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Influence of selected characteristics on failures of the conveyor belt cover layer material

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ABSTRACT

Belt conveying is largely used in the area of coal mining in the surface and underground mining operations. It is primarily applied for transporting of extracted coal from the mining site for further processing. Effectiveness of the coal extraction process depends on high reliability and durability of the conveyor belts. In addition to the technology itself, the material composition of the conveyor belts has a significant impact on ensuring of the above-mentioned requirements. Material properties of the conveyor belts markedly impact their operational properties. In their design stage, the desired conveyor belt properties must be carefully considered. This paper is focused on the effect of several properties of conveyor belts from the aspect of tension-deformation relations. Tensional deformations occurred in conveyor belts are significantly affecting their operation. They affect the extent of dynamic resistance and the conveyor belt's lifetime. More detailed research and analysis, which saves experimental measurements, is also possible by means of the FEM-based simulation tools. The presented research work proved a direct dependence among the modulus of elasticity values and the contact press values, whereby there was applied the elasticity modulus range from 382 MPa to 427 MPa and the consequential differences of the contact press values were identified in the range from 3.95 MPa to 4.399 MPa. These obtained results are significant with regard to failures of the conveyor belt.

1. Introduction

Belt conveyors rank among the most frequently used conveying systems for coal transport in mining industry (Fig. 1). They allow transportation of extracted coal material over various distances. They are especially used for conveying of the coal from the extraction site to the site of its consumption as well as further processing or storage.

From their design point of view, conveyor belts are made from a great number of components the properties of which significantly impact their effective operation [1, 2]. Knowledge of the impact of material properties and technological parameters of conveyor belts on the magnitude of contact forces and dynamic resistance of conveyors play an important role in their construction and operation. This area is researched by Fedorko et al. [3]. In the process of belt conveyor construction, the awareness of the above factors impacts the design of driving and angle pulley and the selection of suitable type of conveyor belt, which translates directly into operating costs and lifetime of the conveyor belt, i.e. aspects to be weighed in when deciding on the conveyor belt replacement.

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Fig. 1. Example of a rubber-textile conveyor belt used in real operation.

For the stated reason, the new knowledge in this field can bring significant economic profits to the operator of this kind of raw material continuous transport systems [4–6].

Several approaches can be deployed in researching of the contact forces and dynamic resistance of conveyors.

The first approach is a direct measurement of the contact forces and dynamic resistances of real belt conveyors. Wang et al. [7] examined dynamic properties of a long belt conveyor with vertical curves by simulating the start and braking of the real system with a variable load. The result is a conclusion that dynamic properties of the belt conveyors with variable load are more complex than those properties in the belt conveyor with a constant load. Petrikova et al. [8] devised an experiment and a simulation to investigate the behaviour of conveyor belt samples made of carbon-black filled rubber reinforced with plain weave textiles. Zhang et al. [9] studied a new automatic defect detection method for the steel core conveyor belt in X-ray imaging system. Frequent defects of steel core conveyor belts are perforation, scratch, corrosion, broken end and joint end of the steel core. Detecting the current state of conveyor belt is important in production processes such as coal mining, where the safety and efficiency of coal production is of high concern.

Another way of examining the contact forces and dynamic resistance of conveyors is creation of a virtual conveyor prototype. Chen et al. [10] researched a virtual model of belt conveyor and performed dynamic analysis of the same. This approach represents a new way of conveyor belt design and safety analysis.

The third option for investigation of contact forces and dynamic resistance of conveyors is creation of simulation models. Nuttall et al. [11] presented a simplified approach to modeling a rolling contact on the surface of a roller and the rubber belt. They examined the parameters of the model with visco-elastic properties and more complex Maxwell models of rolling friction and traction.

The fourth option of contact forces and dynamic resistance research is the use of special test devices and stands. Several authors dealt with this problem. Hotte et al. [12] designed a test rig for examining the form forces of the belt dependent on certain belt and plant parameters. They investigated form stability at various belt tensions and adjustable curve radii. Michalik and Zajac [13] used the new computer integrated system for the automated measuring of strength in the conveyor belt on the equipment for static tests of pipe conveyer belts. Hinterholzer et al. [14] designed the measuring idler station to facilitate the measuring of the occurring kinetic resistance during the moving of the measuring slide and the value of the lateral force during the simulation of a run through a curve without any influence of external friction. Zamiralova and Lodewijks [15] investigated the influence of major pipe conveyor parameters, such as pipe diameter, belt width, transverse bending stiffness, line mass and position of the belt overlap on the load distribution between the individual idler rolls, as well as the ability of the belt to form a stable pipe using a static six-point pipe belt stiffness testing device. Overmeyer [16] developed the test rig for determination of dynamic fatigue strength. This test rig is used to examine conveyor belt splices in terms of dynamic load. Operators can get information about the quality of the belt splices and thus about the fatigue strength. Petríková et al. [17] performed biaxial tension test of the cruciform specimen of rubber layer which is a part of the conveyor belt used for transportation of coal. The specimens were loaded using a homemade biaxial testing device. A numerical simulation of the biaxial test was performed.

The magnitude of contact forces and dynamic resistance depends on the construction of the conveyor belt. Conveyor belt joints are also a factor of importance. Mazurkiewicz [18] presented the results of the laboratory tests conducted on the physical elongation and strength of typical adhesive-sealed joints of conveyor belts. Tests were focused on examination of the strength parameters of joints. Nedbal et al. [19] applied a new method of non-destructive determination of material properties, for example monitoring of humidity, density, porosity, hardening and aging process of the conveyor belt.

The aim of this paper is to point out the impact of selected material properties of rubber-textile conveyor belts on the magnitude of contact forces. This research is needed for a better understanding and for building on the existing knowledge of dynamic resistance of conveyor belts in classic belt conveying systems impacted by contact forces. The main analytic tool applied within this research is the FEM. The paper will describe the impact of Young's transport belt modulus on the magnitude of contact forces on the rollers of