ULTRASONIC THICKNESS TESTING OF REINFORCED RUBBER CONVEYOR BELTS

A conveyor belt is the carrying medium of a belt conveyor system which is widely used across many industrial branches, especially in mining industries for bulk handling of raw materials like coal, coke, iron ore etc. The operation of conveyor belts is closely connected to various kinds of mechanical loading, which causes wear or gradual degradation of the conveyor belts. One of many symptoms indicating such wear and tear is the abrasion of the carrying and of the pulley cover. Decrements in the belt’s cross-section reduce its puncture resistance, thus increasing the risk of core damage. A failure of the rubber belt in conveyor systems can lead to unexpected downtime of the plant and poses high safety risks.

MEASUREMENT METHOD

The primary purpose of thickness measurements is to determine the trended wear pattern and rate of wear for reinforced rubber belts. This maximizes the life of the rubber belt by predicting the end of its lifespan providing a tool for effective maintenance as well as allowing belt changes to be incorporated into the relevant budget cycle.

WHY ULTRASONIC TESTING IS NEEDED

Reinforced rubber conveyor belts consist of many layers of rubber, layers of woven fabric or steel cords or combinations of those. This means that the production process is rather complicated and there are many joints needed. These joints are done by vulcanization process. During this process, there are chances for delamination formation (air pockets) in the joint of the conveyor belt.

This defect is caused mainly by improper vulcanizing pressure or curing temperatures during the joining process. If the joints contain delamination, they will fail during their use in harsh conditions. Therefore, conveyor belt manufacturers also need ultrasonic testing to check the depth and the location of the reinforcement layer across the belt in order to ensure that the product meets the required specifications.
CHALLENGES

Lack of proper calibration points over the belt cross section

The construction of conveyor belts may involve various types of rubber at different layers. This means a calibration through the total thickness is really an average velocity at the current thickness and in the current location. Conveyor belts wear in the center but most calibrations are performed on the edge where the steel cords or fabric layers are normally not present. The fabric layer is a series of peaks and troughs so the true thickness is really an estimate depending where the probe is situated. The SONOWALL 70 meets this challenge and offers different calibration options that are all easy to execute. SONOTEC recommends trying to measure at the side of the belt where the operator can make a one point calibration over the total thickness.

External conditions: temperature & aging

The ambient temperature and aging e.g. due to sun damage is affecting the sound velocity in rubber. It is a much bigger issue compared to steel. If the temperature of rubber is raised by 10°C to 20°C a difference in the thickness reading by at least a couple of millimeters can be seen. Some operators monitor the temperature of the rubber at the time the reading was taken. In theory they could then make adjustments to the readings or try to repeat the test the next time at roughly the same time of the day. Other operators revert to night time testing since the day temperature of the rubber is above the probe limits. The most effective way to eliminate the temperature effect are regular calibrations on the hot rubber. The morning reading will be a lot different to the afternoon reading. And rubber below 10°C is too difficult to measure because it gets stiff. Therefore, it may be neccessary to wait for the rubber to warm up before starting the days readings. Due to the higher pulser voltage (400 V) of the thickness gage SONOWALL 70 operators can start comparatively earlier in the day.
Measurement repeatability (location)

The datum points used to repeat thickness readings over time is not fixed. Some operators make an attempt to find the same test location on the next survey while others do not. There is no perfect solution so assumptions are made about how uniform the readings are over the whole conveyor belt. Only a fraction of the belt is tested at any given shutdown.

Cord thickness measurement challenge

Due to the construction of the cords, cord readings have two issues. Cords are a bundle of spiraling wires so the thickness measurement varies due to where the reading was taken along the wire. The other issue is that the apparent thickness reading on the instrument and the physically measured thickness reading are different. The instrument reading plots out just below the surface of the cord. There are a number of factors. Usually a 2MHz twin crystal probe is used. Probably the wavelength is too big to read the very first wire in the cord. Also, the target wire can be too difficult to isolate on the display (the high resolution and crisp picture of the SONOWALL 70 is an advantage) so the main echo is used instead as the true thickness. Some companies apply a correction factor but the majority do not. In the field operators do not have the time to find these small signals so they record the main echo.

MEASUREMENT OF TOTAL BELT THICKNESS

As the challenges presented above show, reinforced rubber is a rather difficult material to test by ultrasound, as the attenuation inside its structure is quite high. It contains multiple layers of rubber and often even inserts of woven fabric, which prevents ultrasonic waves from penetrating the material easily. A large part of the sound energy reflects off the first layer of reinforcement. Some of it penetrates deeper into the material that can reveal valuable information of the next layers, especially if the belt contains fabric and steel cords.
Given the layered process of the rubber, sometimes complete laminations can be seen in the rubber. Normally, still some of the back wall echo can be seen but the main issue is an unskilled operator not recognizing the presents of laminations. It is the main reason a high resolution A-scan presentation is essential so the operator has a clear understanding of the internal condition of the test object. With the SONOWALL 70 a high resolution A-scan is given.

There are some rubber types where the attenuation is so severe a much higher pulse voltage is required to read the top cover or reach the back wall for calibration purposes. The low pulse voltage rules out the use of many thickness gauges. Typically these conveyor belts have fire resistant qualities and found in underground mines. We try to meet this challenge with a stronger pulser (400 V) integrated in our thickness gage.

However, ultrasonic testing of conveyor belts is limited. The measurement of the total belt thickness is not always possible, especially in case of some steel-reinforced belts combined with fabrics with no sufficient separation between the steel cords. Prior to the inspection, a feasibility study including a wide probe selection should be performed in order to determine the possible testing performance. SONOTEC and its distributors typically offer demonstrations on-site to verify the basic requirements.
MEASUREMENT PROCEDURE

Given the above factors it's not uncommon to find wide variations in thickness readings due to differences between operators and one or more of the above factors causing variations. The most efficient way is to eliminate as many errors as you can and make sure every operator tests exact the same way.

Rubber is a very sound attenuating material. Obtaining two clear back wall echoes is in most cases not possible. Accordingly using the pulse echo technique is recommended. For this reason, the equipment has to be set to single echo mode. SONOTEC recommends dual element probes. In this case, it is important to set up a V-path error correction curve for the probe used during the measurements.

Conveyor belt rubber is usually unique and may vary from belt to belt, it is necessary to calibrate the sound velocity using a sample of known thickness(-es) of the exact rubber which needs to be inspected. Ideally, a two-point calibration is performed which requires two reference thickness of the same material.
If this requirement cannot be fulfilled the suggested approach is to zero the probe and using a one point calibration. The sound velocity of typical rubber used for conveyor belts should be around 1650 m/s. If a sample is not available, V-path error correction, probe zero procedure and a manual adjustment of the sound velocity is the recommended approach.

Measuring the rubber above the reinforcement fabric (top cover) is relatively easy. Fabric is oriented perpendicular to the ultrasonic beam propagation and has a significant acoustic impedance mismatch. The amplitude signal in most cases will be much stronger and easier to evaluate than the back wall echo.

Conveyor belts that consist of steel cords are rather harder to inspect. The cords are not placed over the whole area. One of the difficulties is to locate them by observing the amplitudes that appear before the expected back wall echo. The second difficulty would be the round shape of the cord, which is not an ideal reflector.
SONOWALL 70

The SONOWALL 70 advanced A-/B-scan thickness gage was successfully employed for this kind of application. It shows great advantages over available thickness gages and matches or exceed the performance of market available flaw detectors.

Using SONOWALL 70 for testing rubber belt conveyors brings many advantages to the user:

- **Improved thickness range** due to signal strength (square wave 400V transmitter) and the possibility to use low frequency probes (down to 0.5MHz, single or dual elements)
- **Improved accuracy** due to an improved signal quality (averaging, digital filters selection, low noise amplifier up to 110db dynamic range)
- **Measurement efficiency** (time) optimization due to software flexibility in adjusting automated functions (Auto Gates; Auto Gain and Auto Range)
- **Fast Reporting** due to comprehensive data logger with easy export to Excel (*.xls), PDF or CSV file

PROBE SELECTION

Belt thickness, composition and measuring accuracy will determine the probe selection – but in general, SONOTEC recommends:

- 0.5mm – 5mm dual element 0 degree, piezocomposite, 5MHz TS5i probe
- 3mm – 50mm dual element, 0 degree, piezocomposite, 2 MHz TS2i probe

A big advantage of SONOWALL 70 is the full software support for the third party probes, which opens a possibility to solve any virtually possible task by the device.
ABOUT US

With currently over 170 employees, SONOTEC GmbH is an international growing company. The company has established itself on the worldwide NDT market with UT products developed and made in Germany.

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