

OPINION

for the dissertation presented for awarding the educational and scientific degree
"doctor" on the topic

“OPTIMIZATION OF THE LASER COLOR MARKING PROCESS OF CARBON STEEL PRODUCTS”

with an author Mag. Eng. **PETAR STOIANOV TSVYATKOV**

Field of higher education: 5. Technical sciences

Professional field: 5.1 Mechanical engineering

Doctoral program: Precision instrumentation

Member of the scientific jury: Assoc. Prof. Dr. Eng. Roussi Minev Minev,
Ruse University "Angel Kanchev",
Department of "Materials Science and Technology"

1. Relevance of the dissertation topic

The relevance of the dissertation work dedicated to laser marking is determined by the growing need for durable, high-contrast and environmentally friendly markings on metal products, which provide traceability, protection against counterfeiting and long-term legibility under extreme operating conditions.

Research in the field of color laser marking is focused primarily on titanium and stainless steels, while carbon steel (e.g. C75), despite its wide application in mechanical engineering and toolmaking, is significantly less studied. This creates a significant scientific gap, which the present dissertation aims to fill.

The practical significance of the research is determined by the need to implement sustainable technologies in the production of enterprises specializing in the production of circular saws and band saws.

2. General characteristics of the dissertation work

The dissertation work is of a scientific and applied nature. A significant part of the results included in the presentation were obtained through adequate experimental studies and methods, including: laser marking with fiber laser systems, spectrophotometric measurements, profilometry with a laser microscope, microhardness testing with a dynamic ultramicrohardness tester, scratch resistance testing, corrosion tests in a chamber.

The theoretical methods used are based on the scientific literature and include mathematical modeling of thermophysical processes, numerical calculations of critical power densities, energy balance analysis.

Based on a critical analysis of the current state of the problems related to laser marking, the goal of the research was formulated: to optimize the process of laser color marking of carbon steel products by developing and applying a theoretical-mathematical model, methodological approaches and technological modes, allowing for quantitative study of the influence of laser and technological parameters on the characteristics of the marking.

To achieve the formulated goal, the following tasks were solved: identification and systematization of the factors affecting the contrast; development of a theoretical-mathematical model for determining appropriate laser parameters, development of a methodology for conducting experiments; selection and configuration of a laser source and scanning system; experimental study of the influence of technological parameters on contrast, roughness, microhardness, color difference, color reproducibility, scratch resistance and corrosion resistance.

The cited 150 literary sources give me reason to note that the author knows the researched problem well.

The scientific work submitted for review contains scientific or applied scientific results in accordance with the requirements of Art. 6, para. 3 of the Law on the Development of Academic Staff (LDAS) in the Republic of Bulgaria.

3. Presentation of the dissertation work

The dissertation work consists of 184 pages and includes 107 figures, 20 tables, appendices and five main chapters relating to: (i) analysis of the current state of color marking; (ii) review of the factors affecting the contrast of the marking; (iii) determination of working intervals of technological parameters; (iv) description of the equipment and methodology of the conducted research; (v) experimental results.

The structure and content of the dissertation work corresponds to the requirements and established practice.

The main results of the dissertation work have been reported and discussed at international scientific conferences and have been published in six sources. Four of them are publications that are referenced and indexed in world-renowned databases of scientific information (SJR, Scopus) and one is independent. The candidate's „scientometric“ data correspond to the Law on the Development of Academic Staff (LDAS) and the minimum requirements of the Technical University - Gabrovo.

The candidate presents 9 citations to 3 of his publications, which indicates good popularization and significance of the results.

4. Contributions of the dissertation work

The formulated contributions in the dissertation work are relevant to the obtaining and proving of new facts and confirming those already obtained.

I accept in general the scientific-applied (four in number) and applied contributions (three in number). Considering scientific-applied contribution No. 2 ("defined technological window for color laser marking of carbon steel C75, based on experimentally validated limits of the main parameters, identifying optimal technological regimes for the formation of stable oxide layers, ensuring high corrosion resistance and long-term color stability") in my opinion it is more purely applied contribution rather than scientific-applied.

5. Critical remarks on the dissertation

I have no significant critical remarks on the presented text of the dissertation.

Recommendations for editorial corrections can be made, for example, texts in English in some figures, clarification of the concept of "laser radiation quality", refinement of the concept of "optimization", etc. The latter do not have a significant impact on the quality of the presented dissertation, which is performed precisely and clearly.

6. Authorship of the results obtained

Knowing the work of the doctoral student, I believe that the experimental studies performed, the results obtained and the dissertation are the work of Eng. Petar Stoianov Tsvyatkov.

7. Conclusion

The research work presented in the dissertation has achieved significant results with certain scientific or scientific-applied contributions in the study and optimization of the process of laser color marking of carbon steel.

The doctoral student demonstrates knowledge and skills for independent scientific research using modern approaches, methods and technical means.

I believe that the dissertation work of Eng. Petar Stoianov Tsvyatkov possesses the necessary qualities and meets the requirements of the law. I propose that he be awarded the educational and scientific degree of "doctor".

August 25, 2026

Member of the scientific jury:

/Assoc. Prof. Dr. Eng. Roussi Minev Minev/