TRANSPORT & *LOGISTICS:*
the International Journal

Article history:
Received 15 November 2019
Accepted 31 December 2019
Available online 10 January 2020

ISSN 2406-1069

Article citation info: Ambriško, Ľ., Marasová, D., Antal, R., Determination the tensile properties of conveyor belt in the weft and along the warp. Transport & Logistics: the International Journal, 2019; Volume 19, Issue 47, December 2019, ISSN 2406-1069

DETERMINATION THE TENSILE PROPERTIES OF CONVEYOR BELT IN THE WEFT AND ALONG THE WARP

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Abstract:
The main aim of this work is determination of tensile properties of conveyor belt in the longitudinal direction (along the warp) as well as in the transversal direction (in the weft). The tensile properties of the conveyor belt determine material of the carcass. Fabric conveyor belts have the carcass formed by several layers of textile plies. The warp is created by fibres in the longitudinal direction and the weft by fibres in the transverse direction. In the investigated conveyor belt was applied the usage of polyester fibres in the warp and polyamide fibres in the transverse weft. This conveyor belt has good resistance to formation and propagation of breakdowns and resistance to dynamic fatigue.

Key words:
belt, warp, weft, tension

INTRODUCTION

The transport of different materials is a very important part of technical processes across all industries and the belt transport is a significant element for material transportation systems [1]. Belt conveyors provide high transportation efficiency and speed, long transportation distances, low energy consumption, easy operation, maintenance and good operational safety. Due to all these positive aspects they are most frequently used conveyor type [2]. The conveyor belt is the essential structural component of the belt conveyor which has a significant role in the mining, transportation and handling of part materials [3], as well as in many other areas. Belt conveyors are important components of mineral transport inside the mining plant whether on the surface or underground [4]. Conveyor belts are commonly used in all industries [5]; they are also widely used in grain materials transport [6]. However the high operational cost consisting of maintenance, repairs and renovation is often exceeding the cost of remaining parts such as conveyance system, support system and drives [7].

Conveyor belts are composites made of various materials. The characteristics of different belt components greatly affect the final properties of the belt itself and define the suitability of the belt for a specific function or operation in practice. Rubber cover layers shield the carcass and provide the sufficient resilience to multiple effects impacting the conveyor belt. During the process, the top cover layer comes into direct contact with the conveyed material, which has a negative effect on this layer and may damage it. The abrasion of various materials is very common. The fabric conveyor belts, which are the most commonly used belt types, generally consist of the top rubber cover layer resistant to degradation, the fabric carcass giving the belt's tensile strength, the adhesive compound between the rubber and the carcass, and the bottom rubber cover layer designed to cover the carcass and provide sufficient friction on the drive drum [8].

The determination of conventional mechanical, physical and special properties, which provides complex data on the behaviour of the belt used in difficult loading conditions, is essential for assessing the characteristics and quality of the belt [9]. A conveyor belt's operational service life depends on some factors - conveyed material, operating conditions, belt quality, and material properties. The tensile strength is one of the material properties of conveyor belts [10], mainly determined by the synthetic fabric layers [11] that form the carcass of the belt.

1 EXPERIMENTAL PART

The experimental research discussed in this paper concentrated on the examination of mechanical properties of the EP-type fabric belt in particular the tensile properties of the *EP 630/4 800 4 + 2 Y* belt which is also used for slightly abrasive and sharp-edged materials in smaller pieces. The carcass of the tested belt consists of polyester (E) fabrics in the warp and polyamide (P) fabrics in the weft; the tested belt type is described in Table 1. This combination of textile fabrics determines the final characteristics of the belt. The research is focuses on the evaluation the tensile properties along the warp (in the longitudinal direction) as well as in the weft (in the transverse direction).

***Tab. 1** Characteristics of examined belt (CV - cover layer)*

Carcass type	Nominal strength [$N.mm^{-1}$]	Number of plies	Belt width [mm]	Top CV thickness [mm]	Bottom CV thickness [mm]	CV category
EP	630	4	800	4	2	Y

The experiments were performed in compliance with [12] and using A-type test samples obtained along the warp and in the weft. Progress in experimental research is shown in Figure 1. The samples were exposed to a load in the ZWICK / ROELL Z030 testing machine and the deformation was detected using videoextensometer [13, 14], i.e., a contact-free method.
The elongation was measured by using 2 reference lines drawn on the surface of the tested samples with a spacing of 100 mm.

On the basis of the relationships, the tensile properties of the entire thickness of the conveyor belts were identified, in particular the following:

- TENSILE STRENGTH

$$f_s = \frac{F_r}{b_t} \tag{1}$$

where f_s – tensile strength [N.mm^{-1}],
F_r – the maximum load at the instance of rupture [N],
b_t – sample width [mm].

The resultant value of the belt tensile strength is the arithmetic average rounded to 1 N.mm^{-1} of the values measured for 3 test pieces in the longitudinal direction.

- ELONGATION AT BREAK

$$\varepsilon_r = \frac{L_2 - L_1}{L_1} \times 100 \tag{2}$$

where ε_r – elongation at break [%],
L_1 – distance between the reference lines prior to the loading [mm],
L_2 – distance between the reference lines at the object disturbance [mm].

The resulting elongation at break is the arithmetic average of the calculated values for 3 test pieces in the longitudinal direction, rounded to the nearest 1.0 %.

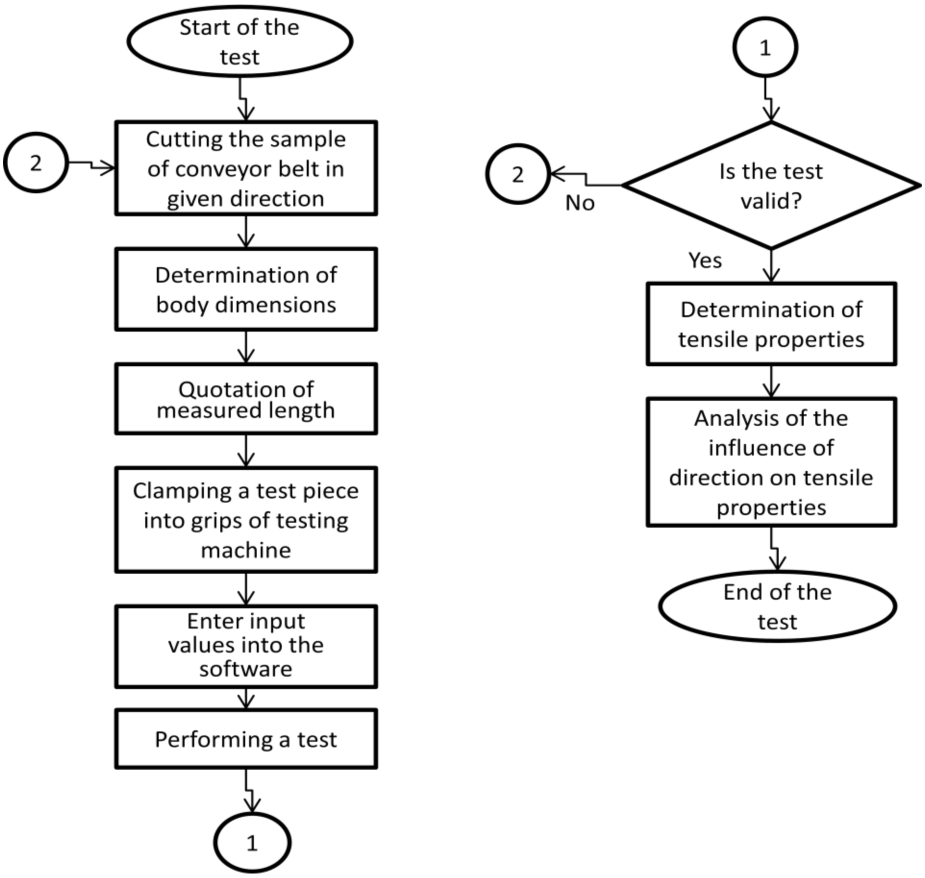

Fig. 1 *Experimental research procedure*

2 RESULTS

The properties of the belt, depending on the direction of the sample collection, reached different values along the warp, as well as in the weft. The resulting average and recorded vales for the test samples are shown in Tables 2 and 3.

***Tab. 2** Results of the tensile test of belt along the warp*

Specimen	L_0 [mm]	b_t [mm]	f_s [$N.mm^{-1}$]	ε_r [%]
1	100	27.3	714	22
2	100	26.7	732	23
3	100	26.7	700	22
Average	***100***	***26.9***	***715***	***22***

***Tab. 3** Results of the tensile test of belt in the weft*

Specimen	L_0 [mm]	b_t [mm]	f_s [$N.mm^{-1}$]	ε_r [%]
1	100	26.7	283	23
2	100	27	272	22
3	100	26.7	272	22
Average	***100***	***26.9***	***276***	***22***

The relation between load and deformation for both directions is shown in Figure 2. During the exposure of the samples to the load, the tensile strength and deformation increased until the rupture occurred. The shapes of the curves are similar; the main difference is the size of the force that reached higher values along the warp.

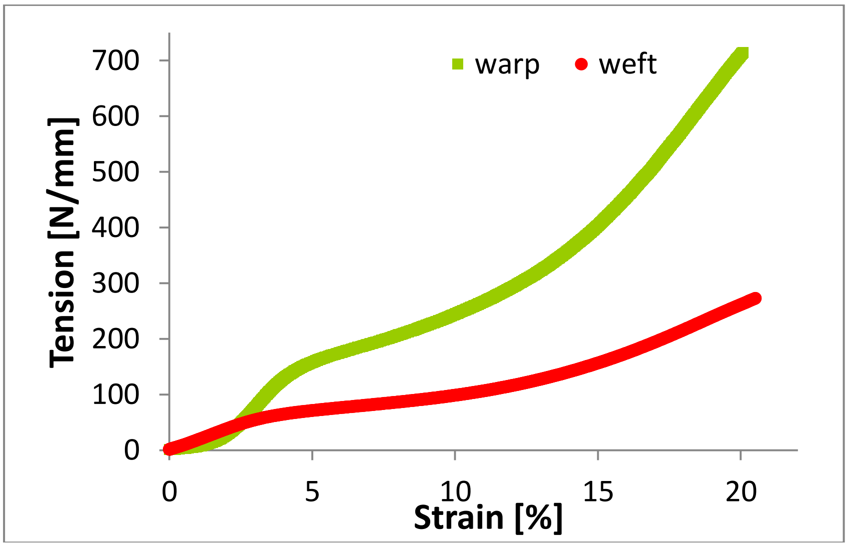

***Fig. 2** Tensile diagrams of tested specimens*

Figure 3 shows the tested samples after the completion of all tests. As for the samples collected along the warp (designated as O), ruptures occurred in all samples in the designated (measured) section of the experiment. As for the test specimens in the weft (designated to as U), the ruptures occurred only in the textile carcass, in the section between the reference lines, without any damage to the rubber cover layers.

Fig. 3 *Ruptured specimens along the warp (designated as O) and in the weft (designated as U)*

Figure 4 shows the impact of the sampling direction on the tensile properties of the belts. The strength of conveyor belt - EP 630/ 4 800 4+2 Y in the weft was 61 % lower. Tested belt elongation along the warp was 0.01 % higher; this value is negligible. Based on these results, we may state that the strength of polyamide is lower than strength of polyester.

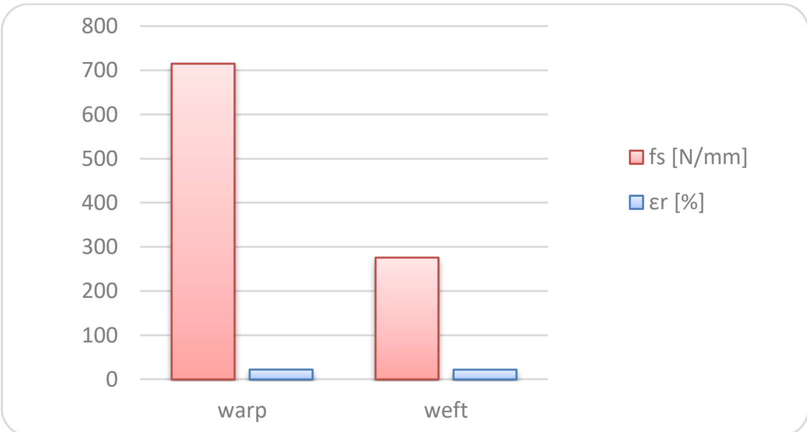

Fig. 4 *Impact of the sample collection direction on tensile properties*

3 CONCLUSIONS

The output of this research is focused on determination of the impact of the sampling direction on the tensile strength and elongation at break for the EP-type fabric conveyor belt. In these types of belts, the carcass contained different fabrics in the warp and in the weft. In the case of the tested EP belt, it was a combination of polyester fabrics in the warp and polyamide fabrics in the weft.

The strength of examined conveyor belt in the weft was 61 % lower than in the warp. The elongation of tested conveyor belt in longitudinal direction, i.e., along the warp, was 0.01 % higher; difference represented by this value has little statistical significance. The tensile strength for polyester fabric was higher than for polyamide; this means that the polyester leided along the warp will endure higher load than polyamide in the weft.

Acknowledgement

The article was prepared with the support from the project titled VEGA 1/0429/18 Experimental Research of Stress-Tension States of Rubber Composites Used in the Mining and Processing of Raw Materials.

This work was also supported by the Slovak Research and Development Agency under the contract No. APVV-18-0248.

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