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HABILITATION THESIS
– ABSTRACT –

Development of innovative manufacturing technologies for complex parts

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The habilitation thesis, entitled "Development of innovative manufacturing technologies for complex parts," is a synthesis of the author's scientific and professional results obtained after earning the PhD title in the field of Industrial Engineering in 2011. It focuses on the achievements that demonstrate the author's ability to coordinate scientific research in the field of Industrial Engineering with applicability in manufacturing. The thesis, structured in three main sections, provides a comprehensive vision of the career evolution, the author's contributions, and future development plans. The sections are: scientific, professional, and academic achievements; results obtained in scientific research; career development plan and evolution perspectives, along with the introduction and bibliography.

Section I: Scientific, professional, and academic achievements

This section highlights the scientific, professional, and academic achievements acquired throughout the author's career, emphasizing constant progress and its impact. It begins with an overview of the author's studies in the field of manufacturing, providing a solid foundation for understanding future professional development directions. The summary of activity underlines the diverse professional experience accumulated within the Technical University of Cluj-Napoca and in the industry, where the author significantly contributed both to student development and to advanced research in the manufacturing field. The section concludes by presenting the relevance of the activities and the impact of the obtained scientific results. The relevance of the activities is detailed through two main components: research activities, focused on innovation and technological progress, and teaching activities, aimed at preparing future specialists for the challenges of the modern industry.

Section II: Results obtained in scientific research

The first part of this section presents the research conducted in the development of the water jet cutting process, a modern, innovative, and versatile machining technology that allows the processing of a wide range of materials. Water jet cutting has gained increasing popularity due to its distinct advantages over conventional machining methods, being used in high-end fields such as automotive manufacturing, aerospace, the medical sector, as well as in common industrial applications. The research projects addressed topics such as eliminating delamination of composite materials, improving the quality of water jet cut parts, and manufacturing biocompatible composite implants using this technology. These studies significantly contribute to the development and optimization of manufacturing processes based on water jet cutting, with extensive practical applications and a major impact on product efficiency and quality.

Another research topic explored was the development of artificial intelligence (AI) models to improve manufacturing processes. The aim of these studies was to develop models based on artificial neural networks (ANN) to optimize process parameters, with the objective of improving the performance and quality of the manufacturing process. A relevant case study is presented, in which an ANN model was developed to eliminate delamination of carbon fiber reinforced polymer (CFRP) composites during abrasive water jet (AWJ) drilling. These studies demonstrated how AI can optimize process parameters,

reduce negative effects such as delamination, and enhance the quality of manufactured parts.

Another research direction presented in this section is process monitoring for detecting equipment failures in manufacturing. Predictive maintenance, achieved through continuous monitoring of equipment operating parameters, is a highly relevant global topic, especially in high-end manufacturing fields where large series components are produced. This approach allows early identification of potential failures and intervention before they cause unplanned downtimes or equipment damage, contributing to operational efficiency and maintenance cost reduction. The research carried out in this field led to the development of a water jet cutting process monitoring system using acoustic emission (AE) to detect equipment failures.

The last part of this section presents several relevant studies on improving the quality of parts manufactured through machining processes. By optimizing machining processes, the goal was to improve the overall efficiency of operations by reducing machining times and associated costs, while maintaining high-quality standards. These studies aimed to develop innovative solutions to balance manufacturing process performance with part quality requirements. The research included investigations on the influence of machining parameters on surface quality in turning, studies on improving chip fragmentation and surface quality in drilling and optimizing drilling parameters using high-performance drills. Additionally, studies were conducted on machining parts using robots and robotic manufacturing to enhance automation and improve machining processes with robots. These studies contribute to the development of innovative solutions that will enable the improvement of manufacturing processes and the achievement of higher quality and efficiency standards.

Section III: Career development plan and evolution perspectives

This section presents the career development plan and professional evolution perspectives, aiming to outline strategic directions for strengthening academic and scientific activity. Grounded on values such as excellence, innovation, and collaboration, this plan seeks both individual progress and contributions to the development of the academic community and the manufacturing field. Structured into three essential components, the plan reflects the priorities and main directions of professional evolution. The first component, the development of teaching activities, aims to improve teaching methods and adapt to modern educational requirements. The second component, the development of research activities, focuses on expanding contributions in emerging and innovative fields. Finally, the career development perspective outlines the objectives for long-term professional progress, thus consolidating the impact in the manufacturing field.

The last chapter, "List of publications," includes the main articles and results obtained by the author after completing the doctoral thesis. This thesis aims to provide an overview of the authors professional journey, highlighting the main achievements and contributions to the field of industrial engineering.