ABSTRACT

Education is one of the basic pillars of society and at the same time the most important, on which the other components of the community are structured and developed. The teaching profession is a vocation marked by the challenges that arise in the activity of training a person from the perspective of life.

The career of a university teacher involves particularities that arise from the harmonious combination of teaching and research activities, but also with the immediate and prospective needs of the economic, social and professional reality for which students are preparing.

The reason why I am writing this habilitation thesis is based on the fact that the projection of a university career cannot be built only on a forecast but is based on proven skills in previous achievements and research activities, assuming a certain continuity.

This habilitation thesis represents a synthesis of the author's teaching and research activity carried out after the public defense, in 2003, of the doctoral thesis entitled "*Contributions to increase the reliability of the mining technological equipment*" developed under the supervision of Professor, PhD eng. Iliaș Nicolae.

The first chapter of the thesis presents the most relevant results obtained by the author in the teaching and scientific research activity after defending the doctoral thesis. Regarding the teaching component, I thought, as a lecturer, the disciplines: technical drawing, machining and cutting tools, machine construction technology I and II, reliability and maintenance, production systems maintenance management, rapid prototyping, etc. The teaching activity was carried out within both the bachelor's and master's degree programs.

In over 20 years of post-doctoral activity, I have accumulated a wealth of experience in the following research areas: reliability of technical systems and maintenance of industrial equipment. The first part of the habilitation thesis includes, in summary, the results that have been published in Web of Science indexed journals (Q1 and Q2).

Chapter 2 deals with the achievements obtained regarding *methods of limiting the consumption of machine components exposed to abrasive wear*. The various operating conditions of machines, installations and equipment determine the development of wear phenomena, but also the negative effects they generate. The analysis of the sheets tracking the operation behavior of equipment for the extraction, transport and use of mineral substances such as hard rocks and coal provided numerous data on the causes of interruptions in operation in the technological lines that serve the activities carried out with the machines and equipment in the facility; thus, it was found that one of the most common and aggressive forms of wear is abrasive wear. In most cases, it is necessary to replace entire subassemblies, but especially, to find methods to reduce the high specific consumption of some spare parts, especially those that come into direct contact with hard rocks. The solutions presented to resolve these issues may be those of reconditioning the worn surfaces of the parts or subassemblies, as well as optimal manufacturing processes using materials improved in terms of tribo-mechanical properties and adapted to the operating conditions of the technological equipment of which they are part.

In chapter 3, entitled "*Study of the Possibilities for Improving Maintenance of Technological Equipment Subject to Wear*", the Reliability Centered Maintenance (RCM) method is presented and used to analyze the components of the KSW-460NE shearer that frequently fail. The cutting drums do not adequately correspond, in terms of their design and the specific operating conditions, to the requirements of the shearer picks (which are in direct contact with coal and hard

inclusions) and guides. As a result, they are subjected to intense abrasive wear and exhibit a high number of defects. Data obtained from monitoring the combine in operation enabled the determination of parameters characterizing the reliability of these components, as well as an analysis of their failure modes and effects. By employing computational techniques, the interpretation of results was facilitated, allowing for the identification of necessary measures to improve the maintenance of the shearer's main components. This included determining optimal replacement intervals to ensure the required levels of reliability and maintainability.

The study's findings support the selection of appropriate hardening materials for reconditioning the cutting elements and guides. These materials require practical testing to further enhance their operational efficiency and extend their replacement intervals.

Underground mining equipment, analyzed in chapter 4, entitled "*Assessment Possibilities of the Quality of Mining Equipment and of the Parts Submitted to Intense Wear*", plays a crucial role in ensuring the continuity of production flows, depending on how well its quality is maintained during operation. The subassemblies of the TR-7A scraper conveyor, which operates in the mining operations of the Jiu Valley coal basin and is subject to abrasive wear, have exhibited a high frequency of failures. These include chains, chain hoists, drive and return drums, as well as hydraulic couplings and certain electrical components of the same machine. Data obtained from monitoring the TR-7A scraper conveyor in operation enabled the determination of parameters characterizing the reliability and maintainability of these components, as well as an analysis of their failure modes and effects. By employing computational techniques, the interpretation of results was facilitated, allowing for the reduction of maintenance costs and achieving a reliability rate of 80% for the most failure-prone components of the TR-7A scraper conveyor.

Chapter 5, titled *"Solutions to Improve the Efficiency of Maintenance Activities for Technological Equipment in Aggregate Extraction Quarries"* analyzes technological equipment used in quarries that extract and supply aggregates for various applications. These operations follow a predetermined flow, depending on the type of rock being exploited and the dimensional characteristics required for the final products. In this context, minimizing operational interruptions for the replacement of high-wear parts, such as excavator and bucket loader teeth, is essential. Technological solutions aimed at extending their operational lifespan are therefore necessary. The wear progression of quarry equipment teeth, which come into direct contact with rocks, was assessed based on data obtained from production processes. This assessment was conducted alongside wear values derived from laboratory simulations of the wear phenomenon to validate the data collected during actual equipment operation. Preventive-repetitive maintenance, specifically reconditioning worn tooth surfaces, was tested and applied directly to the machinery using manual electric welding with coated electrodes. This process effectively reduced operational downtime required for replacing these spare parts.

Chapter 6 explores the influence of surface roughness on wear mechanisms in metal-rock interactions. The excavation and processing of rocks subject cutting tools to intense mechanical stresses, inevitably leading to wear. The factors affecting wear intensity and mechanisms are complex and interdependent, influenced by the physical-mechanical properties of the rocks, the geometric characteristics and materials of the tools, and the parameters of the cutting process (such as cutting force and feed rate). Previous studies have primarily examined wear from a global perspective, without thoroughly analyzing the microstructural evolution of contact surfaces during friction. In this chapter, we conducted detailed investigations using controlled tribometric tests to examine the abrasive wear mechanisms of metallic materials in contact with various rock types, emphasizing the role of surface roughness and the mineralogical properties of the rocks.

Experimentally, we varied stress forces and friction cycles to simulate different working conditions, enabling an evaluation of how these parameters influence wear rate and surface morphology modifications. Microstructural analysis, combined with roughness measurements, allowed us to identify the predominant degradation mechanisms—abrasion, adhesion, and fatigue—and correlate them with material properties and the friction process. The results revealed a strong correlation between the wear capacity of rocks and their petrographic properties, such as hardness, porosity, and hard mineral content. Additionally, surface roughness was found to play a crucial role in wear mechanisms, affecting both the initiation and propagation of defects. Based on the experimental data, we developed a classification of rocks according to their abrasive potential and proposed criteria for the optimal selection of materials and cutting tool parameters depending on the rock type encountered. The findings of this study contribute to improving the durability of mining equipment and reducing operating costs.

The demands that accompany tribological phenomena, as well as the effects they cause (abrasion, corrosion, erosion) on subassemblies belonging to technological equipment, especially mining, require the development of advanced materials that simultaneously present high values of the toughness-hardness couple and not only, solutions in this regard being presented in chapter 7 entitled "*Rehabilitation with advanced materials of structures in the composition of technological equipment, exploited under severe operating conditions in order to increase their lifespan*". In this context, the friction-wear processes that negatively influence the resistance to abrasive wear of the materials of some spare parts and subassemblies must be highlighted, which leads to high maintenance costs.

In order to rehabilitate by reconditioning the structures of the technological equipment, tests were carried out aimed at making welding electrodes from advanced materials and the following results were obtained:

- a new composite electrode was developed and made, for high-efficiency welding charging, with which alloys of the type Fe-25%Cr-4%W-V-Ti-La can be deposited, with fine grain size and high wear resistance specific to hard rock processing activities;
- the extrusion process for welding electrodes was adapted to manufacturing conditions to produce advanced materials that deposit layers with martensitic structures, rich in complex carbides, and with a low diffusible hydrogen content;
- mixtures of filler and base materials with predefined properties were developed and optimized for specific welding parameters to achieve the desired metallographic structures;
- advanced materials were applied in the form of electrode patterns using welding deposition technologies for refurbishing worn subassemblies and spare parts;
- the advanced materials were successfully tested on impact heads of armored conveyors for underground mining and on bucket teeth for front-end loaders. For impact heads, the cost of reconditioning using the new composite electrodes was reduced to less than 10% of the cost of a new part.

Chapter 8 examines *the influence of abrasive wear on the reliability and maintainability of some components of technological equipment in quarries*. The continuity of production flows in aggregate quarries can be assessed through the reliability and maintainability indicators of technological equipment carried out under the specific conditions of the exploited rocks. The analysis carried out for this purpose used the database collected between June 2022 and May 2024 regarding the interruptions in the operation of technological equipment in the Pătârș basalt quarry due to wear and the need to replace some of their subassemblies and components. The results obtained regarding the values of the reliability and maintainability indicators of the metal

components that presented the most numerous failures were complemented by laboratory tribological tests on the evolution of the wear of the surfaces of some samples of the materials of the parts in contact with the basalt; the tests allowed determining the influences exerted by the properties of this rock and the operating regime parameters on the wear of the materials of the parts that were failing. The proposed solutions to improve the performance of the equipment and reduce downtime due to wear are: making experimental prototypes from alternative materials for the sorting station chute; reconditioning metal parts directly in the quarry, by welding loading to reduce disassembly-assembly times during maintenance activities and the duration of flow interruptions as well as the related costs.

The second part of the thesis includes the evolution and development plan of the quarry from a scientific, academic and professional point of view and takes into account the current global economic situation (reducing costs in the most efficient manner possible), safety and accessibility in operation (details that do not endanger people's lives and the possibility of exploiting existing resources to the maximum), as well as increasing environmental responsibility (principles of precaution, prevention and correction of pollution). In this context, the general objective of career development is based on two main approaches, namely:

- the results achieved and current experience: the directions developed to date, in the field of preparation and performance of the activity, which have been partially investigated and which require detailed in-depth study;

- obtaining new important results and knowledge: identifying current directions in order to improve and develop personal and institutional prestige.

In the third part of the habilitation thesis, I present the bibliographical references associated with the first two sections.