KLIPSPRUIT CURVED OVERLAND CONVEYOR, FROM CONCEPT TO IMPLEMENTATION

E. le Roux[1], M. Otrebski[2]

[1] Zutari
[2] Dynamika MH Consultants

1. INTRODUCTION

The paper presents development, design and implementation of a horizontally curved overland conveyor of the Klipspruit Extension Project (KPSX). One of the crucial parts of the design was accommodation of a relatively tight horizontal curve imposed by the terrain, existing infrastructure and land ownership. The design was subject to an external audit and it would be of interest to compare the results and identify sources of differences of the outcomes. Finally, the paper looks at the practical aspects and lessons learned during installation and commissioning.

Zutari, previously known as Aurecon South Africa, was appointed for the detail design and implementation of the bulk material handling system, as well as the supporting infrastructure (that includes geotechnical engineering, bulk earthworks, civils, structural, electrical, control and instrumentation and water reticulation) for the mine development. Dynamika MH Consultants were appointed by Zutari for the detail design and dynamic analysis of the overland conveyor with the horizontal curve.

The purpose of the project was to provide a smooth export production profile throughout the transition period of the existing Klipspruit Colliery production ramp down.

2. OVERVIEW OF THE KPSX PROJECT

2.1 HISTORY OF THE PROJECT, INCLUDING VARIOUS PHASES OF THE DEVELOPMENT

The project went through all project lifecycles starting at concept/pre-feasibility phase feeding into a feasibility phase before it was approved for execution. The execution phase officially started in February 2018 and the project was completed in the second half of 2021.

2.2 DESCRIPTION OF THE SYSTEM

The purpose of the system is to convey coal from the new mine to the existing Klipspruit Colliery, where it is then transported to Phola plant for processing. The overland conveyor crosses the N12 national highway, a wetland and the provincial R545 road.

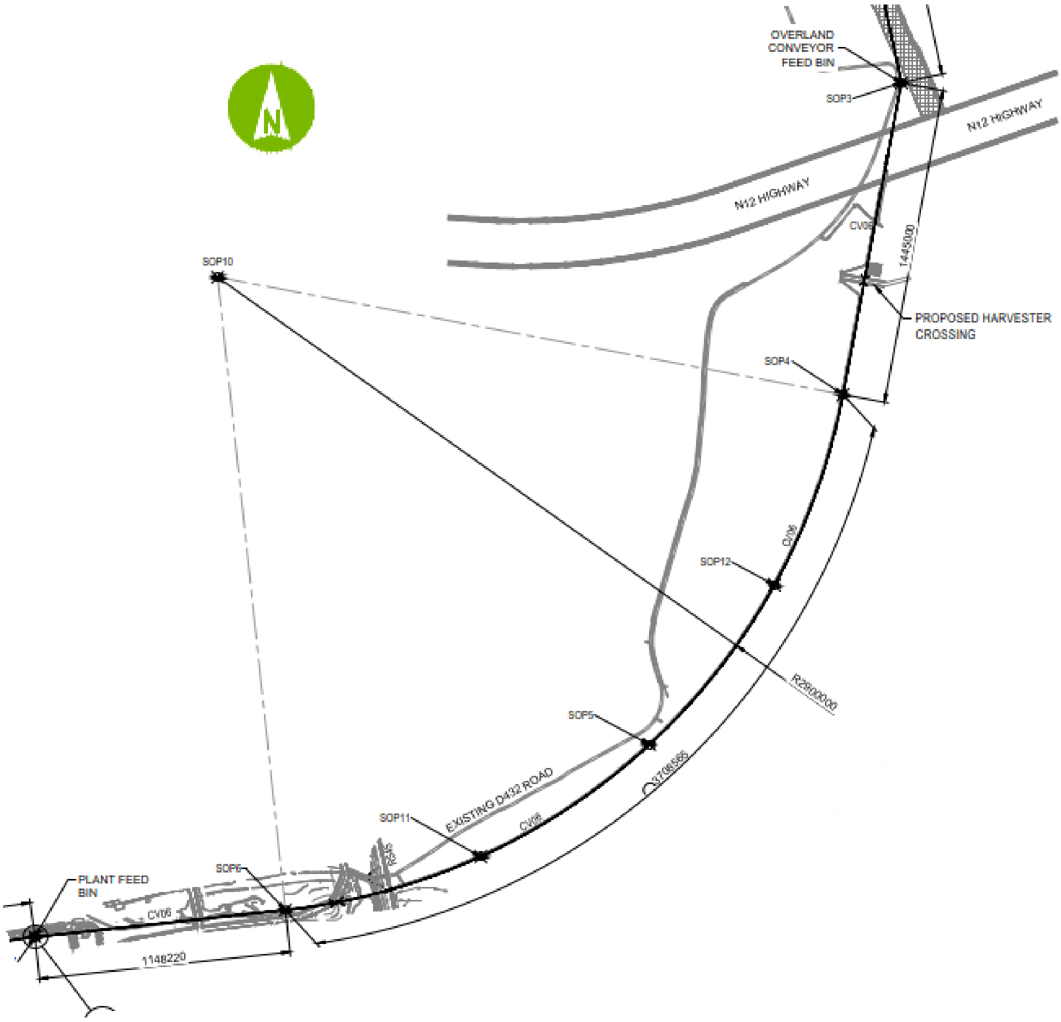


Figure 1. Plan view of Overland Conveyor

The bulk material handling system contains a Run Off Mine (ROM) tip, 5 conveyors (8.5km in total) of which one is the 6.3km horizontal curved overland conveyor as well as 2 x 500T coal storage bins.

2.3 INTRODUCTION TO THE OVERLAND CONVEYOR INCLUDING CHALLENGES AND RESTRICTION IMPOSED BY THE TERRITORY AND EXISTING INFRASTRUCTURE.

The challenges and restrictions imposed on the overland conveyor were the N12 national road crossing, a wetland, the R545 provincial road crossing, farmland and a haul road crossing inside the existing mine.

3. OVERLAND CONVEYOR DESIGN

3.1 BASIC PARAMETERS OF THE CONVEYOR AND OVERALL ARRANGEMENT – SOME DISCUSSION AROUND EVOLUTION OF THE CONCEPT.

Over the period of project development, the technical parameters of the conveyor were subject to several changes. Conveyor length was changed from 7,3km to 6,6km and finally set at 6,3km. Similar fluctuations were applied to the capacity which at some point was considered to be 2700t/h. Initially, the selected belt width was 1500 mm and the belt velocity was 6,6m/s. In addition, the owners team wanted to include as many as possible latest technology available in the design in order to achieve fail proof installation. All these aspects had to be re-checked and re-evaluated once the costs were attached to the final concept. After an in-depth re-evaluation the following basic parameters of the conveyor were approved:

- conveyor length [m] :6310
- conveyor lift [m] :23,26
- design output [t/h] :2200
- belt speed [m/s] :4,5
- belt width [mm] :1350
- idler spacing [m]
    - top :4,0 , 2,0 (horizontal curve)
    - return :8,0 , 4,0 (horizontal curve)
- roll dia. top / return [mm] :178 / 152
- take up type :horizontal gravity
- drive location :148 m from the head
- number of drive pulleys :2
- installed power [kW] :2 x 750
- horizontal curve radius :2900 m

The conveyor was designed to carry coal of the following parameters:

- Density :850 kg/m^3
- angle of surcharge :15 degrees
- particle size :91% not bigger than 200 mm.

A relatively distant position of the drive station was dictated by the fact that the last 450m of the conveyor is elevated in order to cross a road and finally discharge material into a 22m high bin.

The final conveyor profile is presented by Figure 2 below. As can be noted, the horizontal curve stretches over significant part of the conveyor length, 3811m of the total length of 6310m. Several concave and convex curves are present within the length of the horizontal curve.

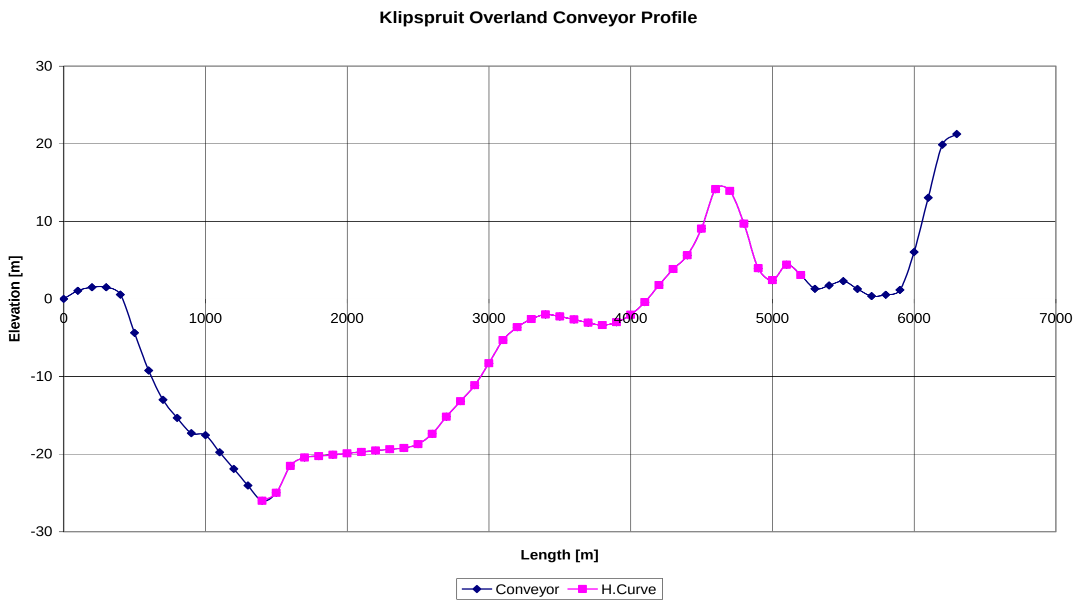


Figure 2. Profile

3.2 DYNAMIC SIMULATIONS AND IMPORTANT OBSERVATIONS

3.2.1 Dynamic Simulation

A complete design was done with the aid of a dynamic simulation package which includes two interdependent programs i.e. main simulation software and dynamic simulation of a horizontal curve. The main program was developed LATE 80's - early 90's and utilised during development of the Syferfontein project [1] while the horizontal curve simulation software, developed at a later stage, and was utilised for the first-time during Sigma project [2].

The program takes into account the following:

- belt properties;
- parameters of components such as idlers, pulleys, etc.;
- parameters of a drive system;
- parameters of a tensioning system;
- conveyor resistance as a function of its geometry, physical parameters, belt sag, climatic conditions and component properties;
- material properties and its flow;
- possible drive pulley slip;
- drive and tensioning systems control.
- random belt mistracking.

The horizontal curve simulation program presents time related belt movement as a result of belt tension changes and material flow.

3.2.2 Important Observations

1. As presented by Figure 3 during loaded stop and/or aborted start up the section of the conveyor stretching from the tail end towards the lowest point of the profile (both the top and return strands) suffers from low tensions and consequently increased belt sag. In fact, the return strand is more affected by this development with minimum tension being 7,9kN and max. sag 357mm. Very low tension would affect stability of the tail turnover.

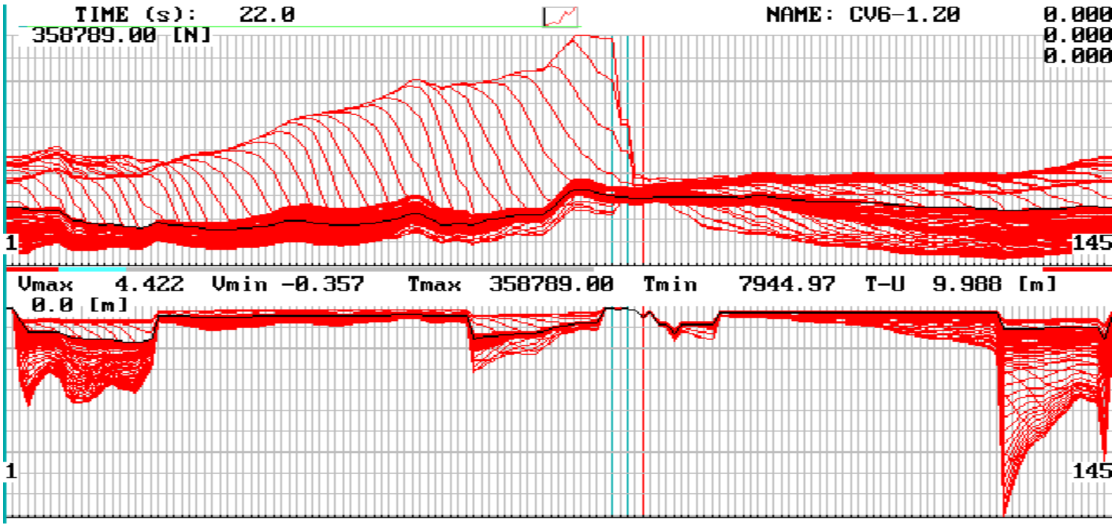


Figure 3. Loaded stop. Take up at the drive. Graphs of belt tension [N] (upper) and belt sag [m] (lower). Area of low tension and excessive sag at the return strand ahead of the curve.

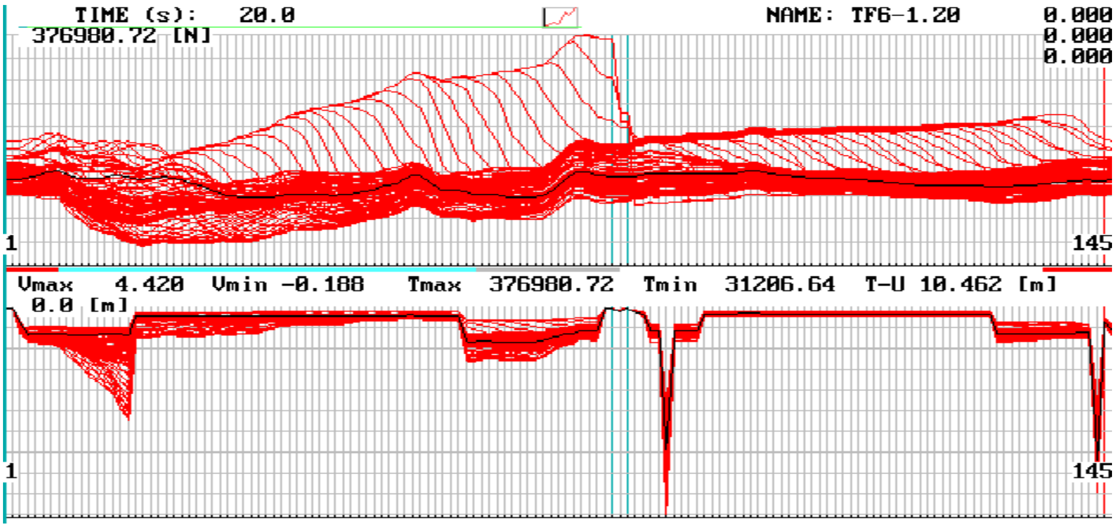


Figure 4. Loaded stop. Take up at the tail. Graphs of belt tension [N] (upper) and belt sag [m] (lower). Tension at the tail section stabilised.

2. After several attempts to improve the situation, it was decided to move the take up from the drive station to the tail end. As can be seen on Figure 4 this has stabilised the tail end section of the conveyor significantly increasing minimum tension values and reducing belt sag.

3. A wide range of power analysis indicated the suitability of 750kW drive units. This was later a subject of discussions as a result of a design audit.

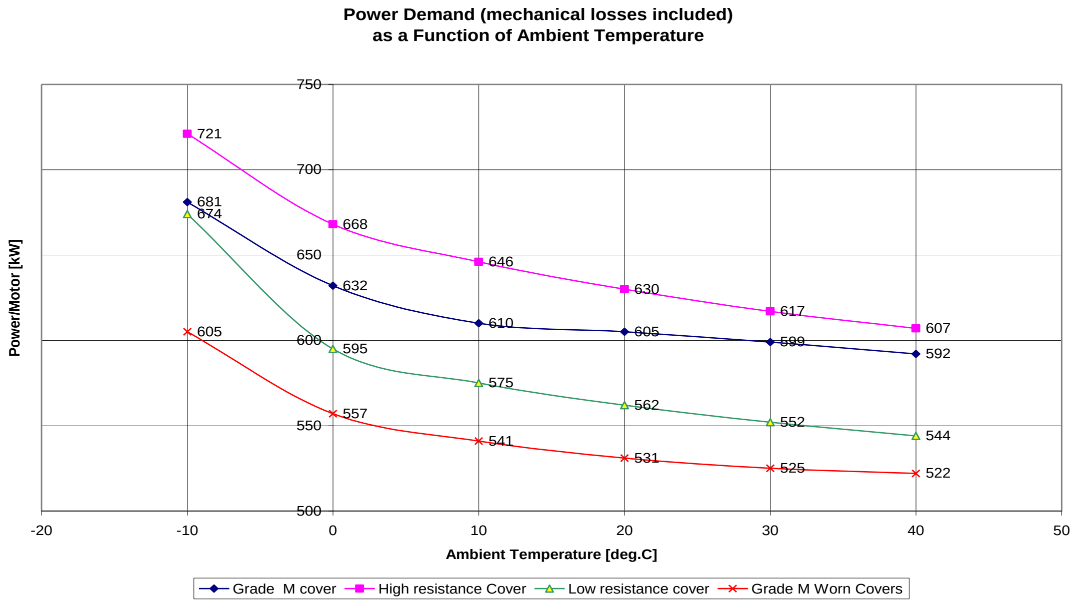


Figure 5. Power demand as a function of ambient temperature.

4. Proposed long start up lasting 210 seconds which included dwell period, provided semi-static conditions of acceleration. After an initial peak of 405kN the maximum tension changes between 375kN to 390kN, in comparison with 378kN recorded during steady run with full load. Based on the values achieved and in terms of client's specifications, belt class St2000 was selected. The resulting steady state belt safety factor is 7,1 :1. However, with a different approach to belt selection, for example recommended by DIN 22101:2011-12, a lower belt class could be selected.

5. Three scenarios were simulated for the aborted start up:

- motors de-energised at the end of the dwell period;
- motors de-energised at 50% belt speed;
- motors de-energised at +- 95% belt speed.

The first of the analysed cases produced the minimum belt tensions, and a % belt sag of significantly higher value than those during fully loaded stop.

The second scenario produced minimum tension 7% lower and belt sag 6% higher during fully loaded stop, however within acceptable limits.

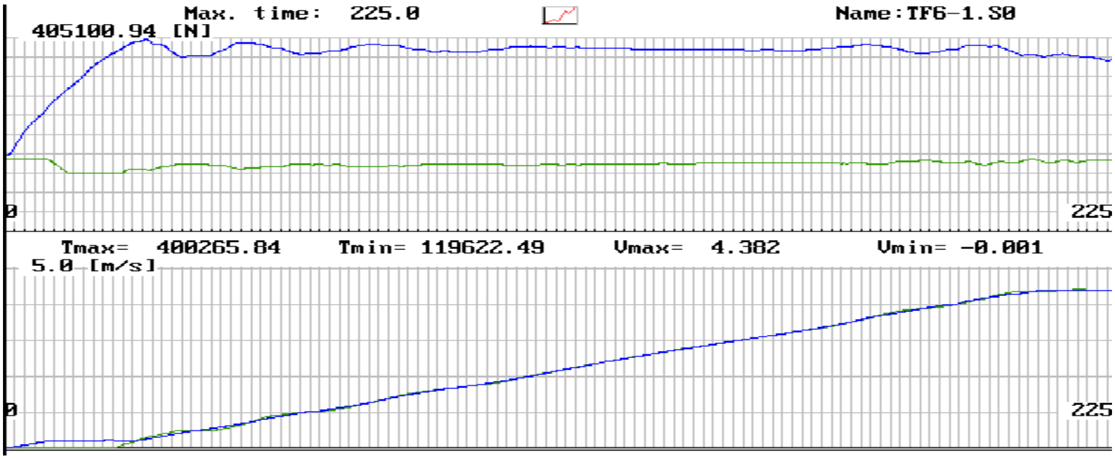


Figure 6. Loaded start. Take up at the tail. Graphs of belt tension [N] (upper) and belt velocity [m] (lower). Head end and tail end values.

6. Material flow simulations (loading and unloading sequence of the conveyor) were performed in order to assess the influence of material flow on power demand, belt tensions as well as belt movement within the horizontal curve.

7. Special cases evaluated included:

- 100 m of overloaded conveyor at the tail end followed by a stop;
- conveyor restart with the overload and blocked chute;
- steady run, stop, start and aborted start with the declines not loaded and material “frozen” in position;
- restart and aborted start with the declines not loaded but flow of material activated.

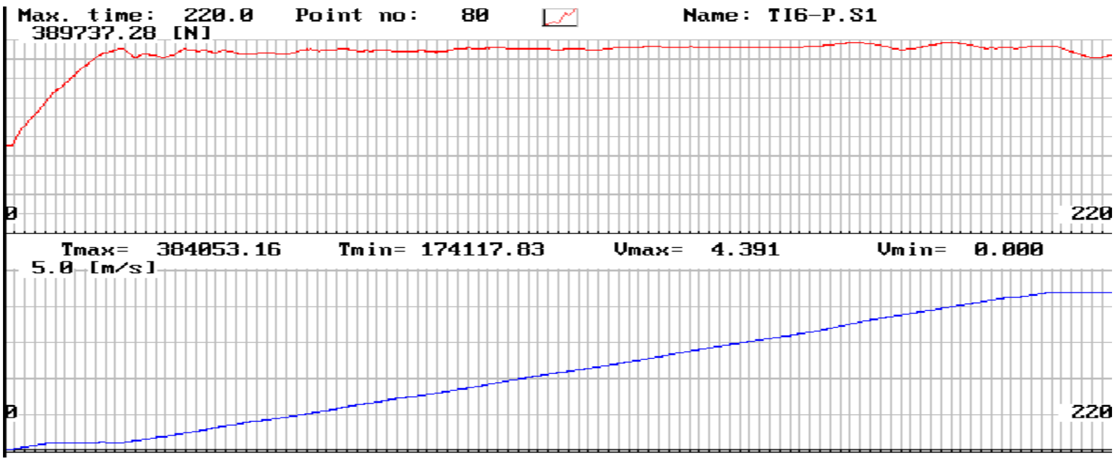


Figure 7. Inclines loaded start. Take up at the tail. No material flow. Graphs of belt tension [N] (upper) and belt velocity [m] (lower).

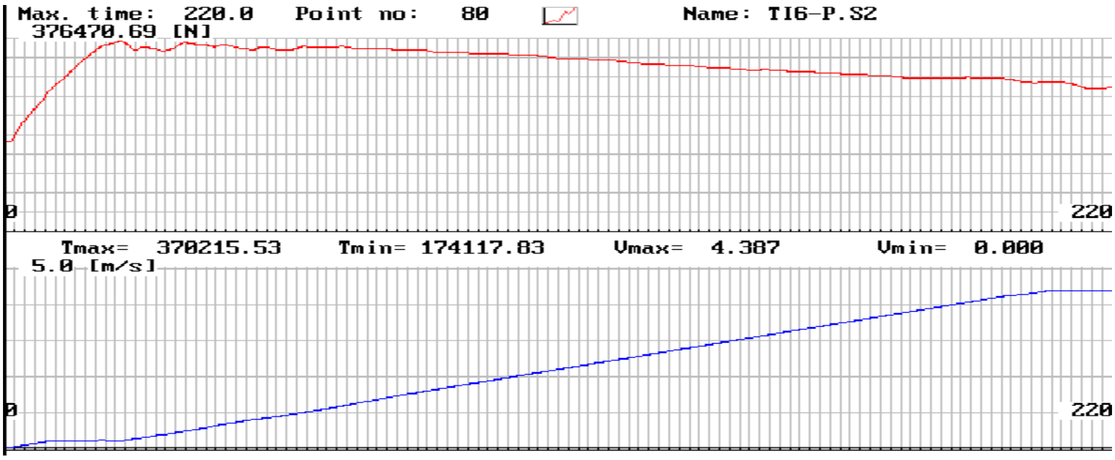


Figure 8. Inclines loaded start. Take up at the tail. Material flow. Graphs of belt tension [N] (upper) and belt velocity [m] (lower).

3.3 DEVELOPMENT OF THE CURVE DESIGN USING DYNAMIC SIMULATIONS

As indicated earlier simulations of belt movements within the horizontal curve were done by a program linked to the dynamic simulation software. The analysis combines the influence of time related parameters such as belt tensions, belt speed and material flow with physical parameters like radii of horizontal and vertical curves, and idler geometry.

There were several challenges to be faced. On the top strand an ideal setting of the idlers would allow belt tracking at or as close to the central position under full load. However, due to combination of horizontal curve radius with vertical curves and specific conveyor performance that was not possible to achieve over the full length of the horizontal curve – progressively moving towards the head end the setup had to allow inward belt position under full load. This was the consequence of significant outward belt movement during loaded stop or aborted start up. On the other hand, during loading sequence and partial load start up the belt tended to move beyond the inner idler edge by a significant margin. As a result it was decided to add additional short roll on every second idler as shown by Figure 9.

It was not possible to provide acceptable control of the return strand belt with the two roll V idlers. Consequently, a decision was made to use three roll 35 degree idlers. This arrangement improved control of belt movement significantly, however, short term movements beyond limits could still be noted.

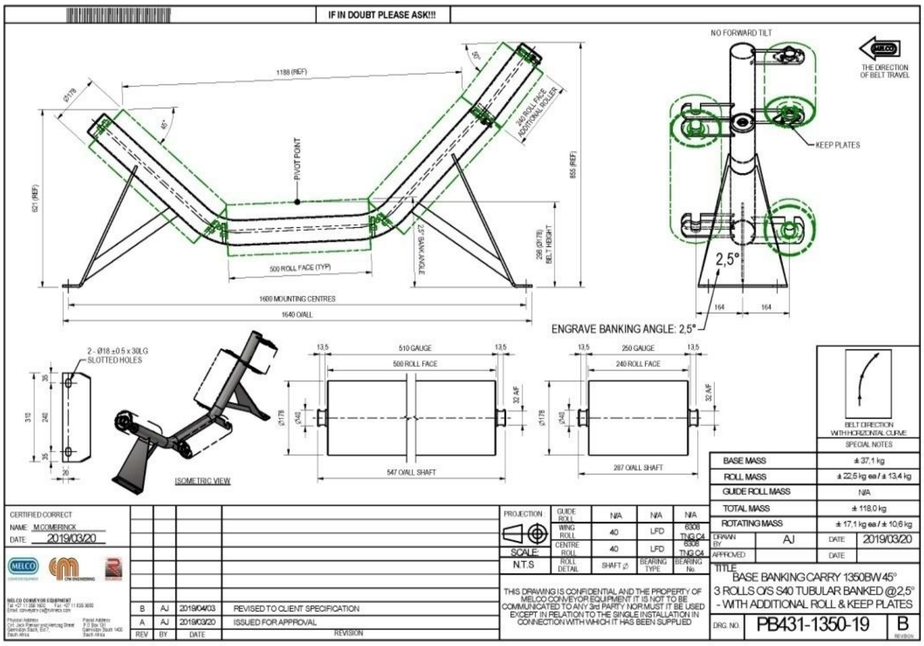


Figure 9. Idler frame

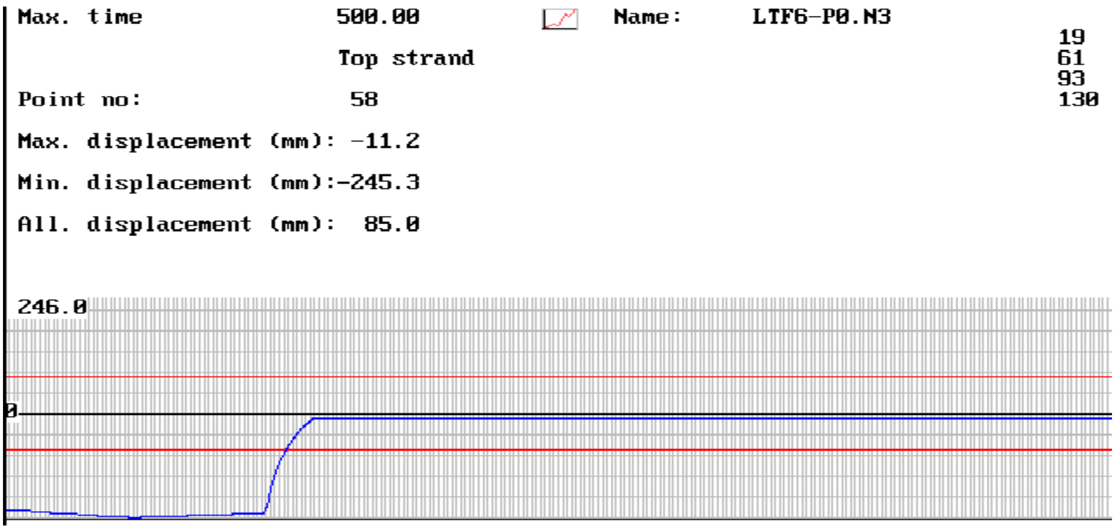


Figure 10. Horizontal curve. Top strand. Belt moves inwards as material approaches and moves back once under load.

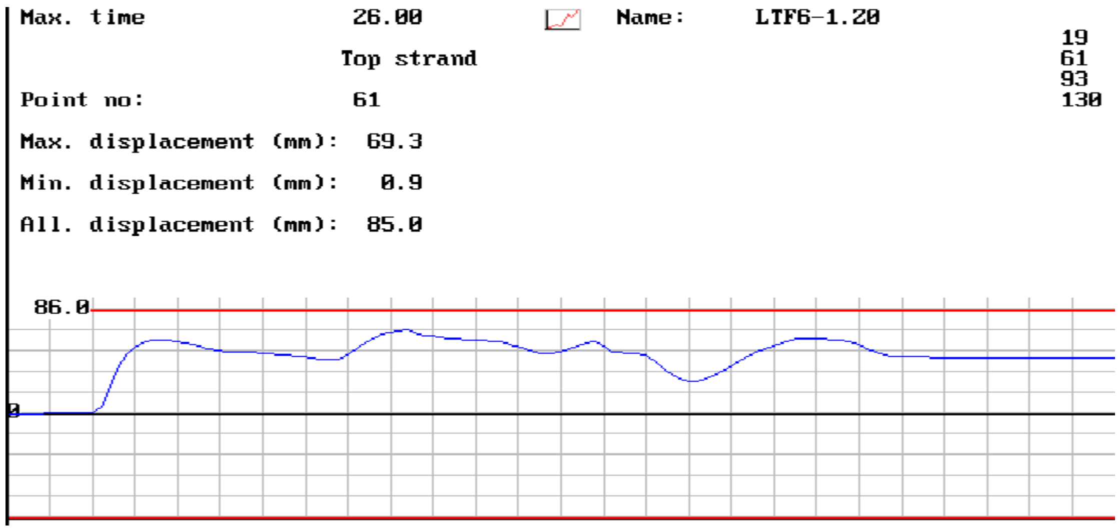


Figure 11. Horizontal curve. Top strand. Loaded stop.

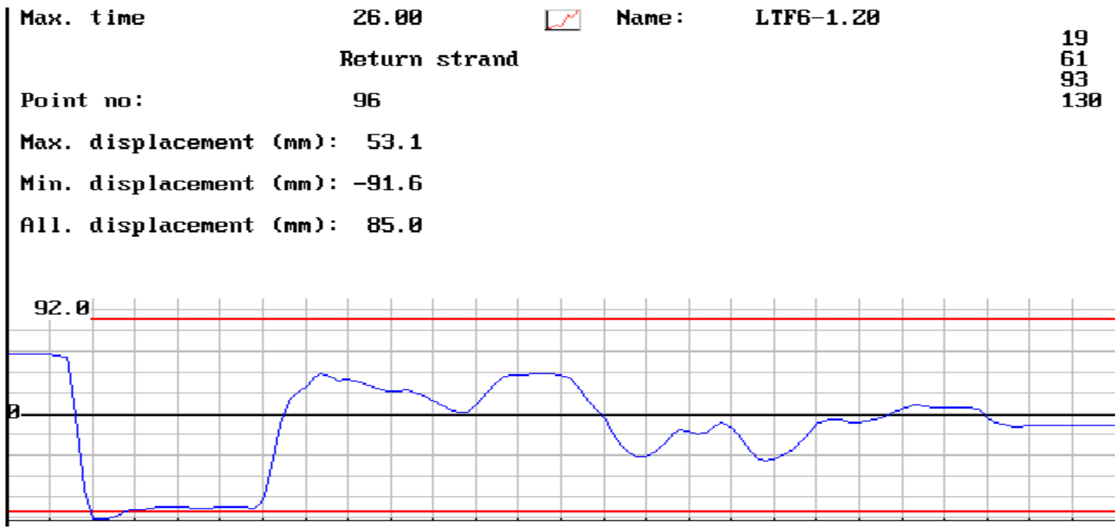


Figure 12. Horizontal curve. Return strand. Loaded stop.

3.4 DISCUSSION OF THE EVALUATION OF THE WORK BY AURECON AUSTRALIA AS 3RD PARTY DESIGN REVIEWER

In terms of client's requirements, the design was to be reviewed by a 3rd party. This was undertaken by Aurecon Australia. The work was performed using commercially available conveyor design packages, both static and dynamic.

Most of the observations and comments were of minor importance and the issues were clarified or resolved to the satisfaction of all parties concerned. However, there were two points of major disagreement which needed more detailed evaluation and resolution. Those were: conveyor power demand and minimum tension levels during stopping under full load.

3.4.1 Conveyor Power Demand

The divergence of the results is best illustrated by Figure 13 which compares resulting values of coefficient f of both the design and the review.

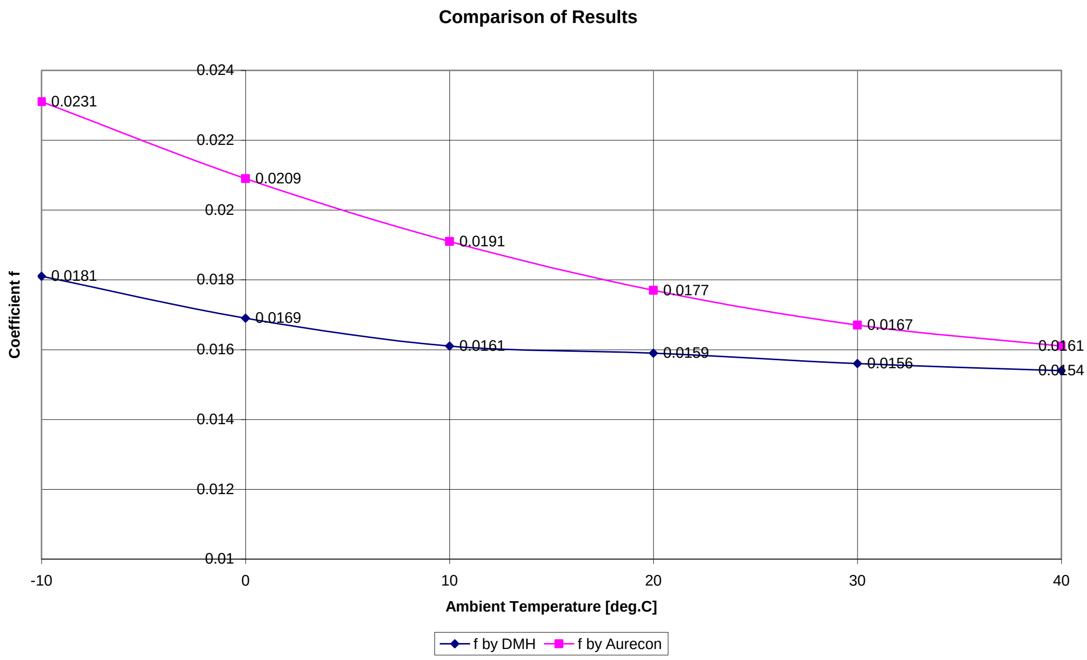


Figure 13. Coefficient f at ambient temperature.

As can be seen, at very high temperatures the difference of the values amounts to about 5% , however the difference significantly increases with the decline of ambient temperatures and at modes -10 degrees C coefficient f derived from Aurecon evaluation is 28% higher. At operating temperatures the conveyor is expected to operate predominantly where the difference is from 19% to 7%.

If one refers to some of the past projects executed in South Africa the following values of C*f can be provided for comparison:

- yard conveyors at Lethabo power station were assessed during commissioning to operate with C*f coefficient between 0,015 and 0,016;
- two overland conveyors of Syferfontein project[1] were assessed during commissioning to operate with C*f coefficient between 0,012 and 0,013;

- three conveyors of Twistdraai project [3] were tested several months after commissioning. The 6,9 km long conveyor CV012 was expected to operate with C*f coefficient of 0,014, while tests showed that over a range of capacities, coefficients oscillated within the range of 0 to -3,5%.

It is important to note that all of the reference values were obtained at ambient temperatures above 0 degrees C. Of the three referenced conveyors CV012 comes closest to the KPSX overland conveyor in terms of length, and design capacity (2200t/h), however, the belt is narrower (1050 mm), velocity higher (up to 5,6 m/s), top idler spacing only 2,2m and 152mm roll at the top and return strands. It is also head and tail driven.

In the "Conveyor Belt System Design" by ContiTech in section D-3.2 there is some guidance regarding selection of the friction coefficient taking into account the quality of assembly and operation, belt velocity and ambient temperature between -30 degrees C and +20 degrees C. Following these recommendations it was possible to generate recommended values for this case which are presented by Figure 14.

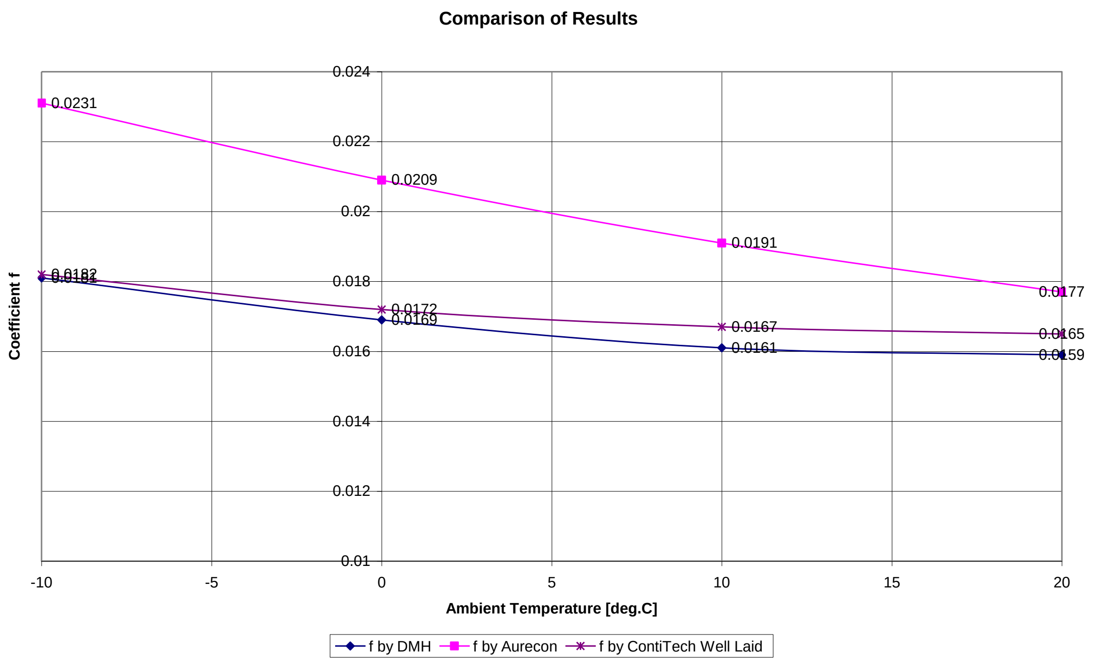


Figure 14. Coefficient f at ambient temperature.

As can be seen ContiTech values are fairly close to those obtained from the simulations. It is worth noting that in this case ContiTech values are a result of long-term operational experience while the simulations used parameters of conveyor components obtained from physical tests during the course of various projects.

At the same time, it is not known what specific belt properties were used in the review process. The importance of this can be obtained from the following graph, Figure 15.

T.Zur et al [4] and L.Gladysiewicz [5] in cases when belt cover properties for the full range of ambient temperatures are not known, the following formula is recommended to calculate indentation resistance:

$$R_T = R_{20} * (1.18 * 10^{-4} * T^2 - 0.0118 * T + 1.189) \quad (1)$$

Where

R_{20} is the indentation resistance at 20 [degrees C]

T is ambient temperature [degrees C]

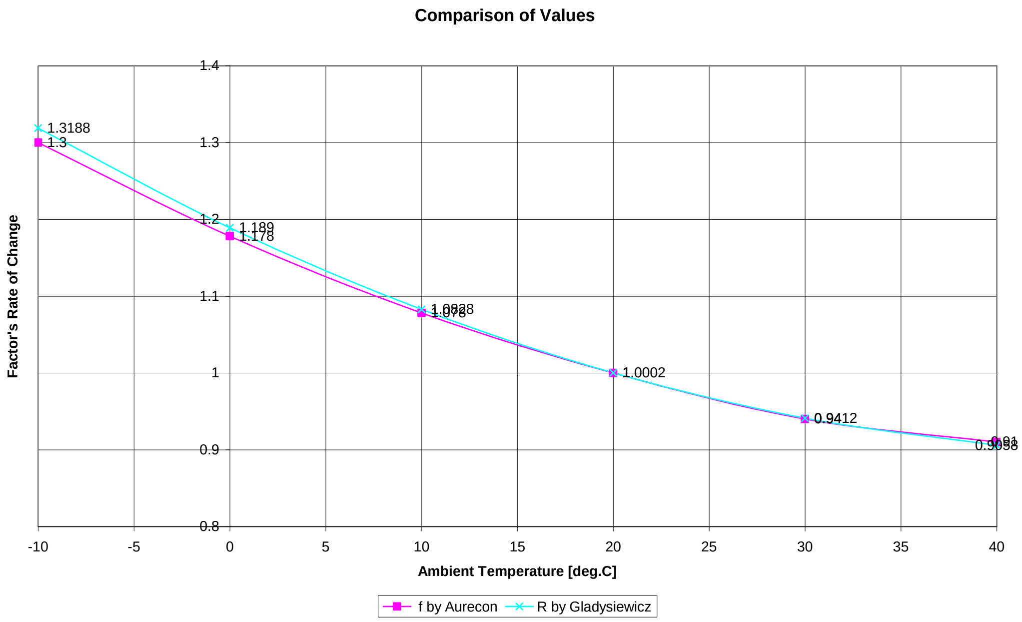


Figure 15. Factor's rate of change at ambient temperature.

With the value of R_{20} at 1 the formula represents rate of change of the parameter R. This was imposed against rate of change of coefficient f of the review. While the review graph represents a combined value of all main conveyor resistances and parameter R applies to the indentation resistance only, the correlation is surprisingly close.

A series of simulations was run applying value R as per (1) and the combined results of all analysis are presented by Figure 16.

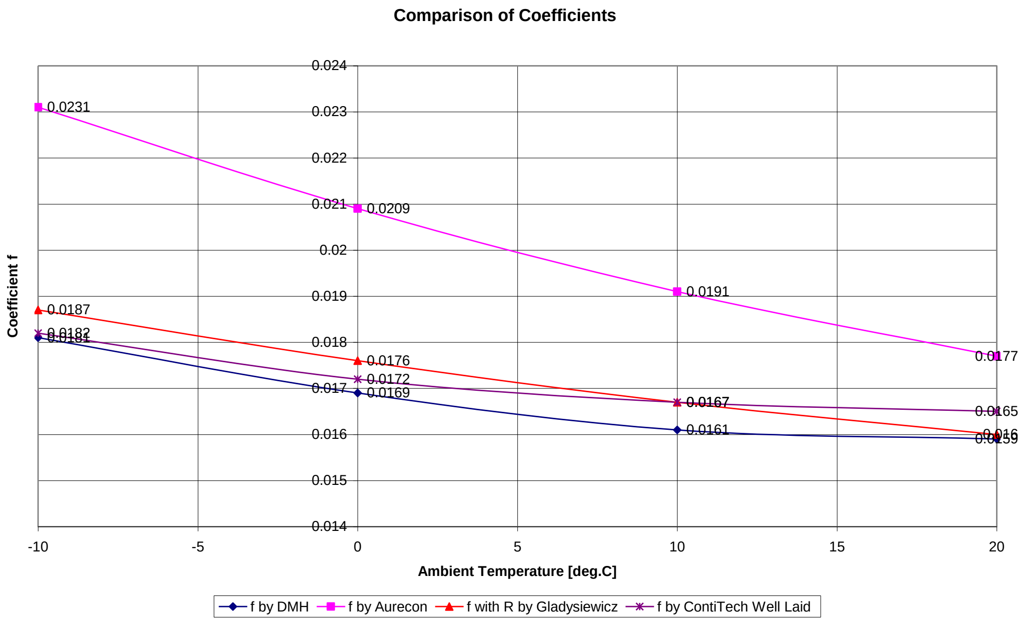


Figure 16. Coefficient f at ambient temperature comparison.

It is apparent that even at 20 degrees C all coefficients were of the same value. The trend of results can be described as a progressive divergence at declining ambient temperatures. It is likely that the review results are influenced by significantly dominant belt cover properties and resulting from the indentation resistance.

In the end the owners team decided to increase drive size to 850kW.

3.4.2 Minimum Belt Tension

The design simulations and verification simulations provided significantly different minimum belt tension during loaded stop. At -10 degrees C design result was higher than the review's value by a factor of 4 . Both were located in the area of the dip but not at the lowest point. Such a big discrepancy could be explained by a significant difference of the power demand between two sets of the simulations. However, if design values of conveyor resistance were brought to the same level of those presented by the review, minimum belt tension recorded was still higher by a factor of 3.

While verifying and comparing various figures it was noted that the belt sag is calculated based on the static formula:

$$y = \frac{m * 9.81 * l^2}{8 * T}$$

Where

y is belt sag [m]

m is the sum of belt and material mass [kg/m]

l is idler spacing [m]

T is belt tension [N]

To arrive at dynamic value one would have to consider belt velocity and rate at which sag changes i.e. d^2y/dt^2.

Consequently, consideration was given to the possibility that significantly lower belt tension was a result of exclusion of belt sag from the composite model of belt section.

If this is so, then length L_0 is the belt segment of which the length does not change over time. Once the sag is introduced it becomes time dependent parameter L(t) and adds to the process values of dL/dt, d^2L/dt^2, dy/dt and d^2y/dt^2.

To test this assumption a series of simulations over a range of ambient temperatures was performed utilising a “no sag” model. Minimum belt tensions recorded were significantly lower than the original design and very close to the audit’s values, however, the area of the lowest tension moved further back from the lowest most point of the profile. It is important to stress that the veracity of this assumption could not be confirmed or denied by investigating the review software.

As an acceptable compromise it was decided to install either a capstan brake at the take up or a low-speed brake at the take up pulley.

This allowed an interesting comparison of the results of two models as presented by Figure 17 and Figure 18.

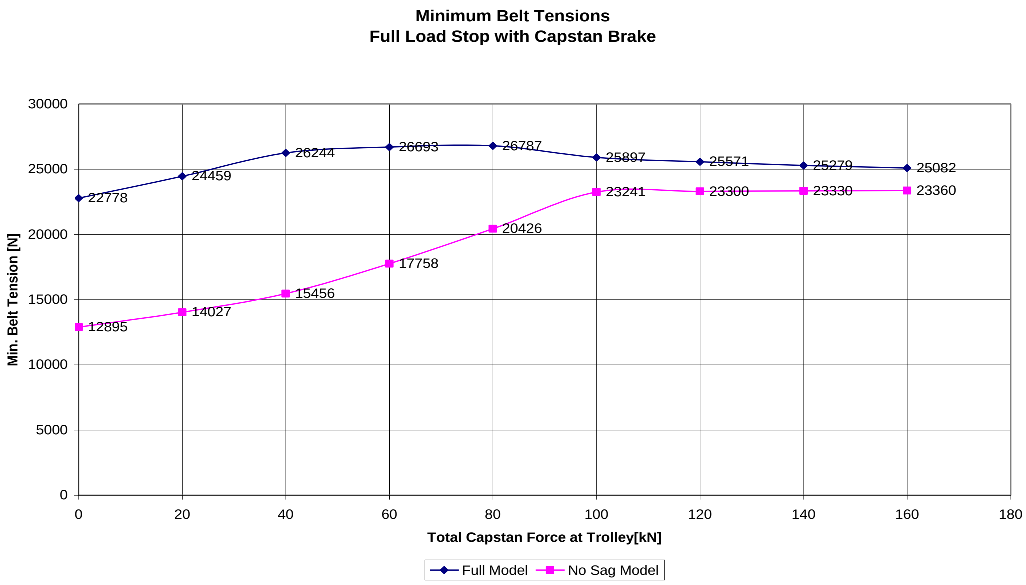


Figure 17. Minimum belt tensions, full load stop with capstan brake.

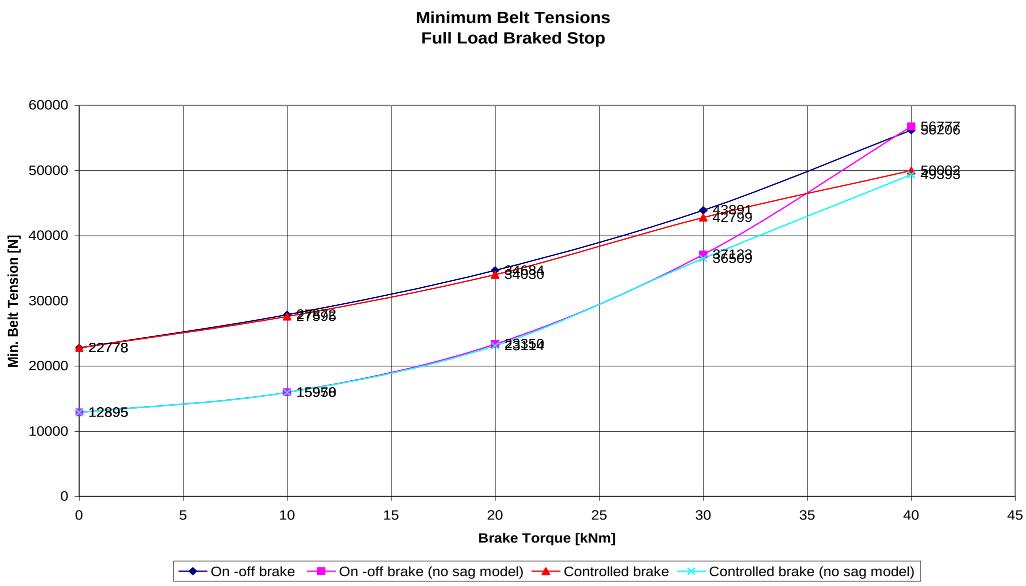


Figure 18. Minimum belt tension, full load braked stop.

What both diagrams clearly show is that with the increase of belt tension and decline of sag's influence the results obtained from both models converge to the point of insignificant differences.

Based on the analysis performed it was decided to install a low-speed brake at the tail pulley.

4. IMPLEMENTATION OF THE PROJECT

4.1 PRACTICAL OBSERVATIONS

1. Surveying

Survey results of different surveyors will show more variations than commonalities. Even though it is very small differences you will find that these arguments are seldomly concluded. For this reason, verification that the critical benchmarks are correct is imperative. Indicate and fix it in the field in such a way that it cannot be destroyed or moved over the life of the project. Identify the set out points (SOP's) of the conveyors in the same manner and align the conveyors from that SOP in the field. The fixed SOP now becomes the reference point for all setting out of hold down bolts.

2. Hold down(HD) bolt construction tolerance

The permissible deviation for HD bolts as per SANS 2001-CS1:2017 Construction works Part CS1: Structural steelwork can be viewed in Figure 19.

Table 7 — Permissible deviations for foundations, walls and anchor bolts

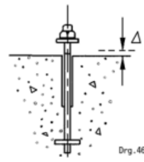
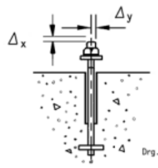
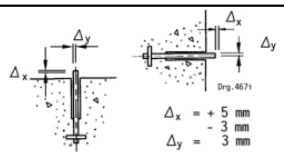
1		2
	Aspect	**Permissible deviation (Δ)**
1	**Foundation level** Deviation from specified level	 Δ = + 10 mm − 20 mm Drg.467f
2	**Vertical wall** Deviation from specified position at steelwork support point	Δ = ± 20 mm
3	**Pre-set foundation bolt or bolt groups in pockets** Deviation from the specified location and level and minimum movement in pocket Δ_x is the horizontal permissible deviation Δ_y is the vertical permissible deviation	 Δ_x = + 5 mm − 3 mm Δ_y = 3 mm Drg.467h
4	**Pre-set foundation bolt or bolt groups** Deviation from the specified location, level and protrusion Δ_x is the horizontal permissible deviation Δ_y is the vertical permissible deviation	 Δ_x = + 5 mm − 3 mm Δ_y = 3 mm Drg.467i

Figure 19. Permissible deviation for HD bolts.

Projects over the last couple of years indicated that the HD bolt allowable installation tolerance for vertical and horizontal deviation, 5mm and 3mm respectively, is very difficult to achieve and that the time it takes to correct the mistakes can be reduced if the designs can accommodate bigger tolerances, especially for HD bolts of the overland modules on an overland conveyor with a horizontal curve.

3. Lifting studies

Allow enough time for the review of lifting studies, don't assume the contractor is competent, they are also human and under a lot of pressure.

4. Alignment

Final alignment must be done in the most manual and practical means as possible. Spend a lot of time in the field to inspect the installation. More often than not if something does not look right, that is the case.

5. Conveyor belt pulling

Don't underestimate the conveyor belt pulling forces, especially over high-rise head ends and when you start to join several conveyor belt rolls. Do the calculations, apply adequate safety factors as per the regulations and ensure correct selection of all conveyor belt pulling equipment (steel wire rope, shackles, clamps snatch blocks and anchor points etc.).

6. Quality process and paper trail

If everything goes well there is no problem. If a problem is encountered the quality process and paper trail will quickly provide clarity and other possible issues can be resolved before it becomes a serious problem.

4.2 PROBLEMS EXPERIENCED AND SOLUTIONS

1. Holding down (HD) bolt construction tolerance.

During construction the final alignment process took much longer than anticipated. Adjustability on the base plates for alignment (2mm allowance on a 20mm hole as per SANS is not enough, use slotted holes where possible).

2. Misalignment between HD bolts and structure base plates

One can identify a lot of reasons for these errors, but ultimately issues like this can be designed out. Design all base plates to be square and symmetrical, group them in different sizes for standardisation (example 200mmx200mm, 400mm x 400mm or 600mmx600mm with standard hole and HD bolt sizing even though it might be overdesigned for certain applications). It must be impossible for steel fabricators or civil contractors to misinterpret the drawings.

3. Preservation of equipment during construction.

All equipment with bearings and especially gearboxes and motors must be preserved during the construction period. Regular rotating of bearings and inspection of equipment is important. For gearboxes use oil and not vapour corrosion inhibitor (VCI), because the vapour escapes if a curious person opens the oil cap or dipstick.

4. Set out points (SOP's) of conveyors are not clearly marked and fixed and have to be re-identified often.

Where conveyor centre lines cross, mark it in such a way that it cannot be moved or destroyed. It must be used for set out of civil plinths, HD bolts, final alignment for mechanical equipment.

5. COMMISSIONING

5.1 COMMISSIONING PREPERATION

In theory, commissioning starts when construction is complete but practically commissioning starts much earlier. For a successful commissioning phase, the construction and alignment must be of a very high standard. The standards and tolerances must be set early on to ensure compliance. For this project the guidelines were very much aligned with the guidelines set by the Conveyor Manufacturers Association of South Africa (CMA). The quality process during construction forms the backbone of compliance to the installation and alignment tolerances.

5.2 COMMISSIONING STAGES

The commissioning process comprised of the following stages:

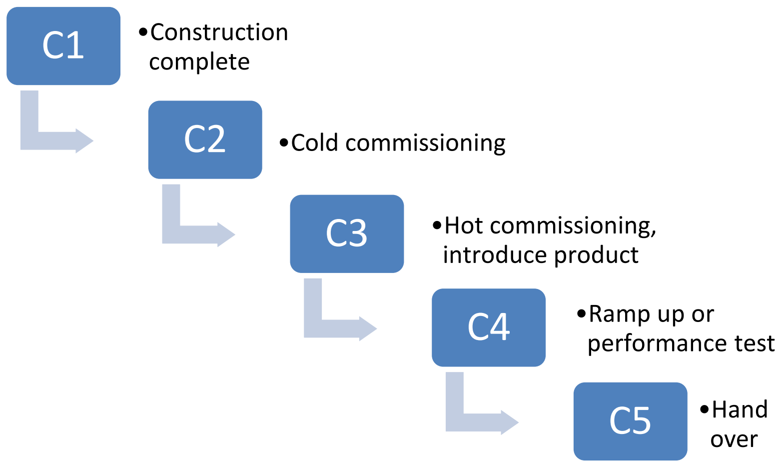


Figure 20. Commissioning stages.

Each of the commissioning stages has his own procedure, checklist and certificate.

5.2.1 C1 Construction complete

C1 complete is when the structures are complete and safe for use and the safety equipment has been installed and tested.

5.2.2 C2 Cold commissioning

C2 is the functional testing of each individual item, energised without product in the following order; Individual components, sub system and the system.

- The individual components comprise of the following: example drive unit, winches magnet, brake etc.
- A subsystem is a complete conveyor on its own.
- The system comprises of all sub-systems and individual components.

5.2.3 C3 Hot commissioning

C3 is when one tests the integrated system in automatic sequence, energised with product.

5.2.4 C4 Ramp up or performance testing

C4 is when the system's performance is verified at steady-state condition and as per design intent and performance criteria have been met.

5.2.5 C5 Hand over

The system's performance meets the criteria and it can be handed over to the end user.

5.3 COMMISSIONING PLANNING

Commissioning planning entail the following aspects:

5.3.1 Commissioning team

Establish and confirm the commissioning team (Commissioning manager, key supervisors, C&I technicians (safety equipment and VSD commissioning) mechanical fitter team for adjustments)

5.3.2 Commissioning Procedure

The commissioning procedure must be clearly defined and understood by the commissioning team. Communication protocol is very important, preferably only one person makes the decision to move on to the next phase.

5.3.3 Risk assessment

A risk assessment must be generated by the team, and everyone involved must be trained on the risk assessment to ensure that everyone knows what to do in the event of any unexpected occurrence.

5.3.4 Method of communication and backup plan

Radios are the most common means of communication but in the event of malfunction the fall back option and what to do next is by Cell phone and then the system must be stopped.

5.3.5 Conveyor belt alignment

Training on belt tracking adjustments to ensure the mechanical fitters are competent to the adjustments.

5.3.6 Allocation of supervisors along the conveyors at strategic locations

For this conveyor the strategic locations were the 1) head end, 2) drive station and belt turnover, 3) R545 crossing, 4) N12 crossing, 5) take up area and belt turn over and 6) the tail end. At the overland portions teams did surveillance on a 500m section with a light duty vehicle (LDV).

5.4 COMMISSIONING OBSERVATIONS AND OUTCOME

The commissioning of the overland conveyor was successfully completed. The hard work during the commissioning preparation and planning paid off. Like all team sports it is required to practice with the teammates. The team who commissioned this overland conveyor "practiced" on 2 conveyors prior to the overland conveyor, one of which was a 1.5 km conveyor, hence the team was fit, and the commissioning went smoothly.

Conveyor belt training in certain areas were required, nothing out of the ordinary. The main commissioning interruptions experienced were due to:

1. Misalignment of the take up pulley, a stoppage was required to align the pulley plummer block with shims.
2. Conveyor belt miss tracking close to the tail end causing excessive wear on the loading chute skirt rubbers, hence it required adjustment.

Both of these activities could only be performed while the conveyor belt is isolated, locked out and made safe in terms of stored energy.

The testing of the conveyor belt safety equipment as well as the process interlocks took a large portion of the commissioning time. Within a few days of running the conveyor belt the conveyor belt alignment was stable and good enough to introduce product. Hot commissioning went very well with no real issues to be noted.

6. CONCLUSIONS

To deliver a successful project it is necessary to be successful in all aspects of the project lifecycle this includes the detail design, a design audit, construction, alignment, quality control on all aspects, commissioning preparation and commissioning itself.

The more effort you put into installation and alignment the easier and quicker commissioning will be because the construction and alignment form the foundation of the system's operation.

If cold commissioning is completed successfully, the feed points are aligned, and chute designs have been done properly hot commissioning is only a formality and one should not experience any issues of great concern.

A SPECIAL THANK YOU TO THE FOLLOWING PERSONS:

Jan Roos, Seriti – Manager Projects

MacWalter Sidindi, Zutari – BMH and Resident Engineer

Kreesen Naidu , Zutari – BMH Engineer

REFERENCES

1 R.Fauerbach, M.Otrebski: The Syferfontein Overland Conveyor System at Sasol Secunda Plant in South Africa; bulk solids handling, 1993

2 R.Fauerbach, M.Otrebski, J.Kunicki: Sigma – A curved Conveyor Plant with Special Control: bulk solids handling, 1994

3 J.A.Kornecki, M.W.Otrebski: Design Optimisation with Risk Analysis to Minimize Belt Cost: Proceeding, Bulk Material Handling by Belt Conveyor II, 1998

4 T.Zur, M Hardygora: Przenosniki Tasmowe w Gornictwie (in Polish): Wydawnictwo Slask Sp.z o.o., 1996

5 L.Gladysiewicz: Przenosniki Tasmowe. Teoria i Obliczenia (in Polish): Wydawnictwo Politechniki Wroclawskiej, 2003.

ABOUT THE AUTHORS

EGBERT LE ROUX

Egbert is a bulk material handling (BMH) specialist with experience in the complete lifecycle of projects. His experience ranges from concept studies, pre-feasibility studies (PFS/FEL2), bankable feasibility studies (BFS/FEL3) to project implementation including but not limited to detail design, procurement, construction support, commissioning, project closeout and handover to the end user.

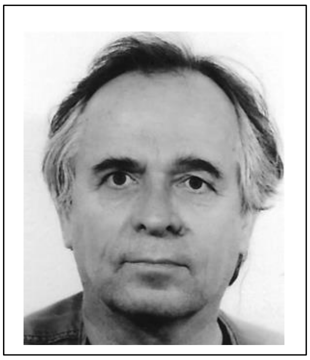
He obtained a Bachelor of Engineering (Honours) in Technology Management in 2010, and a Bachelor of Engineering in Mechanical Engineering in 2008, both from the University of Pretoria in South Africa. He is registered as a professional engineer (PrEng) with the Engineering Council of South Africa (ECSA).

Egbert le Roux

Address: Pretoria, RSA

Mobile: (+27) 72 292 8275

Email: egbert.leroux@zutari.com



MARIAN OTREBSKI

Mr. M Otrebski graduated in 1976 from The Wroclaw University of Technology with a Masters degree in Mechanical Engineering – design and application of bulk materials handling systems and equipment. Since then Mr. Otrebski has worked in the open cast mining environment, has been involved in detail design of major bulk materials handling machines and conveyors, development of bulk materials systems including export and import terminal as well as turn key project execution.

Mr. Otrebski is the owner of DynamikaMH Consultants CC

M. Otrebski MSc. Pr.Eng

Address: 10 Kyanite Street, Sundowner, Randburg, RSA

Tel: (+27) 11 795 3512

Mobile: (+27) 82 414 3615

Email: marian@dynamika.co.za