UPGRADE OF SHAFT CONVEYOR USING HIGH SPEED TRIPPER DRIVE TECHNOLOGY (CASE STUDY MATLA COAL NO. 2 MINE, SHAFT CONVEYOR)

Alan Exton

INTRODUCTION

The continuous requirement to upgrade existing conveyor infrastructure in order to increase production from existing operations is ongoing in mining. Mines that were designed 30 years ago had conveying capabilities to suit the current requirement plus a certain margin for expansion. Today these mines require major upgrading to meet their new conveying requirements resulting from more efficient underground production sections and the increase in the number of sections to produce more coal at a lower operational cost.

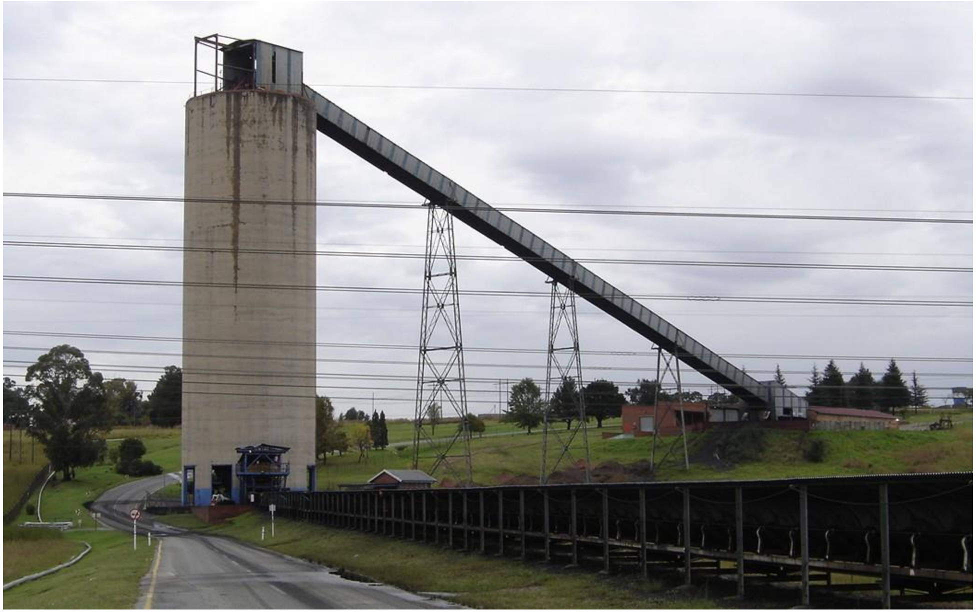
Shaft conveyors are often the bottleneck in the system as sufficient time cannot be made available to upgrade and rectify previous design criteria. A further problem is that shaft space is limited prohibiting an upgrade to a wider higher capacity conveyor. There are also major restrictions on the capacities of the trestles and gantries taking the coal from the pit head to the silo or the stockpile. The cost of sinking a new shaft in an existing older mine is thus not viable unless the life of mine can be extended by a considerable period of time.

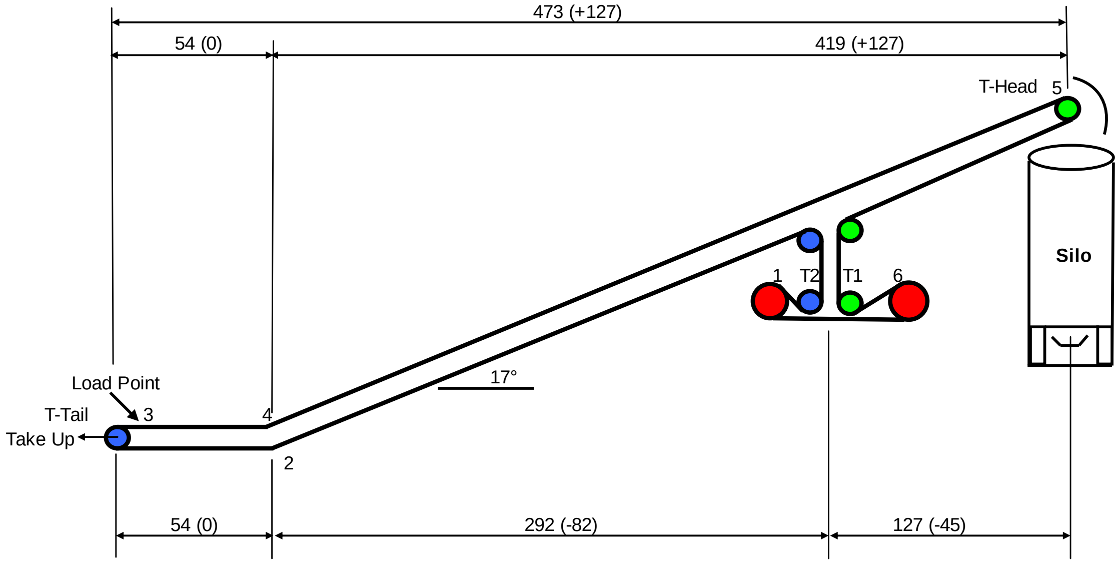
This paper will identify all the problems encountered in the current design and discuss the methods and reasons employed for the new design, in order to increase the conveying capacity of the shaft from 2250 t/h to 3500 t/h, an increase of 56%, in order to meet the mine's new requirements. This upgrade took place over a period of approximately 12 months and included considerable changes to the loading of the conveyor from the underground bunker where new feeders were installed to feed material onto a variable speed sacrificial conveyor before loading the ROM coal onto the 1800kW tripper driven shaft conveyor with a conveying speed of 5.5 m/sec @ 17 degrees.

In order to meet these new drastic conveyor capacity requirements, whilst using the existing infrastructure as far as tensions on the head pulley, loading of the trestles and gantries etc., tripper driven technology was the only alternative. These conveyor modifications were done using fluid couplings on a steelcord belt.

BACKGROUND

The, Exxaro Coal, Matla 2 Mine shaft conveyor upgrade was commissioned in order to accept an increased production capacity from 2 seam longwall and the production from the chain road development. This required a total re-think and included many modifications to the existing conveyor. These modifications to the shaft withdrawal system also included modifications to the bunker by replacing the coal feeders with higher capacity feeders that could be controlled with a VFD to allow for accurate loading of the shaft conveyor. This further necessitated the inclusion of a sacrificial conveyor in order to load the shaft conveyor accurately, whilst also accelerating the ROM coal and fitting a suitable magnet to remove any tramp iron, prior to loading the material onto the high speed shaft conveyor which was fitted with a high strength steelcord belt.





ORIGINAL SHAFT CONVEYOR PROFILE

POINTS FOR CONSIDERATION

The following points were considered, to give meaning and understanding to the issues at hand.

- The shaft was sunk and commissioned in the early 1980's and was designed for a 1350 mm wide conveyor at 17° fitted with a ST1600 belt.
- Access for maintenance on either side of the conveyor structure was one of the major limiting factors that prohibited increasing the belt width within the shaft.
- A further major limitation was that the existing gantries could not accommodate a wider belt.
- The topography from the shaft head to the underside of the silo drops off considerably, which necessitates large gantries and high trestles. (see photographs above and below)
- The supporting steelwork for the drive, HT snubs, LT snubs and head pulley is huge and could not be modified to accept wider pulleys for an increased belt width. Together with the replacement or modification of the gantries and trestles, the cost

due to the loss of production as a result of the extended duration for the upgrade would have compromised the benefit.

Figure 1: Shaft view with 1350 Structure

Figure 2: Top of Silo towards 2 Mine Pithead

OTHER ISSUES TO BE CONSIDERED

The following points needed to be considered

- The original induced design tensions in the gantries and the vertical loading on the trestles needed to be carefully considered. The tensions were thus re-calculated for the original 2250 t/h scenario and these tensions were adopted for the gantries and the appropriate vertical loadings were considered for the trestles.
- The troughing angle for the ROM structure in the shaft had to be increased from 35° to 45° and the idlers were increased from 127 mm diameter to 152 mm diameter.
- The transition radius in the shaft bottom area could not be changed, and thus the new conveyor needed to accommodate the vertical curve.
- A sacrificial conveyor utilising a lower solid woven belt class became a requirement in order to load the shaft conveyor accurately, whilst also accelerating the ROM coal to a suitable speed in order to achieve a smooth transition onto the shaft conveyor with a minimum of spillage.
- A suitable magnet needed to be placed at the head end of the sacrificial conveyor to remove any unwanted tramp iron prior to loading the material onto the higher speed shaft conveyor.
- The tensioning device for the shaft conveyor was to be at the tail end. This necessitated the sacrificial conveyor being placed above the tail area of the shaft conveyor.
- The feed rates of the two new bunker feeders needed to be controlled accurately in order to place the required tonnage onto the shaft belt. In order to achieve this, VFD drives were used on the feeders.
- The drive of the sacrificial conveyor needed to be controlled to accurately place the ROM coal at the correct position on the shaft conveyor allowing for a consistent trajectory to minimise any spillage. The sacrificial conveyor also speeded up the material so that an acceptable differential velocity could be achieved.
- The discharge at the head end feeding into the Silo was fitted with a spoon type deflector to discharge the coal into the centre of the Silo, such that damage is limited to the inner walls of the concrete silo.
- The power to accelerate and run the conveyor needed to be increased drastically to accommodate the 56% increase in capacity.
- From a project duration and cost point of view, the use of the existing equipment had to be maximised.

Capacity Calculation to ISO 5048

	Input Data:	UoM	Original # 35°	Final # 45°	Sac
1	Belt Width	mm	1350	1350	1800
2	Belt Speed	m/sec.	3.6	5.5	3.2
3	Trough Angle	Deg.	35	45	20
4	Surcharge Angle	Deg.	20	20	20
5	Design Tonnage	TPH	2250	3500	3500
6	Bulk Density	kg/m^3	900	900	900
7	Center Idler Face Width	mm	500	500	660
8	Belt Incline	Deg.	17	17	0
9	Length of Conveyor	m	490	460	30.5

Volumetric Capacity to ISO 5048

1	Maximum Loaded Width to ISO 5048	mm	1165	1165	1570
2	Maximum Capacity of Belt @ 100% Loading	TPH	2119	3608	3199
3	Belt Percentage Loading	%	106.19	97.01	109.43
4	Load Mass @ 100% Loading	Tonnes	80	84	8
5	Load Mass @ Design Tonnage	Tonnes	85	81	9
6	Load Mass / Linear Meter @ Design Tonnage	kg	174	177	304
7	Cycle Time - (Load to Discharge)	Minutes	2.3	1.4	0.2

100% Flooded Capacity - (Volumetric)

1	Flooded Load Width = Belt Width	mm	1350	1350	1800
2	Maximum Capacity of Belt = Flooded	TPH	2412	4034	3814
3	Belt Percentage Loading	%	93.28	86.76	91.76
4	Load Mass @ Flooded Tonnage	Tonnes	91	94	10
5	Load Mass @ Design Tonnage	Tonnes	85	81	9
6	Load Mass / Linear Meter @ Design Tonnage	kg	174	177	304
7	Cycle Time - (Load to Discharge)	Minutes	2.3	1.4	0.2

RESULTS OF THE CONSIDERATIONS TO REACH THE CAPACITY COST AND SHUT DOWN DURATION REQUIREMENTS

In order not to exceed the above restraints, the following design was put forward, accepted and executed.

A – SACRIFICIAL CONVEYOR

- A 1800 wide sacrificial conveyor with a VFD was installed under the two plate feeders attached to the underside of the 4 seam to 2 seam bunker. This conveyor is fitted with a tail take up trolley that is tensioned by means of two grease-jacks.
- The plate feeders are also VFD controlled.
- The belting used is solid woven Class 1000. The length of the sacrificial conveyor is 30.5 meters long and normally runs at 3.2 m/sec.
- A cross magnet is fitted above the stainless steel head pulley to remove unwanted tramp iron.
- A 5 metre impact station with skirt boards is fitted to stabilise the coal once loaded onto the shaft conveyor.

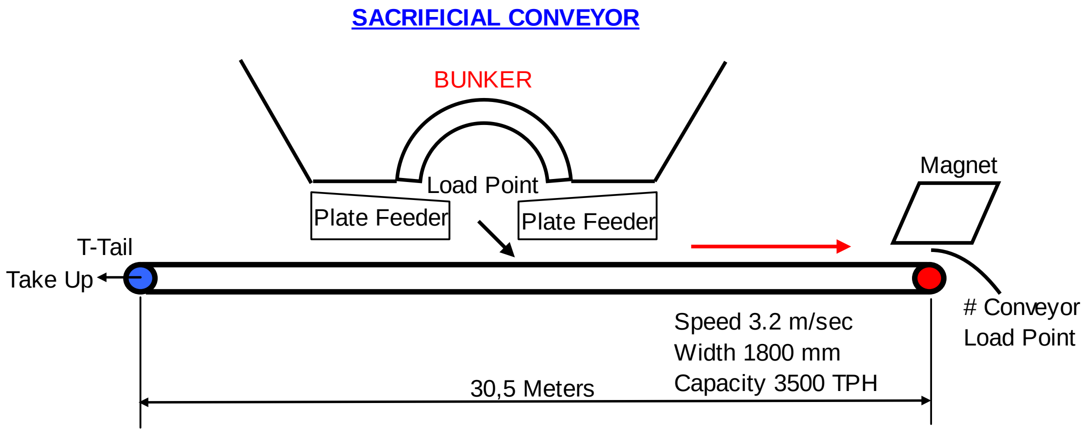
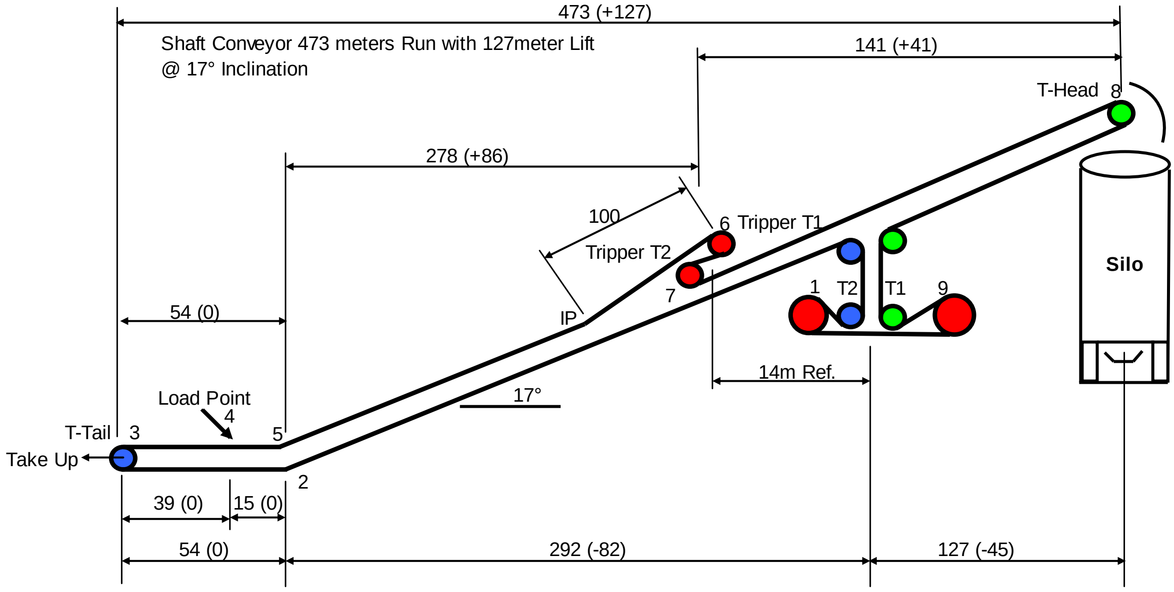


Figure 3: Sacrificial Conveyor

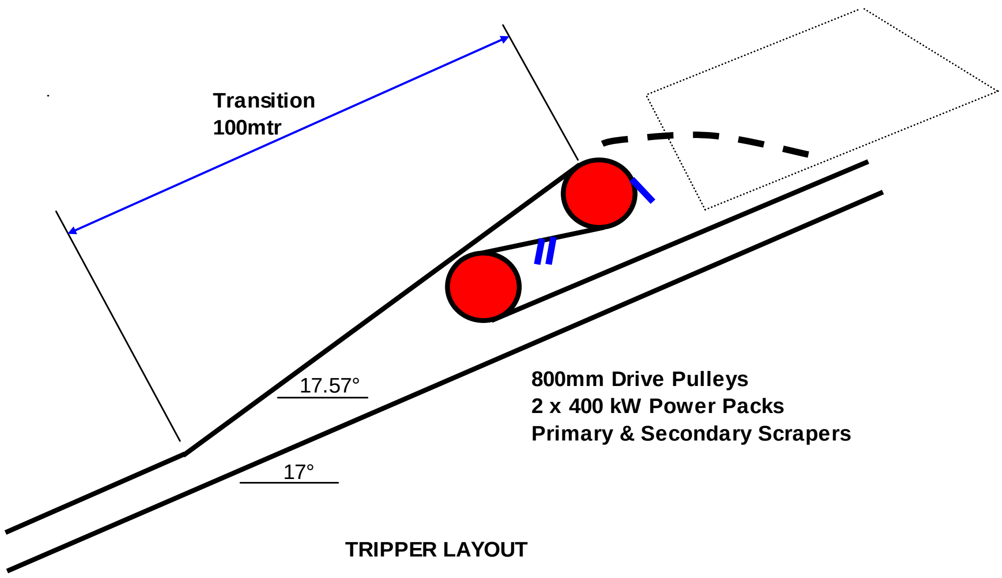
B – SHAFT CONVEYOR

- In order not to exceed the original tensions in the gantries and minimise the increase in loadings on the trestles, the additional power required needed to be applied at a different location within the conveyor. The obvious and acceptable position was to apply the additional power by means of a tripper drive situated at the shaft head driving the carry strand of the belt. The tripper would effectively haul the coal from the feed point to the pit head reducing the tension sufficiently and the existing outbye drive would haul the coal along the gantry to the top of the Silo. The tripper drive comprised 2 off 400 kW power packs with pulleys sized to give a belt speed of 5.5 m/sec.
- The original head drive was driven by 4 off 250kW drives fitted with TSS fluid couplings. The pulleys which were originally sized to give a belt speed of 3.6 m/sec. were replaced with pulleys to take the belt speed up to 5.5 m/sec.
- A new electrical panel was supplied for 6 motors, (2 x 400 kW & 4 x 250 kW = 1800 kW), which is a PLC controlled drive panel. The starting delay times and sequence could easily be selected to offer a smooth acceptable start, all controlled through the PLC.
- The new belting chosen was a ST 2000 in 1350 mm belt width.
- With the shaft inclination being 17° and the requirement to maintain the same beltline, the transition to raise the belting leading up to the tripper pulley needed to be carefully considered. For this reason the intersection point where the belting commences the increase in angle is 100 meters from the first tripper drive pulley. The result is that the conveying angle only increases from 17° to 17,57°
- A new deflection chute was placed at the head pulley to redirect the coal stream vertically into the centre of the silo to accommodate the revised rather flat trajectory.
- The idlers and bases were replaced with 1350 wide 5 roll 152 diameter sets.
- The tensioning was done at the tail end by means of an existing gravity take up unit. It must be noted that the shaft conveyor is positioned under the sacrificial conveyor.

Note: The use of fixed fill delay fluid couplings cannot be used on long centre distance conveyors when using belts with a low modulus of elasticity. In this case where the conveyor length is generally short, with a high lift, and using high strength high modulus belting, fluid couplings were a viable option. Fluid couplings are, in certain cases, acceptable for “Mass Gravity Height” conveyors when using steelcord belting.



FINAL SHAFT CONVEYOR PROFILE



TRIPPER LAYOUT

Figure 5: Tipper layout

Figure 6: Tripper view from bottom

CONCLUSIONS

The following points with the relative resulting conclusions were achieved after the upgrade of the Matla 2 Mine Shaft Conveyor.

- The capacity of the conveyor was increased by 56% from 2250 t/h to 3500 t/h with minimal structural change.
- The only negative result is that the vertical loading in the trestle section has increased by 15% when compared to the original design. This is mainly attributable to the increase in the belt mass as a result of using the higher class heavier belting, having an additional mass of 17 kg/linear meter.
- The loading at the feeders onto the 1800 belt allows for a spillage-free zone which takes the material speed up to 3.2m/sec. From here the material is loaded onto the shaft conveyor with a differential velocity of 2.3m/sec, also providing a reasonably spillage-free transfer.
- The conveyor has now been operational for 1 ½ years and the overall performance has been found to be satisfactory.

SUMMARY

	U of M	Before	After	Diff. Value	% Change
ROM Coal Capacity	TPH	2250	3500	1,250.0	56
Belt Type	Steelcord	ST1800S	ST2000		
Belt Operational Tension Limit	kN	364	405	40.5	11
Belt Induced Tension (Running)	kN	314	240	-74.0	-24
Belt Running Factor of Safety	FoS	1.16	1.69	0.5	45
Belt Speed	m/sec	3.6	5.5	1.9	53
Belt Width	mm	1350	1350		
Power to Run Fully Loaded	kW	896	1415	519.0	58
Installed Power	kW	1000	1800	800.0	80
Reserve Power	kW	104	385	281.0	270
Vertical Loading on Trestles	kg/lin m	254	291	37.0	15
Compressive Load in Gantry Section	kN	627	453	-174.0	-28

ACKNOWLEDGEMENTS

- Nepean Conveyors (Pty) Ltd – Main Contractor
- Exxaro Coal, Matla Colliery – Client
- Mr Pieter Boshoff – Manager Matla Mine 2
- Mr Chris Silver – Operations Manager – Mine 2 & 3

AUTHOR'S CURRICULUM VITAE

ALAN EXTON

The author of this paper has been involved in the mining industry since 1969 when he commenced his training West Rand Consolidated Mines Ltd as an apprenticed Fitter & Turner. During his apprenticeship he obtained a National Technical Diploma in Mechanical Design. After 7 years employment in the mines, he joined the private sector in the Mining Division of Dowson & Dobson (Pty) Ltd. as a Design Engineer. He was involved in the design field of both coal & hard rock mining equipment for various companies until 1990.

In July 1995 Nepean Conveyors (Pty) Ltd. was formed in South Africa and the author was appointed as the founding Managing Director, which position he held until 30 June 2008.

Subsequently the author retired in 2008 and is currently the Managing Director of Accrete Consulting (Pty) Ltd., consulting on conveyors to the Bulk Material Handling industry.

Relevant Affiliations:

- Director of Companies
- Member of the South African Institution of Mechanical Engineers.
- Professional Member of South African Institute of Materials Handling.
- Past Chairman of the Conveyor Manufacturers Association of South Africa Ltd.
- Director of the CMA
- Past Member of Beltcon 8, 9, 10, 11, 12, 13 & 14 Committees.
- Member of IMHC, Beltcon 15 Committee.