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Steep Angle Conveying of Coal Refuse

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Summary

Since the start-up of a Bethlehem Mines Corporation coal preparation plant in Van, West Virginia six years ago, the refuse handling system proved to be a costly maintenance problem and a material handling bottleneck. To alleviate these problems, the original system, consisting of two screw conveyors and a drag conveyor, was replaced by two steep angle pocket belt conveyors. Within six months, the system paid for itself in maintenance savings alone. The following analysis describes the steps leading up to the changeover and reviews its first year operating performance.

1. Introduction

The Van facility is a heavy media plant operated by the Kayford, Boone and Nicholas Division of Bethlehem Mines Corporation. It is designed to handle 127 mm x 0 raw metallurgical quality coal from the Powellton seam at a maximum feed rate of 590 t/h (metric tons per hour). Average clean coal recovery rate is between 50 and 65 %. The plant uses three types of cleaning circuits: coarse material (127 mm x 12 mm) is cleaned in heavy media baths; intermediate size material (12 mm x 0.55 mm) is cleaned in heavy media cyclones; and fine coal (0.5 mm x 0) is cleaned in a hydrocyclone/froth flotation circuit.

During 1979 and 1980, the plant processed 2.38 million metric tons of raw coal to produce 1.32 million clean tons or 0.66 million clean tons annually. With a 55 % recovery rate, it is necessary for the plant to handle 0.53 million tons of refuse annually. Of this quantity, 93 % was generated by the coarse and intermediate size cleaning circuits. The remaining 7 % was generated by the fine coal circuit and handled in a separate system which is not discussed here. The typical split between coarse and intermediate size refuse is 60/40, or an annual average of 296,000 tons of coarse refuse and 197,000 tons of intermediate.

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During this two year period, the Van facility operated approximately 2,400 hours annually. This resulted in an average output of 123 t/h of coarse refuse and 82 t/h of intermediate size refuse. The refuse handling system was under an average load of 205 t/h of material sized 127 mm x 0.5 mm.

2. Original Design

In the original plant refuse handling design, shown schematically in Fig. 1, wet refuse was moved from the coarse circuit in two chutes directly onto the drag conveyor. Intermediate size refuse was fed by a 91 t/h capacity screw conveyor into a centrifugal dryer. Refuse from the dryer was then moved by another 91 t/h screw conveyor. Both screw conveyors had 610 mm diameter screws. The feed conveyor was 4.3 m long inclining at 2.4° and the discharge conveyor was 6.1 m long inclining at 20°. Dewatered intermediate size refuse from the discharge screw conveyor was deposited directly onto the drag conveyor which was a dual chain drive unit rated at 295 t/h. This conveyor was 914 mm wide with 305 mm high flights and was inclined at 34° for 24.4 m. Refuse from the drag conveyor emptied directly into a 454 ton truck loadout bin.

Two basic problems existed with the original system. First, maintenance costs and respective downtime appeared excessive. Second, during operating swings when raw coal with a high reject rate was processed, the plant would either have to slow production or overload the system.

3. Technical Alternatives

Options of either modifying or rebuilding the original system were compared with installing a complete or partially new system. It quickly became apparent that any economically justifiable solution would have to fit within the relative space and geometry of the original system. Major building modifications were deemed impractical due to a multitude of interrelated logistics issues.

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Space and geometry constraints therefore limited the technical search for a viable new system. In essence, it was necessary to elevate at least 450 t/h of combined coarse and intermediate size refuse. This addresses peak loading requirements. In addition, the refuse would have to be elevated approximately 13.5 m in a horizontal distance not exceeding 19.5 m.

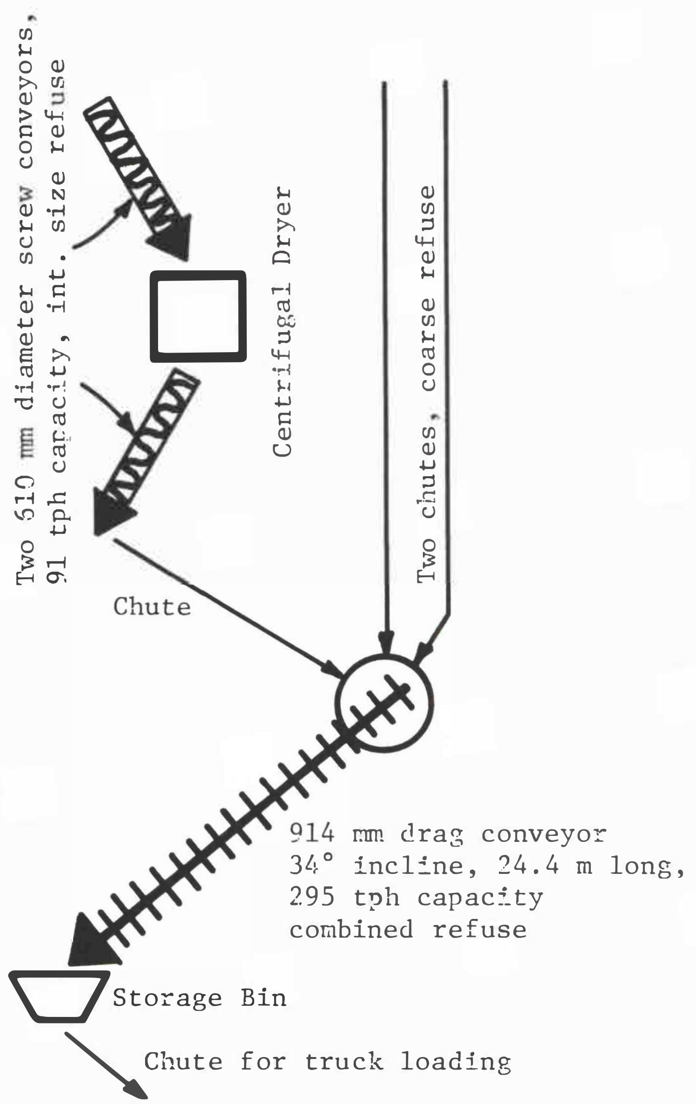

Fig. 1: Schematic of original refuse handling system

For the purpose of this discussion, changes made to the system's intermediate size refuse handling segment are given secondary attention by noting only those changes that have actually been made.

Bethlehem's search for an alternative to the existing drag conveyor included consideration of flat belt conveyors, bucket elevators, screw conveyors and "pocket" or corrugated sidewall belt conveyors.

A flat conveyor belt arrangement would either have required a sophisticated series of transfers and drives or it would have violated the major building modification constraint. A heavy duty bucket elevator scheme could have been developed, but two overriding issues preempted any detailed analysis. First, experience with bucket elevators handling abrasive, sticky material raised the question of high maintenance costs and questionable availability similar to the existing drag conveyor. Secondly, a bucket elevator arrangement would be complex at best due to the prevailing geometry of the chute work to feed and the transfer belt conveyor to discharge. Moreover, material carryback with buckets was a real concern.

The alternative of a 450 plus t/h screw conveyor to elevate the material was discounted as too risky in terms of maintenance cost and availability. This judgement was supported by operating problems with existing refuse screw conveyors.

From a technical standpoint, a pocket belt conveyor appeared to be an attractive alternative deserving careful examination. Specifically, it had the potential for overcoming the problem of the original system. Maintenance costs were expected to be low while corresponding availability high. The problem of system overloading could be overcome by appropriate belt size and conveyor speed. Finally, it looked feasible to install such a system within the established space and geometric constraints.

Confidence in the ability to design a workable pocket belt conveyor scheme for the Van plant was greatly bolstered by a visit to observe a comparable working system that handles coal preparation plant refuse.

4. Economic Analysis

At this point, an economic analysis was necessary to determine if the pocket belt conveyor alternative could be justified when compared with rebuilding the drag conveyor for a third time. Rebuilding of the drag conveyor was the minimum capital expenditure necessary to stay in business. On the other hand, the difference between the higher capital cost of the pocket belt conveyor and the drag conveyor represented discretionary spending which had to be independently justified. A gross economic analysis was sufficient to conclude that the pocket belt conveyor could be justified. A detailed analysis later substantiated this fact.

The following was the basis of the gross analysis: Drag conveyor (1979/80 base period) compared with the pocket belt conveyor.

To avoid overloading the drag conveyor and in turn minimize breakdowns, the raw feed and subsequent output of the plant was throttled back an average of at least 2 % (use 2 %).

Ten percent (10 %) of the plant's controllable downtime was a result of the drag conveyor being out of service. This relates to 1 % of the attempted operating hours being down due to drag conveyor problems.

For analysis purposes, it is assumed that the delay associated with refuse conveyor breakdowns will be reduced to 0.5 % of the attempted operating hours and throttling back the plant will be unnecessary.

Two cases can be developed from this point: (1) if additional clean coal is required, the plant could produce approximately 2.5 % more product with the same number of actual operating hours, or (2) if additional product is not required, 2.5 % fewer actual operating hours would be required.

Average base period production was 660,000 clean tons per year produced with 2,400 actual operating hours. In Case One, 2,400 hours of actual production would provide 677,000 tons of clean coal which is an incremental addition of 17,000 clean tons per year. In Case Two, the 660,000 tons could have been produced with 2,340 actual hours of operation.

For Case One, it is assumed that the cost of clean coal provided by the Van plant is $10 per ton less than outside purchased replacement coal. This results in a (17,000 x $ 10 =) $ 170,000 annual benefit.

In Case Two, the saving results in being able to operate 60 hours less per year. If the plant cost is $ 1,500 per hour to operate, the annual saving is (60 x $ 1,500 =) $ 90,000.

The maintenance cost associated with the drag conveyor averages $ 100,000 per year plus a $ 100,000 capital rebuild every other year. It is estimated that the average annual maintenance cost associated with pocket belt conveyors will be $ 10,000 and there is no expectation of a near-term capital rebuild.

Energy costs were examined and although the pocket belt conveyor is more energy efficient, the difference is less than $ 5,000 annually and in this case, trivial.

The pocket belt conveyor to replace the drag conveyor had an installed capital price of approximately $ 250,000. Since Bethlehem was faced with a minimum investment of $ 100,000 to rebuild the drag conveyor, it was only necessary to justify $ 150,000 as discretionary.

Completing the Case One analysis, the return associated with spending the additional $ 150,000 for the pocket belt conveyor incorporates the following:

Benefit from additional coal produced	$ 170,000
Reduced annual maintenance expense ($ 100,000 — $ 10,000)	90,000
Eliminate alternate year rebuild of drag conveyor ($ 100,000 ÷ 2)	50,000
	$ 310,000

A simple return calculation shows a pre-tax payback in ($ 150,000 ÷ $ 310,000 =) 0.48 years or less than six months.

In the Case Two analysis, the comparative return is as follows:

Savings from reduced operations (60 hours)	$ 90,000
Reduced annual maintenance expense ($ 100,000 — $ 10,000)	90,000
Eliminate alternate year rebuild of drag conveyor ($ 100,000 ÷ 2)	50,000
	$ 230,000

This simple calculation of return shows a pre-tax payback in ($ 150,000 ÷ $ 230,000) = 0.65 years or about eight months.

Payback calculations were ranged for both cases based on various interpretations of the operating data. The most optimistic return is less than six months, while the most pessimistic, which gave no consideration to improving plant productivity, is just slightly over one year.

5. Design Considerations

The pocket belt conveyor system which was approved and installed in 1980 is shown schematically in Fig. 2. Wet refuse is moved from the coarse coal circuit in two chutes directly into the 1.2 m wide pocket belt conveyor. Intermediate size refuse is moved in a chute directly onto a 610 mm wide pocket belt conveyor. This small 181 t/h conveyor which is 3.7 m long and inclined at 45° elevates the dewatered

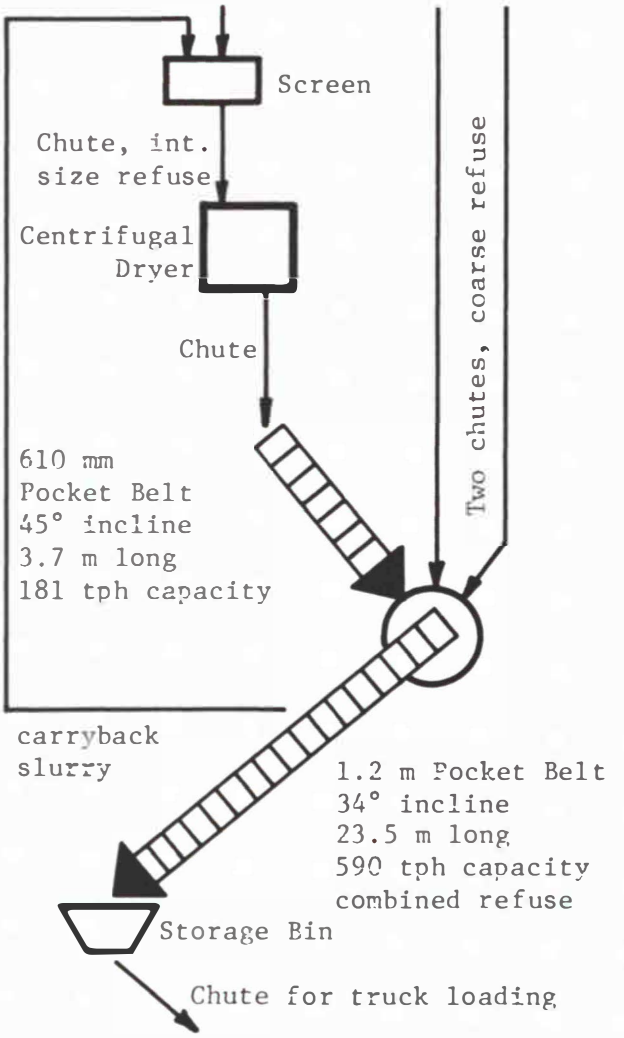

Fig. 2: Schematic of present refuse handling system

intermediate size refuse so it can be deposited directly on the 1.2 m pocket belt conveyor. The 1.2 m pocket belt conveyor, which is 23.5 m long and inclined at 34°, has a rated capacity of 590 t/h (see Figs. 3 and 4 for artist's view of this large conveyor). It empties directly into the existing 454 ton truck loadout bin.

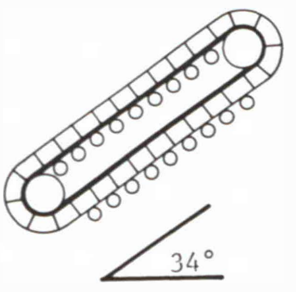

Fig. 3: Pocket belt conveyor, side view sketch

The pocket belt was supplied by the Flexowall Corporation of Clinton, CT. Detailed engineering for the installed system was provided by Regal Construction Company. This firm engineered and constructed the working pocket belt system that was visited by Bethlehem. That experience helped in preparing for potential problems associated with carryback, training and loading. Design considerations relative to these specific points include:

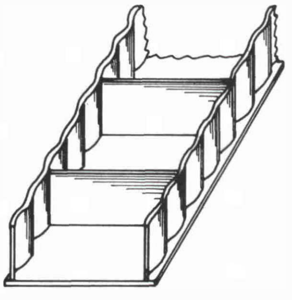

Fig. 4: Pocket belt sketch

a) Carryback

Cross-cleats prevent the cleaning of wet clay-like material from the belt by traditional methods. Provisions should be made to collect carryback on a drop pan and continually wash it to a collection sump for recycling within the system. Space should be provided near the head pulley, on the return side, so a thumper mechanism can be added. A rubber-lagged, winged tail pulley should be installed to shake off material.

b) Training

With the relatively short belt length and a stiff base belt, training is difficult. On the carrying side, training idlers should be placed at every fourth idler spacing. Guide rollers should be placed on the return side to keep the belt on the return idlers.

c) Loading

Cross-cleats on the belt have a tendency to slap material being loaded, which can cause spillage. High side boards should be located approximately 105 mm in from the belt sidewalls and load chutes should discharge close to the belt.

6. Operating Experience

The pocket belt installation has now operated for about two years and is providing exceptional service. Refuse handling is no longer a limiting factor for plant production. It appears that belt life and system maintenance will be comparable to that of a flat belt conveyor. Plant downtime due to conveyor problems has been zero and maintenance expense has been less than $ 5,000 since correction of start-up problems.

The first two weeks of operation were extremely difficult. A carryback problem at start-up was so severe that it had to be resolved immediately or the system could not be operated. The primary aspect of this problem was that material was being carried around the head pulley on the cross-cleats by centrifugal force. This dumped an unmanageable quantity of material on the drip pan. Belt speed was reduced approximately 10 % until a proper discharge trajectory was obtained. At that point, the quantity of carryback was manageable, but still more than desired. Subsequently, a four roll belt thumper was designed and installed and head chute modifications were made. Together, these changes have essentially resolved the problem. At present, total carryback is 1 to 2 t/h (0.25 — 0.5 %) which is recycled within the system.

In addition to the carryback problem, it was necessary to alter one loading chute to minimize wear and spillage, add training idlers on the return to insure that belt sidewalls do not slip off the idler and redesign the four roll thumper for improved mechanical strength.

Bethlehem's positive experience at the Van plant has provided underlying confidence in the workability of steep angle pocket belt conveying. From this experience, the following points should be addressed to minimize start-up and operating problems in future applications:

1. With wet fine material, provide for constant carryback handling and allow a minimum of 2.4 m at the discharge end for thumper cleaning.
2. Be extremely careful when selecting belt speed and pulley diameter. The Van plant's large pocket belt conveyor is limited to a speed of 85 m/min with a 610 mm pulley.
3. Short belts should be equipped with self-aligning training idlers approximately every 6 m on both the carrying and return sides. This is an improvement over guide rollers.