SILESIAN UNIVERSITY OF TECHNOLOGY

Doctoral thesis

Development of a powered roof test method to determine guidelines for a system monitoring its operational parameters

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Abstract

The thesis addresses a highly important and current problem, namely, the adaptation of powered roof supports for the practical application of a system for monitoring their operation. An important part of this process is the development of a method for testing the powered roof support section to determine guidelines for implementing such a system. Each of the completed stages of this work included several analyses based on model and bench tests, as well as under real conditions.

The proposed solutions are to reduce the current difficulties in the operation of powered roof supports in the longwall complexes, especially in difficult geological and mining conditions. In particular, this concerns the issue of limiting the participation of the operator in the functioning of the supports and the improvement of their interaction with the rock mass and the other machines of the mechanised longwall complex.

The second chapter defines the role and importance of powered roof supports in the construction and operation of longwall support sections used today and in the past. The working conditions and the interaction of powered supports with the rock mass are defined, as well as the resulting types of loads that can be exerted on them. The geological and mining conditions that have a significant impact on the operational state of powered roof supports are identified. The process of designing powered roof support sections is illustrated, along with their impact on the efficiency and safety of the entire longwall complex.

The third chapter defines the scientific and practical objectives of the work. The multidimensional and interdisciplinary character of the topic is identified.

The fourth chapter presents the developed research methodology, which is the result of the research carried out using specific research methods. The presented methodology presents the course of research proceedings, which are crucial for achieving the assumed objectives of the research.

The fifth chapter presents model studies on the basis of which stress and deformation states of powered support elements were analysed. Computer simulations made it possible to identify the areas exposed to the greatest stresses and to designate locations that should be excluded when installing sensors monitoring the operational parameters of the supports. The result of the research was to determine the initial mounting locations of the sensors while simultaneously preventing collisions with basic elements of the longwall support.

The sixth chapter describes the course of tests under actual conditions, which involved measurements of leg pressure values during high-energy shocks. In the conducted studies,

variable pressure values in the longwall face were determined for 63 high-energy shocks. Research areas were defined for the comparative needs of the analysed shocks in a given zone. The research areas were located at the beginning, middle and end of the wall excavation. Based on these studies, the impact of shocks during the longwall's advance, the system's efficiency, and the system's response to changes were determined in percentage terms.

For the development of the measurement and recording system for geometrical parameters of the powered roof support operation, bench testing research was undertaken, which consisted of two stages. In the first stage, sensor prototypes were installed on the powered roof support section and the section was controlled, reflecting its operating cycle under actual conditions. It was confirmed that these sensors did not collide with the structural elements of the powered roof support.

Subsequently, after tests on the mine surface, a test bench was developed in the technological hall. The cycle of the conducted research is presented in Chapter 7. During these tests, sensor communication was determined and a calculation formula was defined, on the basis of which parameters of transverse and longitudinal inclinations and the working height of the powered roof support were determined. In addition, the locations for mounting the sensors were refined. The prototype of the measuring and recording system prepared in this way was built on the basic elements of the powered roof support section. The conducted bench tests enabled preliminary tests to be carried out in actual conditions in the longwall face.

Chapter eight describes the course of these tests. Initially, the sensors were attached by magnets to three sections. The study determined the transverse and longitudinal inclination of these sections and the operating height during the coal mining process for 18 mining shifts (6 days). During the research, the method of mounting sensors and calibration was refined, which required changes in the measurement and recording system and the construction of the longwall support. For this purpose, repeated tests were carried out on the test bench in the technological hall.

The ninth chapter presents the course of the second stage of bench tests, the purpose of which was to refine the sensor mounting locations and determine the method of system calibration. On the basis of the conducted tests, additional structural elements were introduced, intended for mounting sensors in the form of mounting brackets. The introduced mounting brackets constituted an integral part of the longwall support sections. They influenced the correct mounting of the sensors while facilitating their maintenance and

calibration in underground conditions. The adapted measuring system and the powered roof support section enabled conducting repeated tests in actual conditions. These tests were aimed at confirming the sensor's mounting locations and the compatibility of the system with the powered roof support construction. The monitoring covered five sections of the powered support, which communicated wirelessly, passing information to the visualization station in the longwall excavation. Then, through the mining plant's infrastructure, data was sent to the station in the power-machine control room, where they were archived and diagnosed.

During the tests, the geometric parameters of the support operation were determined on the test bench and in the longwall face. A research method was developed that enabled the realisation of the stated objectives of the doctoral thesis. The research made it possible to develop guidelines for the monitoring system and the construction of the longwall support sections. The developed system for monitoring the parameters of the longwall support sections has been prepared for implementation in the mining industry. For the implementation of the solution, technical and operating documentation as well as operating instructions were developed and the opinions of certification bodies were obtained. The thesis indicated the direction of conducting further research in order to improve already existing solutions and develop new ones.

Keywords: mining production process, mining machinery, work safety, monitoring systems, roof supports, process efficiency, remote control.