Abstract of Doctoral Dissertation

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entitled "Evaluation of the Mechanical Properties of Elements Manufactured Using 3D Printing Technology for Biomedical Applications"

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The research concerns the strength analysis of materials and models produced using additive technology for biomedical applications. The aim of the research is to estimate the mechanical properties of elements for a given 3D printing technology, taking into account the orientation of settings on the working platform, and to assess the influence of technological parameters of the print on selected indicators of mechanical properties. The secondary objective of the research is to assess the influence of the geometry of the tested elements and the geometric structure of the surface on the values of parameters characterising mechanical properties. The utilitarian objective is the application of the research results in engineering calculations and computer simulations.

Samples with standardised shapes and custom dimensions, as well as components for biomedical applications, were the subjects of the study. Two methods were used to produce virtual 3D models: CAD modelling and reverse engineering (3D scanning, medical imaging). The work produced the following components for biomedical applications: medical robotic hooks, a finger prosthesis and an orthopaedic wrist prosthesis.

The additive manufacturing process uses certified biocompatible polymeric materials that meet a number of European standard requirements in this area. Selected technologies include: PolyJet Matrix, Fused Deposition Modelling and Selective Laser Sintering.

Samples and components for biomedical applications were subjected to dimensional accuracy tests, strength tests, and FEM (Finite Element Method) simulations. The metrological analysis included measurements of geometry and surface geometric structure. In terms of strength tests, static tensile, compression, and bending tests were conducted, along with tribological tests to assess the materials' abrasion resistance, as well as measurements of surface hardness and wettability, and tests of rheological properties. Part of the research followed the methodology of a Design of Experiments (DOE) approach, using a two-level factorial design with interaction effects (2^3) and the Taguchi method. In total, more than 1,000 standardized samples were analysed. FEM simulations focused on defining a material with anisotropic properties.

The interdisciplinary research undertaken (related to both medicine and mechanics) has increased knowledge in the field of biomedical models. Conclusions based on the results will facilitate the work of medical teams and companies involved in additive prototyping.