOCKHEED KINETIC EXTRUDER

TOPICAL REPORT

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I. SUMMARY

ABB CE is evaluating alternate methods of coal feed across a pressure barrier for its pressurized coal gasification process. The Lockheed Kinetic Extruder has shown to be one of the most promising such developments.

In essence, the Kinetic Extruder consists of a rotor in a pressure vessel. Coal enters the rotor and is forced outward to the surrounding pressure vessel by centrifugal force. The force on the coal passing across the rotor serves as a pressure barrier.

Should this technology be successfully developed and tested, it could reduce the cost of IGCC technology by replacing the large lockhoppers conventionally used with a much smaller system. This will significantly decrease the size of the gasifier island.

Kinetic Extruder technology needs testing over an extended period of time to develop and prove the long term reliability and performance needed in a commercial application. Major issues to be investigated in this program are component design for high temperatures, turn-down, scale-up factors, and cost.

Such a test would only be economically feasible if it could be conducted on an existing plant. This would defray the cost of power and feedstock. Such an installation was planned for the CE IGCC Repowering Project in Springfield, Illinois. Due to budgetary constraints, however, this provision was dropped from the present plant design. It is believed that, with minor design changes, a small scale test version of the Kinetic Extruder could be installed parallel to an existing lockhopper system without prior space allocation.

Kinetic Extruder technology represents significant potential cost savings to the IGCC process. For this reason, a test program similar to that specified for the Springfield project would be a worthwhile endeavor.

II. INTRODUCTION

ABB CE is participating in a \$270 million coal gasification combined cycle repowering project that will provide a nominal 60 MWe of electricity to City Water, Light & Power (CWL&P) in Springfield, Illinois. The ABB CE project will demonstrate Integrated Gasification Combined Cycle (IGCC) technology in a commercial application by repowering an existing CWL&P plant. The project duration will be 126 months, including a 63 month demonstration period.

The IGCC system will consist of ABB CE's air-blown, entrained-flow, two-stage, pressurized coal gasifier; an advanced hot gas cleanup process; a combustion turbine adapted to use low-Btu coal gas; and all necessary coal handling equipment. CWL&P's Lakeside station will be the site for this project. The result of repowering will be an IGCC power plant with low environmental emissions and high net plant efficiency. The repowering will increase plant output by 40 MWe through addition of the combustion turbine, thus providing a total IGCC capacity of a nominal 60 MWe. Nearly half of the project will be funded by the United States Department of Energy (DOE), under round II of the Clean Coal Technology Program, while CWL&P, State of Illinois, and ABB CE will fund the rest.

The IGCC will include ABB-CE's slagging, entrained-flow gasifier operating in a pressurized mode and using air as the oxidant. The hot gas will be cleaned of particulate matter (char) which is recycled back to the gasifier. After particulate removal, the product gas will be cleaned of sulfur prior to burning in a gas turbine.

The proposed project includes design and demonstration of an advanced hot gas cleanup process for removal of sulfur from the product gas. The sulfur removal method features a newly developed moving bed zinc titanate system downstream of the gasifier. ABB CE intends to use the General Electric (GE) moving bed, zinc titanate sulfur removal system currently being piloted by GE Environmental Systems, Inc.

In this plant, the gasifier will be producing a low-Btu gas (LBG). The LBG will be used as fuel in a standard GE gas turbine to produce power. This gas turbine will have the capacity to fire LBG and natural gas (for start-up). Since firing LBG uses less air than natural gas, the gas turbine air compressor will have extra capacity. This extra compressed air will be used to pressurize the gasifier and supply the air needed in the gasification process.

The plant consists of three major blocks of equipment. They are the fuel gas island, which includes the gasifier and gas cleanup; gas turbine power block; and the steam turbine block, which includes the steam turbine and the HRSG.

III. BACKGROUND

In order to operate the pressurized gasifier, pulverized coal must be transmitted from the coal bin operating at atmospheric pressure to the gasifier, which operates at about 275 psia. This process is conventionally achieved through the use of lockhoppers. This system of alternately pressurizing and depressurizing a pair of vessels requires a great deal of space, is difficult from a controls standpoint and is very expensive. An alternative method of pressurizing the coal is needed. ABB CE has been looking at several alternate methods. One of the more interesting technologies is the Kinetic Extruder, a centrifugal compressor developed by Lockheed.

The Kinetic Extruder is essentially a rotor installed in a high pressure housing. The rotor has a hollow hub, to which coal at low pressure is transferred pneumatically. A number of channels, called sprues, lead radially outward from the hub. Coal is forced into the sprues by centrifugal force, forming a seal against the high pressure transport gasses (steam or nitrogen) external to the rotor. The sprues act similar to a stand pipe, with centrifugal force caused by the rotor's rotation replacing the force of gravity. The sprues do not extend to the outer surface of the rotor, but open into small chambers at the perimeter. Control air at pressures higher than the system pressure is injected into these chambers, forcing coal through orifices on the outside diameter of the rotor. Some of this air leaks back through the sprues to the low pressure hub, while the remainder mixes into the high pressure transport air (1). Figures 1 and 2 show the Kinetic Extruder and its peripheral equipment.

There are four seals required in the feeder. Seals 1 and 2 are installed between the rotor and housing, sealing the high pressure transport gas from the atmosphere. Seal 3 is between the rotor and the stationary coal feed pipe, sealing the coal filled hub from the atmosphere. Seal 4 between the housing and hub seals the control air from the transport air in the housing so that the control air does not short circuit around the rotor. These seals require a bleed gas to maintain the seal. This gas bleeds into the transport gas, rotor hub and atmosphere. The gas bleeding into the hub must be removed through a vacuum vent in the coal feed pipe. This gas can then be recycled back to the pulverized coal baghouse to remove the dust.

IV. TECHNOLOGY STATUS

The Kinetic Extruder was developed in the 1970's and early 1980's by the Lockheed Missiles and Space Company, Inc., of Sunnyvale, California, then built and tested under a DOE contract. In 1985 the Penn Trading Company, a subsidiary of MPG International, Inc. bought all patent rights to Kinetic Extruder technology from Lockheed. MPG then approached CE with the technology in July, 1986.

Under the DOE contract, Lockheed's model 6 Kinetic Extruder was operated for a total

Under the DOE contract, Lockheed's model 6 Kinetic Extruder was operated for a total of 335 hours. The majority of this operation was non continuous, so no information was gathered related to performance after extended periods of operation. Nitrogen was used as the transport gas, and coal temperatures were maintained at approximately 100 F. The maximum working pressure was 400 psia, and the maximum throughput was 2.25 tph. The system was operated using a number of coals, fed in a closed-loop arrangement, where the feedstock was continuously recirculated through the system. This procedure can skew performance results since coal particle distribution is altered somewhat each time the material passes through the system.

The unit was operated with high-wear parts (sprues, nozzles and funnels) constructed of several different metals so as to compare wear rates of various materials of construction. By evaluating wear rates for the test period, and comparing those to allowable wear in each part, it was concluded by Lockheed that these parts could be constructed to survive one year of operation.(2)

At the completion of this program, the Kinetic Extruder was disassembled and shipped to the Institute of Gas Technology in Chicago. There were plans to conduct additional tests at this location, however funding was never appropriated. To this date the Kinetic Extruder is located, disassembled, at IGT.

Development took place on a scaled-up version. Under a proprietary contract, Lockheed worked on a 6 tpd Kinetic Extruder for an unnamed customer, but the unit was never constructed. Due to the terms of this contract, ABB CE does not have access to data from this project.

The primary goal of test operation by Lockheed was to determine wear rates of those components (inner hub, nozzles and sprues) exposed to highly abrasive coal flow. Although wear rates for several materials of construction were determined, those rates reflected approximately 300 hours of operation. To prove that material wear rates acceptable to utility applications can be achieved, a unit must be successfully operated for a longer period of time. Such an extended test program would also yield information related to other concerns which must be addressed before the system could be commercially implemented. These areas include seal design, scale-up, turn-down and flow measurement. (each of these issues are addressed in the next section.) For this reason, Kinetic Extruder technology has not been developed to the point of implementation in coal conversions processes.

Although the technology is owned by MPG International, only Dr. Bonin and Mr. Meyer possess the knowledge needed to design a version of the Kinetic Extruder without reverting to the earliest stages of investigation. Both of these men have retired from Lockheed several years ago. Due to contractual obligations, any further consultation with them would have to take place through MPG.

V. INVESTIGATION BY ABB CE

The Kinetic Extruder could have the potential of significantly reducing the size and cost of the gasifier island by replacing lockhoppers with much smaller equipment. In its present configuration, the coal lockhopper system for the 600 tpd IGCC Repowering Project requires uses 2500 ft³ of tank capacity. The same system for the char feed system uses 5500 ft³.

It is believed that a Kinetic Extruder system would occupy significantly less space. This is especially true for units approaching commercial scale, since size and power requirements for the Kinetic Extruder increase with throughput at a rate less than lockhoppers. This idea is explained in the assessment section of this text.

ABB CE was first approached with Kinetic Extruder technology by MPG in 1986. At that time it was evaluated as an application in CE's pressurized gasification concept. As development began on the Springfield project, the plant design was seen as a proper facility in which to conduct the long term tests necessary to determine the device's feasibility in utility applications.

It was decided that the full size coal and char feed systems for the Springfield project would initially be constructed utilizing lockhoppers, since that technology is the most technically developed dry feed system to date. With a full size lockhopper system, it would be possible to install a 2 tph Kinetic Extruder system to test materials and system design for a commercial sized plant. This unit would be able to operate parallel to the existing lockhoppers once the remainder of the plant was successfully operating. The 2 tph Kinetic Extruder would be operated for such a duration as to determine its ability to serve as the unit's primary coal delivery system. If this were the case, the lockhoppers could be replaced by a full sized, 25 - 30 tph version if funding permitted. If it were determined that a unit could be designed for higher temperature applications (1000 F), another 25 - 30 tph unit could be constructed to replace the char lockhoppers.

In this effort, preliminary process flow diagrams were developed for 2 tph and 25 tph versions of the Kinetic Extruder, for both the coal and char system. The design of the Springfield project's gasifier island was to include the space necessary to install 2 tph models for both coal and char feed. Budgetary constraints first eliminated the 2 tph provision on the char system, then caused the coal unit to become a future installation.

When preliminary arrangement drawings of the Kinetic Extruder installation were produced, they indicated that in order to allocate space for this future installation, the overall height of the structure would be increased. This is due to the separate receiving and feed bin specified for the 2 tph unit, which are vertically stacked above and below the Kinetic Extruder. Their purpose is explained in the process

description.

A full-sized unit would not need these separate vessels. In fact, the size of the P.C. feed bin could be reduced to that of the K.E. receiving bin, since its sole purpose is to provide an environment of sliding pressure during start-up. In this configuration, the height of the lockhoppers (approximately 20') is essentially replaced by the Kinetic Extruder casing, which is about 5' high, and the size of the P.C. feed bin is reduced by 50 percent (10').

However, for the test case, it was felt that the preliminary general arrangement should not affect the gasifier size, so the requirement to leave space for the 2 tph Kinetic Extruder was dropped. Figure 4 shows the preliminary general arrangement drawing of the 2 tph system installed in the coal feed system. It is believed that the overall height of the 2 tph stack-up could be reduced. Therefore, with some design compromises, a 2 tph test unit could be retrofit to the existing gasifier island at a later date.

A. PROCESS DESCRIPTION:

The equipment necessary for the 2 tph Kinetic Extruder is illustrated in Figure 3, Process Flow Diagram D-06851-020001F-1 - Pulverized Coal 2 tph Kinetic Extruder (Future). A similar PFD was developed for the char system, as well as diagrams for the potential 30 tph configuration. Data sheets for the equipment necessary to operate the 2 tph unit are contained in Appendix I.

Pulverized coal is fed from the existing receiving bin to an oversize screen, to remove any particles which have exited the pulverizer mill, but are large enough to cause bridging across the sprues. This screen will pass particles under 550 microns (over 30 mesh). The oversize particles are collected in a manually discharged hopper with a storage capacity of 500 lbs. The remainder of coal enters a feed bin, sized for 1000 lbs, or 15 minutes of maximum coal flow. This storage is necessary to provide a smooth, uninterrupted flow to the Kinetic Extruder should flow from the screen become irregular. Coal in this vessel is fluidized, and discharged by gravity through a solids flow valve to the hub of the Kinetic Extruder. The hub also receives control gas, to force pressurized coal from the sprues through the nozzles. The hub is connected to a vent line, to remove excess fluidizing gas and control gas, which leaks down through the sprues, from the hub by means of a venturi eductor. The casing external to the rotor receives deplugging gas, and is connected to a receiving bin via feed line and equalizing line. This receiving bin is not necessary to operate the system, but will be suspended on load cells so as to measure the system throughput. Coal is gravity fed from the KE discharge bin to the existing p.c. feed bin, which also receives coal from the lockhoppers.

The process for a Kinetic Extruder operating in the char feed system would be configured similarly. The major difference is that char entering the system is already pressurized, and the Kinetic Extruder has to feed across a barrier of only 40 psia. Because the feedstock is pressurized, the oversize collection tank for char must be a pressurized vessel. The other difference in the char system is not one of process, but mechanical design. Char and transport gas will reach temperatures as high as 1000 F. The Kinetic Extruder itself must be designed to minimize differential expansion in this environment. Alternate seals must also be developed for this application.

B. TECHNICAL ISSUES

In the course of developing this 2 tph system, a number of technical considerations were investigated. Further development would be necessary if the system is installed. It was originally planned to test the existing 2 tph machine at the Springfield project in the coal feed system. The purpose of this test would be to evaluate the design, materials of construction and scale-up considerations. After reviewing this possibility, it became apparent that the existing machine would not be suitable for such a test. In determining that a newly-designed machine would be necessary for this program, the following technical issues were investigated.(6)

1. Temperature

The design temperature of the coal feed system is a major issue. Several coal transport gasses were considered, including steam, air, nitrogen and flue gas. The temperature of the coal would be 200 F or higher for any of the possible transport gasses. If steam is used, the coal temperature must be maintained at 500 F to prevent condensation. Lockheed's test unit operated exclusively with nitrogen as the transport gas, and coal temperatures of 160 F. The seals used in this design would not be reliable above 200 F. A new seal design would be needed. This is not a major concern, since seals have been designed for higher temperatures. The Crane Packing Company, Inc. has developed a seal capable of 930 F (3,4), but it has not yet been tested.

The materials used in the present design would cause problems related to differential expansion at higher temperatures, but it is believed that steel parts could be successfully designed for 500 F. Another concern was the possibility of coal devolatilizing at these temperatures. However, ABB CE has conducted tests early in Budget Period 1 to characterize the design coal. These tests indicated that the coal does not devolatilize at these temperatures.

It is now probable that the coal feed system would utilize nitrogen for transport, rather than superheated steam. Maximum coal temperatures of only 200 F would

then be expected. This is still at the outer limit for operating the present seals. Differential expansion of components will be less of a problem at these temperatures, but material specifications would still have to be modified in order to design for prolonged life in an erosive environment. Even if nitrogen were used for coal transport, the char system would probably utilize high temperature gas, and would still exhibit temperatures of up to 1000 F. If a unit were to be designed to replace both the coal and char lockhoppers, high temperature seals must be developed.

2. Coal feed

Various methods of determining flow through the Kinetic Extruder were examined. It was suggested that building the feed hopper on weight cells, and periodically stopping flow to the hopper to measure discharge rate would be a reliable method. Torque on the rotor could be simultaneously measured, and since feed rate should remain unchanged for any constant torque, a relation could be determined between rotor torque and throughput. It was decided, however, to collect the unit's discharge in a separate bin, constructed on load cells, and measure mass flow in that manner. This discharge bin is already necessary to pressurize the Kinetic Extruder casing during start-up.

It was also determined that maximum particle size should be 1/4 to 1/3 of the nozzle size to avoid bridging. This requires the installation of a coal screen. The 2 tph Model 6 had a nozzle diameter of .087". So for a similar design, maximum particle size should be about .025", or 550 microns (30 mesh).

3. Turn-down

ABB CE desired a turn-down to 10-15 percent of design flow. It seems that this rate may be difficult. On Lockheed's model 6, they achieved 3:1 turn-down by decreasing control gas pressure. Flow could be reduced by reducing rotor speed. However, a minimum velocity is required to maintain the desired pressure differential. If this velocity is to be maintained at low load, the respective velocity at the design load would be very high, and therefore inefficient from a power consumption standpoint.

4. Use of existing model

ABB CE examined the feasibility of purchasing the existing model 6 Kinetic Extruder for testing in the Springfield Project. Previous concerns notwithstanding, it was reported that the unit was last operated with heavy, erosive materials, and would need refurbishing. That statement seemed to suggest excessive wear or damage.

As a result from the testing on model 6, it was determined that a one year life could be expected on all components if the unit were to be refurbished or a similar one redesigned with materials shown to have more durability in the original tests. This life expectancy is only valid for operation with coal at temperatures at less than 200 F. However, the unit could be designed for higher temperatures.

5. Scale-Up

One of the predominant issues of this investigation was scale-up. There are uncertainties involved with designing a full sized (25 tph) unit, based on data from a 2 tph unit. The arithmetic relation between the size of certain components and feed rate is not completely understood. Some of these issues are related to aerodynamic considerations inside the rotor which must be validated through testing.

It was recommended that development toward a 25 tph unit could best be accomplished by testing a 6 tph Kinetic Extruder rather than a 2 tph. In this size range, even if assumed scale-up factors are inaccurate, the unit should still operate well enough to analyze the problem. It may be the case that if these assumptions are incorrect and a 25 tph model is built, the unit might not operate at all. This would make the error in design very hard to determine.

This suggestion would not be possible in the scope of the existing Springfield project. The larger Kinetic extruder and its associated equipment would cost more, as would the accompanying steel to support it. A 6 tph unit could also compose a sufficient fraction of total coal flow to affect product gas reliability. In addition, test data from a 2 tph unit may be needed to scale-up equipment for a 6 tph unit.

6. Cost

Based on rough designs completed by Dr. Bonin, a 2 tph test unit is expected to have a 28 in. diameter rotor, weigh 4000 pounds, occupy a space 3 ft. x 3 ft. x 4 ft., and cost \$300,000. A 30 tph unit would have a 54 in. rotor, weigh 10,000 lb., occupy a 5 ft. x 5 ft. x 6 ft. space and cost \$700,000. In addition, a 1981 quote for 5 - 50 tph units for use in the Netherlands specified a cost of \$1,850,000 each for complete scope. ABB CE also developed a rough cost estimate for in-house engineering and construction of a Kinetic Extruder. The cost was found to be approximately one million dollars, irrespective of size. This cost does not include related equipment such as vessels or piping. At this point in development, any cost estimates should be viewed as very preliminary. In addition to the aforementioned design considerations, cost would depend on who engineered and built the unit (what aspects were subcontracted). In any event, a test program with costs in this magnitude would be difficult to support in the scope of the present Springfield project. A test program such as is described in

this report would have to be funded under an agreement separate from the current contract.

VI. ASSESSMENT

To predict the success of the Kinetic Extruder as a coal feed device for pressurized coal gasification, the system must be demonstrated in a long term test, such as the future installation specified on the Springfield project. Long term testing (over 1000 hours) can answer questions on erosion of parts exposed to high speed pulverized coal flow (sprues, nozzles), and life of seals exposed to high temperatures and high rotating velocities. These are issues which could not be addressed in the 300 hours of noncontinuous testing previously conducted. This is an uncertainty that exists with any new coal feed technology.

Should it prove possible to design components with an acceptable life span for use in an industrial plant, the system would boast several advantages over the present lockhopper system. The greatest of which is size reduction. In its present design, the lockhopper arrangement for the 600 tpd (25 tph) CE IGCC Repowering Project requires nearly 2500 cubic feet of tank capacity, and occupies a volume of approximately 37,000 ft³. A 25 tph Kinetic Extruder would occupy less space. However, more significant spacial reduction can be realized at larger feed rates. The volume of lockhopper space for a given feed system will increase linearly with feed rate. According to estimates by Dr. Bonin, the size of a Kinetic Extruder would increase at a slower rate.

In addition, according to Lockheed studies, power required to spin the rotor increases at a slower rate as well. As feeder throughput is increased from 2 tph to 50 tph, specific power required (hp/tph) drops from approximately 25 to 13. That is, as feed rate increases by a factor of 25, power required increases by a factor of 13. (1,5)

At the 25 tph feed rate, this size advantage does not translate into capital savings. The quoted cost for the present coal lockhopper system is relatively equal to the projected cost for a 25-30 tph Kinetic Extruder. The previous paragraphs indicate that the Kinetic Extruder will offer capital savings over lockhoppers for commercial-scale units (50-100 tph). However, greater savings in both capital equipment cost and associated structure cost could be realized if the Kinetic Extruder could be implemented in the char reinjection system. The char lockhopper system is much larger than that of coal, representing the largest volumetric consideration on the gasifier island. It remains unclear whether a Kinetic Extruder could be designed for the high temperature environment of the char feed system. It is the belief of ABB

CE that the potential savings resulting from successful operation of a Kinetic Extruder warrants further investigation into the feasibility of a high-temperature design.

In the event that installation of the Kinetic Extruder becomes economically advantageous, the system will still exhibit disadvantages to the present design. The 2 tph test version will use an expected 50 KW of auxiliary power, while a full-scale model for the demonstration project will require 240 KWe, with a 75 tph commercial-scale unit consuming 700 KWe. In addition, several components are exposed to wear or fatigue, which will require periodic inspection and/or replacement. Sprues, nozzles and the inner hub of will exhibit some erosion, while bearings and seals, exposed to high speed and temperatures will need replacement. It should be mentioned the maintenance and replacement cost of the solids handling valves in the present lockhopper design are probably greater than the equipment replacement costs of the Kinetic Extruder.

VII. CONCLUSIONS

The Kinetic Extruder is a promising but unproven technology. With testing and development, it has the possibility of representing capital savings in the pressurized coal gasification process. Such development can only be achieved through long-term operation. The only means of implementing such a program in an economically advantageous manner would be to install a small-scale version of the Kinetic Extruder parallel to the existing feed system on an existing pressurized coal conversion unit such as an IGCC.

A stand-alone test unit would not be economically feasible. Since coal must be continuously circulated through the Kinetic Extruder system for over 1000 hours, the cost of power and coal would be very large. In an application such as a parallel retrofit on an existing IGCC, coal used in testing would be consumed by the conversion process, utilizing power and coal that was necessary for the plant's operation.

This is the provision ABB CE intended to allow on the IGCC Repowering Project. As a result of cost reduction measures, space allocation for this future installation has been removed from the present design. However it is believed that a test unit could be incorporated into this plant at a later date. It is the belief of ABB CE that if a Kinetic Extruder could be designed to process char, such a test program would be a worthwhile exercise.

ABB CE is also investigating alternate coal feed systems for the future, such as the Dynamic Sleeve, Piston Type Coal Feeder. This design is an adaptation of the piston cement pump, and can probably be designed for high-temperature environments. Similarly to the Kinetic extruder, wear will probably be the

predominant obstacle in design, and will also require long-term testing to determine viability. Costs of this system are expected to be similar to that of the Kinetic Extruder.

VIII. REFERENCES

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6. Personal discussions with Dr. J.H. Bonin.

IX. FIGURES

FIGURE CAPTIONS

Figure 1	The Lockheed Kinetic Extruder
Figure 2	A Sample Kinetic Extruder System
Figure 3	Process Flow Diagram for 2 tph Kinetic Extruder
Figure 4	Stack Up Arrangement of 2 tph System

Figure 1 Source: Meyer & Bonin

LARGER SIZES OF KINETIC EXTRUDER

7 TPH

DIAM: 36 IN.
RPM: 3600
PRESS: 600 PSI
HP: 280

50 TPH

DIAM: 48 IN.
RPM: 2800
PRESS: 600 PSI
HP: 650

Figure 2 Source: MPG International (5)

Figure 4 Source: ABB LCI

APPENDIX I

**EQUIPMENT DATA SHEETS FOR 2 TPH KINETIC EXTRUDER SYSTEM INSTALLED
IN COAL FEED SYSTEM**

ABB COMBUSTION ENGINEERING, INC.

EQUIPMENT DATA SHEET

CLIENT: Combustion Engineering, Inc. EQUIPMENT: PC Kinetic Extruder (2 tph)
LOCATION: CWL&P Lakeside Station TAG NO.: PA-20-011
REVISION: 2 QUANTITY: 1
PAGE: 1 of 3
BY: TGD, MLK
DATE: 10/07/92

PULVERIZED COAL KINETIC EXTRUDER (2 tph)

OPERATIONAL FUNCTION: To feed PC from PC Kinetic Extruder Feed Bin FE-20-021 to the Coal Extruder Discharge Bin FA-20-061. The PC Kinetic Extruder also functions as a pressure seal at this point.

MATERIAL: Pulverized coal, steam

	MCR	DESIGN
PRESSURE, psia		
COAL INLET	ATM.	ATM.
COAL OUTLET	322	400
DEPLUGGING STEAM	410	450
TRANSPORT GAS VENT	ATM	ATM.
TEMPERATURE, F		
COAL INLET	500	550
DEPLUGGING STEAM	718	750
TRANSPORT GAS VENT	500	550
FLOW RATE, lb/hr		
COAL	4000	4500
DEPLUGGING STEAM	20.0	22.5
TRANSPORT GAS VENT	400	450
SEAL BUFFER GAS	620	700
ENVELOPE:	40" X 21" X 32" does not include space for motor or space for cover removal	
WEIGHT:	7474 lb	
ELECTRIC MOTOR:	50 kw	

LOCKHEED
ENERGY
• DEVELOPMENT
• RESEARCH

2 TPH KINETIC EXTRUDER

THE LOCKHEED KINETIC EXTRUDER (2 tph)

ABB COMBUSTION ENGINEERING, INC.

EQUIPMENT DATA SHEET

CLIENT: Combustion Engineering, Inc. EQUIPMENT: PC Screen Feeder
LOCATION: CWL&P Lakeside Station TAG NO.: FH-20-071
REVISION: 2 QUANTITY: 1
PAGE: 1 of 1
BY: TGD, MLK
DATE: 9/16/92

PULVERIZED COAL SCREEN FEEDER

(For 2 tph Kinetic Extruder)

OPERATIONAL FUNCTION: To meter pulverized coal from the receiving tank
FE-20-011 to the PC Screen FD-20-011.

MATERIAL:	Pulverized Coal
BULK DENSITY, lb/ft ³	
LOOSE	36
PACKED	44

SURFACE MOISTURE CONTENT	Negligible
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PARTICLE SIZE DISTRIBUTION	70% Thru 200 Mesh
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WORKING PRESSURE	Atmospheric
PRESSURE DIFFERENTIAL	

	MCR	DESIGN
TEMPERATURE, F	500	550
CAPACITY, lb/hr	4,450	5000

OPERATION	Continuous
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Feeder must be able to turn down to a continuous feed rate of 1000 lb/hr.

ABB COMBUSTION ENGINEERING, INC.

EQUIPMENT DATA SHEET

CLIENT: Combustion Engineering, Inc. EQUIPMENT: PC Coal Screen
LOCATION: CWL&P Lakeside Station TAG NO.: FD-20-011
REVISION: 2 QUANTITY: 1
PAGE: 1 of 1
BY: TGD, MLK
DATE: 9/16/92

PULVERIZED COAL SCREEN

(For 2 tph Kinetic Extruder)

OPERATIONAL FUNCTION: To screen oversized PC from the PC Screen Feeder FH-20-071. Screened material passes to PC Kinetic Extruder Feed Bin FE-20-021. Oversized material passes to Oversize Coal Collection Tank FA-20-051.

MATERIAL: Pulverized Coal
BULK DENSITY, lb/ft³
 LOOSE 36
 COMPACT 44

PARTICLE SIZE DISTRIBUTION
MATERIAL TO SCREEN 70% Thru 200 Mesh, Top Size 80 Mesh
MAXIMUM SIZE TO PASS
THRU SCREEN, microns 550

	MCR	DESIGN
TEMPERATURE, F	500	550
MATERIAL FLOW TO SCREEN, lb/hr	4450	5000
MATERIAL FLOW FROM SCREEN NOT TO BE LESS THAN, lb/hr	4000	4500

ABB COMBUSTION ENGINEERING, INC.

EQUIPMENT DATA SHEET

CLIENT: Combustion Engineering, Inc. EQUIPMENT: Oversize Coal
Collection Tank

LOCATION: CWL&P Lakeside Station TAG NO.: FA-20-051

REVISION: 3 QUANTITY: 1

PAGE: 1 of 2

BY: MLK

DATE: 10/07/92

OVERSIZE COAL COLLECTION TANK

(For 2 tph Kinetic Extruder)

OPERATIONAL FUNCTION: To cool solids retained from PC Screen FD-20-011
and allow removal from Kinetic Extruder System.
Cooling water from Slag Tank Water System
EA-30-021 will be used.

MATERIAL: Pulverized Coal, Miscellaneous

BULK DENSITY SOLIDS, lb/ft³ 45

PARTICLE SIZE Material will be from a screen sized
to remove greater than 550 micron.

	MCR	DESIGN
TEMPERATURE, F	150	550
STORAGE CAPACITY, lb solids	445	500
DISCHARGE RATE	Manually controlled, TBD	
COOLING WATER		
FLOW, lb/hr	632	692
TEMPERATURE, F		
IN		100
OUT		140
ENVELOPE	30" dia. 6'-3" high	

OVERSIZE COAL COLLECTION TANK

FA-20-051

ABB COMBUSTION ENGINEERING, INC.

EQUIPMENT DATA SHEET

CLIENT: Combustion Engineering, Inc. EQUIPMENT: PC Kinetic Extruder
Feed Bin

LOCATION: CWL&P Lakeside Station TAG NO.: FE-20-021

REVISION: 2 QUANTITY: 1

PAGE: 1 of 2

BY: TGD, MLK

DATE: 10/07/92

PULVERIZED COAL KINETIC EXTRUDER FEED BIN

(For 2 tph Kinetic Extruder)

OPERATIONAL FUNCTION: To store coal from the PC Screen FD-20-011 and
provide continuous flow to the PC Kinetic Extruder
PA-20-011

MATERIAL: Pulverized Coal

BULK DENSITY, lb/ft³

 LOOSE 36

 COMPACT 44

PARTICLE SIZE DISTRIBUTION 70% Thru 200 Mesh

	MCR	DESIGN
TEMPERATURE, F	500	550
PRESSURE, PSIA	15	50
STORAGE CAPACITY, lb	1,000	1,300
DISCHARGE RATE, lb/hr	4,000	4,500

SILO DISCHARGE Single hopper

HOPPER ANGLE 26 deg. from vertical plane

FLUIDIZING STEAM Three elevations

DISCHARGE RATE CONTROLLED BY PC Kinetic Extruder PA-20-011

TANK ENVELOPE 24" dia. 4'-11" high

FEED BIN AND DISCHARGE BIN FOR 2TPH KINETIC EXTRUDER

REVISION 1
10/15/92

ABB COMBUSTION ENGINEERING, INC.

EQUIPMENT DATA SHEET

CLIENT: Combustion Engineering, Inc. EQUIPMENT: PC Kinetic Extruder
Vent Eductor

LOCATION: CWL&P Lakeside Station TAG NO.: EG-20-021

REVISION: 2 QUANTITY: 1

PAGE: 1 of 1

BY: TGD, MLK

DATE: 10/06/92

PULVERIZED COAL KINETIC EXTRUDER VENT EDUCTOR

(For 2 tph Kinetic Extruder)

OPERATIONAL FUNCTION: To provide venting from PC Kinetic Extruder
PA-20-011 to PC Baghouse FD-20-021.

MATERIAL	Steam	
	MCR	DESIGN
INLET		
FLOW RATE, lb/hr	400	450
TEMPERATURE, F	500	550
PRESSURE, psia	atm	atm
MOTIVATING GAS		
TEMPERATURE, F	718	750
PRESSURE, psia	410	450
OUTLET PRESSURE, in.wg	11	20

ABB COMBUSTION ENGINEERING, INC.

EQUIPMENT DATA SHEET

CLIENT: Combustion Engineering, Inc. EQUIPMENT: Coal Extruder
Discharge Bin

LOCATION: CWL&P Lakeside Station TAG NO.: FA-20-061

REVISION: 2 QUANTITY: 1

PAGE: 1 of 2

BY: TGD, MLK

DATE: 10/06/92

COAL EXTRUDER DISCHARGE BIN

(For 2 tph Kinetic Extruder)

OPERATIONAL FUNCTION: To store coal from the PC Kinetic Extruder
PA-20-011 and discharge to the PC Feed Bin
FA-20-011.

MATERIAL	Pulverized Coal	
BULK DENSITY, lb/ft ³		
LOOSE	36	
PACKED	44	
PARTICLE SIZE DISTRIBUTION	70% Thru 200 Mesh	
	MCR	DESIGN
COAL		
TEMPERATURE, F	500	550
PRESSURE, psia	322	400
CAPACITY, lb	670	750
DISCHARGE RATE, lb/hr	4,000	4,500
PRESSURIZING STEAM		
TEMPERATURE, F	672	700
PRESSURE, psia	410	450
CAPACITY, lb/hr	40	50
SILO DISCHARGE	Single hopper	
HOPPER ANGLE	26 deg. from vertical plane	
TANK ENVELOPE	24" dia. 4'-11" high	

FEED BIN AND DISCHARGE BIN FOR 2 TPH KINETIC EXTRUDER

REVISION 1
10/15/92

DATE

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4/19/94

END