ANALYSIS OF CAUSES WHICH DETERMINE THE DEGRADATION OF CONVEYORS WITH METAL INSERTS

Sabin DIMULESCU, Lucian Blaga University of Sibiu, Sibiu, Romania
Dan DOBROTĂ, Lucian Blaga University of Sibiu, Sibiu, Romania

Abstract: *The paper aims to analyze the causes that lead to the rapid degradation of the conveyor belts with metal inserts and their removal. Thus, the analysis revealed three main causes, namely the separation of the metal cord inserts from the rubber matrix, the longitudinal splicing of the conveyor belts with metal inserts, the appearance of micro cracks on the bearing face and on the rolling face. The analysis highlights the main aspects of the major problems encountered during the operation of conveyor belts.*

Key words: conveyor belts, causes, degradation, problems with metal inserts.

1. INTRODUCTION

Conveyor belts ensure the transport of raw materials, are very important in production processes and have a high applicability in areas such as mining, food industry, petrochemical industry, silos, sorting stations, construction etc. Conveyor belts are an integral part of production equipment and technology units, and by their use, companies increase production efficiency significantly, from discontinuous production to continuous production [1].

Steel cord conveyor belts are based on rubber-metal adhesion, are generally used to equip high-capacity conveyors with good resistance to breaking reliability and flexibility. They are classified into: general use tapes; antistatic and flame resistant strips [2].

Figure 1 shows a steel cord insert. The casing is made of parallel steel cords and covered with a rubber layer on both sides. The bands used are made of steels with a tear strength of 1300-6300 N / mm, and to enhance the adhesion to rubber and protect them against corrosion are covered with a layer of brass or zinc. The diameter of the wires is between 3.8 and 8.3 mm. The ratio of the cords and their diameter decreases with increasing diameter and usually has values between 2 and 3 for 4 mm diameter and 1.5-2 for larger diameter cords. The steel cord inserts are executed only with covered edges.

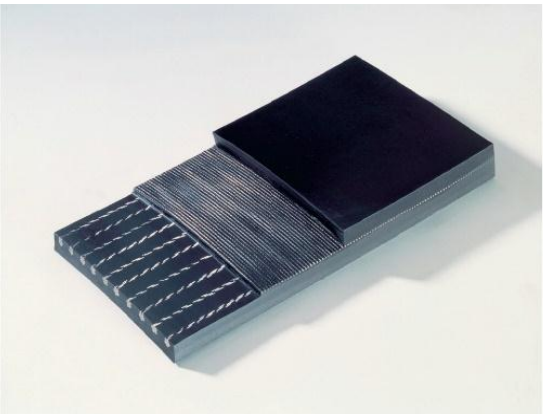

Figure 1. Structure of conveyor belt with metal inserts

Conveyor belts are classified into different strength classes, and the strength class of metallic inserts is influenced by the number and breaking strength of the metal insert (Table 1).

Table 1. Strength classes of conveyor belts with metal inserts

Clasa de rezistenta	Grosime placi de acoperire (mm)		Grosime totala (mm)	Latime banda transportoare (mm)						
	Placa portanta	Placa de rulare		800	1000	1200	1400	1600	1800	2000
ST 800	4	4	14	■	■	■				
	6	4	16	■	■	■				
ST 1000	4.5	4	14		■	■				
	6.5	4	16		■	■				
ST 1250	4.5	4	14		■	■	■			
	6.5	4	16		■	■	■			
ST 1600	6	4	18		■	■	■	■		
	8	4	20		■	■	■	■		
ST 2000	6	4	18		■	■	■	■	■	■
	8	4	20		■	■	■	■	■	■
	8	6	22		■	■	■	■	■	■
	10	6	24		■	■	■	■	■	■
ST 2500	7	4	20		■	■	■	■	■	■
	8	5	22		■	■	■	■	■	■
	9	6	24		■	■	■	■	■	■
	10	8	27		■	■	■	■	■	■
ST 3150	8	4	22		■	■	■	■	■	■
	10	4	24		■	■	■	■	■	■
	10	7	27		■	■	■	■	■	■

Conveyor belt layers are made to provide the conveyor with environmental stress, mechanical and chemical action of the carried material, the carrier plate is resistant to abrasion and UV radiation, and the treadmill provides wear and tear resistance from the contact with the bearing rollers [3, 4].

Conveyor belts with steel cord inserts working under heavy conditions, with vibrations and permanent shocks must have high resistance and flexibility. The ratio between the thickness of the tread and the thickness of the bearing plate must be 1: 1, 1: 2, 1: 3 [5]. In order to cover the entire variety of stresses to which the conveyor belts are subjected, the casing cover plates must be made of a particular type of rubber which has to be resistant to the specific working environment (6). The cover plates are made of different rubber mixtures having the following characteristics [7, 8]:

- resistance to high physical and mechanical stresses in dynamic conditions (NR);
- resistance to abrasion and environmental stresses under ordinary temperature conditions (SBR);
- resistance to oil products, fat (NBR);
- high temperature resistance (EPDM);
- Flame resistance (CR).

The total thickness of a strip is given by the sum of the cover faces and the case having standardized values ranging from 14 to 17 mm. The thickness of the strip is given in millimeters (mm) and the tolerances allowed are:

- for thicknesses less than or equal to 18 mm = +/- 1 mm;
- for thicknesses greater than 18 mm = +/- 10%.

The lengths of the steel cord are specified in meters. Steel cord straps over 18 m thick are made up to 210 m in length due to their large gauge weight up to 20 tons. Over this gauge in the manufacturing process and their manipulation can be difficult.

2. ANALYSIS OF THE CAUSES WHICH DETERMINE THE DEGRADATION OF STEEL CORD INSERT BANDS

Conveyor belts work under heavy conditions with high humidity, UV radiation, dust and large temperature variations between -30 ° C and +45 ° C being physically and mechanically highly demanded, all of which cause problems in operation and removal of the use of the conveyor belts

From the analysis of the causes leading to the removal of the conveyor belts the following were identified:

a - detachment of the cable strands from the rubber matrix, Figure 2;

b - longitudinal splicing of the bands, Figure 3;

c - the appearance of micro cracks on the cover faces, Figure 4.

The detachment of the rubber strands of the rubber matrix is caused by the degradation of the bond between the metal insert and the rubber matrix, can be determined by the vibrations occurring during the operation of the belts, the vibrations transmitted between the two components, the metal insert and the rubber matrix. Modeling vibrational phenomena involves defining the structure and parameters of bodies in vibration, functions that describe the excitation and levels of dynamic response. The rubber is a very good shock absorber and the metallic insert is rigid, there are differences between the particle vibration amplitude and the vibration velocity of the particle at the rubber-metal interface. Increasing the degradation coefficient of the bond between the metal insert and the rubber matrix causes defects to occur, the phenomenon of pulling out the metal insert in the rubber matrix (Figure 2). Pulling the metal insert in the conveyor belts causes the conveyor belts to be quickly removed without being able to determine the period.

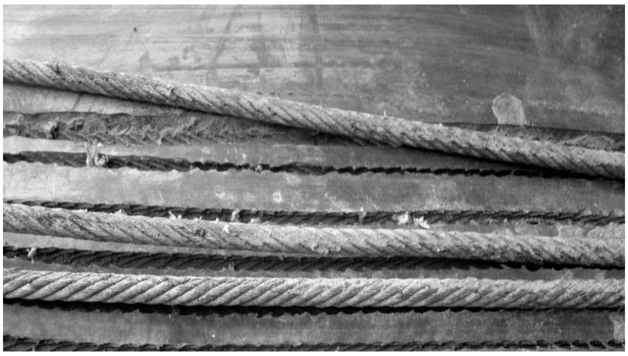

Figure 2. The method of pulling out the metal insert from the conveyor belt

One of the causes may also be the recipe for preparing the rubber compound used to make the conveyor belt. A large amount of added sulfur in the composition (9-12%) can lead to too much stretching of the rubber and during exploitation and consequent permanent vibrations it is possible to create the phenomenon of detachment of the rubber strands of the cable matrix.

When preparing the rubber recipe next to sulfur, add other constituents such as:

- vulcanization accelerators (ZnO, P_2O_5) are introduced to reduce the duration and temperature of vulcanization;

- Curing agents are required to increase breakage and wear resistance;

- fillers have a passive role, do not act on the properties of the rubber recipe but reduce the cost;

- plasticizers ensure plasticity of the rubber and make it resistant to low temperatures;

- antioxidants reduce aging of rubber;

- regenerated rubber is used to reduce manufacturing costs.

These structural constitutions must be added in appropriate quantities, depending on the working environment of the strip. A poor recipe for curing agents, with small amounts of plasticizers and oxidants, leads to the production of low-life bands.

Longitudinal splicing of conveyor belts with metal inserts is one of the causes that lead to the rapid removal of conveyor belts. This phenomenon occurs due to inappropriate operation and high wear of the conveyor belt cover faces (Fig.3).

If working conditions are excessive they lead to the premature aging of running faces causing their thinning and implicitly the phenomenon of longitudinal splintering. A very important factor is also the quality of the rubber in the casing covers and, if it does not have the specific features of the band's working environment, the degradation of the cover faces is inevitable. Improved wear on the conveyor belt faces after commissioning may also occur due to the aging of the rubber due to its long storage under improper atmospheric conditions.

Figure 3. The longitudinal splicing of the conveyor belt

In order to obtain conveyor belts with certain physical-mechanical properties, it is necessary to add raw materials to the rubber to give the finished product the desired qualities. These raw materials are added under certain conditions according to a prescription. Establishing manufacturing prescriptions for conveyor belts are required by their functional conditions.

The main functional conditions imposed on conveyor belts are:

- traction resistance, elongation at break, hardness, elasticity, abrasion resistance, tearing, compression;

- resistance to atmospheric conditions;

- resistance to high temperatures;

- resistance to aggressive media, mineral or vegetable oils, greases, fats, acids, bases, salty liquids.

The appearance of micro cracks on the cover faces is one of the causes that lead to the removal of conveyor belts. Conveyor belts with steel cord capacity due to too high loads can cause a drum friction phenomenon, a phenomenon that can lead to a higher surface temperature. The high surface temperature over time can destroy the chemical bonds in the rubber layer resulting in an advanced degradation of the conveyor belt.

Also, the exposure of the conveyer belts to humidity, gaseous pollutants, UV radiation, reduces their life span. UV radiation also leads to breakage of surface polymeric bonding of the rubber layer causing the appearance of transverse microchip networks Fig.4.a.b.

The conveyor belts are required for friction wear on the rolling-guide components and the polluting environment with tailings dust, clay, coal dust in which they work. The vulcanization process of steel cord conveyor bands is discontinuous and is carried out on 10-12 ml cured vulcanized presses.

A cause that can lead to the degradation of the coating faces of the conveyor belts can also be determined by the high temperature that exists in the strip after vulcanization. The temperature accumulated in the rolled strip on the drum immediately after vulcanization is maintained, and the cooling is done over time by heat loss. This prolonged time in which the drum roll is kept at a temperature close to the vulcanization temperature can lead to the destruction of chemical bonds in the rubber layer.

The pollutant environment with tailings dust, clay, coal dust, requires friction wear on the rolling-guide components. The steel cord reinforced rubber band responds both to demands due to the heavy material 1.8 - 2.2 t / m3, with large dimensions 0-400 mm and high humidity, as well as lower demands such as those of 1, 2 - 2.4 t / m3, granulation 0 - 350 mm and medium moisture

When the rubber coatings (Figure 4a, b) have reached a degree of wear which endangers the constraining structure of the conveyor belts, one of the main measures intended to extend the length of use of the belts is their reconditioning.

a) network of cracks on the carrier face

b) network of cracks on the rolling face

Figure 4. Transverse cracks on conveyor belt

The reconditioning of the conveyor belts consists in the repair of the rubber layers and of the damaged inserts, as well as their adjustment to the initial manufacturing sizes. Such an operation is preceded by a series of activities, which mainly aim at preparing the strip structure. The re-conditioning of the bands leads to a prolongation of their lifetime, as well as a reduction of the costs for the economic agents.

The average durability of the transport bands is four years, and the financial effort made by these units is high. In the literature, reconciliation costs are reported as about 50% of the acquisition costs of a new strip. There are also economic benefits and the correct application of conveyor belt maintenance activities, increasing their life span.

3. CONCLUSIONS

In order to increase the lifetime of the conveyor belts, it is necessary in the steel cord manufacturing technology to pay particular attention to the choice of material and optimum manufacturing parameters. Optimizing the manufacturing process according to the conditions in which the conveyor belt works can lead to a considerable improvement in the lifetime of the steel cord conveyor belts.

In order to increase the life of the conveyor belts and to avoid the occurrence of the phenomena presented, the following parameters must be considered :

- choosing a high-strength rubber recipe for steel cables;
- the working temperature of the rubber during calendering;
- preheating and homogenizing the rubber on the rollers before calendering;
- work speed;
- tensioning of steel cables at the calender entrance;
- choosing the coating material of the steel cord;
- choosing optimal curing parameters (time, pressure, temperature).

If the above mentioned parameters are not chosen properly, various defects leading to the removal of the conveyor belts may occur, namely: porosity on the cover faces; incomplete vulcanization; air voids between the housing and the cover faces; lack of linearity; low resistance to traction, elongation, breaking, hardness, elasticity, abrasion, tearing.

REFERENCES

1. G. Li, J. Zhu Tan, J. Ming Gong, Chemical Degradation of the Silicone Rubber in Simulated PEMFC Environments, Advanced Materials Research, Volumes 197-198, 2011, pp 741-748, DOI 10.4028/ www.scientific.net/ AMR.197-198.741

2. D. Dobrotă Dan, G. Dobrotă, An innovative method in the regeneration of waste rubber and the sustainable development, 2018, Journal of Cleaner Production, pp. 3591-3599, vol. 172

3. Gh. Amza, D. Dobrotã, A. Semenescu, D. Iancului, Researches concerning the ultrasonic energy's influence over the resistance at extraction of the metallic insertion from the rubber matrix, Materiale Plastice, vol. 45 (2008), no. 4, pp. 377-380

4. P. Cheremisinoff, Handbook of Polymer Science and Technology, M Dekker, New York, 1989.

5. S.H. Zhu, M.K. Cheung, C.M. Chan, Interfacial characterization of compatibilized PVC/SBR blends by solide state N.M.R. and T.E.M., Polymer 39(24), (1998), 6099;

6. D. Dobrotă, Adhesion degradation of rubber and steel insert for conveyor belts, Journal of Adhesion Science and Technology, *vol. 27*, no. 2, pp. 125-135, 2013

7. R.F. Noguiera, M.I.B. Tavares, Carbon-13 NMR study of poly(alphamethylstyrene), Polymer Test., 20 (2001), 379;

8. Grosh Swapan, K., Bhattacharya, A.K., De, P.P., Rubber Chem. Technol., 2001, 74, 5, 883.