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DETERMINATION OF MECHANICAL PROPERTIES OF COMPOSITE MATERIALS-THE RUBBER CONVEYOR BELT WITH CARTRIDGES MADE OF POLYESTER AND POLYAMIDE

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Abstract: A large number of cracking the conveyor belt, which occurs during exploitation at stress level lower than the permitted, indicates a risk of damage and breakage. Therefore in designing it is necessary to define criteria by which one can achieve safety of exploitation conveyors with rubber belt from damage and breakage. In this analysis it is very important to treat the rubber conveyor belt as a classical composite material, which consists of a rubber as a matrix and a polyester- polyamide canvas as reinforcements. Rating of mechanical and exploitation properties, i.e. the emergence and development of damage in composite materials due to the static and dynamic loads is complex phenomenon's which consist: micro cracks in the rubber, a breakage of fiber of polyester-polyamide canvas, weakening of connection rubber-canvas and delamination. In this paper is presented the results of experimental studies of composite materials the rubber conveyor belt with cartridges made of polyester and polyamide. It is also presented the results of a new and exploited rubber conveyor belts in the direction of the load action, as follows: tensile strength, modulus of elasticity, Poisson's coefficient and strain.
Keywords: conveyor belt, tensile strength, stress-strain, Poisson coefficient, modulus of elasticity

1. INTRODUCTION

The belt conveyor is the main, most expensive and least durable component conveyors with rubber belt. An appropriate choice of rubber belts in mines with underground and in surface exploitation has not been paid adequate attention always. This results in the application of rubber belts of inadequate performance of concrete structural design of belt conveyors and working environment conditions.

The consequence is a lower degree of utilization of the transport system, in order to halt due to: traction, the need for centering bands, intervention on the devices for tightening, tearing rubber bands, connection rubber bands, etc. which resulting with losses in transport and shorter lifetime of rubber bands. A part of these problems arises as a result of inadequate maintenance, due to the fact that the achievement of higher production is often on the priority, and timely maintenance actions are in the second plan are. All this causes a reduction in efficiency of transport [1,2].

2. THE EXPERIMENT

Rubber conveyor belt is composed of upper and lower rubber mantle (lining) and core of conveyors belts. The core comprises a polyester-polyamide. The manufacturer of rubber belts for certain parts of the belts states the following properties which are given in Tables 1 and 2.

Table 1. The physical-mechanical characteristics of the core of the conveyor belt

Attribute materials	Type of material	
	P, (polyamide)	E, (polyester)
Normal tensile strength, [N/mm]	990	1150
Elongation at break, [%]	17	14
Modulus of elasticity,[N/mm^2]	5.5	13.8
The mass of material, [g/cm^3]	1.14	1.38

Table 2. Other characteristics of rubber conveyor belts

The thickness of the rubber conveyor belt, [mm]	20
The thickness of the support (upper) rubber lining, [mm]	6
The thickness of the sliding (bottom) rubber linings [mm]	4
Number of bearing cartridges in bar [-]	4
The adhesion between the bearing rubber lining and cartridge, [N/mm]	min. 3.5
The adhesion between the cartridges, [N/mm]	min. 4.5
The adhesion between the sliding rubber lining and cartridge, [N/mm]	min. 3.5
Tensile strength, [N/mm]	2000

Testing to tension, using extensometer and strain gauges is performed on an electro-mechanical testing machine. The test procedure is defined in ASTM D3039 [4]. Before the test, dimensions of the test tube are measured, and then on the test tube the strain gauges are glued. During the testing procedure deformation ε extensometer and strain gauges are registered continuously in the function of the introduced load.

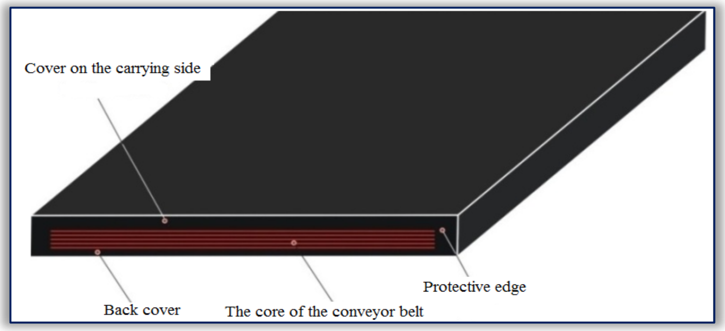

Figure 1. Cross-section of rubber belts with textile cores

Introduced load was registered by the load measuring cell with capacity of 100kN. Unit elongation was measured by an ultrasonic extensometer with measuring range up to 100% elongation, and the class of accuracy of 0.05.

Strain gauges in addition to measuring the deformation, are also used for accurate calculation of the modulus of elasticity (used as individual measurement LY13 10/120 and 4/120 of the scales chains KY19) and Poisson's coefficient (10/120 rosette XY91). Preparation and gluing of rosette and chains gauges are shown in Figure 2.

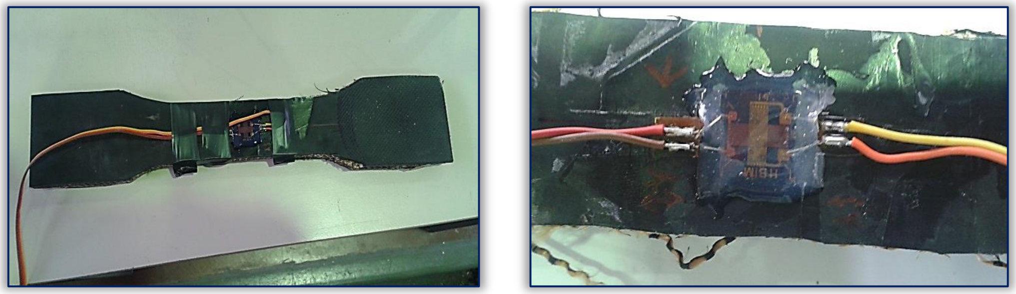

Figure 2. Prepared specimens with the rosette 10/120 XY91

For collecting and processing data from strain gauges and measured results the following electronic equipment are used:

- Multichannel measuring device UGR 100;
- Personal computer, with associated software for data acquisition;

The results of determination of tensile properties of test tubes taken from a composite rubber conveyor belts and rubber as a matrix polyester -polyamide canvas as reinforcements are given in Table 3 for test tubes sampled from the longitudinal direction, and in Table 4 for test tubes sampled in a transverse direction [4,5].

Table 3. The results of the group of longitudinal test tube of the new conveyor belts

Designation the tubes	Tensile strength, R_{m1}, MPa	Interruption strength, N/mm	Modulus of Elasticity E_1, MPa	Deformation ε_1, %
NU-1-1	115.4	2192.0	2.11	112
NU-1-2	100.3	1904.6	2.07	128
NU-1-3	104.5	1950.0	2.26	153
NU-1-4	110.5	2100.0	2.18	113
NU-1-5	105.7	2009.3	2.31	108

Table 4. The results of the test group of transverse tube of the new conveyor belts

Designation the tubes	Tensile strength R_{m2}, MPa	Interruption Strength R_{k2}, N/mm	Modulus of elasticity E_2, MPa	Deformation ε_2, %
NP-1-1	21.9	442.9	0,42	98.5
NP-1-2	19.7	426.4	0,38	98.7
NP-1-3	23.0	448.8	0,29	97.9
NP-1-4	21.8	424.2	0,33	97.1
NP-1-5	21.4	417.8	0,35	96.8

In order to accurately determine the elastic modulus, and most importantly Poisson's coefficient, for these tests measuring tape, measuring rosettes and chains of measuring gauges are used. As measuring gauges have limited deformable characteristics (there are used the most recent types of measurement rosette and chain of measuring gauges which measure the deformation a maximum of up 5%), are used solely to determine the Poisson's coefficient, and to confirm if the results of determining the modulus of elasticity obtained by extensometer reliable .

The results of the determination of tensile properties, and the Poisson's coefficient for test tubes taken from the new rubber conveyor belt of composites made from the rubber as a matrix and the polyester-polyamide canvas as reinforcements are given in Table 5 for the test tubes sampled in the longitudinal direction, and in Table 6 for the test tubes sampled from the cross-direction. [4,5,]

Table 5. The results of the group of longitudinal test tube of the new conveyor belts

Designation the tubes	Tensile strengthR_{m1}, MPa	Interruption strengthR_{k1}, N/mm	Modulus of elasticityE_1, MPa	Poisson's coefficient ν_{12}	Deformation ε_1, %
NU-2-1	101.2	1.968.5	2.35	0.380	113.9
NU-2-2	116.8	2.124.7	2.31	0.393	102.7
NU-2-3	108.5	2.056.8	2.23	0.384	99.5

Change in the longitudinal and transverse deformation in introduction of the axial load in the time is shown in Figure 3. From the ratio of the transverse and longitudinal deformation Poisson's coefficient is determined.

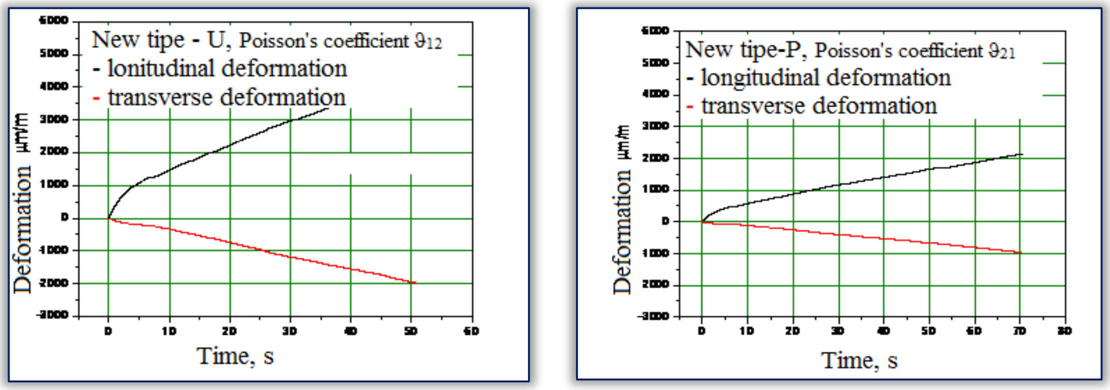

Figure 3. Change of longitudinal and transverse deformation, the new tape
- longitudinal direction, transverse direction

Since one of the objectives of testing and assessment of the homogeneity of the rubber conveyor belt, it has been testing to tension using the chain gauges 4/120 KY19. Chains gauges are used exclusively for assessing the homogeneity of the test material.

Changing the deformation state of specimens taken from the new, in the longitudinal and transverse direction is shown in diagram on Figure 4.

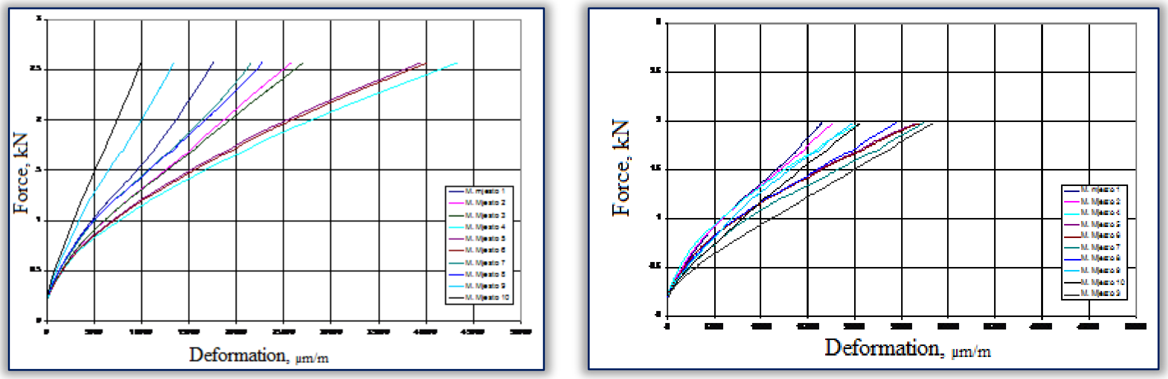

Figure 4. Changing of deformation state, the new tape -longitudinal direction, transverse direction

3. CONCLUSIONS

Based on testing of test tubes we got the mechanical properties for the test tube N-In (new-longitudinal) and N-P (new-lateral). The obtained Ki values of tensile strength are in the range of 108.8 MPa for N-U tubes while testing of test tubes by introducing load transversely on the direction of movement of conveyor belt, the obtained values are in the range of 19.2 MPa for the Group N-P.

The obtained values for the Modulus of elasticity are in the range from 2.3 MPa for N-U while for the load in the transverse direction Modulus of elasticity are in the range from 0.4 MPa to N-P.

Deformations which are obtained with this research are very interesting, where it is noticeable that for N-U (new-longitudinal) 105.4% while for the transverse test tubes, deformations are 95.8% in N-P (new-transverse).

The Poisson's coefficient is also determined. For the U-N (new-longitudinal) Poisson's coefficient is 0.386 and for the P-N (New-transverse) it is 0.333.

If we compare the results of the test stress-deformation with the results of the strain gauges is visible slightly dissipation individual results. Slightly dissipation of individual results can be explained because the rubber conveyor belt consists of three materials which have different tensile strength (rubber, polyester and polyamide). Also, due to entanglement of fibers polyester-polyamide and various stress distribution along the axis of the fiber, all fiber is not the same strain. The result is a different time firing fiber. Some fibers are firing at lower and some at higher loads. The fibers that earlier firing cause disorder in the zone of fracture, i.e. there are local transverse stresses with torn fibers.

About significant participation of the shearing stress components, it is confirmed by the obtained stress-deformation dependence, shown in Figure 4, which is not linear in contrast to most composites. By increasing those stresses it is coming to the delamination, i.e., cracking fiber-matrix connection and the crack formed by adjacent of fiber, grows along the adjacent fiber and causes macro breaking crack. The result is a local delamination and cracking fiber, but composite still carries the external load. With the increase of the stress local damage are spread and the final fracture came with a strong acoustic effect as a result of the simultaneous cracking of a large number of fibers.

Note

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