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AN ATMOSPHERIC FLUIDIZED BED DESIGN STUDY FOR UTILIZATION OF COAL WASHERY REJECTS AT COAL VALLEY, ALBERTA

F. D. Friedrich and M. M. McDonald
Combustion and Carbonization Research Laboratory

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AN ATMOSPHERIC FLUIDIZED BED COMBUSTOR DESIGN STUDY FOR THE UTILIZATION OF COAL WASHERY REJECTS AT COAL VALLEY, ALBERTA

by

F.D. Friedrich* and M.M. McDonald**

ABSTRACT

A study for the utilization of coal washery rejects at Coal Valley, Alberta was undertaken by Luscar Ltd., with Energy, Mines and Resources funding. An atmospheric fluidized bed combustor burning coal washery rejects would replace the present pulverized, clean coal fired burner which provides heat to the 726 tonne (800 short tons) per hour coal dryer. It would also provide site heating, replacing the propane heaters used at present.

The study was undertaken in three phases. In the first phase, Dorr-Oliver Canada was subcontracted to recommend which of the reject streams would be most practical as a fuel for an FBC facility. They also carried out a conceptual design and budget cost estimate for the FBC equipment. Secondly, a conceptual design and a budget, capital and operating cost estimate of the FBC fired dryer and plant heating system, including all building and installation costs, was carried out by CSBI Consulting Ltd. In the third phase, Luscar used the capital and operating cost estimates to analyze the economic viability of the proposed project.

This report describes the existing Coal Valley plant, the proposed FBC plant design and the capital and operating cost estimates. It is concluded that, although the use of coal washery rejects is technically feasible, it is not economically viable under the conditions existing at Coal Valley.

*Research Scientist, **Research Engineer, Combustion and Carbonization Research Laboratory, Energy Research Laboratories, CANMET, Energy, Mines and Resources Canada, Ottawa, Canada K1A 0G1

ETUDE CONCEPTUELLE D'UN FOUR ATMOSPHERIQUE A COMBUSTION EN LIT FLUIDISE POUVANT UTILISER DES RESIDUS DE LAVAGE DU CHARBON A COAL VALLEY EN ALBERTA

par

F. D. Friedrich* et M. M. McDonald**

RESUME

Le présent document décrit une étude qui porte sur l'utilisation des résidus provenant du lavage du charbon à Coal Valley. L'étude, entreprise par Luscar Ltd., a été subventionneé par Energie Mines et Ressources, Canada. On s'est proposé d'employer les résidus de lavage et de les brûler dans un four a combustion en lit fluidisé au lieu d'utiliser du charbon propre pulvérisé dans un brûleur conventionnel pour chauffer le séchoir à 726 tonnes (800 tonne courte) par heure.

On pourrait aussi, en utilisant les residues de lavage, remplacer les appareils de chauffage à propane employés actuellement pour fournir de la chaleur sur place.

On a divisé l'étude en trois stades. Au premier stade, le sous-traitant Dorr-Oliver Canada a déterminé lequel des courants de résidus serait le plus susceptible d'être utilise comme charge d'une installation de four à combustion en lit fluidisé. Cette compagnie a aussi conçu un modèle et a dressé une estimation du coût budgétaire des matériaux pour le four. Au deuxième stade la CSBI Consulting Ltd. a fait un design conceptuel et une estimation du budget, du capital et des dépenses d'exploitation pour le séchoir et le système de chauffage, incluant toutes les dépenses de construction et d'installation. Au troisième stade, Luscar s'est servi des estimations du capital et de l'exploitation pour analyser la viabilité économique du projet proposé.

Le présent rapport décrit la centrale comme elle existe actuellement, le plan proposé de la centrale à combustion en lit fluidisé et les estimations du capital et des dépenses d'exploitation. On a conclu que, bien que l'utilisation des résidus de lavage du charbon soit faisable du point de vue technique, étant données les conditions actuelles a Coal Valley, elle n'est pas viable du point de vue économique.

*Chercheurs scientifiques, **Chercheurs ingénieur, Laboratoire de recherches sur la combustion et la carbonisation, Laboratoires de rechereche énergétique, CANMET, Energie, Mines et Ressources, Ottawa, Canada K1A 0G1

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INTRODUCTION

In 1980, EMR entered into a contract with Luscar Ltd., Edmonton, Alberta for a co-funded study of a fluidized bed combustor burning coal washery rejects at their Coal Valley, Alberta, coal mine. The coal washery rejects would replace the existing pulverized coal fired burner system, and would provide sufficient heat for space heating and thus displace propane from the existing plant heating system.

Dorr-Oliver Canada Ltd. was sub-contracted to: investigate properties of the various reject streams available; recommend the one most practical as a fuel; and prepare a process diagram including combustor, gas clean-up equipment, a heat recovery exchanger to provide heat for space heating and the necessary combustor controls. Dorr-Oliver also submitted a budget cost estimate for the equipment included in their scope of supply. Subsequently, Luscar had a budget cost estimate prepared by CSBI Consulting Ltd. to include building, erection and installation, and general services costs not included in the Dorr-Oliver estimate.

This report reviews the design considerations, discusses the FBC plant design, and gives the capital and operating costs for the project.

THE EXISTING COAL VALLEY PREPARATION PLANT

The Coal Valley mine and preparation plant are located near Robb, Alberta, approximately 230km (145 miles) west of Edmonton. The elevation is about 1400m (4650 ft) above sea level. Outside temperatures ranging from -40°C to 35°C, (-40°F to 95°F) and frequent winds up to 100 km/h (60 mph) are natural factors contributing to high construction costs in the area.

The preparation plant has a design throughput of 726 tonnes (800 short tons) of raw coal per hour. The cleaning process involves several complex stages, with high-ash material constituting about 30 wt % of the raw feed being rejected in five different streams. The origin and composition of the reject streams are listed in Table 1. Simple calculation shows that the total rejects, at design throughput, contain about 586 MW (2×10^9 Btu/h).

The cleaned coal stream is passed through a single-stage, fluidized-bed dryer which, at design capacity, has a thermal demand of 64.5 MW (220×10^6 Btu/h). This is supplied by a pulverized-fired (PF) furnace burning cleaned coal in a direct-fired system. That is, the hot combustion gases, laden with whatever ash does not settle out in the furnace, are tempered with fresh air and fed directly to the dryer deck. Inadequate mixing of the tempering air occasionally leads to fires in the dryer, and slag formation in the combustor is a routine problem.

Space heating constitutes another thermal demand at the preparation plant. It is presently met by propane-fired unit heaters and peaks at 9.7 MW (33×10^6 Btu/h). Thus the total demand for heat, which could be met with rejects, peaks at 74.2 MW ($252 \text{ X } 10^6$ Btu/h).

FBC DESIGN CONSIDERATIONS

Previous Developments in Fluidized Bed Combustion of High Ash Materials

The ability to cope with high-ash fuels is recognized as one of the major advantages of FBC and such applications have been under study by many agencies. It is not intended to present a literature review here, but two pieces of work carried out by participants in the present study deserve mention.

In 1976, EMR, Luscar Ltd., and Copeland Systems Incorporated collaborated in a short-term pilot-scale study to establish the combustion performance of Coal Valley coal in a FBC (1). When raw coal with 18% ash was found to burn readily, with no problems of sintering or slagging, it was mixed with fly ash to simulate washery rejects by raising the ash content, first to 44% and then to 72%. The high-ash materials also burned readily, even when water equivalent to 10% by weight of the fuel was injected into the combustor. It was these favourable results that led to the present study.

More recently (2), Dorr-Oliver and E. Keeler Company, under the sponsorship of the U.S. Department of Energy, have collaborated in the construction of an atmospheric FBC boiler now operating at Shamokin, Pennsylvania. It is fueled by anthracite culm, washery rejects deposited during the past 100 years of anthracite mining in Pennsylvania, which has a typical ash content of 67%. The boiler has a steaming rate at MCR of 10,600 kg/h (23,400 lb/h). The combustor is approximately 3m square (10 ft x 10 ft) and operates with a bed depth of 1.2 m to 1.8 m (4 ft to 6 ft), and a temperature of from 790 to 900°C (1450 to 1650°F).The plenum chamber is divided into three zones to assist in control of turn down. Water cooled walls surrounding the bed, in-bed tubing, and a single-pass convection tube bank provide a means to recover heat.

Boiler start up took place in August 1981 followed by a three month shake down period during which the equipment and control systems were proved. Since then the unit has functioned for over 6000 operating hours.The results of tests have shown that design output has been surpassed by a small margin, and that an actual turndown ratio of 4.5 to 1 has been achieved, substantially bettering the design turn down of 2.5 to 1. Fuel properties experienced (heating value: 9.1 to 9.7 MJ/kg (3910 to 4170 Btu/lb), 0.73 to 0.94% sulphur, 67.3 to 69.3% ash, dry basis) have been somewhat inferior to design values (9.76 MJ/kg (4200 Btu/lb), 0.57% sulphur, 66.85% ash, dry basis). Reduction of SO_x emissions by 90% has been attained using calcium/sulphur mole ratios above 2.5. Emissions of NO_x are low because of the low bed temperatures. Low particulate emissions have resulted from the use of a bag-house dust collector.

Maintenance has been limited to patching the castable refractory. No measurable tube erosion has been reported for either of the water wall, in-bed or convention tube bank. One problem which has occurred consistently has been binding of the screens by the feed culm when moisture levels exceed 10%. This has reduced the capacity of the feed system.

Fuel Selection and Pilot-Scale Tests

From Luscar's point of view the most advantageous reject stream with which to fuel the FBC would be thickener underflow, because that would solve the plant's most serious waste disposal problem. However, it was recognized that while material of such high moisture content can be incinerated in an appropriately designed FBC, the resulting flue gas would be too high in humidity for subsequent coal drying. Dorr-Oliver, after reviewing analytical data for all the reject streams, identified the heavy media cyclone rejects as the preferred fuel, for the following reasons:

1. The size consist of 12 mm x 28 mesh (1/2 in. X 28 mesh) can be fed directly to the combustor without further preparation.

2. The moisture content is low enough to produce a low-humidity flue gas for efficient drying.

3. This stream of rejects is large enough to provide all of the energy requirements for drying and heating, therefore no blending with other streams would be required. Also, a single pick-up point in the preparation plant, and a single transport line to the FBC would suffice.

Representative analytical data for the heavy media cyclone rejects are given in Table 2. Using a 0.3 m (1 ft) diameter pilot scale combustor, Dorr-Oliver carried out approximately 50h of combustion trials with a 2720 kg (6000 lbs) sample provided by Luscar Ltd. This sample had a somewhat lower calorific value than Table 2 would indicate; 8.3 MJ/kg (3585 Btu/lb) on a dry basis, rather than 8.57 MJ/kg. (3687 Btu/lb), but performance was satisfactory in every respect. Combustion efficiency exceeded 98% at bed temperatures above 750°C. (1380°F).

Design Requirments for the Proposed Fluidized Bed Combustor

In preparing the list of requirements which the proposed FBC system should be designed to meet, reliability of the coal drying plant was the most important concern. Others were that there be no negative impact, either environmentally or operationally, relative to the existing plant. The following list resulted:

1. The existing pulverized-fired furnace and burner system upstream of the coal dryer is to be left intact, on a standby basis.

2. No changes are to be required to the existing induced-draft fan and gas scrubber downstream of the coal dryer.

3. The hot gases entering the dryer from the FBC are to be no higher in ash content than the gases supplied by the existing PF system.

4. The coal dryer shall be capable of the same turndown with the FBC system as with the existing system; that is, 4 to 1, or 64.5 MW to 16.1 MW (220 X 106 Btu/h to 55 X 106 Btu/h).

5. The FBC system shall provide plant heating in addition to hot gas for coal drying. Plant heating demand shall not interfere with drying capacity, but the FBC will only be required to provide plant heating when it is operating to provide heat for coal drying. The existing propane fired heating system shall remain in place on a standby basis.

7. The fuel for the FBC may be a portion of the total reject stream, or a portion of one of the five component streams. Fuel preparation should be minimal, and the fuel should move from the washery to the combustors by conveyor.

8. Ash from the FBC shall be cooled below 120°C (250°F) and shall be removed by truck or mine hauler.

9. The FBC system, including the hot fluid generator for plant heating, shall be automated insofar as possible, and shall not require licensed operators.

Of the foregoing, Items 3, 4 and 5 were recognized as placing rather stringent constraints on the design of the FBC system. For the FBC system burning fuel with 70% ash to carry no more of it into the dryer than the PF system burning fuel with 10% ash, some sort of hot gas clean-up system was almost certain to be required. It was necessary to avoid either contamination of the cleaned coal with fly ash or overloading the scrubber and induced draft fan downstream of the dryer. On the other hand, no information was available about hold-up of fly ash in the cleaned product, or the additional burden acceptable to the scrubber. Thus specifying no increase in ash loading seemed the only safe course.

Requiring the FBC system to provide the coal dryer with the same turndown range as the existing PF system was perhaps an unduly arbitrary decision, as the need for high turndown could be avoided by modifying plant operational procedures. The dryer turndown of 4 to 1, coupled with the plant heating requirement, translates into a turndown range of 4.6 to 1 for the FBC; that is, a maximum capacity of 74.2 MW (64.5 MW drying + 9.7 MW heating) (253 X 10^6 Btu/h (220 X 10^6 Btu/h drying + 33 X 10^6 Btu/h heating)) versus a minimum capacity of 16.1 MW (55 X 10^6 Btu/h) (dryer at 25% capacity, no heating).

DESIGN DESCRIPTION

Process Design

The work sub-contracted to Dorr-Oliver consisted of first recommending and testing, on a pilot scale, which reject stream should be used to fuel the FBC, and second, developing a design and cost proposal for the combustor. The scope for the latter included a fuel delivery hopper, the combustor itself with all feeders, blowers, ash removal equipment, instruments and controls, hot gas clean-up equipment, heat exchanger to supply plant heating, ductwork and controls for blending ambient air with the cleaned flue gas and supplying the mixture to the dryer at the correct temperature, and all necessary ash handling and cooling equipment, up to and including an ash storage hopper. The process flow diagram showing the main equipment is given in Figure 1. The design philosophy adopted emphasized simplicity, minimal capital and operating costs and as little impact on the existing dryer operation as possible.

Combustor Design

A single compartment, cold windbox design was selected for the simplicity, fast turndown and low capital costs associated with this type of combustor. The reactor is supported on its own foundation and has a mild steel shell lined on the inner surfaces with refractory. Ports are provided for feed inlet, ash outlet, start up burners, pressure and thermocouple taps, manholes, sight glasses and drain flanges.

Fluidizing air is distributed in the bed through specially designed tuyeres located in the distribution plate at the base of the bed. This plate is refractory lined to withstand the high bed temperature and provides support for the weight of the bed. When the bed is started up initially or after a long shut down, the bed material is preheated by propane burners. Two burners are provided, complete with fuel train consisting of regulators, shut off valves and safety devices to allow the system to be heated up gradually to the operating temperature.

The level of the bed in the combustor is controlled by sensing the differential pressure across it. This is compared to a set point corresponding to the required bed depth. When the depth increases beyond the required value, the ash discharge valve is opened to drain bed material and restore bed depth to normal. Freeboard pressure is also sensed and compared with set value. Inlet vanes on the fluidizing blower can be adjusted, if required, to the desired pressure.

Water sprays are used for emergency cool-down of the fluidized bed reactor. A high pressure water pump is used for this purpose.

Fuel Feed System

The feed material is conveyed from the washery heavy media cyclone rejects stream to the fuel storage bin by a belt conveyor. The storage bin has sufficient capacity for several hours of FBC operation. Bin level is used to control the operation of the belt conveyor.
The fuel is fed to the reactor by two variable speed screw conveyors at the bottom of the bin and via a short chute to the reactor. Seal air prevents leakage of hot gases from the reactor through the feed screws. The possible use of alternative rejects of large size is allowed for by providing space for crushers between the belt conveyor and the bin.

Combustion Air Supply

Air for bed fluidization, combustion and cooling is provided by two separate blowers operating in parallel. Ambient outside air is drawn in via the inlet duct comprising an air intake, air flow measuring device and a valve.

The fan exit ducts are interconnected to provide flexibility of operation and are connected to the FBC windbox.

Control of Turndown

As described earlier, the turndown abilities were required to be the same as for the existing pulverized coal fired system. Thus special control and turndown facilities were needed to meet the extreme turndown requirements. Turndown is achieved first by reducing bed temperature. The variable speed screw feeders are slowed down along with fluidizing airflow rate to reduce the bed temperature to the desired set point. Fluidizing air partially by-passes the bed at low loads and is diverted for gas tempering.

At the lowest loads in summer conditions, the hot gases from the FBC are partially dumped to maintain the dryer inlet temperature within desired limits. The hot gases are diverted to the ash cooler exhaust scrubber where they are cooled and cleaned prior to venting.

Flue Gas Clean Up

The gases exiting from the FBC are ash laden and at a higher temperature than required for the dryer. They are cleaned and quenched with cooling air before transfer to the drier windbox.

The main duct carrying the hot flue gases is split into three parallel ducts. Gas cleaning takes place with the ducts each utilizing two stages of cyclones. The primary cyclone stage has two cyclones in parallel, and the secondary has four cyclones, again in parallel. The hot gas ducts and the cyclones are lined with refractory for thermal insulation and abrasion resistance. Expansion joints and supports are provided at appropriate points. Valves are also provided to allow the gas flow in each of the three ducts to be shut off.

At about 2/3 load, one of the three clean-up trains is shut off. This maintains the efficiency of the cyclones at reduced loads. At the lowest output levels, part of the hot gas output is diverted, after passing through the cyclones, to the ash cooler exhaust scrubber.

Gas Tempering and Interface with the Coal Dryer

After cleaning, the hot flue gas must be tempered with cooling air to control the gas temperature to dryer inlet requirements. Cooling air is also used to protect equipment from the high flue gas temperatures. A separate cooling air blower provides air for cooling in two stages; the first just after the cyclone stages and the second, final tempering, immediately prior to injection into the coal dryer. Cooling is also provided in the freeboard of the combustor by using part of the fluidizing air. Additionally, at low turndown levels, fluidizing air is by-passed to the cooling blower outlet and controlled by a modulating valve.

The pressure in the dryer windbox is controlled, as with the existing pulverized coal burner, by the dryer exhaust fan. The dryer fluidizing blower inlet dampers are manually set.

Plant Heating Heat Exchanger

As described previously, the FBC is designed to provide plant heating requirements in addition to dryer load requirements.

Plant heating load is met by providing a gas-to-liquid heat exchanger, using a freeze proof heat transfer fluid to carry the heat to the plant heaters at 315°C (600°F). The hot gas used has been cleaned, quenched and diverted from the main gas duct. A valve in the heat exchanger duct varies the gas flowrate depending on a temperature signal from the outgoing liquid line. A restriction in the main gas duct provides the pressure drop to give the necessary gas flow rate through the exchanger.

Ash Cooling and Handling

The combustion of washery rejects in the fluid bed combustor results in a considerable volume of waste material made up of ash and rock. This waste material leaves the combustor in two streams, the larger particles are periodically drained from the bed through a discharge valve to maintain the bed level, and the finer material is carried away by the gas stream.

The coarse material is conveyed on a water cooled drag conveyor for subsequent cooling in the ash cooler. The fines are removed by the primary and secondary cyclones in the hot gas ducts and are conveyed by drag conveyors to the fluidized-bed ash cooler which cools the ash streams with cool fluidizing air supplied by a separate blower and by quench water sprays. The cooled ash is then conveyed to the ash bin for storage and to periodic removal by truck to land fill. The moist, hot air from the ash cooler is first passed through a cyclone where the entrained fine ash particles are removed before passing through a scrubber-cooler where water sprays cool the air before it is vented to the atmosphere.

The scrubber-cooler is also used at low loads to cool the hot gases which are dumped from the hot gas ducting. This maintains the temperature of the gas stream to the coal dryer at desired levels.

Instrumentation and Control

As explained under Design Requirements, the FBC is automated as much as possible and to the extent where licensed operators are not required. Sensors and indicators are provided for various process parameters to provide an indication of the system status and to allow diagnostic checks to be made. Existing air systems provide instrument and high pressure air to operate valve actuators.

The mode of control of the FBC system is that the output is controlled by the coal dryer plant and plant heating load requirements. The FBC load "follows" the demand of the coal dryer.

To ensure safe and reliable operation of the FBC plant, the following interlocks are provided for safe start-up and operation of the system:

a) Before FBC fluidizing air blowers are started:
   - fan dampers are closed;
   - cooling spray water is running;
   - coal dryer ID fan is running;
   - purge air and instrument air are available;
   - quench air blower for hot gas tempering is running;
   - hot ash conveyors are started and running;
   - fluoseal air supply is available;

b) Before ash cooler fluidizing air blower is started:
   - blower dampers are closed;
   - cooling spray water is running;
   - ash cooler fan is started and running;

c) Before hot ash conveyors are turned on:
   - cooling water is on;
   - ash cooler fluidizing blower is started and running;

d) Sufficient emergency spray water pressure available before combustor feed screws are turned on.

e) Plant load heat exchanger fluid circulating before gas flow control valve opens.

Performance Specifications

The FBC performance and design basis can be summarized as follows:

Output: 64.5 MW (220 x 10^6 Btu/h) maximum dryer input.
9.7 MW (33 x 10^6 Btu/h) maximum plant heating input.

Turndown: 64.5 to 16.1 MW (220 to 55 X 10^6 Btu/h) for dryer.
9.7 to 0.5 MW (33 to 1.6 X 10^6 Btu/h) for plant heating.

Fuel: Heavy media cyclone rejects, size consist 13 mm x 28 mesh.
Moisture: 20%
Ash: 67% (dry basis)
Heating value: 8.57 MJ/kg (3687 Btu/lb) (dry basis).

Ambient Conditions: 1400 m (4,650 ft) above sea level.
-40 to 35°C (-40 to 95°F) ambient temperature.

Controls: Existing dryer controls to remain. FBC to follow dryer and plant heating loads.

Turndown Control: Lowering of bed temperature and fuel feed rate and by dumping a small amount of FBC output hot gas.

Ash Disposal: By truck to land fill after cooling to less than 120°C (250°F).

FLUIDIZED BED PLANT DESIGN

The plant layout drawing showing the location of the principal buildings on the site is given in Fig. 2. The new FBC building will adjoin the dryer building and will necessitate the relocation of the propane storage area.

Fuel Delivery and Storage

Fuel for the FBC, heavy media cyclone rejects, is taken from the washery. The rejects are ploughed off to a new conveyor system, comprised of three 760 mm wide belt conveyors which transfer the fuel to the new FBC building. Two of these conveyors are within the washery building and the third transfers the material, in an enclosed and insulated conveyor gallery up a 14.5° incline, 70 m (227 ft) to the FBC building. The conveyors have a fire protection system with sprinkler heads every 3 m. (10ft).

Although feed from the heavy media cyclone rejects is not expected to require size reduction, provision is make for the inclusion of a crusher rated at 100 t/h (110 tons/h) with a by-pass chute.

The delivered feed is transferred to a bin holding sufficient feed for several hours operation at full load. Transfer conveyor operation is controlled by bin level.

Process Building

An insulated, steel framed building 52 x 40 x 30 m high (160 x 120 x 93 ft high) is provided to house the FBC reactor, fuel storage bin, ash conveyors, gas clean up and other equipment. It is equipped with crane ways, monorails, equipment support steel and platforms, heating and ventilation equipment. Fresh water and service water for cooling are provided as are plant and service air supplies from existing systems. Sump pumps and piping are included to handle water drainage.

The building is equipped with a fire protection and monitoring system. An indoor substation will provide the necessary electrical supply to the plant.

Plant Heat Distribution

A new heating system will be installed to heat the mine buildings. The heating medium will be a thermal heat transfer fluid heated by FBC hot gas-liquid heat exchanger to a temperature of 315°C (600°F).

The system includes circulating pumps, storage tank, expansion tank, piping and insulation, air handling equipment, controls and wiring. Heat is supplied to the complete mine site with the exception of the warehouse, central engineering and laboratory buildings which will continue to be heated by the existing propane heaters.

Ash Handling and Disposal

Bottom ash and cyclone ash will be conveyed to the fluidized bed cooler discussed earlier and from there to a 91 tonne (100 ton) capacity truck feeding bin. Ash will then be trucked from the bin to the disposal site.

The disposal of FBC combustion residue will be carried out in a manner similar to that of other washery rejects, into "cells" constructed within a large waste rock dump. The cells are subsequently buried and mixed with overburden with at least 7 m being placed over the residue material. When sufficient mined out area is available in the mine pit, waste material can be dumped in the open excavation, overburden being again used as a capping upon completion of waste disposal in an area.

This method of ash disposal in mine pits is similar to that currently employed at a number of coal fired thermal electric power plants in Alberta, and is thus expected to be an acceptable method at Coal Valley.

The use of the FBC would reduce the amount of tailings to be disposed of and hence have a beneficial effect on the environmental aspects of the mining operation.

Integration of Controls with Dryer Operation

The operation of the FBC will be fully integrated into the operation of the coal dryer. The existing programmable load controller (PLC) will be used to control the FBC system, with additional PLC components being provided as required. Instrumentation will be provided to monitor the performance of FBC and the control room will be combined with that of the coal dryer to allow the existing operator to tend both the coal dryer and the FBC. Little operator attention will be required with the automatic control system.

CAPITAL COST ESTIMATE

The total capital cost for the FBC plant was estimated at $22.33 million. A breakdown of the major items is given in Table 3, Capital Cost Estimate. The FBC equipment cost estimate was provided by Dorr-Oliver Canada and the over-all plant estimate was done by CSBI Consulting Ltd.

The estimate includes all relevant items including site development, buildings, equipment, installation, owner's costs, engineering and project management.

OPERATING COST ESTIMATE

The plant operating costs were estimated to be $325,000 per annum. This was based on the assumption that the major controls for the FBC equipment will be located in the present washery control room and that the additional manpower required is limited to one person on day shift only for general clean-up and equipment tending. Maintenance costs in the above figure include an allowance for propane and heating costs during shutdown of the FBC heating system.

ECONOMIC ANALYSIS

An economic analysis was carried out by Luscar using Luscar's economic criteria, Dorr-Oliver's process information and the capital and operating cost estimate prepared by CSBI Consulting. The analysis was based on a coal plant production of 3.17 million tonnes (3.5 million tons) per year. The annual amount of cleaned coal required for drying purposes with the present pulverized coal burner was taken as 47160 tonnes (52,000 tons). The cost of the propane was taken as $0.07 (1980 dollars) per ton of cleaned coal. Also included in the analysis is the replacement of approximately 9.7 MW (33×10^6 Btu/h) of propane and oil space heating to generate savings of approximately $660,000 in 1983 dollars.

Analysis indicated that the project would not be economically viable because of the high capital costs involved, and would require a reduction of approximately 35% in capital costs before it would be.

CONCLUSIONS

As a result of the study and testwork undertaken, the following conclusions have been reached:

1. Any of the coal rejects or combinations of rejects from the Coal Valley washery, crushed to size if necessary, can be burned in a properly designed fluidized bed combustor.

2. For the thermal dryer heat supply, only about 10% of the total rejects generated at maximum washery design capacity will be required.

3. Heavy media cyclone rejects are best suited for the dryer application. Moisture levels are low enough to eliminate humidity problems in the hot dryer gas and no crushing or screening of feed would be required.

4. Operation and control of an FBC dryer can be interfaced with the existing dryer operation and be operated from a single control room with no additional manpower requirement.

5. The extreme turndown range required by the dryer and plant heating load can be met by appropriate design of the FBC combustor systems.

6. The economic analysis of the proposed FBC indicates that a significant reduction in capital costs is required before the project would be viable.

7. The economics of drying using rejects as fuel is highly site specific. Plants presently using natural gas as fuel would experience a much greater fuel saving than Coal Valley. In new plants, the high capital costs of the FBC plant would be partially offset by the capital costs of the alternative system. Thus, in other circumstances, the burning of coal washery rejects could well be economically viable.

ACKNOWLEDGEMENTS

This report is principally a summary of work done by Luscar Ltd.,Dorr-Oliver Canada Ltd. and CSBI Consulting Ltd. and contains material presented in Reference 3. It has been rewritten as an EMR report mainly to make the information more readily available and to present it in a somewhat briefer format.

The assistance of H. P. Raghunandun on the preparation of the figures is also acknowledged.

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3. Luscar Ltd., "Report on atmospheric fluid bed combustor burning washery rejects"; Contract Serial No. ISQ79-00170, Requistion Number 18SQ23440-9-9067. Available from Micro Media Ltd., 144 Front St. West, Toronto, Ontario, M5J 2L7.

Table 1 - Origin and composition of the washery reject streams

Source	Moisture %	Ash, % dry basis	HHV, dry basis MJ/kg	HHV, dry basis Btu/lb	Size Consist	
1. Wemco Drum	10	65	10.8	4660	100 mm x 13 mm	(4 in. X 1/2 in.)
2. Heavy Media Cyclone	17	65	11.0	4720	13 mm x 28 mesh	(1/2 in. X 28 mesh)
3. Spiral Classifier	40	29	22.5	9680	28 mesh x 100 mesh	
4. Solid Bowl Centrifuge	-	-	15.5	6640	100 mesh x 0	
5. Thickener Underflow	65	57	13.6	5840	28 mesh x 400 mesh	
Total Rejects	18	60	12.6	5420	100 mm x 0	(4 in. X 0)

Table 2 - Analytical data for heavy media cyclone rejects

	As Produced	Dry Basis
Ultimate Analysis, wt %		
Moisture	20.1	0.0
Ash	53.5	67.0
Carbon	17.7	22.2
Hydrogen	1.6	1.9
Nitrogen	0.4	0.5
Oxygen	6.6	8.3
Sulphur		
Sulphatic	< 0.01	0.01
Pyritic	0.03	0.04
Organic	0.07	0.08
Higher Heating Value		
MJ/kg	6.85	8.57
Btu/lb	2950	3685

	Reducing		Oxidizing	
Ash Fusibility Data	°C	°F	°C	°F
Initial Deformation	1280	2336	1290	2354
Softening	1350	2462	1360	2480
Hemispherical	1395	2543	1405	2561
Fluid	1460	2660	1480	2696

Size Fraction Analysis, dry basis

Size Fraction		Ash Content	Higher Heating Value	
	wt %	wt %	MJ/kg	Btu/lb
19 mm x 12 mm (3/4 in. X 1/2 in.)	3.04	63.8	10.20	4380
12 mm x 6 mm (1/2 in. X 1/4 in.)	20.20	61.9	9.62	4140
6 mm x 3 mm (1/4 in. X 1/8 in.)	28.34	56.5	13.84	5950
3 mm x 16 mesh (1/8 in. X 16 mesh)	16.90	67.4	8.22	3530
16 mesh x 28 mesh	9.52	69.8	7.40	3180
28 mesh x 0	22.00	86.7	0.11	50

Table 3 - Capital cost estimate

Site Development	238,300
Relocation of Propane Tank Farm	42,000
Building and Structures	3,141,200
Process Equipment	14,225,900
General Services	137,000
Power Supply or Services	156,450
FBC Building Power Distribution Equipment and Installation	466,100
Instrumentation	150,450
Mine Plant Heating System	946,400
Owner's Costs	1,058,000
Miscellaneous Costs, Approvals etc.	195,000
Equipment Rental	151,000
Engineering	575,000
Project Management	850,000
TOTAL PROJECT COST	$22 332,600

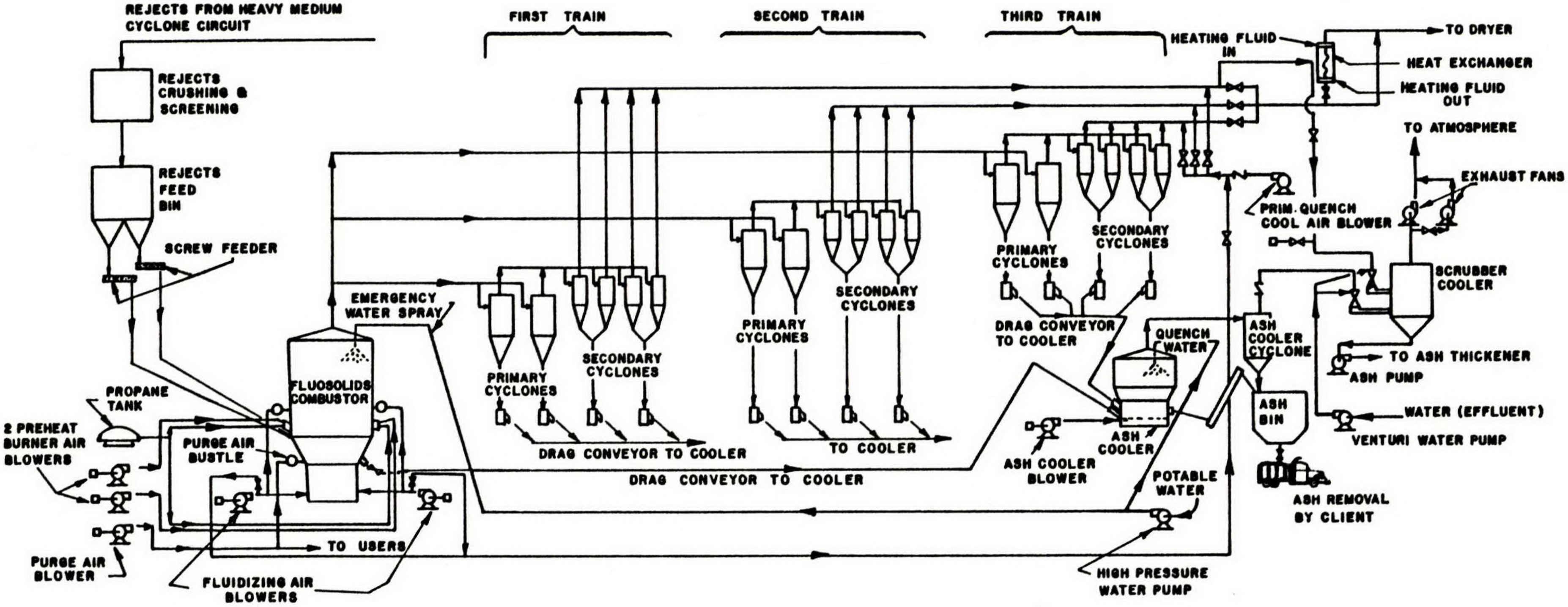

Fig. 1 - FBC system process flow diagram

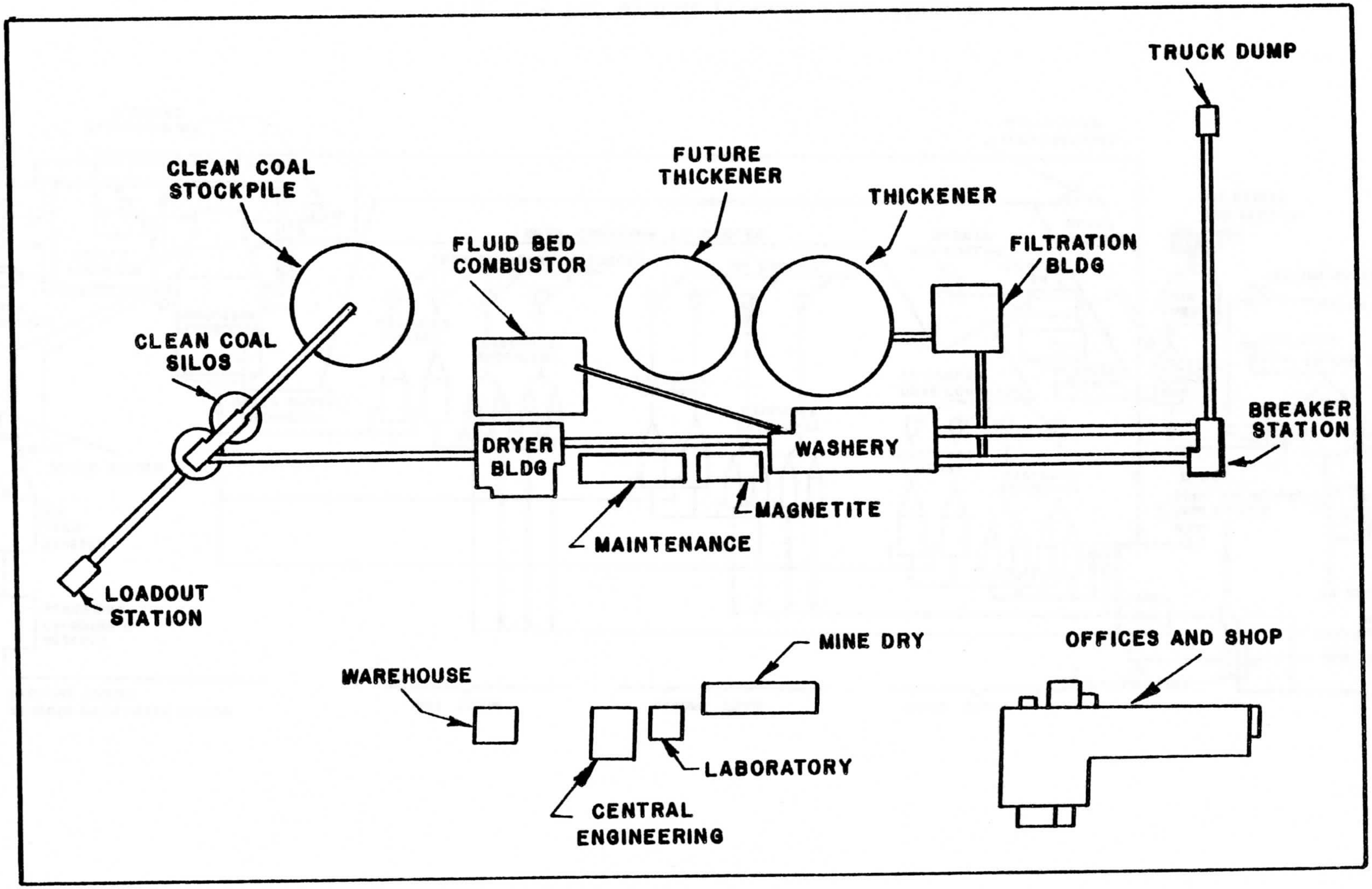

Fig. 2 - Plant lay-out