ABSTRACT
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DOCTORAL DISSERTATION

Using industrial automation systems
to assess energy intensity of continuous transport of spoil
in an opencast mine

Belt conveyors are the most widespread means of continuous transport of output in lignite opencast mines, mainly due to high capacities and high operational reliability in heavy operating conditions. For decades, belt conveyors it was perfected in terms of construction. The current era of conveyor-transport development is oriented towards efficiency, in particular energy intensity. Of course, the improvement in the efficiency of belt transport is still based on the search for new structural solutions of individual conveyor elements (idlers of reduced rotation resistance, energy saving belts or drives with high efficiency), but due to the high technological level of other solutions, the management of belt transport whether application the so-called predictive diagnostics is becoming more and more important. The main topic of doctoral thesis is the possibility of using information resources available within the operating industrial automation systems for detailed identification of electricity consumption consumed by belt conveyance systems with the target possible minimization of the energy intensity of transport of spoil with conveyors.

The main components of the dissertation are: in **the first part** - introduction to the topic with emphasis on its specificity, analysis of the state of knowledge, more detailed research tasks and formulation of the thesis and in **the second part** - identification of the key elements of the transport process affecting energy consumption, analysis of the technological possibilities of tools to achieve set goals (infrastructure of measuring, software for: data collection, advanced analytics and reporting in the data warehouse system). T**he third part** of the dissertation touches the issues of building a stream of information dedicated to a specific recipient and supporting operational decisions, assessing the effectiveness of solutions and analyzing the transport process oriented to improving energy efficiency.

The original achievement of the author is a comprehensive definition and analysis of the energy efficiency problem of the technological process (earlier work touched singular elements of the system), proposals of efficiency indicators and their long-term analysis and finally propositions for algorithms and their practical implementation in the IT environment of the data warehouse used in the mine.
t was demonstrated that despite enormous progress in control and measurement techniques, there is a justified need to **verify the quality of data** and analyzes regarding the validation of data acquisition parameters. The results of these analyzes allowed for the formulation of directions for the modification of control and measurement layouts (to be implemented in future mine investments).

One of the important achievements at dissertation is the proposal of **energy intensity indicators** and preparation of analyzes based on these indicators. The analysis of energy intensity carried out as part of the experiment for selected conveyors from the route transport of spoil in the mine concerned indicated that the universal and reliable parameter supporting operational decisions can be *the energy intensity factor w_e*.

The coefficient w_e is defined as the energy needed to transport a unit of mass or unit of volume of spoil on a route of one meter.

The next, detailed achievements of the author in the dissertation are:
- **data processing procedures** (in particular algorithms for simulation of displacement of spoil from the excavator, on which its quantity volume is measured, through individual conveyors of the transport route to the places its reception),
- procedures for **aggregation** of primary data,
- **the method** of current **analysis of energy intensity** of continuous transport of spoil by means of energy intensity factor. Knowledge of the energy intensity ratio allows: compare the efficiency of work of different conveyors, to recognize abnormal states on a regular basis in the automation system as well as the transport system and identify sources of excessive energy intensity in transport, it can also be helpful in the analysis of variant conveyor construction solutions (e.g. when selection a drive, belt or rollers),
- **modification of the measurement method** of key sizes and the way of data archiving in the data warehouse, so that the measurement results would not only serve to control the energy intensity ratio, but were also used in predictive diagnosis,
- **an innovative method of measuring**, on each conveyor, electric energy and size of the transported mass of spoil, in order to be able to use, among other things, the measurement of energy of "idling" of conveyor (the work without load) for the initial assessment of the technical condition of this conveyor,
- identification of **relation** - "**an energy** - **an efficiency**", as well as the indication of the possibility of a variant determination of optimal roads for spoil transport and changes in control system of belt conveyors,
- an indication that in the measurement data from industrial automation contained are manifold **diagnostic information**. Extraction of this information, its proper interpretation, it's a large field of activity for science, consequently, it should provide many diagnostic tools to the business practice.

In addition, **directions for further research** have been defined, in the scope of:
- analysis of the change of the method of coupling motors with the gear the main drive of conveyor, from currently used constant, to dynamic,
- studies in an area of designing energy-saving conveyors with particular emphasis on the operation of conveyors in changing atmospheric conditions and the selection and way installation of sensors.