

REVIEW

on the dissertation for the acquisition of the educational and scientific degree "DOCTOR"

Author of the dissertation: M.Eng. Gabriela Viktorova Kotseva

Topic of the dissertation: Mechanical and tribological studies of polymers and composites produced by 3D printing

Reviewer: Prof. Dr. Eng. Kosta Boshnakov, appointed as a member of the scientific jury by order 302/28.11.2025 of the director of IICT-BAS

1. Relevance of the problem developed in the dissertation in scientific and scientific-applied terms.

The relevance of the problem developed in the dissertation is undeniable both in scientific and scientific-applied terms. Additive technologies and in particular 3D printing of polymers and composites occupy an increasingly important place in modern engineering, finding application in the manufacture of functional elements subjected to mechanical loads and tribological interaction.

From an applied point of view, the dissertation work is relevant with the development of practical applications, including those with a clearly expressed social effect (tactile perceptions for people with visual impairments), which goes beyond purely theoretical interest.

Despite their widespread use, the mechanical and tribological behavior of 3D printed materials is still not sufficiently understood, which necessitates the need for targeted scientific research in this area.

2. Degree of knowledge of the state of the problem and creative interpretation of the literary material.

The bibliography to the dissertation includes 226 literary sources, the majority of which are in Latin. Over 50% of the literary sources are after 2010.

Classical and fundamental works on tribology, mechanics, physics and contact phenomena, the development of modern tribology, the mechanical behavior of materials, the introduction of additive technologies and their development, the tribology of polymers and composites, energy efficiency and sustainable development, 3D printing, tribological properties of 3D printed materials and applied and socially oriented research are reviewed.

The author demonstrates very good knowledge of the current state of the scientific problem and applies the necessary methods in the research conducted in the dissertation work.

Based on the literature review and modern scientific achievements in the field of mechanics and tribology of polymers and composites obtained through 3D printing, the following **goal of the dissertation has been formulated**:

By studying and determining the mechanical and tribological properties of polymers and composites obtained through 3D printing, new knowledge about their parameters, characteristics, and innovative applications will be acquired. Optimization of technological processes and development of new approaches in the design of functional polymer and composite materials produced through additive technologies. To improve input data in simulation processes, which would lead to more accurate results.

To achieve the goal of the dissertation, eight tasks have been formulated.

3. Brief overview of the dissertation work

The first chapter provides an overview and analysis of tribology as an interdisciplinary science, its basic principles and applications, and a systematization of the main mechanical and chemical factors that determine the behavior of surfaces during friction. The chemistry of tribo-surfaces, the physical properties of materials and surfaces, and the forms of wear in tribology are examined. In conclusion, the role of tribology in industry and economy is emphasized.

The second chapter discusses the technology of tribological research, the necessary devices and systems for their conduct, 3D technologies, materials and printing devices. Special attention is paid to polymers and composites for 3D printing. The software package EDEM Software is briefly presented, suitable for simulation of 3D printed samples and calculation of coefficients of sliding friction, rolling friction and material recovery.

The third chapter is devoted to the development of methodologies for conducting research. 3D printing technologies are presented for the purpose of preparing samples for research. Methods for 3D printing of plates, cylinders and spheres have been developed and the necessary samples have been printed from them for conducting research. Methods for studying tribological properties of polymers and composites obtained by 3D printing have been developed.

In order to enable virtual research and analysis of the behavior of materials under different loading conditions, a methodology for simulation modeling has been developed in the EDEM Software environment.

In the fourth chapter, the results of experimental studies conducted on 3D printed polymer and composite materials with different sample geometry – plates, cylindrical and spherical samples – are presented and analyzed. The main goal of the experimental studies is to evaluate the influence of geometry, technological parameters of printing and material composition on the tribological and mechanical characteristics of the studied samples. Basic tribological parameters, such as the coefficient of sliding friction, the coefficient of rolling friction, as well as the coefficient of elastic recovery after deformation, have been determined.

The friction coefficients of 3D printed samples have been studied. The experimental results obtained for the main tribological characteristics of a large set of materials, namely: sliding friction coefficient, rolling friction coefficient, as well as the coefficient of recovery of elastic deformation after contact loading, are presented and analyzed.

The possibilities for applying the tribological characteristics (roughness, surface resistance, layer height) of various 3D printed materials have been studied and discussed in order to determine their role in the tactile resistance and perception of people with visual impairments and people born blind.

Simulation studies of 3D printed samples have been conducted with EDEM software and it has been shown that the obtained results correspond to the experimentally determined recovery coefficient.

The fifth chapter publishes guidelines for future research, including improving 3D printing methodologies, expanding research on mechanical and tribological properties, improving simulation models, application in engineering and social practice to improve the lives of visually impaired people, and developing the scientific and applied base.

The dissertation ends with a conclusion, scientific-applied contributions, bibliography, declaration of originality, publications on the dissertation topic and the following two appendices: Appendix 1. Overview and definitions in tribology, which also includes an Overview of some of the existing systems for tribological research, Processing of tribological research data and Appendix 2. Overview of 3D printing technologies.

4.Compliance of the chosen research methodology and the set goal and objectives of the dissertation with the achieved contributions.

The goal of the dissertation and the tasks for its achievement are specifically formulated and logically justified. They are aimed at acquiring new knowledge about the parameters and characteristics of polymers and composites obtained through 3D printing and optimization of technological processes.

To achieve the goal of the dissertation, a set of 3D printing methodologies have been developed to study the tribological and mechanical properties of polymers and composites obtained through printing, and a methodology for creating simulation models in the EDEM Software environment.

A large number of experimental studies have been conducted on the influence of technological parameters of 3D printing and the results of experimental studies on the tribological and mechanical characteristics of polymer and composite materials obtained from printing have been analyzed.

The chosen research approach allows for obtaining reliable results and achieving significant scientific and applied contributions.

5. Scientific-applied and applied contributions of the dissertation

This dissertation contains the following more important scientific-applied and applied contributions:

1. Methods for 3D printing using additive technologies of plates, cylinders and spheres are proposed.

2. Methodologies for conducting experimental studies on 3D printed polymer and composite materials have been developed: methodology for analyzing the microhardness of polymers and composites, methodology for studying tribological properties of polymers and composites obtained by 3D printing, and methodology for creating simulation models in the EDEM Software environment.

3. The experimental results obtained for the main mechanical and tribological properties of polymer and composite materials obtained through three-dimensional printing technology (3D printing) are presented and analyzed, namely: sliding friction coefficient, rolling friction coefficient, recovery coefficient and microhardness of the materials.

4. Tribological characteristics (roughness, surface resistance, layer height) of various 3D printed materials for the tactile perceptions of disadvantaged people were studied and analyzed.

5. Simulation studies of 3D printed samples with EDEM Software have been conducted and verified.

6. The influence of the technological parameters of 3D printing on the tribological and mechanical characteristics of the printed polymer and composite materials has been analyzed, which is the basis for the optimization of industrial production processes.

6. Evaluation of publications on the dissertation work

7 scientific papers are attached to the dissertation work. They are co-authorship by the PhD student, her scientific supervisor and colleagues. In 5 of them, M.Eng. G. Kotseva is the first author. 4 of the conferences were held abroad and 3 in Bulgaria.

Three of the scientific publications [3,4,5] are in editions that are referenced and indexed in world-renowned databases of scientific information, and the remaining four are in non-refereed journals with scientific review or in edited collective volumes.

The scientific publications are at the required scientific level and reflect the main scientific research and achievements in the dissertation work.

7. Assessment of the compliance of the abstract with the requirements for its preparation, as well as the adequacy of reflecting the main points and contributions of the dissertation work

The abstract is 55 pages long. A bibliography of 94 literary sources is included. It is designed in accordance with the dissertation work. It reflects the goal, objectives, main research, results obtained and contributions of the dissertation work and adequately reflects the content and significance of the dissertation.

8. Opinions, recommendations and notes.

- I believe that the description in the dissertation of the equipment used to study the hardness of polymers and composites (pp. 60-64), as well as of a large part of the 3D printing processes (pp. 66-75), is too detailed.

- Regarding the publications on the dissertation:

- Although not all citation styles require the inclusion of the conference venue and period, when they are included in the title of the proceedings, their inclusion is recommended and from my point of view, this increases the information about the specific scientific work.

- Publication [2] is in Bulgarian. Why is it listed in English in the list of publications?

9. Conclusion with a clear positive or negative assessment of the dissertation work

My overall assessment of the dissertation work of M.Eng. Gabriela Viktorova Kotseva is positive.

The analysis of the fulfillment of the minimum national requirements for acquiring the educational and scientific degree "Doctor" in the professional field 5.2 Electrical Engineering, Electronics and Automation and the requirements of

the Regulations on the specific conditions for acquiring scientific degrees and for occupying academic positions at the Institute of Information and Communication Technologies shows that in the group of indicators A, with a required score of 50 points, with the presented dissertation, M.Eng. G. Kotseva achieves these points and in the group of indicators G, with a required score of 30 points, M.Eng. M. Kotseva has achieved 66.64 points, with three of the applied scientific publications in the group of indicators G being in publications that are referenced and indexed in world-renowned databases of scientific information (G7).

Based on my positive assessment of the dissertation work and the information presented in this review, I propose to the esteemed Scientific Jury to award **M.Eng. Gabriela Viktorova Kotseva the educational and scientific degree "Doctor", in the scientific field 5. Technical Sciences, professional field 5.2 Electrical Engineering, Electronics and Automation, scientific specialty "Automated Information Processing and Control Systems".**

Date: 23.01.2026

На основание

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