TECHNOLOGY AND CONVEYOR BELTING – PROTECTION AND MONITORING OF CONVEYOR BELTING

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INTRODUCTION

Conveyor belting is one of the most expensive components on a conveyor system and a fully functional conveyor system is crucial to the operation of a mine or plant. With the ever increasing cost of mining operations it has become of cardinal importance to ensure the safe and efficient running of the conveyor systems. Belt replacement and unplanned downtime could have a detrimental effect on any operation.

It has therefore become critical to be able to protect conveyor belting and to be able to accurately predict remaining belt life. This will not only safeguard against unplanned breakdowns and loss of production but also put the end user and manufacturer to better plan for future belt requirements, thus reducing required inventory and increasing mechanical availability.

GENERAL

Condition monitoring goes a long way towards achieving this. Through the use of ever changing and advancing technologies it has become possible to more effectively perform condition monitoring. The result is more reliable systems and information.

WHY CONDITION MONITORING?

The most important reason for doing condition monitoring on any belt is to ensure the safe and most cost effective operation of the conveyor system. Through effective monitoring producing reliable results is it possible to ensure the longevity of any conveyor belt, reduce unplanned stoppages due to breakdowns and ensure more accurate stock planning.

HOW?

There are a myriad of systems, tools and procedures for doing condition monitoring each with its own advantages and disadvantages. From simple visual inspections to highly sophisticated and very expensive 24/7 on-line systems.

With the aim to increase belt life and availability, the two key areas to concentrate on is most likely the measurement of belt wear and protecting the belt against longitudinal rips.

This paper will concentrate on some of the latest technology available for rip detection and wear or thickness measurement.

BELT RIP DETECTION SYSTEMS – CURRENT SITUATION

There are a number of systems currently available on the market such as electro mechanical systems operating with cables or gates running underneath the belt linked to micro switches and tied into the tripwire system as illustrated in Figure 1 and Figure 2 below.

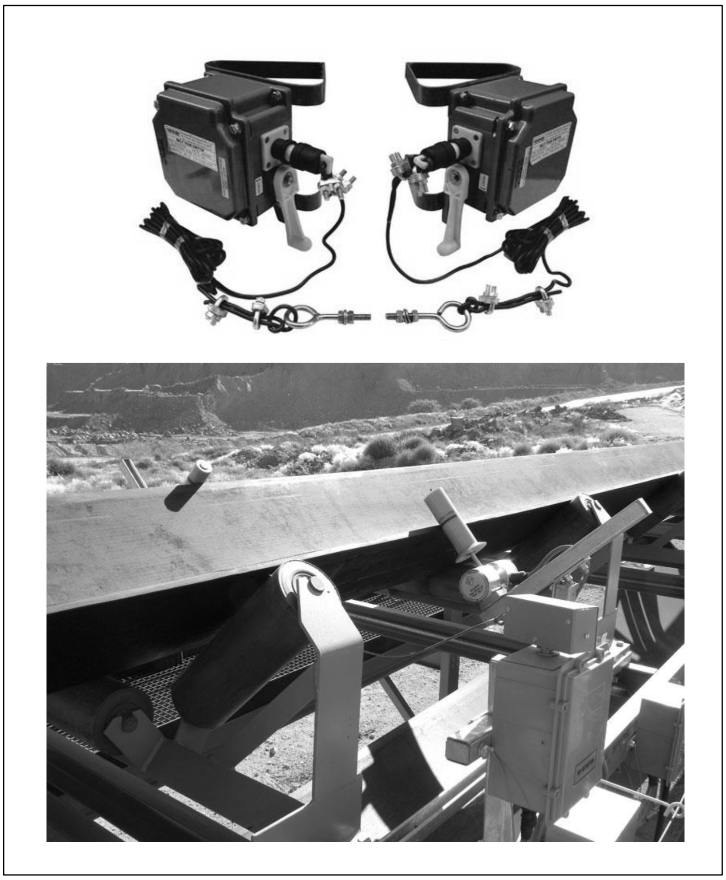

Figure 1 – Example of a Cable System

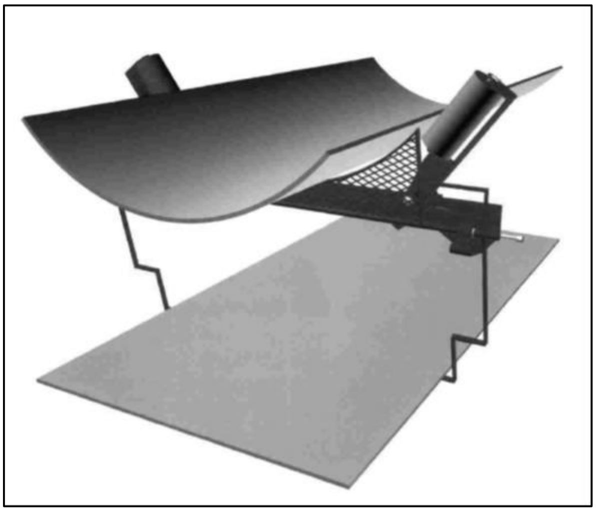

Figure 2 – Example of a gate system. Detects longitudinal rips, top and bottom cover damage, belt misalignment.

SENSOR LOOP SYSTEMS

The most commonly used system is the so called sensor loop system. There are numerous variations on this system but the basic principle is the same.

To monitor the steel cord belt, inductive loops are embedded into the belt. The loops are – dependent on the belt width- 320 mm wide and 4,5 mm high and come encapsulated in a rubber flap which can be easily fitted into the belt.

These coils may either be fitted underneath (preferably for less stress) or on top of the steel cords with a minimum cover of at least 1 mm of rubber over the steel cords.

The inductive loops are used to transfer electro-magnetic signals from transmitter to receiver.

The transmitter and receiver are positioned opposite each other on either side of the belt. See Figure 3.

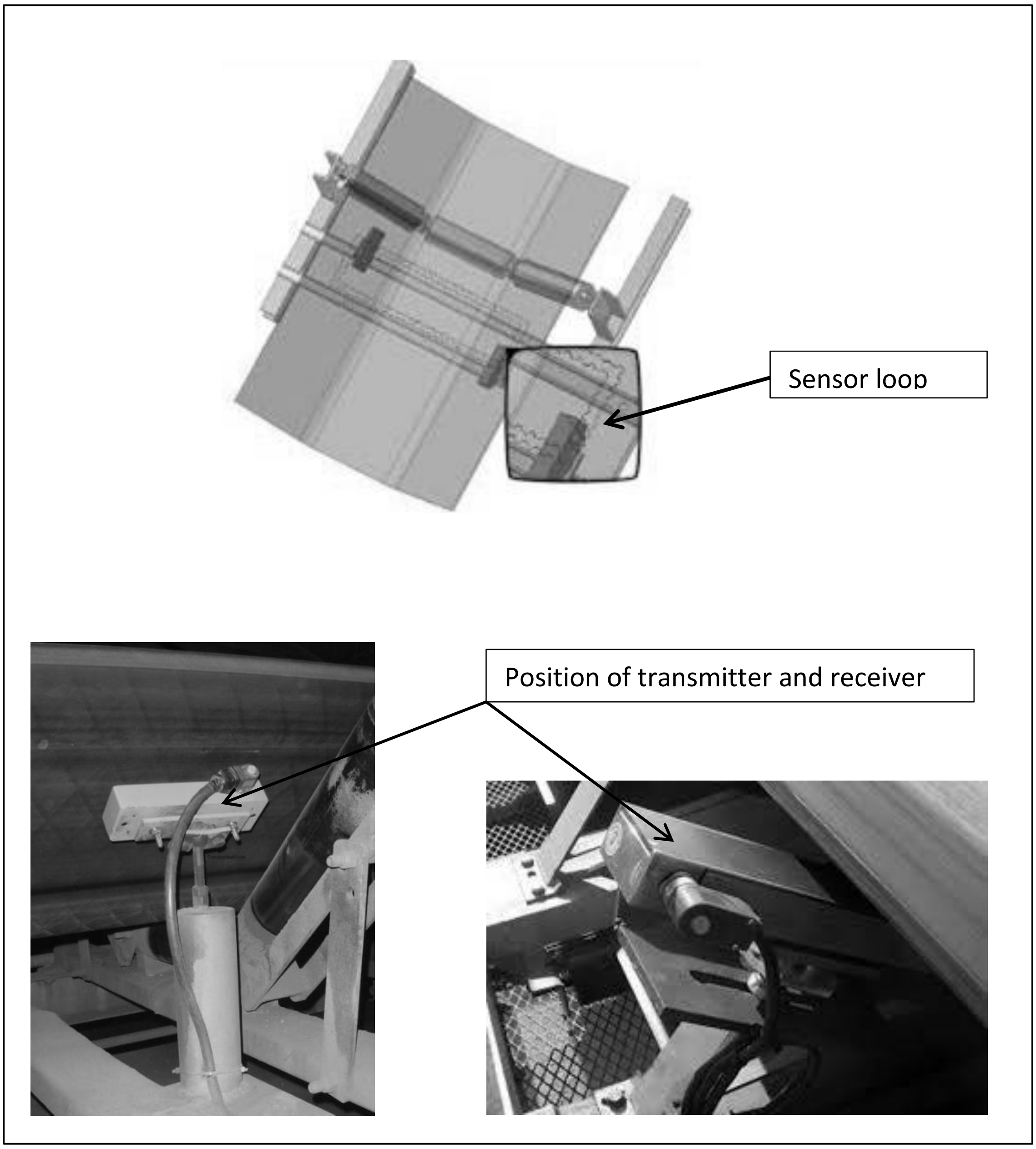

Figure 3.

When the belt is in operation, these coils pass over the transmitter/receiver pair and a signal is transmitted via the inductance coil from the transmitter into the receiver. By knowing the distance between successive coils and the belt velocity, the system can calculate the time interval between coils.

In the case of a belt rip, the appropriate coil will go "open circuit" and thus prevent a signal from being transmitted. The system will acknowledge this as a fault and stop the belt.

The sensor loop embedded in the belt works like a bridge between transmitter and receiver of the system interface. If the belt is ripped the system cannot measure any analog value from the destroyed coil.

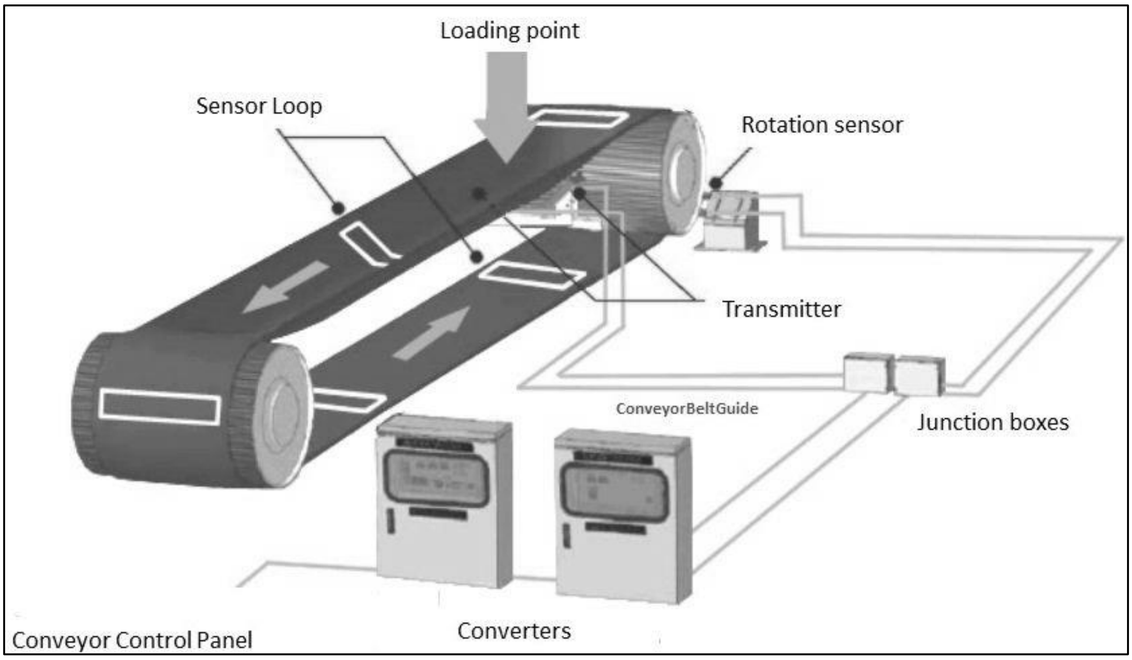

Figure 4. Inductive coils System layout.

After initial installation, the system carries out the “identification run“ and the master control unit will store all the successions of coils in the belt. When finishing the „identification run“ the system knows the internal spaces between every coil in the belt.

The Control Unit expects the corresponding analog values depending on the speed of the belt within a certain time. If this time is exceeded (missing the expected value) the master switches off the motor drive and stops the belt.

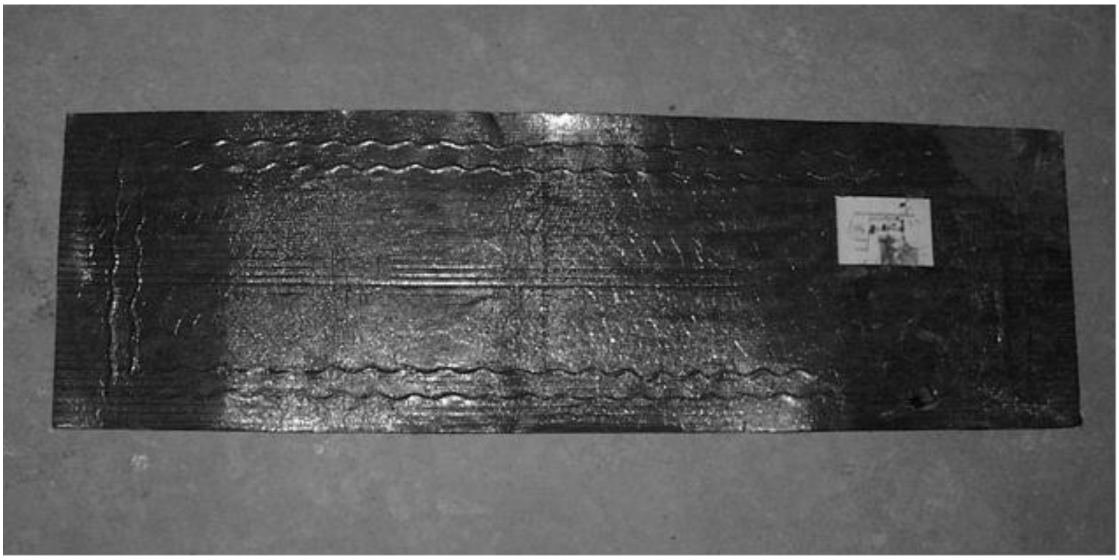

Figure 5.

The rip detection system is used to detect longitudinal rips on predominantly steel cord conveyor belts and in very rare cases plied belting and to prevent greater damage to the belt by stopping the belt drives.

Tears usually occur at the loading point and provoked by foreign bodies. Less frequent damage will occur along the length of the belt or at the discharge point.

The belt rip detection system is utilized wherever there is a danger of longitudinal belt rips, in most cases on long overland conveyors or conveyors critical to the reliable operation of a plant or mine.

Inductive coils should be selected according to belt width and type of rubber. They can be supplied either as raw rubber plates for installing in steel cord conveyor belting during manufacture or as vulcanised plates for retrofitting for cold and hot vulcanisation. This is time consuming and can take as long as a normal splice (6 – 8 Hours)

Figure 6. Retrofitting of Sensor loop

The total number of coils necessary to protect the conveyor is user dependant. If embedded in short distances (like 15-20m) in case of rip, the maximum tear will only be 20m. With surface conveyors, the coils are integrated usually every 100 to 200 metres, whereas the distance between coils in underground installations does normally not exceed 50 to 80 metres. For very important and hazard exposed belt conveyors the distance range is 10 to 50 metres.

The system works on the principle of “secondary“ rip detection, i.e. rips are detected only after they have occurred. They cannot be prevented but the damage can be reduced to a minimum.

Disadvantages

- High frequency of nuisance trips have been reported. Resulting in system being bypassed.
- Relative high initial cost
- Transmitting and receiving units susceptible to damage through spillage due to its proximity to the belt.

Figure 7. Damage to transmitter cable due to spillage

- Long downtime for retrofitting damaged sensor loop coils.

THE FUTURE – NOW

Advances made in RFID technology has made it possible to use this type of systems in condition monitoring and in particular in Rip detection systems.

RFID – Radio Frequency Identification is the wireless use of electromagnetic fields to transfer data, for the purpose of automatically identifying and tracking objects fitted with identifying tags. Passive tags are powered through electromagnetic induction from magnetic fields produced near the reader. Active tags are fitted or connected to a power source. RFID Tags does not have to be in line of sight of the reader to be read or identified.

RFID have been integrated into sensor loop systems during the last couple of years. The function of these tags was mainly for identification of the sensor loops and to facilitate in the identifying of the location of the damage to the belt.

Recent advances made in RFID technology have given rise to the development of a rip detection system where the RFID tag forms the backbone of the system. The RFID tag is no longer used for identification purposes only.

This system utilizes UHF RFID tags. UHF RFID tags incorporate the use of electromagnetic or electrostatic coupling in the radio frequency portion of the spectrum to communicate to and from the tag.

Figure 8. Example of RFID tag

UHF RFID tags operate in the 800 to 950 MHz range and use less power and are better able to be read through nonmetallic substances. This makes it ideal for use in rubber products. UHF tags offer better range and can transmit data faster. UHF tags can be read at speeds in excess of 20m/s.

The recently developed RFID Rip Detection system utilizes UHF RFID tags with a single strand antenna running across the width of the conveyor belt in place of the more traditional sensor loop. This means that the antenna size is reduced considerably from approx. 400mm wide to only 100 mm wide. The thickness of the antenna and RFID tag is less than 3mm in diameter which lends it to the insertion in belting with thinner covers.

Due to the tags resistance to high temperatures and pressures it can be fitted to any belting during the manufacturing process. Plied, steelcord and PVC nitrile belting can now be fitted with rip detection loops.

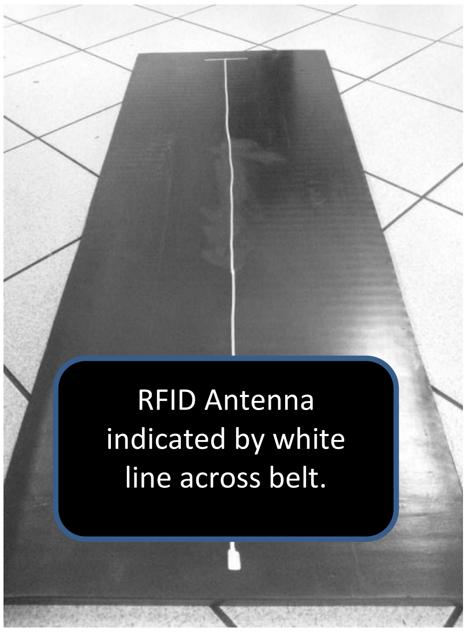

Figure 9. RFID Antenna embedded during vulcanization

A major advantage in this development is the cost of the antennas and the ease of retrofitting to an existing belt. At roughly 1/10th of the price of a standard sensor loop the antenna can be retrofitted to any existing belt with sufficient covers in approx. 2 hours, compared to 6 – 8 hours needed to retrofit the standard sensor loop.

Due to the low cost of the antenna it makes sense to reduce the intervals at which the antennas are inserted in the belt, it is now possible to limit the potential loss of belting due to rips to a minimum. 10 to 15 m intervals as opposed to the standard 50 m with traditional sensor loops. A rip of 50 m or more will in most cases make it necessary to fit an insert in the belt and two splices. By reducing the potential loss of belting to 10m there is no need for an insert or two splices, further reducing down time and production loss.

The system consists of the following,

- UHF RFID antenna – Embedded in conveyor belt
- RFID Reader
- Master Control unit

Figure 10. UHF RFID reader

Once installed, the system requires one revolution of the belt to memorize the individual RFID tags and the distance between each tag. It then switches automatically to active mode once the first tag is recognized.

In the event of the master control not reading the expected tag after the memorized number of pulses it will stop the conveyor.

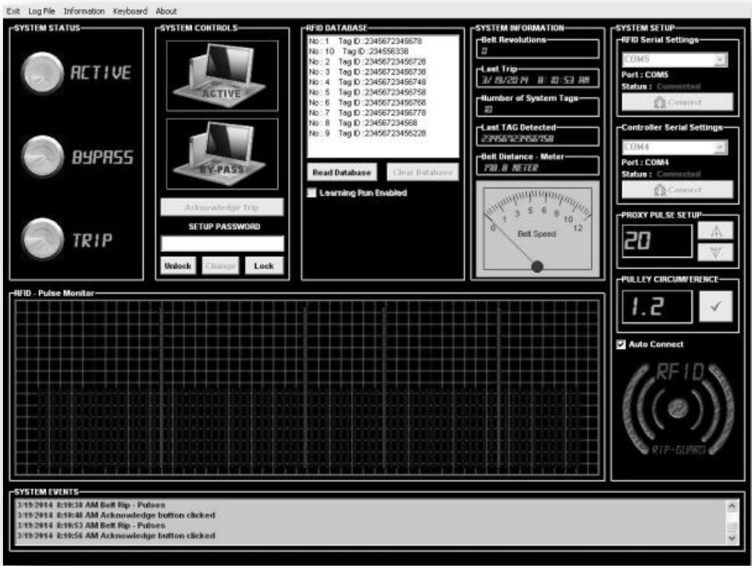

Figure 11. System Master control unit

UHF RFID tags are read and write capable which makes it possible to write information to the tag. Up to 8 pages of text information can be written to the tag. Conveyor belt databooks, quality documentation, installation dates etc. can now be written to the tag and accessed on site using a handheld scanner.

Thus through the cost effective use of the latest technology available it is possible to reduce the risk of catastrophic longitudinal rips in all conveyor belting and minimize to impact in such an event

2 – BELT THICKNESS AND WEAR MEASUREMENT AND MONITORING

Another method of condition monitoring revolves around the measurement of belt thickness at regular intervals in order to determine the wear rate and pattern of any particular belt. Through this measurement and tracking of the wear it is possible to, with a fair degree of accuracy, determine the remaining belt life and identify any abnormal wear patterns which might indicate ineffective or damaged components in the conveyor system.

A major drawback with this has always been the time required to do the measurements and to create a useable report.

Figure 12. Measurement is done with handheld ultrasonic measuring equipment.

Figure 13. Handheld ultrasonic thickness measurement tool.

The process most often requires a full lock-out of the system an only when the system is safe will it be possible to measure the belt. Measurements are taken at pre-determined intervals across the width and length of the belt. This could take up to 8 hours depending on the accuracy required. All these measurements are then used to plot a graph of the wear on the belt.

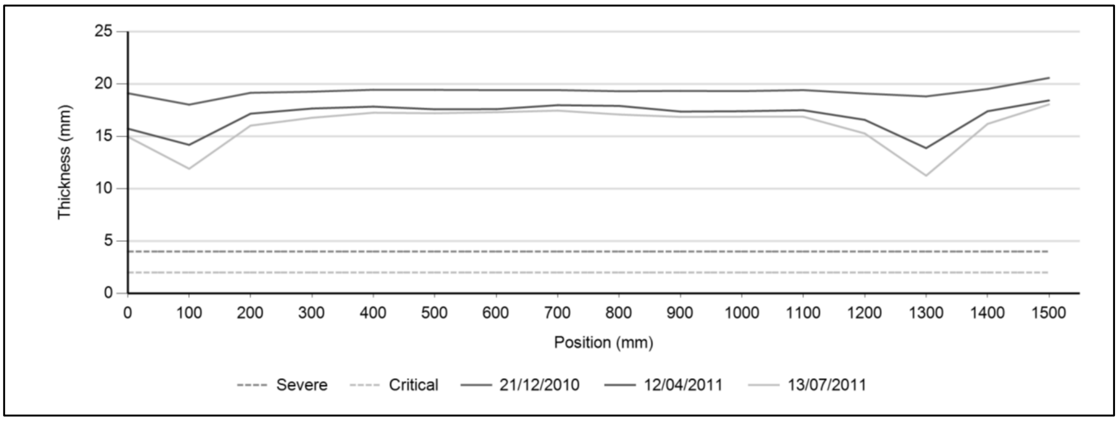

Figure 14. a Graph of thickness measurements showing cover damage by skirting rubber.

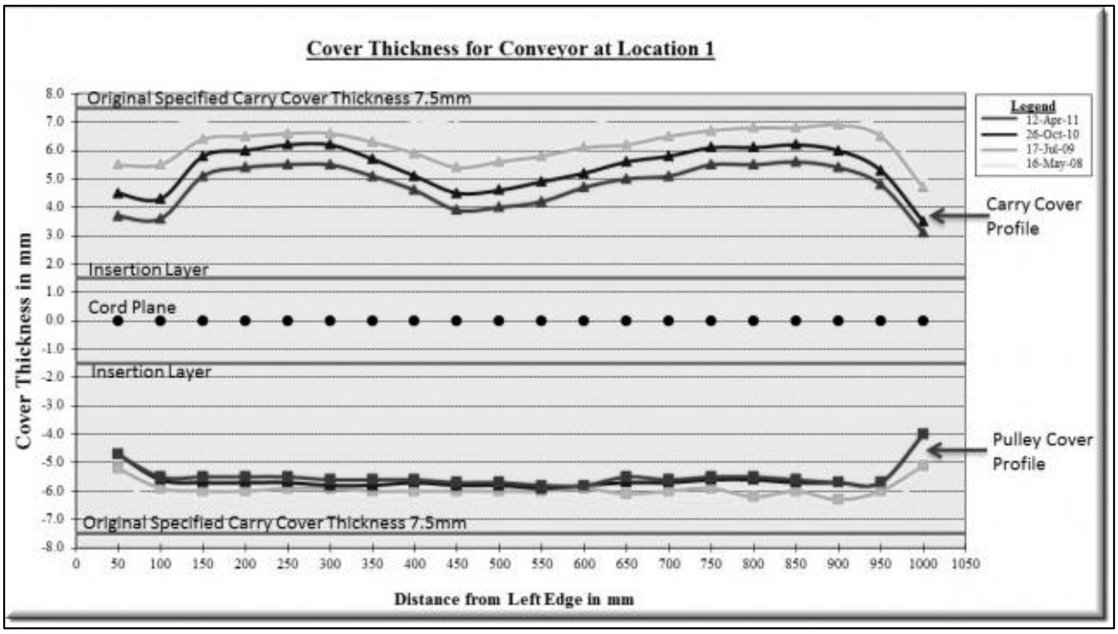

Figure 15. a Graph showing wear profile at one point across belt width.

Various systems have been developed in recent years to measure this more accurately. From using laser modules (Figure 16) to electro mechanical systems to lower a measuring unit down to the belt to perform the measurements (Figure 17).

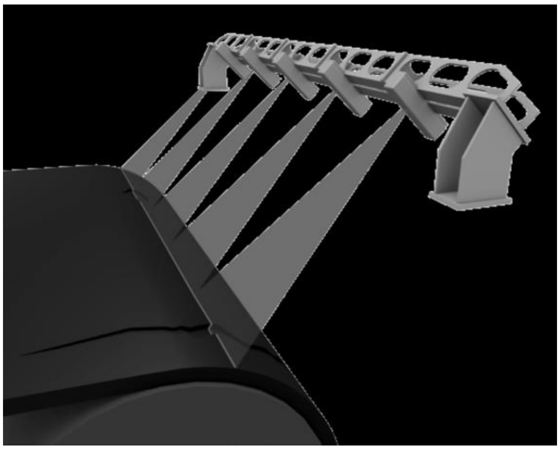

Figure 16. Laser Modules

Figure 17. Electro Mechanical unit

Enhancements in the robustness and accuracy of ultrasonic sensors have made the development of cost effective and reliable belt thickness measurement systems possible.

Continuous belt thickness monitoring has been made possible by combining RFID and ultrasonic technology.

Current systems offer the possibility to measure the thickness of any flat conveyor belt across the full width and for the full length of the belt. All this is done during production.

The only downtime is when the system is installed during normal planned maintenance.

The system consists of the following

- Master Control Unit
- RFID Reader
- Ultrasonic sensor unit

The latest ultrasonic sensors utilized are capable of measuring 100 samples per second at an accuracy of 0.05mm.

The ultrasonic sensor array is mounted on the return side at a distance of approx. 150 mm from the belt facing the top cover. As most wear will occur on the top cover, measurements are taken from this side in order to determine the full belt thickness. Due to the accuracy of the sensors it is crucial for the belt to be free from belt flap or any oscillations. For this reason calming idlers is fitted with the sensor array.

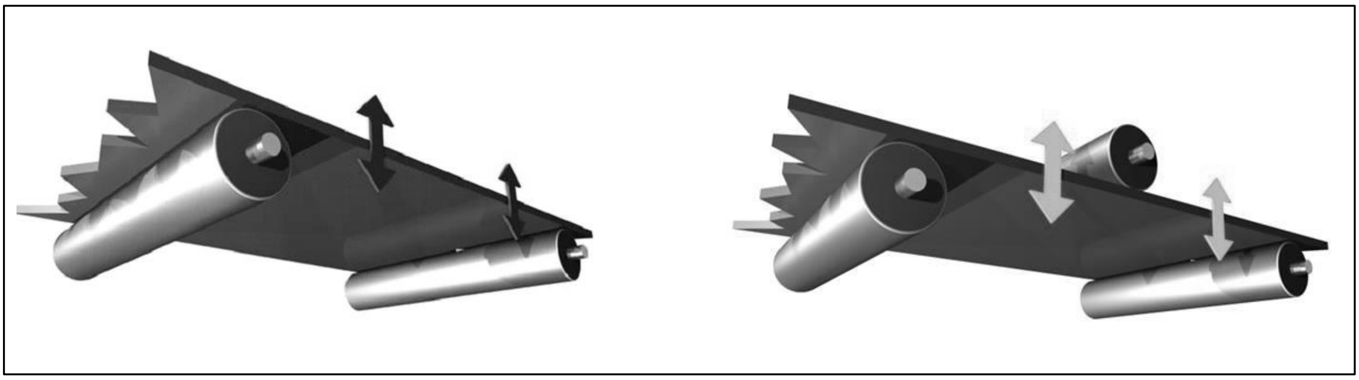

Figure 18. Calming idlers fitted to reduce oscillations

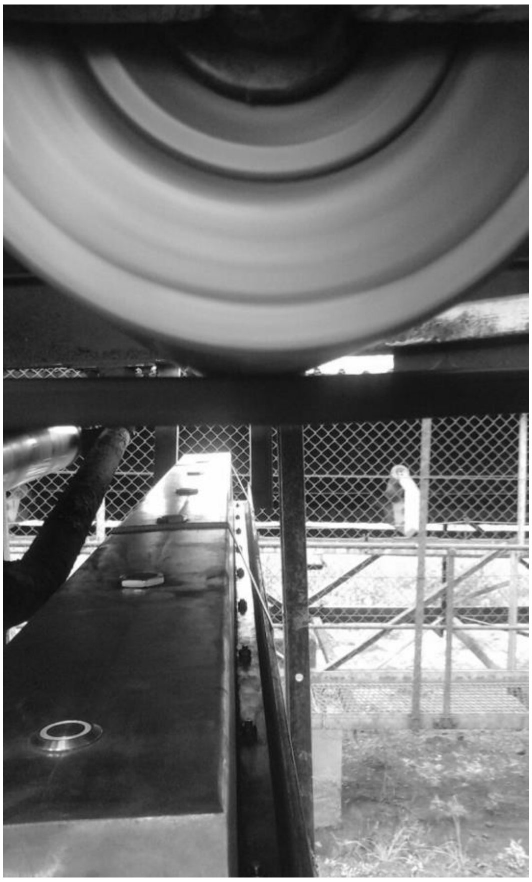

Figure 19. Sensor array fitted below calming idler

A RFID tag is installed in the belt. The system recognizes this tag and triggers the measurement for one full belt cycle. The information is processed and stored. Data for each measurement cycle is date and time stamped and saved.

Once installed the master control unit can be linked to the control room for remote access to information and measurement results. Measurement results are immediately available.

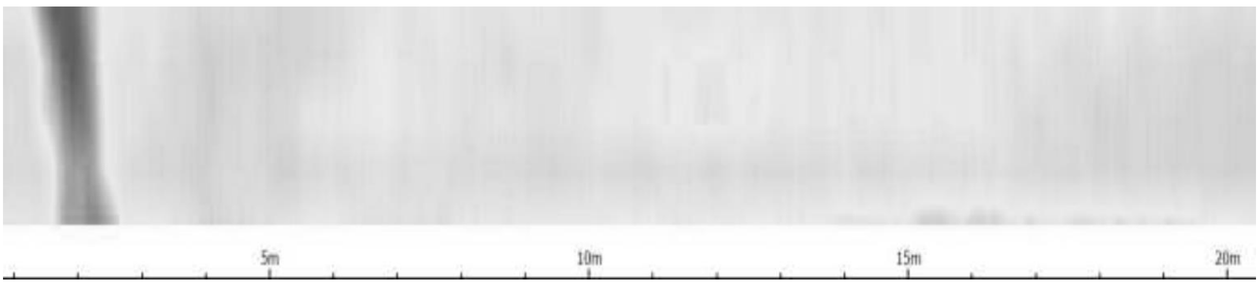

Figure 20. Shows a splice at 2 meters with normal wear to the belt, however slight impact damage can be seen at 12 meters, and damage to the side of the belt occurring between 15 to 19 meters.

By utilizing the information gathered it will be possible to detect excessive and abnormal wear and rectify the problem before a catastrophic failure can occur. The wear rate will enable the end-user to more accurately determining the remaining belt life and therefor optimize their planning and reduce stock holding.

CONCLUSION

Through the effective use of ever changing and developing technology it is now possible to operate and maintain equipment more safe and efficiently than ever before.

The ever changing industrial environment will in future put more challenges to us to ensure safe and efficient operations. It will require constant R&D, development and application of technology at our disposal realize this.

Who knows what the future holds?

ABOUT THE AUTHOR

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André is Technical Sales Manager for Dunlop Industrial Products, a member of the REMA Tip Top Group of Companies.

André is also General Manager for REMA TIP TOP Technologies South Africa.

Jointly responsible for developing the first Continuous Belt Thickness Monitoring System capable of measuring belt wear and thickness while in operation.

André was also involved in the development of the RFID Rip detection system for Steelcord, plied and solid woven conveyor belting.

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