THE NAMAKWA SANDS DUAL CARRY CONVEYOR (DCC)

WHAT WE HAVE LEARNED FROM 13 YEARS OF OPERATION

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INTRODUCTION

The Dual Carry Conveyor (DCC) at Namakwa Sands was designed, constructed and commissioned by Tekpro Projects in 2002, complete with its unique 'Pretzel' top and bottom strand swop over system.

As well as simultaneously carrying material in both directions, the DCC has also been extended over the years from its initial length of 3.5 km, via an intermediate length of 4.7 km to its current length of 6.3 km.

Due to significant changes in the mine plan, the conveyor has not only had to extend at a greater rate than originally predicted, but has had to transport material at increased capacities as well.

As a result, the practical aspects of operation of the DCC at extended lengths and at high capacity have been identified and addressed, so much so that it is now intended to extend it to 8.9 km, which is well in excess of its original design length of 7.5 km.

Over the years, much has been learned from the operation, start-up, control and take-up philosophies, as well as the original duty specification as compared to the actual capabilities of the DCC.

Through this paper, it is hoped to share the experiences and knowledge gleaned from well over a decade of involvement in this interesting project.

IMPORTANCE OF THE INITIAL AND FUTURE DESIGN CRITERIA

Initially, the DCC was specified to carry run of mine (ROM) mineral sands in one direction from the mine to the plant at 1000 t/h, whilst at the same time carrying tailings at 991 t/h in the opposite direction back to the mine. To achieve this, the DCC could have been fitted with a 900 mm wide belt operating at 3.85 m/s (as the bulk densities are approximately 1.7 t/m^3 and 1.6 m^3 for the ROM and tails respectively, but also taking into account the low angles of surcharge).

The client however, insisted on the DCC being fitted with a 1050 mm wide belt running at 3.5 m/s, even though this was considered to be somewhat conservative at the time. This has turned out to be extremely fortunate, however, because (as with numerous other conveying systems) the DCC is operating at significantly increased capacity, with proposed future requirements being double the initial ones.

With approximately 40% spare volumetric capacity available on the belt and a further 20% additional capacity available by increasing the speed of the variable speed drives

(VSDs) from 50 Hz to 60 Hz, the only remaining obstacles are those relating to increased tensions in the system. Otherwise, the DCC can be made to handle 200% of its original duty.

It is at this point therefore, that the importance of considering the future requirements of a conveying system from the outset must be highlighted.

All too often, in order to win a tender, the supplier will offer conveyors with the narrowest belt widths operating at the highest practical speed, in order to be able to come in at a low price and get the job. In return, the client often looks at his cash flow and budget, and awards the project on price. This can prove to be an extremely bad move, especially when the inevitable first 25% plant upgrade comes along (as is so often the case) and for upgrades thereafter.

THE CONFIGURATION OF THE CONVEYOR

Initially, both the tails as well as the ROM had to be loaded onto the upper strands of the conveyor, as follows:

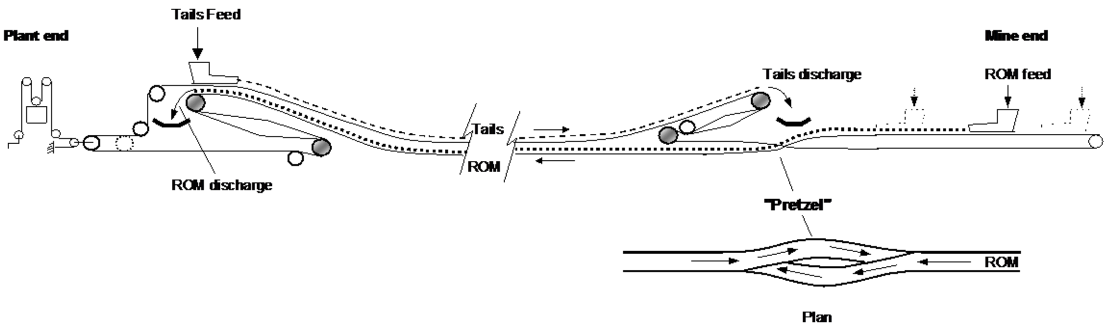

Figure 1. Both tails and ROM loaded

The tails are loaded at a fixed point at the plant end, whereas the ROM was initially loaded via a shiftable conveyor anywhere along the tail of the DCC.

The Pretzel

For the above reasons, during the first years of operation, the DCC was fitted with the unique 'Pretzel' belt swop-around system, which performed very well.

Figure 2. The Pretzel

Figure 3. Relocated mine end tripper/drive

Following the extension of the DCC to 4.7 km however, the mine end tripper/drive station was re-located closer to the mine. The requirement for a variable ROM loading position fell away and as a result, the Pretzel section was taken out and stored for future use.

The operation of the Pretzel was a total success, and worked perfectly from the very first press of the start button. This being despite being subjected to high belt tensions brought about by the mine-end C drive being lame during starting. This is discussed in the VSD section below.

The current configuration of the DCC is as follows:

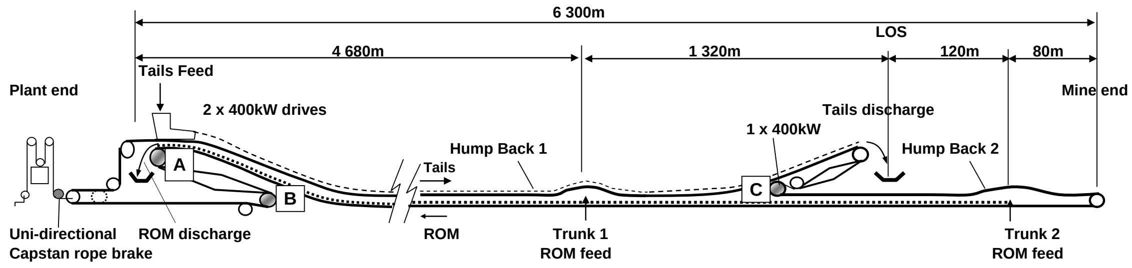

Figure 4. Current profile

Capstan Brake

Our calculations showed that on extending the DCC from its initial length of 3.5 km to 4.7 km, a capstan brake would be needed on the gravity take-up tower. This is in order to dissipate some of the strain energy stored in the stretched belt, which would otherwise go directly into raising the counterweight as the conveyor coasts to a halt.

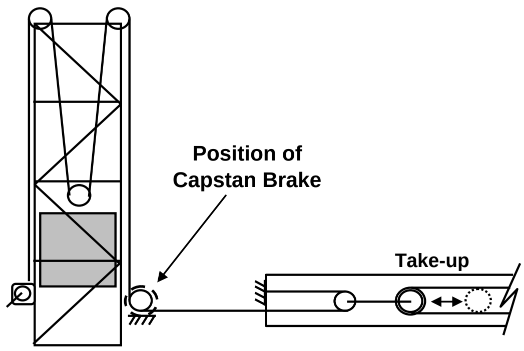

Figure 5. position of Capstan Brake

The selection of the type of capstan brake was driven by simplicity, and as such it is a counterweight band brake of the type that does not require any accessories or power/C&I connections. The type in service on the DCC is based on the following principle:

Essentially it is a horizontal capstan, shaped like a chimes wheel, around which the take-up rope is wrapped through 450 degrees at the base of the vertical gravity tower.

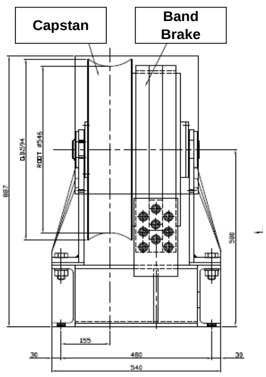

Figure 6. The capstan fitted with a special band brake

The capstan is fitted with a special band brake with 540 degrees of wrap. Referring to the diagrams below, one end of the band brake is securely fixed. A lever arm, fitted with an adjustable counterweight applies tension to the other end of the band brake.

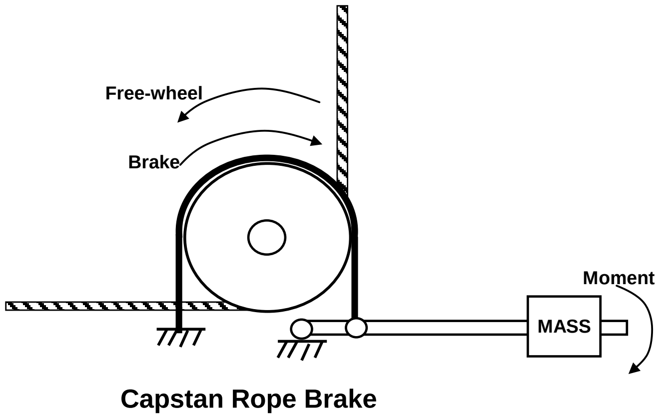

Figure 7. Operation of the capstan brake

On starting, the capstan brake all but free-wheels, thus allowing the counterweight to drop whilst at the same time delivering most of the counterweight's T2 to the take-up.

On stopping however, the take-up tries to retract, but has to overcome not only the force from the counterweight mass, but also the force from the capstan brake. The energy dissipated by the capstan brake no longer goes towards raising the counterweight. It has become clear that the reliable operation of the capstan brake is essential to the DCC.

After a year or so, the bolt (as shown in the diagram below) which connects the end of the brake band to the counterweight arm broke due to metal fatigue:

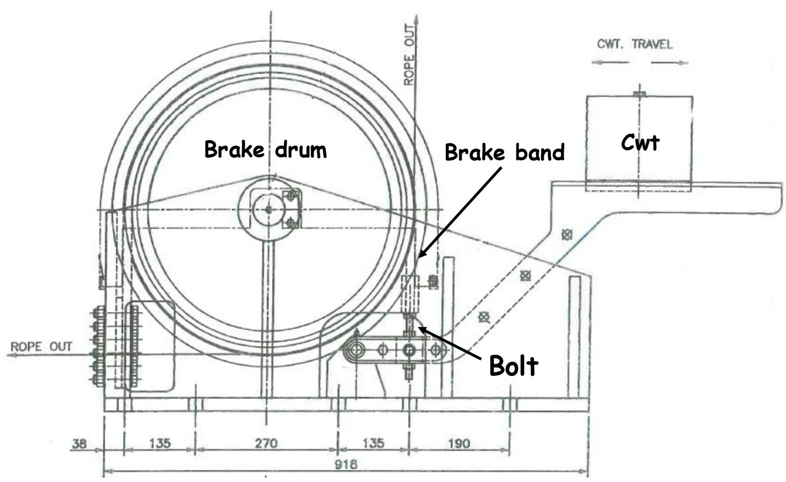

Figure 8. Failure of capstan brake

Failure of the capstan brake caused the counterweight to rise uncontrollably during stopping and now, at its current length, the reliability of the DCC's operation depends on the integrity of this one bolt, otherwise the take-up tower can get damaged, as can the plant end drive units, as discussed below.

The Idlers

Due to the highly corrosive coastal atmosphere, the idler rolls are plastic type.

As a result, the sealing of the bearings against foreign material is basically standard supply, but not ideal for the harsh coastal duty in the presence of very fine airborne sand.

Compounding the problem of seal failure, the configuration of the DCC's modules is not, in hindsight, ideal. The concept is that the lower belt strand carrying the dusty ROM sand is protected by the side sheeting and the upper strand, carrying wet tails:

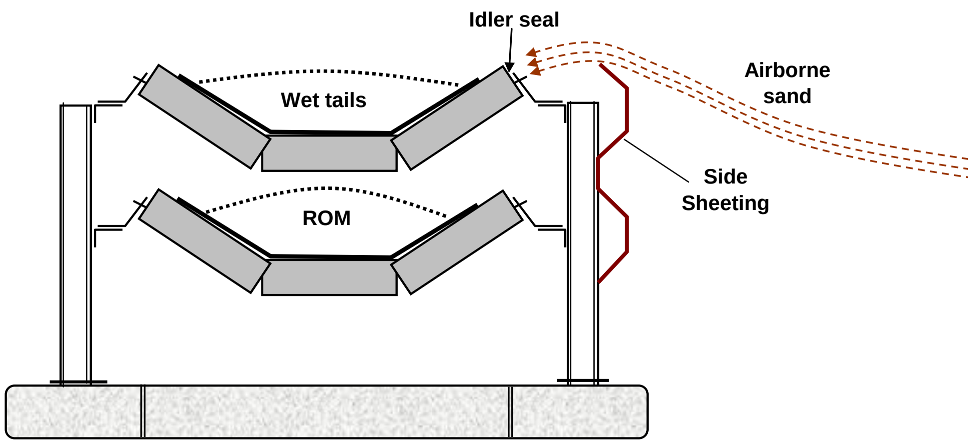

Figure 9. Aerodynamics of the module

However, the aerodynamics of the module with a strong side wind is such that airborne sand targets the upper wing roll idler seal on one side.

As a result, there was considerable premature idler bearing failure of these rolls, especially where the DCC passes through an area of very fine sand.

The reason for the premature idler failure is attributed to the over reliance on labyrinth seals, combined with only one lip seal that gets overwhelmed and quickly worn out by being packed with ultra-fine sand. This ingress is further hampered when it rains, and the water washes the fine sand further into the bearing cavity through the labyrinths.

Although not the actual arrangement of the seals that failed, the following diagram is fairly typical of a sealing arrangement for a plastic idler roll:

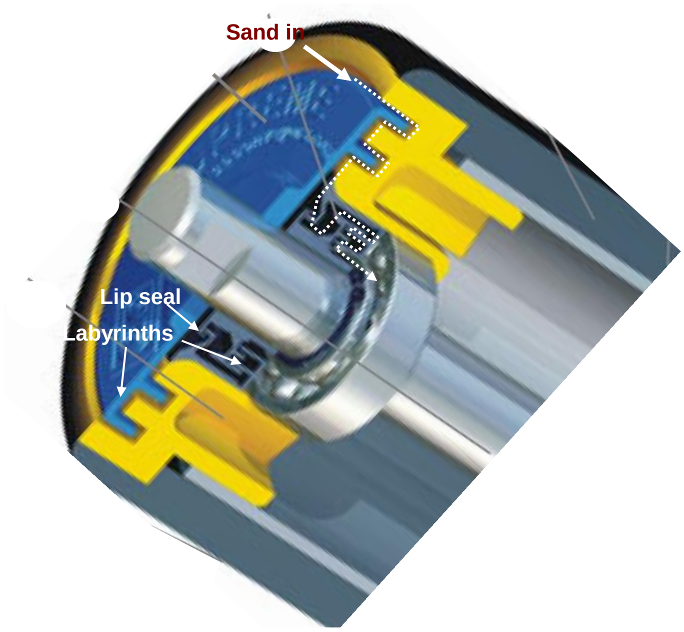

Figure 10. Sand in the end seal of the shaft

The four minute start up time of the DCC enabled the sand that was collected in the outer labyrinth of the actual rolls to slowly gravitate into the seal on the shaft (without flinging it out) and thereafter destroy it.

On opening the seals and the bearings it was found that they were caked with fine sand embedded in grease.

In order to resolve the problem, the replacement rolls were fitted with dust covers as well as an additional lip seal.

As a result of the operation of the DCC, idler manufactures could consider using the same sealing arrangement typically found on the wheel bearings of 4x4 vehicles. This consists of an oil seal with two lips. Not only does this arrangement keep the dust out of the bearing, but such vehicles are often driven for miles off-road, including across rivers and sand dunes, with no long term ill effects.

Belt turn-overs

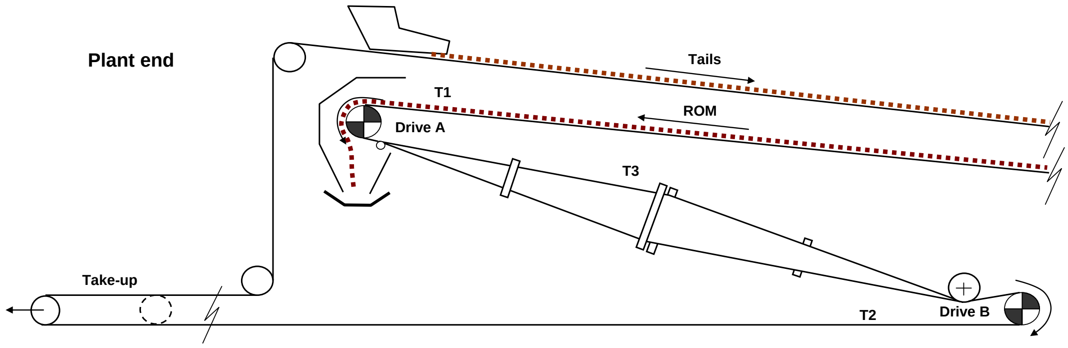

Figure 11. Drive arrangement with intermediate turn-over design

Eyebrows were raised when the above drive arrangement with intermediate turn-over design was proposed. The 'old school' maintained that:

- All long overland conveyors should have belt turn-overs
- Belt turn-overs must be horizontal
- They must be on the low tension area after the drive
- All larger drive units must be mounted at ground level.

It was found on other overland conveyors with belt turn-overs fitted after the drive stations that by the time the belt reaches the turn-over, it has passed through so many rotating components that the carry-over material has already been dislodged, and the belt is almost clean. As such turn-overs are seemingly of little actual benefit.

For the DCC however, the situation is totally different, and we have used the above configurations have been used at both ends of the conveyor because:

- The belt has to be turned upside down to always run top cover side up, as it is a dual carry
- Putting the turn-over inclined between the drive pulleys, and not putting all the drives at ground level, dramatically reduces the number of pulleys and support steelwork required, and is therefore considerably more economical.

Despite breaking the above 'old-school' rules, both the DCC's belt turn-overs have operated with suitable reliability over the long period of the DCC's operation. There is absolutely no reason not to use this configuration in future.

THE BELT

The DCC was fitted with an St 1250 1050 mm wide belt, as is fairly standard on both the East and West mines. This was deemed sufficient for the duty, even at full length, but has been found to be susceptible to impact damage on other conveyors on the mine. St 1250 is actually a fairly light duty conveyor belt, and despite there still being original belting on the conveyor, from 2013 onwards, all replacement belting on the DCC is the heavier duty St 1600. This is beneficial to the DCC, as currently the belt is over stressed at the plant end as drives A and B have to do the majority of the work, because the mine end C drive is ’lame‘ during starting, as is discussed further below.

Maintenance of the mine end pulleys

There are four pulleys on the DCC at the mine end. These are currently 6.3 km away from the take-up at the plant end. In order to maintain these pulleys, it is necessary to slacken off the belt, and to assist in this, the tail pulley was mounted on a frame which enabled it to slide in by 1.5 m.

In practice, this was not really enough, and to this end, we have installed a 30 m winch operated fixed take-up system at the tail pulley. This not only provides plenty of belt slack for maintenance, but also provides useful belt storage.

The drive units

The DCC has three of its four 400 kW VSD drive units currently installed. Drives A and B are at the plant end adjacent to the gravity take-up, and drive C is at the mine end, 6 km away from the take-up.

The history related to the control of the VSD drives is covered below. Here though, the experience with drive units themselves is discussed, as the plant end drives failed prematurely.

The premature failures are attributed to:

- The gearboxes not meeting the design specification
- Drives A and B having to do the majority of the work, as the C drive is lame during starting, as is discussed further below
- Shock loading from the belt, as it suddenly contracts during stopping, when the critical bolt on the capstan brake had failed due to fatigue.

Regarding the shock loading from the belt when the capstan brake is inoperative, this is a weak point of drives using VSDs instead of fluid type couplings. The latter gives protection to the gearbox from the high inertia of the motor spinning at 1485 rpm. On stopping, the sudden release of strain energy dissipating in the contracting belt causes a sudden and large counter torque on the drive pulley. In other words, the inertia of the motor tries to drive the gearbox, whilst the contracting belt force on the pulley tries to stop the gearbox. The net result can be damage to the internal gearing.

The drives have been replaced with heavier duty ones, and the problematic bolt connection in the capstan brake has been upgraded. For the same reason, the high speed couplings have also been upgraded, as they only lasted two to three months. The new ones have now lasted over a year without failure.

Torque limiting high-speed couplings are also indicated here, but our experience with them on other conveyors has been met with little success to date.

VSDs

Generally, the overall availability of the DCC has been acceptably high. The fibre optics have posed a few problems however, and the level of support from the VSD supplier has been somewhat frustrating.

The philosophy that if a conveyor has VSDs, it can be run at whatever slower speed that would be required, in order for it to always run full (and therefore possibly save power) has not been adopted on the DCC. This is due to the fact that the over-stressing of the belt as a result of the lame C drive would be made worse. Also, in practice, the mine requires to put through as much ROM and tails as possible. The DCC is now also loaded at multiple feed points, which makes the concept even more impractical.

The drive configuration of the DCC is as follows:

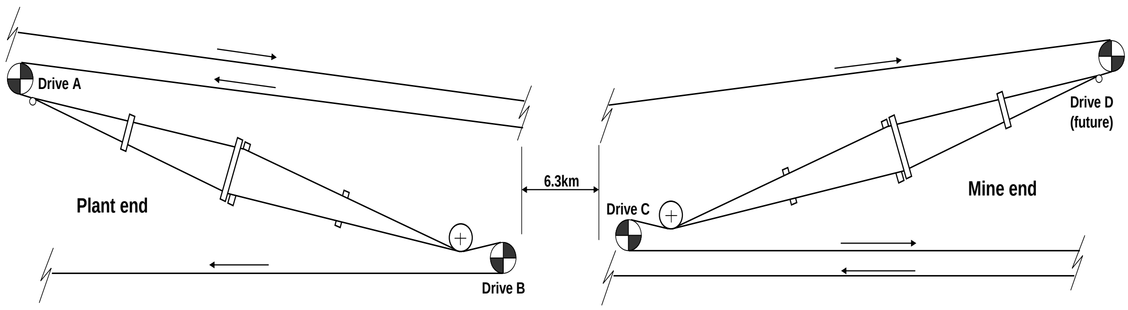

Figure 12. DCC drive configuration

Since the active take-up is at the plant end, the A and B drives start first. Once the ROM belt has stretched sufficiently to give movement of the belt at the mine end, C drive is to start and follow the A and B drives. The control philosophy was originally such that to avoid the mine end drives lifting the counterweight when the ROM belt is full, but with the tails belt empty, the mine end drive(s) are limited to provide 80% of the torque provided by the plant end drives.

This was the original philosophy, but proved difficult to achieve, as the current C drive is lame during starting.

The following trace shows this:

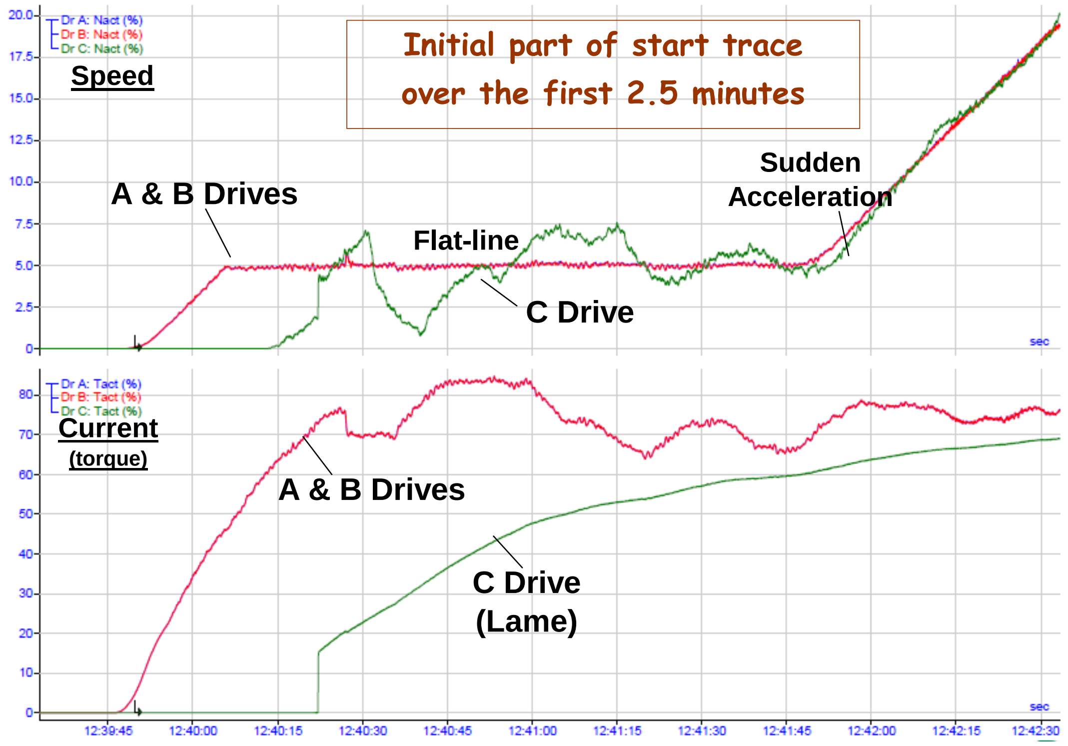

Figure 13. Initial part of start trace over the first 2.5 minutes

The plant end drives follow each other faithfully, and their traces are completely superimposed. The C drive however, does not pull its weight until four minutes after the start has been initiated. This is purely a fault of the VSD control.

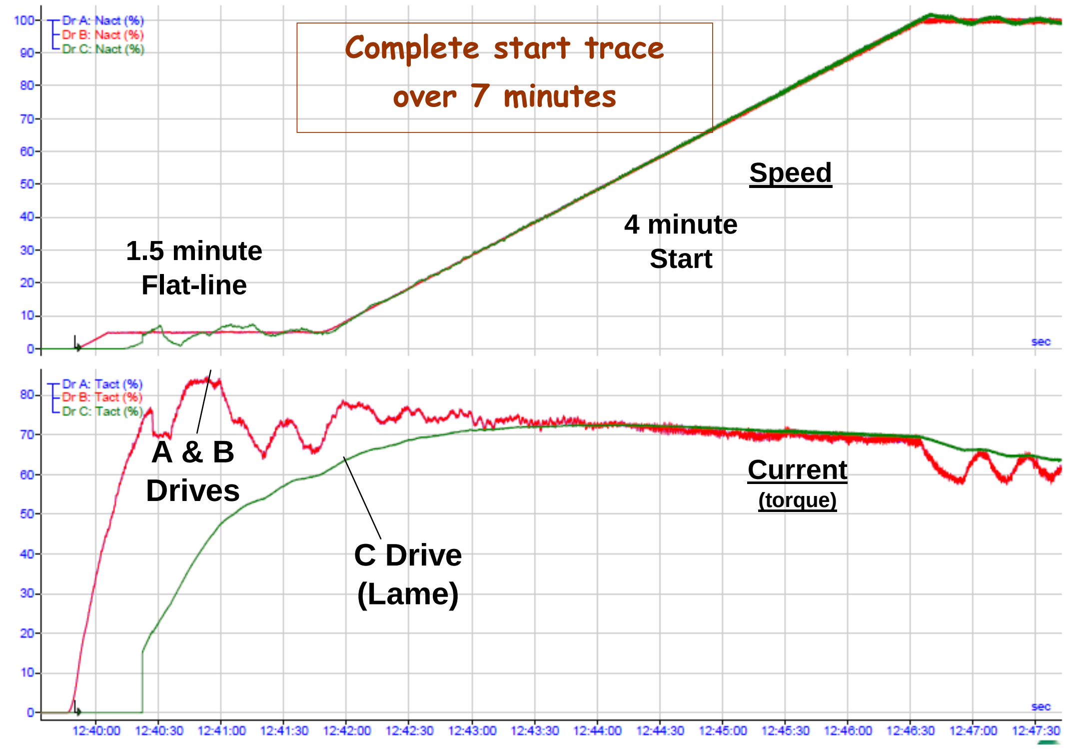

Figure 14. Complete start trace over seven minutes

In addition, it can be seen that there is now a one and a half minute flat line at 5% speed which is not part of the original philosophy, and thereafter a sudden (and undesirable) acceleration at the beginning of the four minute uniform acceleration to full speed.

Because of the above, when the conveyor is fully loaded with ROM as well as tails, drives A and B at the plant end are overloaded, and consequently over-stress the belt.

This has caused belt splice failures, despite there being adequate safety factor for being started as originally specified.

For a 21 km overland conveying system, which we have also designed with both head and tail drives, Professor Alex Harrison of Conveyor Technologies suggested that we consider adopting a different starting philosophy.

Adapted to suit, this philosophy is soon to be implemented on the DCC as well. Operated by a PI-characteristic controller in the PLC, the basis of the philosophy for the DCC is as follows:

- Start the A and B drives
- Allow them to stretch the ROM belt and continue to accelerate until they reach 80% of their rated torque
- Cap the A and B drives at 80% of their rated full load torque
- Drive C (as well as drive D in future) then starts, and provides whatever *additional* torque is required to accelerate the conveyor uniformly over a set start ramp over four minutes.

In this way, Drives A and B can never be overloaded, the belt can never be over stressed, splice failure will be vastly improved and all load cases will be easily catered for.

On-board safeties

The DCC is equipped with an intelligent on-board protection system. As such, it is relatively complex, and used the latest in technology for the time. It is felt that the availability would be even better had a non-intelligent or more basic on-board protection system been used. Even so, the availability of the overall ROM and tailings systems (for which the DCC is the lifeline) including the ROM stockpile feed at the plant end and tails load out station at the mine-end, is over 95%.

CONCLUSION

There can be no doubt that the DCC has been a very big success, and has brought about all the savings hoped for during the concept stage. It is hoped that the lessons learned and described in this paper will be of help to others should they be designing Dual Carry, or even conventional overland conveyors.

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