

ABSTRACT

M. WÓJCICKI: IDENTIFICATION OF THE SYNERGISTIC EFFECTS OF MINING ENVIRONMENTAL FACTORS IN REDUCING THE WEAR OF CHAIN LINKS IN ARMoured CONVEYORS

The efficiency of the production process constitutes a key factor determining the economic viability of operational activities in enterprises. An illustrative example of an industry where the working environment plays a crucial role is mineral resource mining. In underground mining, both in longwall and room-and-pillar operations, productivity largely depends on the applied means of local transport, including armoured conveyors. These devices are characterized by high resistance to harsh mining conditions and are suitable for use in the most demanding environments. Nevertheless, individual components and assemblies are subject to accelerated wear, which may limit their ability to perform transport functions. Particular attention should be given to mining chain links, which constitute the primary component of the traction drive in armoured conveyors.

The scientific objective of this study was to identify the synergistic effects of mining environmental factors in the context of reducing the wear of chain links in armoured conveyors. The study adopted the following hypothesis:

The combined influence of abrasive particles and variable dynamic forces, both in the presence and absence of corrosive factors, results in an additional interaction effect during the multifactorial wear process of chain links.

The first chapter introduces the topic of the influence of the mining environment—such as water, abrasive particles, and dynamic loads—on the degradation of chain links used in armoured conveyors.

The second chapter discusses the rationale for conducting the research. It highlights the ongoing challenges associated with the operation of chain drives and the potential occurrence of synergistic phenomena in machine component wear, where the combined effect of multiple factors exceeds the sum of their individual impacts. It is noted that such synergistic interactions can significantly shorten the service life of working components, and understanding them can support the design of more technically durable armoured conveyors adapted to specific environmental conditions. It is further emphasized that, despite the importance of synergistic effects in the operation of armoured conveyors, the scientific literature lacks studies that identify this process in the context of mining chain links.

The third chapter defines the research aim, problem, and hypothesis, as well as the scope of the study. Chapter four presents the construction of chain links used in mining, their manufacturing and operational techniques, and the scope of their applications.

Chapter five describes the adopted research methodology and the measurement methods used in both laboratory and field studies. The chapter also presents a custom-designed experimental setup dedicated to the analysis of the synergistic wear process of chain links.

Chapter six details the conducted experiments, including the selection of experimental conditions, link interaction parameters, and environmental materials that accelerate joint degradation processes.

Chapter seven presents the results of laboratory studies, including measurements of corrosion rates in mine waters and their mixtures with abrasive particles, as well as tribological tests of abrasives in demineralized water. The aim was to identify materials that determine chain link wear for subsequent field experiments.

Chapter eight describes the field studies on link wear in joints under the combined influence of degradation factors. This chapter includes a description of the experiments, results, a detailed analysis of wear forms (SEM, EDS, metallography, hardness profiles, and direct observations of chain links), and an analysis of wear products.

Chapter nine presents developed models of multifactorial wear of chain links in mining environments, considering three possible operational conditions of armoured conveyors.

Finally, chapter ten summarizes the study, presenting conclusions drawn from the conducted research and indicating further research directions based on the experimental results obtained. The scientific dimension of the work consisted primarily in determining the synergistic effects of various factors of the mining environment in the process of chain link wear. The analysis of the conducted stand tests revealed that synergism is the most frequently occurring interaction phenomenon during the degradation of chain links in the joint, and its intensity and occurrence are strictly conditioned by the nature and type of the combined environmental factors. The research results proved that the very selection of the parameters of these factors plays a decisive role in the rate of wear of chain link joints. In every case, it was also confirmed that changing the configuration or adding further degradation factors affects the overall level of joint wear through interaction. Confirmation of the interaction effect was the demonstration that the component resulting from the combined action of dynamic and abrasive factors within a given environmental group differs from the sum of the effects exerted by these two factors separately. This fact makes it possible to conclude that the adopted research hypothesis has been confirmed.

In addition to its scientific nature, the work was also oriented toward achieving a practical goal related to the implementation aspect of the doctoral project. The utilitarian result of the research was the development of a concept and technical assumptions for a full-scale test stand, which makes it possible to conduct wear tests on chains of various sizes in accordance with the PN-G-46701:1997 standard.