Separation of Reject Coal Stream Constituents

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Abstract

Mill rejects from Western Power's Collie coal fired power station contain a large amount of coal, along with the unwanted pyritic sulphur and free silica constituents. The purpose of this project is to develop a profitable process which will allow the liberation of some of this coal. Particle size distributions and float/sink testing were determined for samples taken from the rejects, and average rejects density and tonnage data was collected. It was found that a vibrating screen of aperture size 8mm would be able to liberate approximately half of the coal, and reject the majority of the gangue minerals.

1.0 Introduction

1.1 Description of research area

The purpose of this project is to develop a process which will separate unwanted "gangue" minerals from coal rejected from pulverisers at Western Power's Collie 330MW coal fired power station. This project has been deemed necessary by Western Power due to the large amount of material rejected by the station's pulverisers compared to the industry norm. This anomaly has caused a significant amount of coal to be wasted since the station's commissioning in 1999, with the reject material being dumped into an ash storage dam on site. This has the added effect of wasting dam storage space which is currently running out.

This problem is thought to be unique to Collie Power Station, because Western Power does not receive washed coal, unlike its counterparts in other parts of Australia and the world (World Nuclear Association 2004). The formation of clinker on boiler tubing is also far more of a problem at Collie than at Western Power's other coal fired stations, making the rejection of pyritic material a necessity and a priority over minimising the loss of coal.

There is no standard industry technique for winning coal from such a small flow of minerals. Once the decision to invest in coal preparation plant is made, it makes economic sense to clean the entire run-of-mine product stream, so separation plant is designed for high capacities. For this project it is desirable to utilise existing technology, but in this case it is economically preferable to use as few processes as possible treating as wide a particle size range as possible.

1.2 Definition of research question

It was hypothesised from initial observations that the rejects were usually dominated by coal, especially in the higher particle size fractions. This would allow the design of an economically viable method of returning a significant proportion of the rejected coal to the burning process.

To test the hypotheses made about the character of the rejects, a sampling and testing program needed to be devised which would identify the average volume collected per unit time, reject particle size distribution and rejects mineral composition. This information would allow the assessment of various coal separation options based on the value of coal which could be liberated for each option.

1.3 Definition of results and proposal solution

As expected, the rejects were found to be dominated by coal under normal conditions, especially in the larger particle size fractions. It was found that approximately half of the coal could be won, and the majority of the gangue minerals rejected, if a vibrating screen of aperture size 8mm was employed to split the rejects into two product streams.

2.0 Methods and Procedures

To establish a basis for selection of a suitable separation technique and to allow net present value costing of separation plant using coal savings, rejection data was collected, and the character of the rejects ascertained.

2.1 Rejects Sampling and Testing Program

The rejection rate under various mill conditions was recorded and attempts were made to correlate it with the mill parameters. The angle of repose of the rejects pile was also measured during these tests. Subsequently, samples were taken from rejects pile under low and high rejection rate conditions, with these conditions manufactured by manipulating the mill air flows. The particle size distribution of each sample was determined using laboratory sieves, and the bulk density and moisture contents were determined.

To determine the weight proportions of coal and gangue minerals for each particle size fraction, the samples were float/sink tested using a heavy liquid of specific gravity 1.7kg/L. Float sink testing was also done on all the separated gangue fractions using a lithium polytungstenate (LST) solution to confirm that the heavy minerals were composed primarily of quartz and pyrites as expected, and to obtain the particle size distributions of each mineral.

Bulk density tests using a truck and weighbridge were also undertaken on large stockpiles of rejects to determine a longer-term average density and to observe its variation. The volume of rejects collected over a continuous period of four months was also determined using estimates of number of truckloads dumped to the ash dam every two days. This was to establish an average value and variation and watch for longer-term trends in the volume collected.

2.2 Parameters for Costing

The cost of separation methods chosen will be affected by a number of factors. The value of the coal saved by the process, as well as the ash dam storage not occupied by the liberated coal, are the two contributing factors to the revenue created by any proposal.

The costs incurred by the separation process include the capital cost of the equipment, structural, piping and instrumentation costs, labour costs for setting up the equipment, the amount of service water used, the equipment power requirements, and maintenance and operation costs for the plant. In some cases, there will be additional specific costs related to the particular method chosen.

A number of different separation techniques were assessed and compared to come up with the best candidate for preliminary costing.

3.0 Results

3.1 Character of the rejects

It proved impossible to establish values governing relationships between mill parameters and rejection rate because the state of the mills appears to be the dominant factor in the amount of material rejected. Since 3 of the 5 mills are in service at any one time, with one being overhauled as part of a cycle and another on standby, each mill is generally in a different state of repair. The amount of wear on the table and grinding wheels is a major factor in determining the amount of coal rejected, since worn down parts increase the chance that a coal particle will be partially ground or not ground at all. As a result, samples were taken with the rejection rate deliberately altered by changing the mill air flow by an arbitrary amount.

The density calculated in the weighbridge experiments was found to be close to the sampled density at high rejection rate, and was relatively steady in value, so this was assumed to be representative of the character of the rejects under normal conditions. A correction factor for the calculation of coal savings was developed using interpolation.

As expected, the rejects contained a large amount of coal under normal operating conditions, particularly in the higher size fractions.

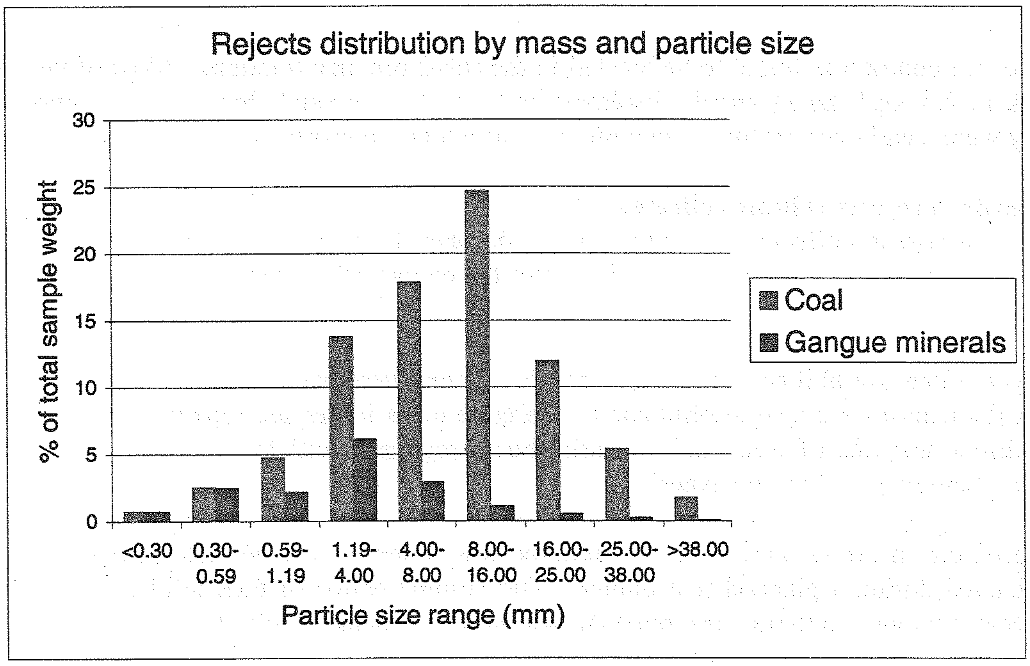

Figure 1 Diagram showing distribution of coal and gangue minerals for high rejection rate sample

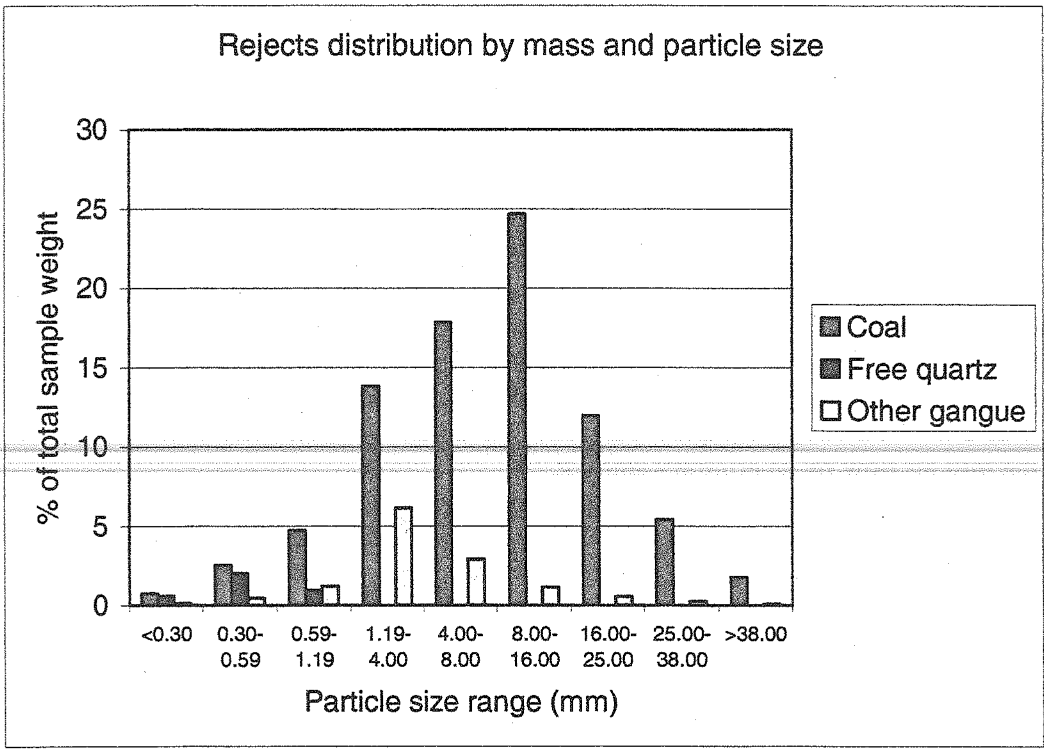

Figure 2 Diagram showing distribution of coal, free quartz, and pyrite and composite mineral particles for high rejection rate sample

Most of the free quartz was found to be located in the sub-2mm size fractions. Most of the particles which sank in 2.85kg/L heavy media displayed surface pyrite crystals but in size fractions above 4mm many were clearly composites containing coal as a major constituent.

3.2 Trends in rejects volume collected

The volume of rejects collected by estimation of dumped load every two days was found to be highly variable over short periods and cyclical over the course of the four months of data collected so far.

Apparently random variability over short periods is consistent with the previous volume tests. Short-term fluctuations are also attributable to the three mills in service rejecting at different rates due to different amounts of wear and the mills being regularly withdrawn from service for both scheduled and unscheduled maintenance.

A pronounced dip in the amount of rejects dumped was observed immediately after multiple mills were overhauled during a planned unit outage. The volume collected then gradually recovered as the mills wore out again, although the rejection was still very peaky due to the normal variability of mills in service and individual mill wear rates.

To correct for the fluctuations in rejected tonnage over the course of data collection, a 95% confidence limit underestimate for the average rejects volume was used, equating to 4935 tonnes per year rejected including 3669 tonnes of coal.

3.3 Consideration of coal separation options

Due to the predominance of coal in the reject size fractions above 8mm, and the fact that almost all the gangue minerals lie below 8mm, a simple vibrating screen of aperture size 8mm would achieve a good separation without the need for any expensive separation plant. Screening at 8mm would allow 87.73% by mass of the gangue minerals to be discarded, and 52.48% of the coal to be saved, with the screen overflow comprising 88.99% coal according to interpolation. This method would require minimal use of service water compared to most separation techniques, with a small amount of spray water used to aid the screening. This would also allow the use of an existing overflow pit which would be overloaded if large flows from a separation plant required drainage.

The 11.11% heavy minerals present in the returned screen overflow would increase the amount of mill wear. The effect of recirculation is hard to quantify, but it should be noted that silica is the more abrasive of the two gangue minerals (Hodge 2001), and is only present below about 4mm in the particle size distribution. It is also important to note that most of the particles greater in size than 8mm are not pure pyrite crystals, but composite grains containing a mixture of coal and pyrite, further reducing the expected mill wear.

A number of other separation techniques were also considered. In each case it was assumed that the separation was only to be applied to the underflow of a screen of aperture size 8mm, due to the simplicity and economy of screening, and the difficulty of performing separation on wide particle size ranges. Crushing the rejects down to a uniform size prior to separation was rejected as an option, due to the operational difficulties associated with crushing a damp feed, as well as the relatively large capital cost involved.

Some of the separation techniques used commonly in the coal industry and other mineral ore separations were considered "non-starters" for this project. These included magnetic and electrostatic separation, which require a very fine feed material and large amounts of power for separation to take place (Weiss et al. 1985). This would require crushing and would create a dust problem, ruling such methods out on economic grounds.

Two other methods ruled out for economic reasons were froth floatation and dense media separation. In the case of froth floatation, the feed is required to be extremely fine and a reagent is required (Weiss et al. 1985), both conditions unacceptable to Western Power, and would portain a prohibitively high startup cost. Dense media cyclones could deal with the size range in question (Weiss et al. 1985), but the cost associated with agitating and retrieving the magnetite or ferrosilicon would not be economically viable for this low capacity application.

The separation techniques with the most economic promise for this application are gravimetric ones, due to the fact that water can be used as the separation medium and the lower capital cost, in general, of the equipment required. Some gravimetric separation methods are unsuitable for the particle size range requiring separation, namely teetered bed separation, which is used to treat sub-1mm particles, and spiral concentration, which is used to process sub-3mm particles (Woolacott & Eric 2001).

Other gravimetric methods include Wilfley shake tabling, which is heavily load dependent and requires close supervision, but has a low capital cost and efficient separation (Burt 1984). Jigging, a technology used generally in large-scale separations and with a high capital cost, may be scaleable to this application, as could a hydrocyclone, although hydrocyclones generally require a tightly controlled, small size range (Wills 1979). These possibilities are currently under further investigation.

3.4 Process flow diagram for solution

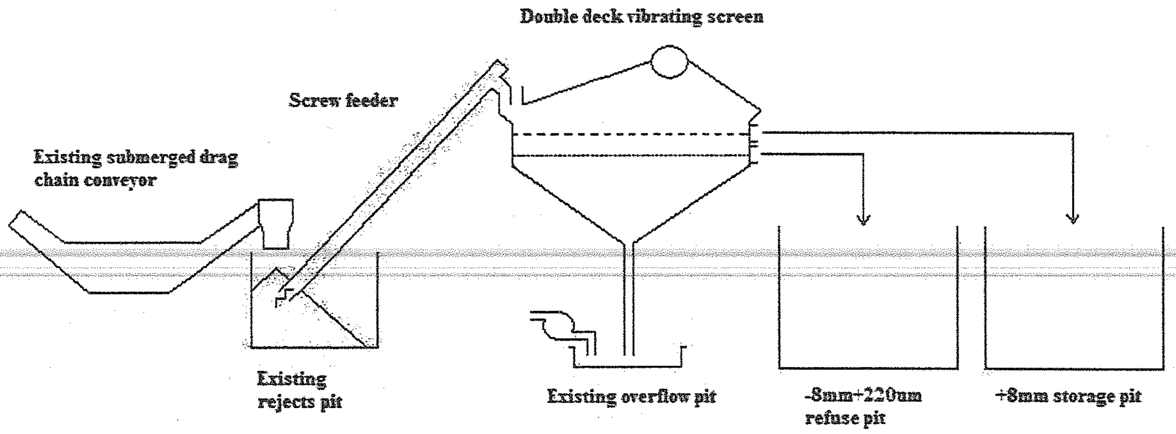

Figure 3 Flow sheet for screw feeder to double deck screen option

A screw feed from the existing rejects pit was chosen to allow ready access to the stockpile during periods of maintenance to the conveyor and screens. This would also provide a saving in space, which is an important practical consideration due to the possibility of major works in the area in the future.

The screen apparatus consists of two decks, the upper deck having an aperture size of 8mm and the lower deck 220um. The lower deck is required to dewater the smaller particles to prevent free water being deposited in the concrete refuse pit. Water is introduced to the top screen with the rejects feed through a weir box at 5-7 tonnes per hour. The screens are to be driven by two 3.7kW motors.

Trucking to the stockpile and ash dam from separate pits was chosen because direct return to the bunkers is not feasible due to their extreme relative height and the complexity and expense of altering the current bunker setup. Movement of the coal to the stockpile by other means was not considered as the stockpile is a considerable distance from the rejects pit and is on the other side of the boiler.

4.0 Conclusions

From stockpile sampling of the rejects stream, the particle size distribution of the rejects and mineral composition under normal conditions were found. The hypothesis that the larger size fractions of the rejects are dominated by coal was verified. This led to the development of a solution in which the rejects stream would be split at 8mm particle size using a vibrating screen, with approximately half the coal being saved and most of the gangue minerals discarded by retaining the screen overflow.

Further investigation of the possibility of jigging and hydrocyclones as separation devices is underway, with possible sighter testing using a Wilfley Table, although disadvantages to both techniques have been noted.

Future work required by this project includes the detailed design of instrumentation and structural support by tender and site construction.

5.0 References

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