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HABILITATION THESIS
– ABSTRACT –

Applications of 3D printing technologies in the industrial and medical field

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The habilitation thesis entitled "Applications of 3D printing technologies in the industrial and medical field" is structured in six chapters that include the main achievements and scientific, professional and academic contributions of the author after finalizing the doctoral studies, along with the professional career development and future directions of research which are taken into consideration by the author.

The first chapter of the habilitation thesis, entitled "Scientific, professional and academic achievements" summarizes the main results that were obtained by the author within the most important institutional and research projects in which he was involved in as coordinator or key member of the research team. Beyond the practical and innovative results that have been obtained and the list of relevant scientific papers that have been published as a result of these researches developed and obtained in the field of 3D printing, within this chapter there are highlighted also the main results that were reached with immediate applicability in both, industrial and medical field.

The second chapter of the habilitation thesis, entitled "Representative researches on the development of models with applicability in the industrial field using 3D printing technologies" presents in more detail some of the most representative researches that were developed by the author in cooperation with various prestigious partners that are coming from the industrial sector. Thus, in this chapter, there are presented a series of researches that were carried out in absolute premiere in Romania regarding the designing, manufacturing and testing of active elements tools for the injection molding of plastics (research that was carried out in cooperation with Plastor SA company from Oradea and SLM Solutions GmbH company from Germany), the designing and topological optimization of an AIRBUS aircraft component made by selective laser melting - SLM (in cooperation with SLM Solutions GmbH company from Germany), as well as a series of researches that were carried out regarding the designing of metallic parts that were cast in ceramic molds which were made using the Binder Jetting 3D printing method, with applicability in the railway field (this research being developed in cooperation with Benninger Guss company from Switzerland).

Chapter three of the habilitation thesis, entitled "Representative researches on the development of models with applicability in the medical field using 3D printing technologies" presents a series of innovative researches that were realized by the author within the National Centre of Innovative Manufacturing of the Department of Manufacturing Engineering (Technical University of Cluj-Napoca) regarding the designing, manufacturing and testing of lattice structures that were integrated within the designing structure of medical implants that were realized using various 3D printing manufacturing processes, such as Selective Laser Melting (SLM) , Fused Deposition Modeling (FDM) or Selective Laser Sintering (SLS). The results presented in this chapter have highlighted the usefulness of such advanced manufacturing methods in solving different types of surgical problems, but also on how such methods can also be used to realize customized medical orthoses by 3D printing technologies.

Chapter four of the habilitation thesis, entitled "Representative researches on the development of customized solutions for calibration and testing of new subassemblies and materials for 3D printing processes" continues the same route of topics which were presented within the previous chapters, highlighting in addition to what has already been presented, the need to develop new types of materials and manufacturing processes based on 3D printing. Of course, this involves a series of high advanced researches, as they were highlighted in this chapter, researches related not only on the designing and producing of new subassemblies, but also on the designing and producing of caliper parts and calibration procedures for 3D printing equipment items. All these aspects depends on several factors, such as the characteristics and deformation of different types of materials that are used in the 3D printing

processes, technological parameters that are used for 3D printing (parameters being specific and different to each process), manufacturing strategy that it is used, orientation of the models to be manufactured in the working area, and last, but not least particularities of the shape design and accuracy of these models, in the end. Different types of computing applications are presented in this chapter as they were designed within the National Centre of Innovative Manufacturing at the Technical University of Cluj-Napoca, in order to determine the scaling factors that are required to compensate the deformations resulted from the 3D printing processes, so that the physical models of the parts that will be produced using these methods would be as close as possible to the ones designed using specific CAD programs.

Chapter five of the habilitation thesis entitled "Plans for future career development " presents the main research directions that are aimed to be reached by the author in the field of 3D printing in the future, consisting in the use and integration of different types of lattice structures within the structuring models of the active elements of tools made of aluminum material for plastic injection (research in this sense being already started in cooperation with Dedienne Roumanie company from Făgăraş and SLM Solutions GmbH from Germany), then continuing with the development and use of the hybrid manufacturing methods (methods that combine 3D printing processes with material removal processes (CNC)), the development and testing of new 3D printing methods and new types of materials that can be used for the 3D printing processes, with applicability in the industrial and medical field. The designing and integrating of bionic and biomimetic structures in the designing process of the models that are about to be manufactured by 3D printing, in close correlation with the new types of materials and structures developed in the industrial and medical field, including the 3D bio-printing domain are and will continue to be high topics of interest for the author, these domains representing key directions that are aimed to be followed within significant research projects in the future, this aspect being part of the strategy and vision that exists within the National Centre of Innovative Manufacturing of the Technical University of Cluj-Napoca, aspect that was confirmed by the results that were reached in the last 25 years since this Center has been opened and led by professors Petru Berce and Nicolae Bâlc at TUCN.

Publishing of scientific articles in ISI journals (Q1 and Q2 ranking), continuing with the increasing of visibility of researches that are developed within the National Centre of Innovative Manufacturing, gaining of new institutional and research projects within different national and international competitions to create the premises, context and general framework in which young researchers will feel the support they need for developing their future career, as well as the development of dedicated research master programs with applicability in the industrial and medical field (based on the existing cooperation with industrial partners and those from the advanced research institutes that are activating in the industrial or medical field) are also aimed to be further on developed by the author in cooperation with valuable members of the National Centre of Innovative Manufacturing.

The last chapter of the habilitation thesis (chapter six) entitled “Final conclusions” summarizes the main results of the researches that were presented in the thesis, along with the future perspectives of continuing the researches. Not far away, different types of materials, 3D printing solutions and new applications are aimed to be developed within the BRIGHT project (https://bright-project.eu/) and the project financed with Norwegian funds EMERALD, projects which will be in progress until 2023, these projects being coordinated by the author of the habilitation thesis, the main objectives of these projects being oriented in supporting hospitals in their fight against the pandemic (BRIGHT) and in developing of new types of 3D printed bio-mechatronic / bio-mimetic applications to support people with special needs (with amputated arms), this being one of the main objective of the EMERALD project.