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PhD dissertation abstract

Classification of belt conveyors energy efficiency

The energy efficiency of belt conveyors is closely related to current trends in energy-efficient transportation systems, sustainable development goals, and European legislation. Until now, the topic of energy efficiency in belt conveyors has been focused on technical improvements such as reducing resistance to motion, using modern drive and control solutions. Importantly, the energy efficiency of a working conveyor is influenced not only by used components and modern technical solutions but also by factors regarding the conveyor's operation, component wear, and working conditions. Currently, there is no established methodology for assessing the energy efficiency of belt conveyors. The current practice for conveyors evaluation is based on the use of the Specific Energy Consumption (SEC) index, which does not allow for objective comparison of conveyors with highly diverse operational parameters.

In the analysis of energy efficiency in an open-pit lignite coal mine, a comparison of energy consumption was conducted among conveyors operating in a continuous transportation system. The study determined the impact of the transported volume on electrical energy consumption and SEC index. It was shown that the incline conveyors are characterized by higher energy consumption due to the resistance associated with lifting the material, which significantly affects the structure of the conveyor's resistance to motion. To mitigate the impact of lifting resistance that results from the transportation task, the electrical energy required to overcome the elevation was subtracted. Based on the modified by lifting resistance energy efficiency index and the amount of transported material, and using a k-means algorithm observations were divided into groups reflecting energy efficiency classes.

The analysis methods developed and used for assessing conveyors in the open-pit mine were implemented to verify conveyors in the underground mine. Despite differences in design and operational parameters of the analyzed conveyors, similar relationships to those identified in the first stage of the study were observed. Based on the obtained results, it was proposed that the classification of belt conveyors in terms of their energy efficiency requires generating a dataset representing conveyors with different design parameters, operating at full loads, and under comparable conditions. Monte Carlo simulations were used for this purpose, with random and fixed input values representing actual parameters of belt conveyors operating in the underground mine. The computational model based on the basic method of calculating conveyor resistance to motion allowed for obtaining output data, including the specific energy consumption parameter. The generated simulation data was verified by comparing them with real dataset, and then divided based on the inclination angle and conveyor load. For observations in each inclination angle and load group, quartile positions of the energy efficiency index were determined as the threshold values for energy efficiency classes. These values were used as a stopping criterion for an iterative algorithm assigning energy efficiency labels to operating belt conveyors.

The proposed method for classifying belt conveyors in terms of their energy efficiency considers the inclination angle and conveyor load as the main operational parameters, while treating the specific energy consumption as the reference parameter for energy efficiency classes. The developed matrix-based energy efficiency classes are a reliable and universal tool for assessing the quality of operation and control of the conveyor transport system.

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