REVIEW

by Prof. DSc. Eng. Georgi Atanasov Mishev

of a dissertation for the award of the educational and scientific degree "Doctor"

in: field of higher education 5. Technical sciences

professional field 5.1 Mechanical engineering

doctoral program “Methods for controlling and testing materials, products and equipment”

Author: M.Eng. Miroslav Dimitrov Simov

Topic: Increasing the service life of plastic molding tools

Scientific supervisor: Assoc. Prof. Dr. Eng. Velko Slavchev Rupetsov, PU “P. Hilendarski”

1. General description of the materials presented

By order No. PD-22-1993 of 20.10. 2025 of the rector of Plovdiv University "Paisiy Hilendarski" (PU), I am appointed as a member of the scientific jury for ensuring a procedure for the defense of a dissertation on the topic of Increasing the service life of plastic molding tools for acquiring the educational and scientific degree "doctor" in: field of higher education 5. Technical sciences, professional field 5.1 Mechanical engineering, doctoral program “Methods for controlling and testing materials, products and equipment”.

The author of the dissertation is M.Eng. Miroslav Dimitrov Simov - a full-time doctoral student at the Department of Mechanical Engineering and Transport, with scientific supervisor Assoc. Prof. Dr. Eng. Velko Slavchev Rupetsov from the Faculty of Physics and Technology at the P. Hilendarski University.

The set of materials on paper presented by M.Eng. Miroslav Dimitrov Simov is in accordance with Art. 36. (1) of the Regulations for the Development of the Academic Staff of the University of Sofia, and includes the following documents:

– application to the rector of the University of Plovdiv for the opening of a procedure for the defense of a dissertation;

– CV in European format;

– minutes of the departmental council, related to reporting the readiness to open a procedure and preliminary discussion of the dissertation;

– dissertation;

– abstract;

– list of scientific publications on the topic of the dissertation;

– copies of scientific publications;

– declaration of originality and authenticity of the attached documents;

The doctoral student has attached 3 publications.

2. Brief biographical data about the doctoral student

Eng. Miroslav Simov was born in 1976. In 1995 he completed his secondary education at TMT Smolyan, majoring in "Mechanical Engineering Technology", and his higher education in 2002 at the Technical University of Sofia, Plovdiv branch, majoring in "Mechanical Engineering Technology, Metal Cutting Machines and Tools". Since 2022, he has been a full-time doctoral student at the Department of Mechanical Engineering and Transport of the Faculty of Technology of Plovdiv University "Paisiy Hilendarski".

The professional career of M.Eng. Simov began as a teacher at the Vocational High School of Technology and Transport in the town of Smolyan, later as an injection mold designer and head of the "Maintenance and Repair of Injection Molds" department at the company "Arexim Engineering EOOD" in Smolyan and a senior designer at the company "FESTO EOOD" in Sofia.

The candidate has a wide range of scientific interests related entirely to plastic molding tools and technology.

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3. Relevance of the topic and appropriateness of the set goals and objectives

The use of plastic products worldwide is constantly increasing, due to the improvement of their physical and mechanical properties through the addition of special fillers. The working surfaces of these tools are subjected to complex loads – friction, bending and pressure on the one hand and from the cyclic temperature fluctuations when filling the mold with the polymer. The additional glass and mineral fillers in the polymer also have a strong abrasive effect on the forming surfaces. The flame retardant and UV-protection additives, combined with the residual moisture in the granulate, the high temperature of the melt and other factors, have a chemical effect on the working surfaces. When the tool is opened and the part is removed, the working surfaces of the injection mold are again subjected to friction. The adhesion of the polymer to the working surfaces of the tool, as well as its shrinkage after cooling, additionally lead to high efforts required to separate the finished part from the injection mold. This leads to increased requirements for the life cycle of tools for injection molding of polymer materials.

The most effective way to increase the life cycle of tools is to increase the wear resistance of their working surfaces. It is precisely to solve this important problem that the goal and objectives of the dissertation work are aimed.

4. Knowing the problem

The literary sources used by the doctoral student are 137, of which 20 in Cyrillic and 117 in Latin. By year they are as follows: from 2016 to 2025 there are 29 sources; from 2006 to 2015 – 38 sources; from 2000 to 2005 – 17 sources and until 1999 there are 14 sources. There are 36 sources from the internet platform. This gives me reason to believe that the doctoral student has become familiar with the latest research in the field of methods and means for increasing the wear resistance of tools for injection molding of polymer materials.

The creative analysis of literary sources allowed the doctoral student to correctly formulate the goal and objectives of the dissertation.

5. Research methodology

To solve the goal and tasks of the dissertation, the doctoral student used theoretical and experimental research methods. Several methods were used to study the wear intensity of hard coatings and determine their mechanical and tribological characteristics.

The justification for choosing specific materials and research tools is made thoroughly and professionally.

The use of modern tools in experimental research allowed the doctoral student to fulfill the set goal and obtain adequate answers to the tasks set in the dissertation.

6. Characteristics and evaluation of the dissertation work

The dissertation submitted to me for review contains 139 pages divided into 6 chapters, an introduction, a conclusion, main contributions and 137 literary sources. It contains 93 figures and 24 tables.

In Chapter I – Literature Review – a comprehensive bibliographic review of the current state of the problems in using tools for injection molding of polymer materials is made. The factors influencing the resource of plastic injection molding tools are analyzed; a brief overview of the wear of these tools is provided; materials and coatings for polymer injection molding tools are reviewed. A critical analysis of the current state of the problem and relevant conclusions have been made.

Based on this analysis and conclusions, the goal and objectives of the dissertation have been correctly formulated.

In Chapter II – Analysis of Injection Mold Defects – a detailed analysis of the types of wear of injection molds and methods for increasing their wear resistance is made. The conclusions made support the doctoral student in subsequent research to increase the resource of the tools.

In Chapter III – Materials, Methods and Instrumentation for Experimental Research – the doctoral student has correctly selected the steel and coating for research, in accordance with the needs of the industry. A set of methodologies are indicated that the doctoral student uses in experimental research.

In Chapter IV – Simulation of the Injection Molding Process. Factors Affecting Wear and Possibilities for Optimization of Tool Design – a computer simulation of the injection molding process of polymer materials is made. The simulation results provide information about the intensive wear of the working surfaces of the injection mold at the casting points, as well as indicative data on the melt pressure necessary to calculate the minimum closing force of the injection mold.

In Chapter V – Experimental studies of wear resistance, topography of the hard coating and laser-welded layers on STAVAX ESR steel – presents the results of the experimental study of the wear resistance of a Ti/TiN/TiCN hard coating deposited on STAVAX ESR steel depending on the normal load. The results of the study of the topography of the hard coating are presented. The results of the study of the hardness and roughness of laser-welded layers on STAVAX ESR steel are also presented.

In Chapter VI - Practical Methods for Restoring the Workability of Defective Injection Molds - the doctoral student has described from his practical experience the restoration of tools by laser coating of cracks and sandblasting of the working surfaces of injection molds.

At the end of the dissertation, a conclusion is made regarding the development and possible directions for future research.

I believe that the presented results are credible and are the authentic work of the author and his supervisor.

7. Contributions and significance of the development for science and practice

The seven contributions of the dissertation proposed by the doctoral student are divided into scientific-applied and applied. The scientific-applied contributions are three and relate to obtaining and proving new facts about the hard alloy coating Ti/TiN/TiCN applied to STAVAX ESR steel. I do not consider the third contribution to be scientifically applied, since it does not touch upon the goal and objectives of the dissertation, and also no new scientific facts have been obtained and proven. I

believe that this contribution should be classified as applied contributions. The applied contributions are four (plus one more) and relate to obtaining confirmatory facts that are extremely useful for practice. They have significance for practical use, and some of them have already been implemented in companies producing plastic products.

The contributions are the author's own work and reflect the results of the dissertation work.

8. Assessment of dissertation publications

Three publications are presented, which are in English. All publications fully reflect the results of the dissertation work. Two of them are articles, one is a report at an international conference in our country. One is a solo paper, and the other two have two co-authors, with the doctoral student in first place. Two of the articles were published in a journal with an impact factor.

I have no information that they have been cited by other authors.

9. Personal participation of the doctoral student

The dissertation represents a scientific research development in the field of increasing the life cycle of tools for injection molding of polymer materials. Considering the fact that the entire professional career of M.Eng. Miroslav Simov has been in the design, maintenance and repair of injection molds for plastic injection molding, the publications presented on the dissertation, which reflect the main results in it, in which the doctoral student is in first place, give me reason to assume that the presented dissertation work, including the contributions, are an indisputable personal contribution of the doctoral student.

10. Autor's abstract

The submitted abstract contains 32 pages. It is structured according to the requirements and reflects the essence of the dissertation work, the achieved results and its contributions.

11. Critical remarks and recommendations

I have the following critical remarks regarding the presented dissertation:

1. Figure 4.8 does not correspond to the table below it: at time t=3.6 s, a pressure of 48.77% is not given;
2. There is a discrepancy between the title of Chapter IV and the conclusions – there is no simulation analysis of the factors influencing wear;

3. An experimental study of the Ti/TiN/TiCN coating applied to STAVAX ESR steel was conducted – the intensity of wear from normal force. It would be good to study more factors, for example, sliding speed (flow of liquid plastic);
4. It is not clear how research on the topography of the hard coating contributes to increasing the service life of plastic injection molding tools;
5. There are no generalized conclusions from the results in Chapter V, and these results are the most important for formulating the scientific and applied contributions.

The critical remarks made do not belittle the results achieved in the dissertation.

12. Personal impressions

I have known M.Eng. Miroslav Simov since he was my student at the Technical University of Sofia, Plovdiv branch. Even as a student, he showed interest in new technologies and was, not by chance, the top student in his class. In his professional career, he developed as a very good designer of injection molds, reaching the position of head of the "Maintenance and Repair of Injection Molds" department. He is currently a leading designer of these tools in the region and is doing excellently as a senior designer in one of the largest companies in Smolyan - Festo EOOD.

The developed dissertation and the presented publications show that he has the potential for a serious scientific worker. He knows the production of plastic products and the problems of injection molding tools to perfection. I can responsibly claim that all these achievements define him as a promising and reliable scientist.

13. Recommendations for future use of the dissertation contributions and results

Many of the applied contributions mentioned in the dissertation have been implemented in production. I recommend that M.Eng. Miroslav Simov continue solving the problems of injection molding tools by expanding the scope of research to more hard-alloy coatings on different steel grades.

CONCLUSION

The dissertation contains applied scientific and applied results that represent an original contribution to science and meet all the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria (ADABRB), of the Regulations for the Implementation of the ZRASRB and the relevant Regulations of the PAISII HILENDARSKY PU.

The dissertation shows that the doctoral student, M.Eng. Miroslav Dimitrov Simov, possesses in-depth theoretical knowledge and professional skills in the field of tools, hard alloy coatings and

tribological research, demonstrating qualities and skills for independently conducting scientific research.

In view of the above, I confidently give my ***positive assessment*** of the research conducted, presented by the above-reviewed dissertation, abstract, achieved results and contributions and ***I propose to the esteemed scientific jury to award the educational and scientific degree "doctor" to M.Eng. Miroslav Dimitrov Simov*** in the field of higher education 5. Technical sciences, professional field 5-1 Mechanical Engineering, doctoral program “Methods for controlling and testing materials, products and equipment”.

26.11. 2025 г. Reviewer:

(Prof. DSc. Emg. Georgi Mishev)