IMPUMELELO MINE PROJECT – 26.8 km OVERLAND CONVEYOR SYSTEM

Jan Botes

Hatch Goba (Pty) Ltd

1. INTRODUCTION

Knowledge of the design and technology to construct long overland conveyors has been demonstrated through the years and a number of long overland conveyors are in operation today. This knowledge and technology, together with the proven track records of long overland conveyors suggest that there is no reason to limit the length of an overland conveyor. Overland conveyors in operation have established that conveyors can follow topography closely, within limits, with numerous horizontal curves, vertical curves and compound vertical and horizontal curves[1].

Among the benefits of longer overland conveyors are reduced belt wear, longer cycle times, less initial capital cost, reduced fines generation and lower operating cost. Long overland conveyors with intermediate drives have the additional advantages of a lower belt class, shorter horizontal curve radii and smaller drive units. The disadvantage of a conveyor with an intermediate drive is the increase in the number of maintenance areas, the extra electrical and instrumentation work required and a higher initial capital cost when compared to an equivalent single flight installation[2,3].

Throughout the world, distances that material has to be conveyed are becoming longer and longer. Once the decision has been made to convey the material via a conveyor system, the next question to be answered is the length of the conveyor flights.

The final decision is influenced not only by knowledge of the design and technology available to construct the overland conveyor system, but also by the governing legislation, supporting infrastructure, operational requirements, industry technology available, material to be conveyed and safety procedures required to run the overland conveyor for the life of operations.

The objective of this paper is to highlight the considerations taken into account during the design and construction of the Impumelelo overland conveyor to ensure a safe system, with ease of maintenance and low operational cost.

2. BACKGROUND

The Impumelelo overland conveyor forms part of the coal supply network to the Sasol Synfuel Operations. The conveyor has its origins an approximate distance of 26.5 km west of the current Sasol Synfuel's complex in Secunda, South Africa.

The Impumelelo overland conveyor (OLC) is 26 816 m in length with an elevation difference of -49.8 m. The 1 200 mm belt has an operating capacity of 2 000 tph at a belt speed of 6,54 m/s. The selected belt class is an ST2000 belt with total installed power of 4 900 kW.

The overland conveyor is loaded from a 15 000 tonne bunker via a reclaim conveyor with coal with a nominal size of 160 mm. The overland conveyor discharges either on a 4 000 tonne moving head conveyor or a reclaim conveyor.

The start-up time of the OLC is 600 seconds with a stopping time between 53 seconds and 75 seconds, depending on the belt load conditions and the type of stop initiated. This includes emergency stops and initiated stop sequences.

Figure 1 below shows the undulating conveyor formation profile with the intermediate drives at around 18 km from the tail end. The maximum elevation difference of the OLC formation work is 112 m, with the intermediate drives at a formation lift of -80 m and the end of formation elevation at -66 m, just before the head end transfer tower.

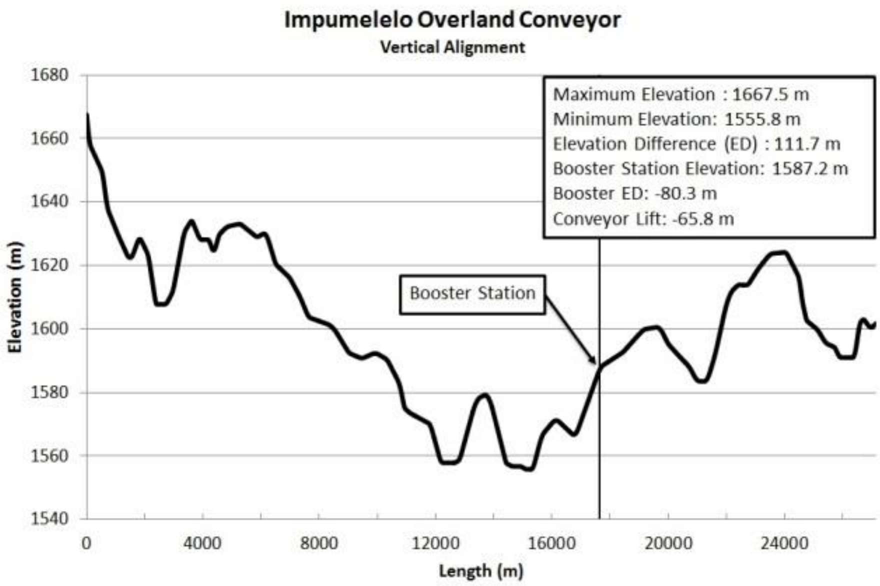


Figure 1. Vertical alignment

Figure 2 below shows the horizontal alignment of the conveyor with four horizontal curves of 10 200 m, 6 000 m and two 4 600 m curves. The conveyor crosses various roads and two major rivers.

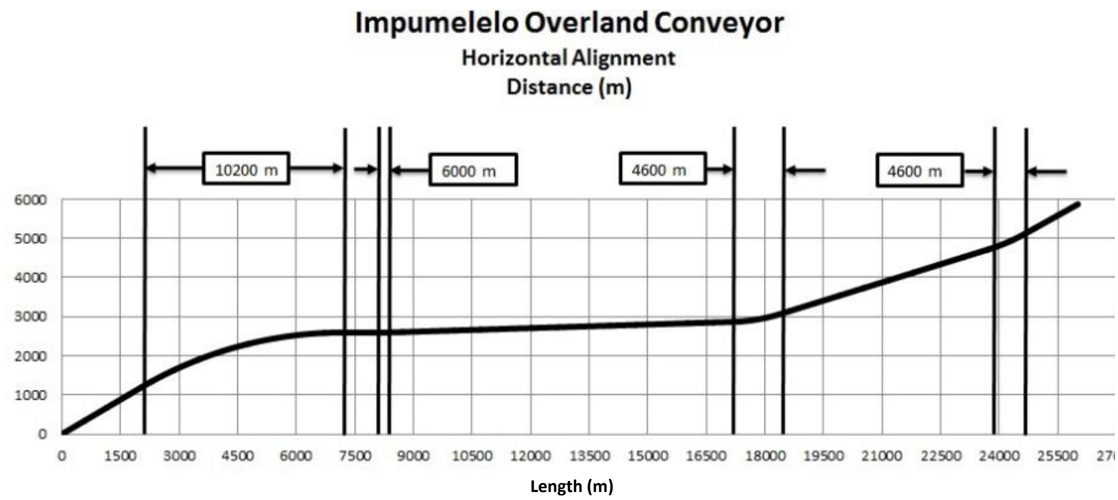
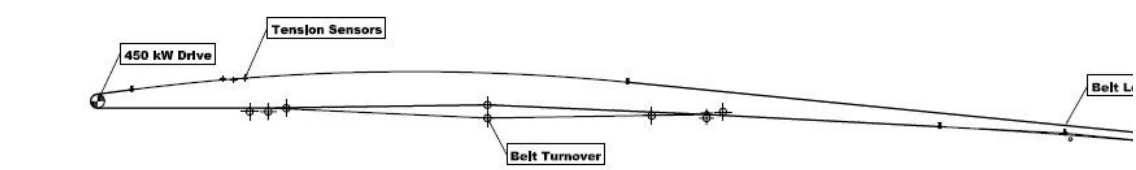


Figure 2. Horizontal alignment

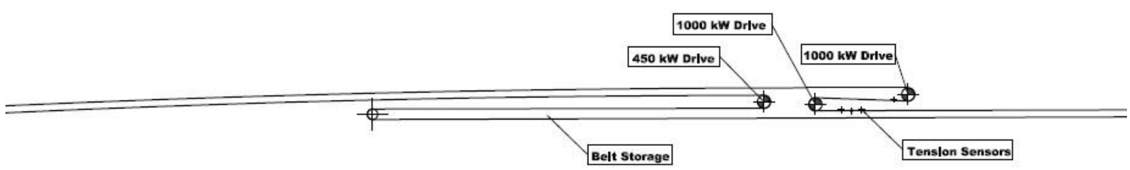
The drive configurations of the OLC are as follows:

- Two 1 000 kW drives on the carry side at the intermediate drive
- Two 1 000 kW drives at the head end
- One 450 kW drive on the return side at the intermediate drive
- One 450 kW drive at the tail end.

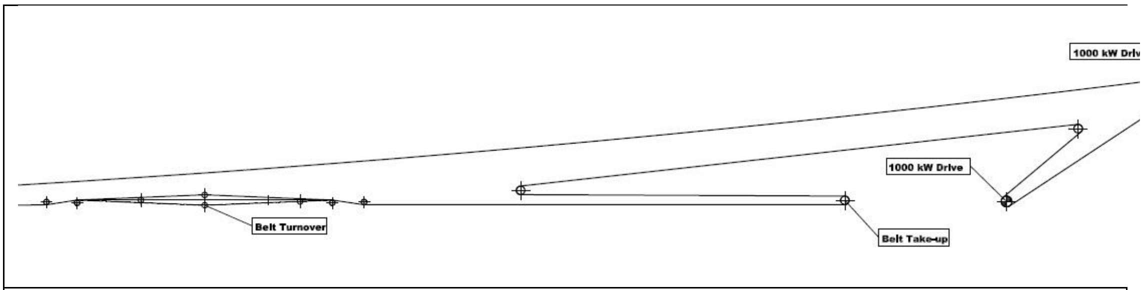
Figure 3 below shows the drive configurations at the tail end, intermediate station and the head end.



Tail Drive Arrangement



Intermediate Drive Arrangement



Head Drive Arrangement

Figure 3. Drive configurations

The OLC has a dynamic take-up at the head end and belt storage or static take-up at the intermediate drive. The static take-up is used for permanent stretch in the conveyor belt as well as required splice allowance.

The idler configuration can be seen in Figure 4 below. The carry side belt has a three-roll idler configuration varying between 35–45 degree-through angle. The idler roll diameter of the carry side is 178 mm with a high density polyethylene (HDPE) sleeve. The idler frame spacing is alternated between 4 m and 5 m, eliminating belt flap, with an effective idler spacing of 4,5 m.

The return side idlers have a three-roll idler configuration with a 30 degree through-angle, a 152 mm diameter roll and an HDPE sleeve. The return side idler frame spacing is 8,25 m and 9,75 m respectively.

Figure 4. Overland idler configuration

Figure 5 shows a small portion of the overland stringer section and underlines the care that was taken to align the conveyor during the installation.

Figure 5. Overland conveyor stringers and 4 600 m curve

3. DESIGN CONSIDERATIONS AROUND SAFETY

According to the CMA Guideline[4], safety around the conveyor can be divided into three areas:

- Safety around belt conveyors
- Conveyor system protection devices
- Basics of conveyor guard design.

Each of the above topics has been divided into sub-topics in the CMA Guideline. It is not the purpose of this paper to discuss each of these topics; however this paper will focus on specific topics related to the Impumelelo overland conveyor that required specific attention.

3.1 Stored Energy

Stored energy must be released before any work commences on a conveyor. The stored energy within a conveyor is released by lowering the counterweight. However, with a conveyor of this length and a maximum elevation difference of 112 m, it was concluded that lowering the counterweight would not be enough to release the stored energy. Potential energy remains within the belt due to the belt self-mass and the difference in elevation of 112 m. The break-away torque of the idlers could reduce this potential stored energy, but can result in an uncontrolled movement. It was determined that a normal belt clamp would not be enough to isolate any possible movement. To be able to safely carry out maintenance on the pulleys, a larger clamp system was designed to clamp the belt and to assist with slack pulling at specific pulleys. Three sets of permanent hydraulic operated belt clamps were installed at the three drive areas, one clamp on the carry side and one on the return side.

Additionally, it was recognised that lowering the counterweight would not allow for safe slack pulling at the tail drive and the carry side of the conveyor at the intermediate drive, due to the inherent tension in the belt caused by the elevation differences. A third hydraulic assisted movable clamp was installed at the tail drive and the intermediate drive to pull the slack in the belt. This additional clamp works in conjunction with the other two clamps. These clamps were designed to be able to pull the full load of the belt without damaging the carcass of the belt.

3.2 Lock Out System

Regulation 8.9.2(b) of the Mine Health and Safety Act of 1996 stipulates

> *. . .the power supply and all sources of stored energy of a stationary conveyor belt installation are isolated, made safe and locked-out during either repairs, maintenance or cleaning of spillage in the designated sections*.

This remains a challenge on all long overland conveyors. The current standard operating procedure adheres to the Act and the conveyor is locked out at all three substations before any maintenance commences. This is a total travelling distance of more than 58 km per maintenance event.

3.3 Belt Alignment

As part of the design and construction, the alignment of the conveyor was identified as one of the critical issues. Not only for the tracking of the belt, but also for power consumption and extended idler life. The design of the OLC was done to a very high accuracy level with precision surveying and laser alignment for the alignment of the conveyor modules.

Over and above the normal belt alignment switches, belt side guide rolls are installed on all the horizontal curves as a precautionary measure. Under normal belt drift conditions, running empty/full and during start-up, the side rolls would not be required. The side guide rolls would only be required during belt pull in and any condition where the tension in the belt was higher or lower than the designed tensions. The design of the conveyor stringer sections allows for the belt to drift without running into the side of the structure.

3.4 Holdbacks /Park Brakes

During the dynamic simulations it was identified that the OLC could have run back after stopping at the head end and the intermediate drives under certain conditions. The initial idea was to install holdbacks. However the disadvantage was that the holdbacks would have to be released or disconnected to allow the belt to be pulled backwards during pulley maintenance. This would contribute to excessive maintenance downtime, as well as being an inherent safety risk when the stored energy in the belt was released with the holdback engaged.

The chosen solution was to install small, high speed park brakes that would be applied just before the belt came to a complete standstill. The brakes would be applied until the dynamic oscillation in the belt had stopped. The park brakes would be automatically released after a predetermined period of time. The advantage of this solution is that the belt could be pulled backwards when required during maintenance without additional risk of releasing the stored energy in the belt caused by the holdbacks.

3.5 Blocked Chute/Bin Levels

One of the requirements of the OLC is either to load onto a tripper conveyor, feeding a 4 000 tonne bunker or the reclaim conveyor underneath the 4 000 tonne bunker allowing the bunker to be bypassed. Both these conveyors have a short stopping time versus the possible 75 seconds stopping time of the OLC, with the disadvantage that a large overflow bin of 28 m^3 (24 tonne) is required at the head end of the OLC.

A flopper chute is used to redirect the coal onto the tripper conveyor or the reclaim conveyor. The risk identified with the flopper chute not working, the possible build-up of coal into the head pulley and the possible consolidation of coal in the feed chute resulted in the design allowing for an overflow bin in both of the feed chute legs.

3.6 Pull Cord System

A pull cord with the associated controls and instrumentation have been installed on both sides of the conveyor along the full length of the OLC. The biggest challenge faced with this type of installation is the theft of the instrumentation cables and pull cord, and is more likely with these long overland conveyors where the greater part of the conveyor is located in remote areas. As an attempt to reduce the risk of theft, the instrumentation cables are buried alongside the conveyor.

Another challenge with this system is the voltage drop in the instrumentation signal over the long length of the conveyor. Suppliers have to rethink their strategy in installing their equipment on any of these long overland conveyors, especially with limited power sources available along the conveyor route.

3.7 Rip Detectors

The specifications called for rip detection on the OLC by means of a belt scanning system with loops installed in the belt. The belt loops were installed at 60 m intervals instead of the required 50 m intervals due to limitation on the number of loops that could be memorised by the scanning system.

At the designed belt speed, the OLC cycle time is 2 hours and 16 minutes, requiring extensive time to 'learn' the belt loop profile for monitoring. The mean time to repair any belt failure, requiring a belt insert, would require this additional time to re-learn the belt loop profile.

Two large magnets are installed on the OLC feed conveyor to minimise the risk associated with tramp metal damaging the OLC.

3.8 Belt Break/Failure

Catastrophic belt failures can happen at any point along the conveyor length, although more likely closer to the drives due to the higher tension in the belt. An extensive review process was followed in collaboration with the end user to identify the risks associated with belt failures and to evaluate current best practices in the repair of belt failures.

The overland conveyor belt was procured in 1 000 m rolls to reduce the number of splices, ensuring the minimum number of ‘weak’ points in the 58 km-long belt. Research and testing at Hannover University in Germany determined that a belt splice retains only 36% of the belt breaking strength after 10 000 cycles, which indicates that the belt splice is the ‘weak’ point in the belt[3].

Pre-formed splices are used to eliminate any possible issues with manually prepared splices. A destructive test was conducted on a pre-formed splice to verify the compliance of these splices.

As part of the maintainability of the conveyor belt, belt crossovers are installed approximately every 500 m along the length of the conveyor. In the event of a catastrophic belt failure the belt has to be repaired in the field as a temporary mechanical splice would not be able to take the tension of the fully loaded belt. With a stopping time of 75 seconds, the two ends of the failed conveyor would be approximately 200 m apart. This requires special pulling frames to allow the maintenance staff to pull the two ends together.

Figure 6 below shows the 10 tonne pulling frames that are used to pull the ends together. Nine structural frames are provided that can be relocated to the required position in the field. The 52 civil bases are permanent structures allowing the structural frames to be bolted into place as required. These pulling frames are installed next to the belt crossovers to assist the maintenance staff with the repair of the belt.

The ends of the broken conveyor are pulled together with the use of front end loaders (FEL). The front end loader safe pulling load was determined to be a maximum of 10 tonnes. The final placement of these frames was dictated by this maximum pulling force.

The belt pulling procedure is a series of pulling the slack of the belt from the back and clamping the belt in position until all the slack lies between two pulling frames, where the belt is spliced.

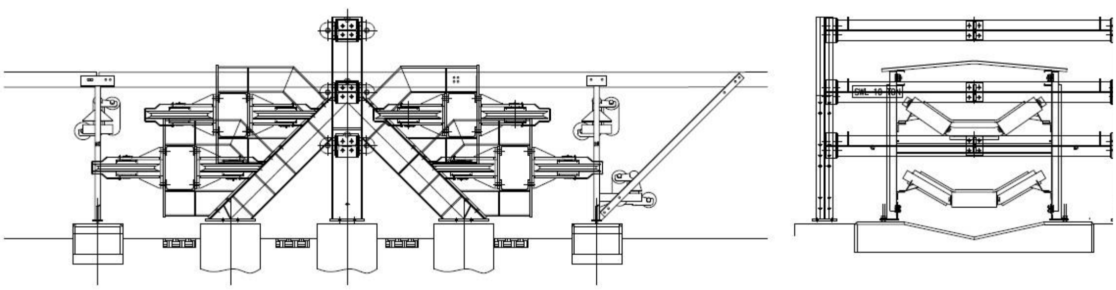


Figure 6. Ten tonne belt pulling frame

4. CONCLUSION

Technology and knowledge has advanced the design of longer and longer single flight overland conveyors. Various factors influence the final selection of the length of the conveyor flight by the designer. During the design of the Impumelelo overland conveyor it became clear that the evaluation weighting of certain aspects considered as part of the design shifted significantly compared to the evaluation weighting of shorter conveyors.

The Impumelelo overland conveyor is one of the longest conveyor belts in the world and the operation of this conveyor belt is similar to any other conveyor belt. The most significant difference is related to safe maintenance of this conveyor belt.

The lock out procedures need to be revisited since it takes some time to lock out the conveyor before any maintenance can commence.

The long stopping time requires special care to ensure no spillage during stopping or chute build up and eventually chute block up with associated risks in unblocking a chute.

The length of the conveyor belt and the topography play a major role in the general maintenance of the conveyor belt. Special belt clamps and pulling points are required to ensure general maintenance can be safely undertaken on the pulleys and during belt repairs.

The limitations of equipment suppliers should also be considered as part of the selection criteria.

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SASOL Mining (Pty) Ltd

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ABOUT THE AUTHOR

JAN BOTES

Jan Botes obtained his mechanical engineering degree in 1989 from the University of Pretoria, his GCC (Government Certificate of Competence – Mine and Works) in 1991, his Honour's degree in 1993 and his Master's degree in 2008.

He started his engineering career at Anglo American as an engineer in training at the New Vaal Colliery back in the 1990s. He then moved on to education, where he started as a lecturer and ultimately ended up as Head of Department of Mechanical Engineering at the Tshwane University of Technology.

At the end of 2008 he joined Goba, Consulting Engineers and Project Managers. Ever since he has conducted numerous feasibility studies, concept studies and designs and has worked on the execution of materials handling projects like Klipspruit Expansion Project, Thubelisha Shaft Project and Impumelelo Mine Project.

Jan Botes
Hatch Goba (Pty) Ltd
17 Harrowdene Park
Western Service Road
Woodmead
Johannesburg
South Africa
jbotes@hatch.co.za
Cell: +27 82 779 7046
Tel: +27 (11) 239 6441

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