Coal clearance system at Zondagsfontein Colliery

by P. Mogodi*

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Synopsis

The purpose of the project was to propose a coal clearance system (coal transportation system from the mining face to the plant) that could be used for the planned underground operations at Zondagsfontein Colliery. Components of the current coal clearance system were overlooked during feasibility studies. Subsequent studies of the coal clearance system revealed that the combined capacity of the two trunk belts does not match that of the shaft (main) belt. As a result production downtimes will be encountered due to bottlenecks in the system.

Ways of addressing this challenge were analysed by weighing both advantages and disadvantages and ultimately a surge bin option was selected. Belt conveyor simulations were conducted in order to determine the optimum capacity of the surge bin. The configuration of the surge bin in relation to the two trunk belts was chosen by considering development cost, advantages, and disadvantages of each option. It was concluded and recommended that a 500 tonnes capacity surge bin is required to remove the bottleneck from the system.

Introduction

Zondagsfontein Colliery is an Anglo Coal Inyosi mining project located in Kendal, Mpumalanga Province[1]. The mining project has already passed exploration, prefeasibility and feasibility stages and is currently under mine construction (development of working areas, shaft sinking and mine planning). The mine is expected to start operating in the first quarter of 2010 with a life of mine of 20 years. Board-and-pillar underground mining methods will be used to extract coal from the number 2 and 4 seams[2].

The coal clearance system is used to transport coal from different sections of the mine to the silo and the plant on surface. It includes different components such as belt conveyors, different machines (shuttle car, feeder, and feeder breaker), and storage facilities (silo)[2]. The assignment as posed required the proposal of a coal clearance system that could be used for the planned underground operations at Zondagsfontein Colliery.

The assigned coal clearance system was designed on the basis that:

- There are 8 continuous miners operating simultaneously.
- 7 million tonnes (Mt) of coal will be produced from underground the (u/g) sections per annum.
- Each continuous miner section will be comprised of 1 continuous miner (CM) unit, a series of shuttle cars (S/C), and a feeder breaker.
- There are 253 working days per annum.
- There are 3 shifts per day (night, afternoon and day shifts).
- There is a 3-hour production with belt conveyor availability of 95%.
- The day shift will consist of 4 hours of maintenance[2].

Design of coal clearance system as per feasibility studies

There is a sequence of activities that takes place before and during clearance of coal from the underground sections to the surface (illustrated in Figure 1 and 2). Initially the continuous miner will cut coal at a variable rate and it will be dumped onto the shuttle car[3]. The feeder breaker will receive coal from the shuttle car and it will then be used to reduce the size of coal lumps before they are dumped on the section belts. There are 8 section belts with a capacity of 1 000 t/h each which feed onto two trunk belts with a capacity of 4 000 t/h each. The two trunk belts will dump coal on to the shaft belt, which has a capacity of 4 200 t/h.[4] From the shaft belt the coal will be transported to the two silos on surface till it finally reaches the plant[3].

* *University of Witwatersrand, South Africa.*

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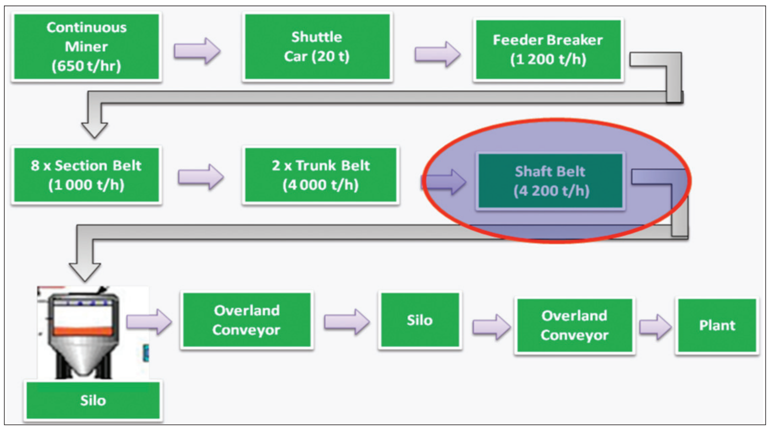

Figure 1—Coal clearance system and rates of different components[3]

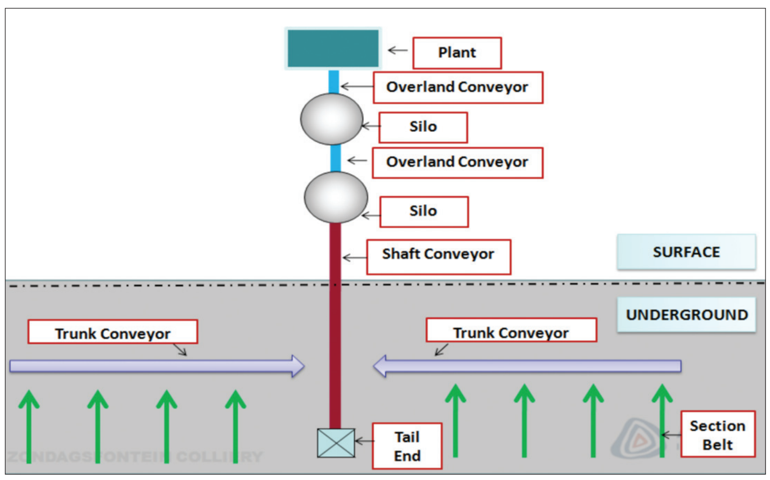

Figure 2—Layout of the coal clearance system as per feasibility studies[3]

The shaft belt design capacity of 4 200 t/h is smaller than the required capacity of 8 000 t/h[2]. As a result, a number of problems will be encountered (which are explained in the next section). Figure 2 illustrates the layout of the coal clearance system.

Challenges that will be encountered

Certain components of the current coal clearance system were overlooked during feasibility studies. As a result, a number of challenges will be encountered when the mine is operational (Figure 3)[2]. Shaft belt capacity (4 200 t/h) is less than the combined capacities of the two trunk belts (8 000 t/h)[4]. As a result, there will be a build-up on the shaft belt resulting in a flooded belt and finally spillage (particularly when all the belts operate at peak capacity). In addition to spillage, other challenges that will be encountered are:

- Overloading of the shaft belt
- Increased wear rate on the belt and idlers
- Breakdown of the system[2].

Spillage can trigger spontaneous burning of coal, methane explosion, and coal dust explosion. They can occur if coal gets stuck between moving parts. These are not only safety hazards but also health hazards. Worn belts and other components would require replacement. The overall impact of the potential challenges is loss of production time (due to maintenance and accidents), high cost (for replacements of the belt), and loss of coal resource (due to spontaneous combustion and explosions). As a result, an insufficient amount of coal would be supplied to the coal market (Eskom and export)[2].

Overcoming the potential challenges

Option A—speeding up the shaft belt

The speed of the coal clearance system shaft belt can be increased in order to remove the bottleneck. A higher belt speed will increase the capacity (tonnes per hour)[5]. Since the capacity will be higher, belt flooding or buildup of coal will not take place. Spillage of coal will be minimized. Consequently, more coal (tonnage per hour) will be transported from the sections[5].

The downside (disadvantages) of increasing the speed of the shaft belt involves the following:

- There will be increased wear of the shaft belt.
- Higher power requirement of the shaft belt section (power packs will be increased or changed to accommodate the new speed of the belt).

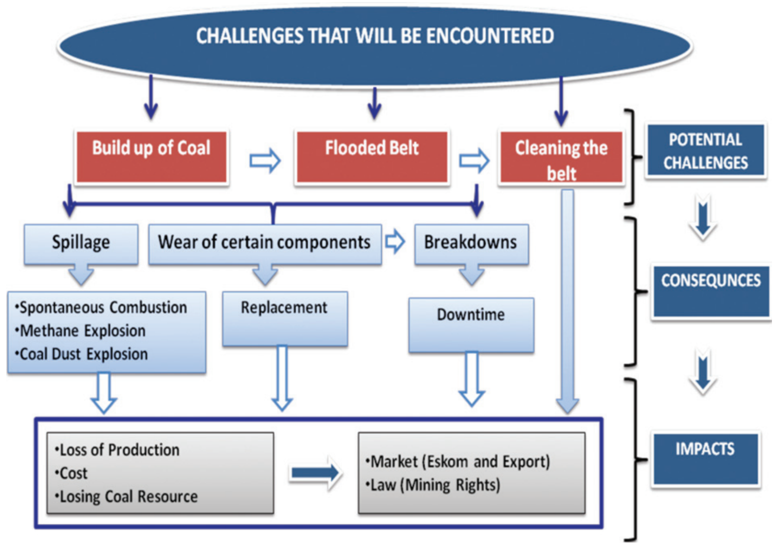

Figure 3—Challenges, consequence, and impacts that could result due to current design of coal clearance

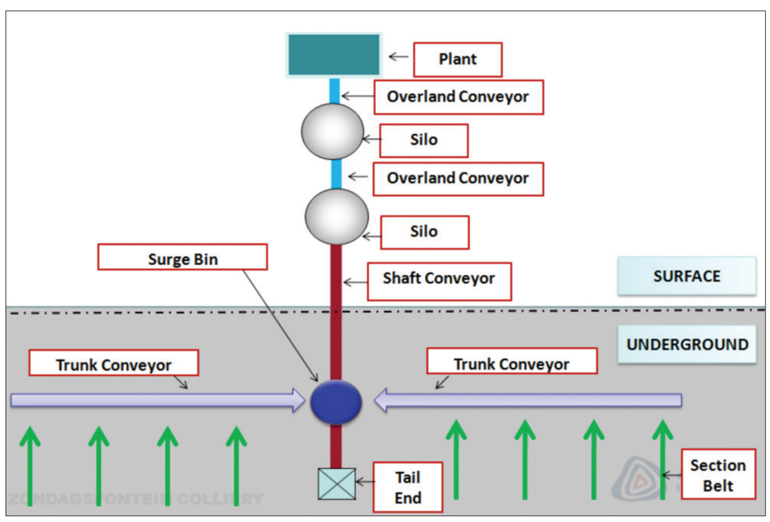

Figure 4—Proposed coal clearance system[3]

- When the belt speed is increased, coal tends to lift off the belt and generate dust.
- Spontaneous combustion and coal dust explosion can occur as a result of the increased amount of coal dust in the ambient atmosphere.
- Installation of power-packs and replacement of the belt will increase the operational cost[5].

Option B—reducing tonnage per hour

Reducing tonnage per hour can be achieved by limiting the amount of coal handled by different components of the system (i.e. belts and feeder breaker)[5]. The capacity of the feeder breaker can be limited to a certain amount (tonnes per hour) in order to get the desired amount of coal on the shaft belt. Advantages of reducing tonnage per hour are:

- Spillage on the shaft belt will be minimized.
- Since the quantity of coal is controlled on the shaft belt, belt flooding will not take place.
- Mining and engineering downtimes will be minimized. As a result greater operational efficiency will be achieved[5].

The downsides of reducing the tonnage per hour in order to achieve the desired amount of coal on the shaft belt are:

- Optimization of the system will be a problem (due to limited capacity)
- The production target of 7 million tonnes per annum will not be reached[5].

Option C—installation of a surge bin

The surge bin (also known as underground silo) is a storage facility between two components[6]. It will regulate the transfer of coal from the two trunk belts to the main belt (shaft belt). It will regulate the amount of coal that would be dumped onto the shaft belt. The surge bin should be installed either between the no. 4 seam and no. 2 seam or below the no. 2 seam. Figure 4 illustrates the coal clearance system with the surge bin installed between two trunk belts and the shaft belt. Coal from the trunk belt will be stored temporarily before being transferred to the main shaft belt[6].

Advantages of a surge bin (bunker) in a coal clearance system are:

- The surge bin facilitates belt overruns on shutdown without spillage.
- It minimizes spillage at transfer points between the two trunk belts and the main shaft belt.
- An underground bunker will facilitate a single point of transfer onto the shaft belt.
- It ensures controlled and constant feed onto the shaft belt[6].

Disadvantages of a surge bin in a coal clearance system are:

- The initial cost of the surge bin is high.
- It is a fixed design (for the life of mine, hence it cannot be relocated).
- During surge bin breakdowns, production will be stopped[6].

Futher analysis of option C

Based on the analysis that was conducted, option C was selected because it will have a relatively positive effect on production and safety of the mine. A conveyor simulation was conducted in order to determine the capacity of the surge bin. Other parameters that were analysed are underground silo capacity, silo outlet, total production, total spillage, and maximum and average level of the silo[6]. Table I shows the results of eight scenarios that were analysed.

The capacity of the surge bin was limited to 500 tonnes due to the high initial cost of development, hence any capacity above that was not considered[6]. From Table I it can be deduced that scenarios 3, 5 and 8 have minimum spillage compared with the other scenarios. Hence scenario 5 was the most suitable with a belt capacity of 4 200 tonnes/hour and no spillage at the underground silo. It gives the same advantages as scenario 8 but at a lower capacity, and hence lower capital cost. Figure 5 illustrates the tonnage profile of coal in the surge bin for scenario 5 over a period of 170 hours. The maximum capacity of the surge bin will not be reached, so spillage will not be encountered.

Layout and location of the surge bin

There are two layouts that can be used to connect the current coal clearance system with the surge bin[2]. The layout of the surge bin dictates where it should be located. In option 1 the surge bin is installed between no. 4 seam and no. 2 seam, whereas for option 2 the surge bin should be below no. 2 seam. Figure 6 shows the designs of the layout and location of the surge bin for both options 1 and 2. The main advantages of using option1 is that the surge bin can be used to store coal from the two seams. The main disadvantage is accelerated wear of the shaft belt. Option 2 involves instal-

Table I

Further analysis of option 1✖

Scenario	Surge bin capacity	Outlet rate of surge bin (tons/hour)	Total production	Total spillage (@ surge bin)	Max level of surge bin	Average level of surge bin	Max level of surface silo
1	350	4200	297431	277	350	40.9	5889
2	400	4200	297747	95	400	41.63	5896
3	450	4200	297309	15	450	33.1	5947
4	450	4000	297089	397	450	58.25	5954
5	**500**	**4200**	**297279**	**0**	**465**	**34.1**	**5956**
6	500	4000	297258	350	500	60.8	5971
7	600	4000	297280	225	600	54	5983
8	600	4200	297279	0	465	34	5956

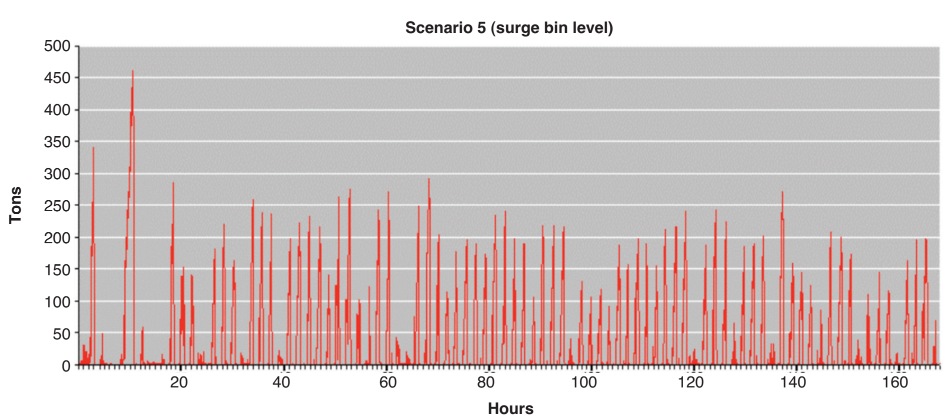

Figure 5—Scenario 5 of the surge bin level✖

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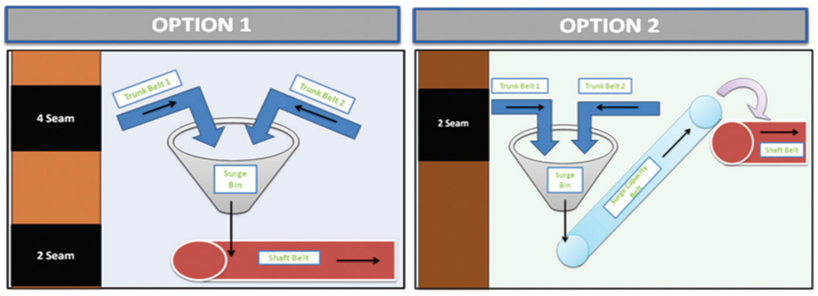

Figure 6—Location of the surge bin in relation to the geology

lation of a feeder belt which will transfer coal from the bin to the shaft belt. A disadvantage of option 2 is that additional cost will be required for the operation and maintenance of the feeder belt.

Option 1 for the layout of the surge bins was recommended for the following reasons:

- ➤ The design of option 1 will require less operational cost compared to option 2. Option 2 will have a higher operational cost due to the maintenance and replacement of the feeder belt.
- ➤ The surge bin will be located between no. 2 and 4 seams and it can be used as a storage facility for the two seams. If option 2 is selected another surge bin will be required for the no. 4 seam.
- ➤ When production starts in the no. 4 seam, smaller development will be required. If option 2 is selected, larger development will be needed, leading to additional capital costs on the design[2].

Table II

Total cost for the surge bin, option 1 and option 2

Costs	
Surge bin	
Cost of raise boring	R 285 714.29
Cost of concrete lining	R 91 025.00
Total cost	R 376 739.29
Option 1	
Cost of development	R 1 907 664.00
Cost of support	R 90 372.59
Total cost	R 1 997 991.59
Total cost (including surge bin)	R 2 374 730.88
Option 2	
Cost of development	R 1 365 000.00
Cost of support	R 7 386.60
Total cost	R 1 372 386.60
Total cost (including surge bin)	R 1 749 125.89

Cost analysis

Table II shows the cost analysis to determine the capital cost required for developing the surge bin layout and design for option 1 and option 2. The cost of raise boring and concrete lining were calculated in order to determine the total cost of developing a surge bin. The cost of development and support installation was considered for the design of option 1 and 2.

It can be deduced from Table II that more capital is required for the design of option 1 compared with option 2. Although option 2 has a lower cost of development and support, more money will be required for the capital and operational cost of the feeder belt (which were not included in the table). There will be an additional cost for developing another surge bin when production begins in the no. 4 seam[2]. The no. 2 and no. 4 seams will use the same surge if option 1 is implemented. The calculated costs in Table II do not include the cost of necessary steelwork that may be required or labour.

Conclusion and recommendations

A coal clearance system of a mine has to be cost-effective and productive. There are a number of factors that affect and influence the design such as mining layout, mining method, componets of the system, and required production rate. Suggestions were made to improve the current coal clearance system. The first improvement suggestion was directed at overcoming potential challenges that will be encountered if the current coal conveying system is implemented. It was recommended that a surge bin with a capacity of 500 tonnes should be installed in order to remove the bottleneck in the system.

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