

OPINION

for a dissertation for the acquisition of the educational and scientific degree "Doctor",
in the field of higher education 5. Technical Sciences,
Professional field 5.1 Mechanical Engineering,
PhD program "Precision Device Engineering",

Author: mag. Eng. Petar Stoyanov Tsvyatkov,
Topic: "Optimization of the laser color marking process
of carbon steel products",

Member of the Scientific Jury: Prof. Dr. Eng. Iliya Slavov Zhelezarov

1. Topic and relevance of the dissertation

The relevance of the dissertation on the topic "Optimization of the process of laser color marking of a carbon steel product" is determined by the increasing importance of laser marking and its establishment as an effective method of product identification, thanks to surface modification of metal products using the high energy density, good directionality and coherence of laser radiation. The use of laser marking in industry provides durable, high-contrast and environmentally friendly markings on metal products, which guarantees identification and traceability in the process of operation of the products.

The purpose and objectives of the dissertation are correctly formulated on the basis of the analysis made and make it possible to fill a scientific gap, such as the laser marking of carbon steels and specifically C75 steel, which is widely used in industry.

2. Research methodology

In the development of the dissertation, the research related to it and the analysis of the results obtained, the PhD student Mag. Eng. Petar Stoyanov Tsvyatkov has used a methodology that corresponds to the topic, goals and objectives of the dissertation, including theoretical research based on mathematical modeling of thermophysical processes, numerical calculations of critical power densities, energy balance analysis and experimental studies related to laser marking with fiber laser systems, spectrophotometric measurements, profilometry, microhardness testing and scratch resistance, cocoa and corrosion tests, especially important for carbon steels.

3. Contributions of the dissertation

In the dissertation "Optimization of the process of laser color marking of a carbon steel product" and the publications related to the competition, the candidate mag.Eng. Petar Stoyanov Tsvyatkov offers the following scientific, applied and applied contributions.

The four scientific and applied contributions are related to the developed and tested integrated methodology for optimization of the laser color marking process, which combines analytical models, numerical analysis and experimental dependencies, while at the same time determining the critical values of power density, corresponding to the oxidation, melting and evaporation modes under impact on steel C75; a technological window for color laser marking of carbon steel C75 based on experimentally validated boundaries of the main parameters has been defined, and optimal technological modes for the formation of stable oxide layers providing high corrosion resistance and long-term color stability have been identified, quantitative dependencies between contrast, color difference and surface morphology of laser-marked areas have been established, as these dependencies have been experimentally validated for C75 carbon steel and complement previously missing systematic data in the scientific literature; A correlation between microhardness, wear resistance and coefficient of friction on laser-marked surfaces has been proven, revealing and analyzing the mechanisms of instability of color markings associated with thermal fluctuations, insufficient energy accumulation and incomplete overlap of laser lines.

The dissertation includes three applied contributions related to the developed practical instructions for industrial implementation of the process of color laser marking of carbon steel C75, in accordance with the requirements for reproducibility, performance and operational stability; an applicable colour reproducibility assessment methodology that can be used as a quality control tool in serial and mass production and specific colour solutions with potential for anti-counterfeiting applications; The practical applicability of the results for the targeted design of markings with predefined functional properties (contrast, fastness, color stability) is demonstrated, which allows the process to be adapted to specific industry requirements.

4. Publications and citations of publications on the dissertation

The PhD student, Master Eng. Petar Stoyanov Tsvyatkov, includes 6 articles and reports on the developed dissertation, which have been published in prestigious scientific journals. Five of the publications are in editions included in the world databases Scopus/WoS, and 4 of them are in SJR (Scopus). One of the publications is an independent one, and in three of them the author is the first author. A good attestation for the quality of the publication

activity is the large number of citations – 9 of which in publications, included in global Scopus/WoS databases.

5. Authorship of the results obtained

I accept the authorship of Mag. Eng. Petar Stoyanov Tsvyatkov for the developed dissertation, the publications and contributions to it, taking into account the methodological support of its supervisors. I am confident in this by the results of the research, applied and applied work of the candidate, which has been published in prestigious scientific journals and has been reported at international scientific forums.

6. Opinions, recommendations and remarks on the dissertation

I express my positive impression of the dissertation, of its relevance, originality and practical applicability. A very good impression of the author's work is left by the presented analyses and developments on the topic, the results of experimental research, practical implementation in industrial conditions.

I have no critical comments on the dissertation. Petar Stoyanov Tsvyatkov to continue the work on the topic and publish in the form of a manual or manual, including a methodology and instructions for optimizing the processes of color laser marking.

7. Conclusion

I believe that the presented dissertation meets the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria. The results achieved give me grounds to propose to acquire the educational and scientific degree of "Doctor" from a Mag.Eng. Petar Stoyanov Tsvyatkov in the field of higher education 5. Technical Sciences, professional field 5.1 Mechanical Engineering, PhD program "Precision Instrumentation".

Gabrovo, 31 August 2026

Member of the scientific jury:

/prof. Dr. Eng. Iliya Zhelezarov/