PROCEEDINGS

of the Union of Scientists - Ruse

Book 5

Mathematics, Informatics and Physics

Volume 12, 2015

RUSE

PROCEEDINGS
OF THE UNION OF SCIENTISTS - RUSE

Union of Scientists - Ruse
16, Konstantin Irechek Street
7000 Ruse
BULGARIA
Phone: (++359 82) 828 135,
(++359 82) 841 634
E-mail: suruse@uni-ruse.bg
web: suruse.uni-ruse.bg

Contacts with Editor
Phone: (++359 82) 888 738
E-mail: zzdravkova@uni-ruse.bg

PROCEEDINGS
of the Union of Scientists – Ruse

ISSN 1314-3077

ISSN 1314-3077

Proceedings

of the Union of Scientists – Ruse

Contains five books:

1. Technical Sciences
2. Medicine and Ecology
3. Agrarian and Veterinary Medical Sciences
4. Social Sciences
5. Mathematics, Informatics and Physics

The Ruse Branch of the Union of Scientists in Bulgaria was founded in 1956. Its first Chairman was Prof. Stoyan Petrov. He was followed by Prof. Trifon Georgiev, Prof. Kolyo Vasilev, Prof. Georgi Popov, Prof. Mityo Kanev, Assoc. Prof. Boris Borisov, Prof. Emil Marinov, Prof. Hristo Beloev. The individual members number nearly 300 recognized scientists from Ruse, organized in 13 scientific sections. There are several collective members too – organizations and companies from Ruse, known for their success in the field of science and higher education, or their applied research activities. The activities of the Union of Scientists – Ruse are numerous: scientific, educational and other humanitarian events directly related to hot issues in the development of Ruse region, including its infrastructure, environment, history and future development; commitment to the development of the scientific organizations in Ruse, the professional development and growth of the scientists and the protection of their individual rights.

The Union of Scientists – Ruse (US – Ruse) organizes publishing of scientific and popular informative literature, and since 1998 – the "Proceedings of the Union of Scientists- Ruse".

BOOK 5

"MATHEMATICS, INFORMATICS AND PHYSICS"

VOLUME 12

CONTENTS

BOOK 5

"MATHEMATICS, INFORMATICS AND PHYSICS"

VOLUME 12

Physics

Applications

web: suruse.uni-ruse.bg

INFLUENCE OF SPEED AND FREQUENCY OF PROCESS LASER MARKING OF PRODUCTS OF STRUCTURAL STEEL

Nikolay Angelov

Technical University of Gabrovo

Abstract: *The influence of the speed and frequency for the laser marking of samples of structural steel was investigated. The experiments were carried out with laser CuBr, working in the visible area. The dependences of the contrast of marking from the speed and frequency were received and analyzed. Work intervals for the speed and frequency of laser marking these materials were determined.*

Keywords: *laser marking, structural steel, CuBr laser, work intervals.*

INTRODUCTION

Speed and frequency are basic parameters influencing the contrast and quality of the marking of products [1–3]. The time of impact on the sample and the energy, that is absorbed in the material in the area of treatment, depend from the speed. It is decisive in the choice of the method of marking. As it is known, main operation modes of lasers are continuous in a pulsed regime. It is preferably the lasers for marking to work in pulse mode. They have a frequency of several kHz to hundreds of kHz.

Due to the exceptional importance of the speed and frequency of the laser marking process for each case, they should be optimized by conducting experiments.

The purpose of the study is to obtain work intervals on power density of laser radiation and speed of laser marking on products from structural steels 15kp and 30ChGS (in BDS).

EXPERIMENT

Steel 15kp is used for making elements of piping, fittings, plugs, fasteners, shafts, levers. From steel 30ChGS shafts are made, axles, gears, brake bands of engines, flanges, plating, blades of compressor machines, levers, pushers responsible welded structures operating at variable loads fasteners. The basic characteristics of these steels are given in [5].

Experiments have been made with a CuBr laser. On Fig. 1 a laser technological system for marking with CuBr laser is shown:

Fig. 1a – Appearance of the used laser technological system;

Fig. 1b – Scheme of the laser technological system: 1 - computer; 2 - control unit; 3 - power supply; 4 - technological laser ; 5 - optical system; 6 - system for deflection ; 7 - cooling system; 8 - MOPA system; 9 - power of the working head; 10 - protected block; 11 - tristimulus table.

The basic parameters of laser technological system for marking with this laser are given in Table 1 [4], [6].

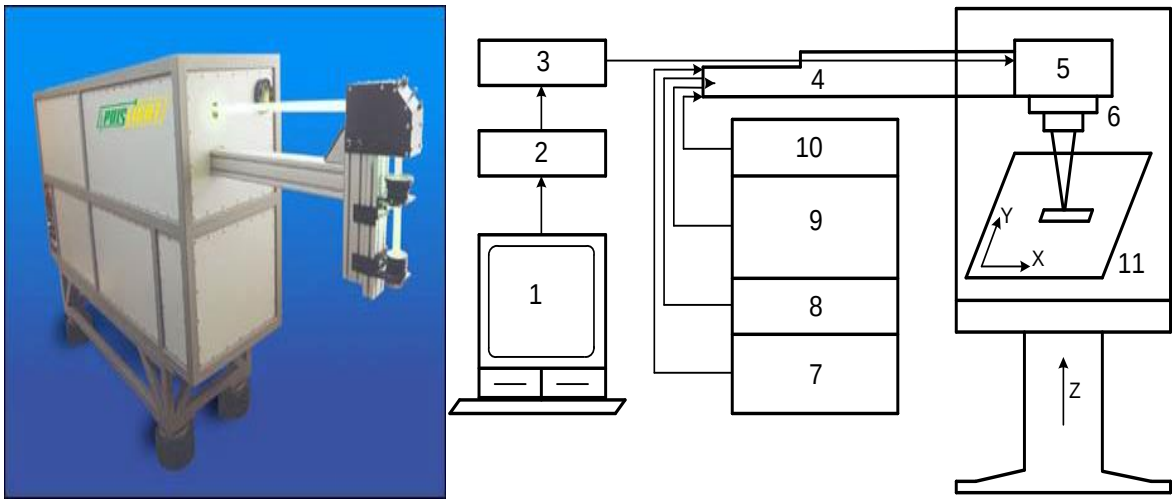

Fig.1. Laser technological system for marking with CuBr laser

Table 1

Parameter	Value
Wavelength λ, nm	578
Power P, W	10,0
Frequency ν, kHz	20,0
Pulse duration τ, ns	30
Pulse energy E_p, mJ	0,50
Pulse power P_p, kW	16,7
Beam quality M^2	< 1,7
Positioning accuracy, μm	2,5
Efficiency, %	10

EXPERIMENTAL RESULTS

1. Study of the dependence of the contrast *k from the speed *v* of marking.**

A large number of experiments were performed. Parameters, that are kept constant during the experiments, are given in Table 2. The speed of marking of laser radiation varies in the interval $v \in [20; 100]$ mm/s in 10 mm/s.

Table 2

Parameter	Value
Power density q_S, W/m^2	$1{,}27.10^{10}$
Diameter d, μm	30,0
Frequency ν, kHz (only for task 1)	20,0
Speed v, mm/s (only for task 2)	50,0
Pulse duration τ, ns	30
Step Δx, μm	50
Defocusing Δf, mm	0

Graphs of the experimental dependence $k^* = k^*(v)$ for samples of structural steels 15kp and 30ChGS are shown on Fig. 2: 1 – 15kp; 2 – 30ChGS. From their analysis the following conclusions can be drawn:

- With increasing speed nonlinear decrease of the contrast of marking for both steels is observed .
- The comparison of the two graphs shows that the contrast of the marking of steel 15kp is about 6-7% greater than that of steel 30ChGS for each speed of the interval. This fact is explained by the different optical and thermo-physical characteristics of the two materials.
- The rate of change on the contrast of the marking is:

Interval Sample	v Є [20; 60] mm/s	v Є [60; 100] mm/s
Steel 15 kp	– 0.25%/(mm/s)	– 1.38%/(mm/s)
Steel ChGS	– 0.225%/(mm/s)	– 1.32%/(mm/s)

- The work intervals of speed for laser marking with CuBr for power density $q_S = 1{,}20.10^{10}$ W/m^2 are:

For visual perception of marking	Steel 15 kp Steel ChGS	v Є [20; 81] mm/s v Є [20; 76] mm/s
Using a readers	Steel 15 kp Steel ChGS	v Є [20; 97] mm/s v Є [20; 95] mm/s

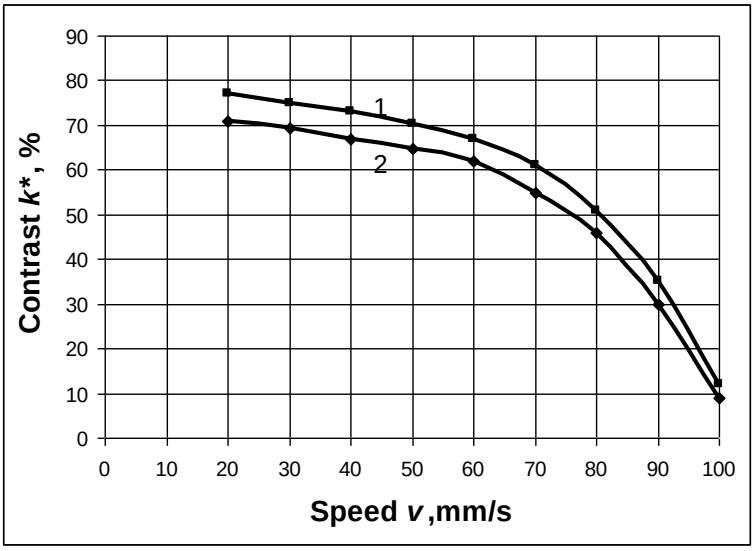

Fig.2.

2. Study of the dependence the contrast *k of the marking from frequency v.**

The parameters, which are kept constant during the experiments, are given in Table 2. The frequency varies are in the interval v Є [4, 20] kHz with step 2 kHz.

On Fig. 3 graphs of the experimental dependence $k^* = k^*(v)$ for samples of structural steels are shown: 1 – 15kp; 2 - 30ChGS. From their analysis one can draw the following conclusions:

- With increasing frequency a nonlinear increase of the contrast of the marking for the two materials is observed. It is explained with better absorption of laser energy for larger frequencies;
- The rate of change of frequency in the interval of studies is:

1,44 %/kHz for structural steel 15kp;
1,23 %/kHz for structural steel 30ChGS.

- The work intervals of frequency for laser marking with CuBr for power density v = 50 mm/s are:

For visual perception of marking	Steel 15 kp Steel ChGS	$\nu \in [6; 20]$ kHz $\nu \in [8; 20]$ kHz
Using a readers	Steel 15 kp Steel ChGS	$\nu \in [4; 20]$ kHz $\nu \in [4; 20]$ kHz

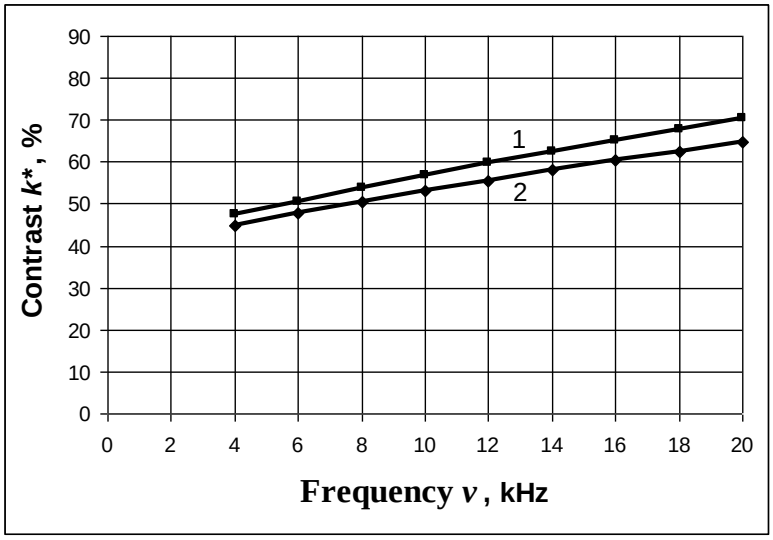

Fig.3.

CONCLUSION

The results from experimental studies serve to fill the technological tables with working process parameters for each case of laser marking. So this assists the operator of laser technological systems. Moreover, it increases production efficiency.

REFERENCES

[1] Lazov L., N. Angelov, Osnovni faktori, opredelyashti kachestvoto na markirovkata na metali I splavi, Mejdunarogna nauchna konferenciya AMTECH'07, Gabrovo, 23-24 November 2007, tom I, pp. 102-107.

[2] Dinev S., Lazerite v savremennite tehnologii, Izd. Alfa, Sofia, 1993, pp. 99-101.

[3] Dichev, D., Hr. Koev, Models for analysis of dynamic error for instruments, measuring parameters of moving objects. International virtual journal for science, technics and innovations for the industry MTM' 2011, issue 9/2011. ISSN 1313-0226.

[4] Pulov D., Optical system for collimating laser beams in the LWIR spectral range, International scientific conference UNITECH'14, 21-22 November 2014, Gabrovo, Volume III, pp. 372-378.

[5] www.splav.kharkov.com/main.php.

[6] www.pulslight.com.

CONTACT ADDRESS
Assist. Prof. Nikolay Angelov Petrov, PhD
Department of Physics, Chemistry and Ecology, Faculty of Economics
Technical University of Gabrovo
4 Hadzhy Dimitar Str., 5300 Gabrovo, Bulgaria
Phone: (++359 66) 827 318
E-mail: angelov+np@abv.bg

ВЛИЯНИЕ НА СКОРОСТТА И ЧЕСТОТАТА ЗА ПРОЦЕСА ЛАЗЕРНО МАРКИРАНЕ НА ИЗДЕЛИЯ ОТ КОНСТРУКЦИОННА СТОМАНА

Николай Ангелов

Технически университет – Габрово

Резюме: *Изследвано е влиянието на скоростта и честотата за лазерно маркиране на образци от конструкционна стомана. Експериментите са извършени с лазер на CuBr, работещ във видимата област. Получени и анализирани са зависимостите на контраста на маркировката от скоростта и честотата. Определени са работни интервали за скоростта и честотата за лазерно маркиране на тези материали.*

Ключови думи: *лазерно маркиране, конструкционна стомана, лазер на CuBr, работни интервали.*

The paper is dedicated to **International Year of Light and Light-based Technologies, 2015 (IYL 2015).**

Requirements and guidelines for the authors - "Proceedings of the Union of Scientists - Ruse" Book 5 Mathematics, Informatics and Physics

The Editorial Board accepts for publication annually both scientific, applied research and methodology papers, as well as announcements, reviews, information materials, adds. No honoraria are paid.

The paper scripts submitted to the Board should answer the following requirements:

1. Papers submitted in English are accepted. Their volume should not exceed 8 pages, formatted following the requirements, including reference, tables, figures and abstract.

2. The text should be computer generated (MS Word 2003 for Windows or higher versions) and printed in one copy, possibly on laser printer and on one side of the page. Together with the printed copy the author should submit a disk (or send an e-mail copy to: vkr@ami.uni-ruse.bg).

3. Compulsory requirements on formatting:

- font - Ariel 12;
- paper Size - A4;
- page Setup - Top: 20 mm, Bottom: 15 mm, Left: 20 mm, Right: 20mm;
- Format/Paragraph/Line spacing - Single;
- Format/Paragraph/Special: First Line, By: 1 cm;
- *Leave a blank line under Header - Font Size 14;*
- Title should be short, no abbreviations, no formulas or special symbols - Font Size 14, centered, Bold, All Caps;
- *One blank line - Font Size 14;*
- Name and surname of author(s) - Font Size: 12, centered, Bold;
- *One blank line - Font Size 12*;
- Name of place of work - Font Size: 12, centered;
- *One blank line;*
- abstract – no formulas - Font Size 10, Italic, 5-6 lines ;
- keywords - Font Size 10, Italic, 1-2 lines;
- *one blank line;*
- text - Font Size 12, Justify;
- references;
- contact address - three names of the author(s) scientific title and degree, place of work, telephone number, Email - in the language of the paper.

4. At the end of the paper the authors should write:

- The title of the paper;
- Name and surname of the author(s);
- abstract; keywords.

Note: The parts in item 4 should be in Bulgarian and have to be formatted as in the beginning of the paper.

5. All mathematical signs and other special symbols should be written clearly and legibly so as to avoid ambiguity when read. All formulas, cited in the text, should be numbered on the right.

6. Figures (black and white), made with some of the widespread software, should be integrated in the text.

7. Tables should have numbers and titles above them, centered right.

8. Reference sources cited in the text should be marked by a number in square brackets.

9. Only titles cited in the text should be included in the references, their numbers put in square brackets. The reference items should be arranged in alphabetical order, using the surname of the first author, and written following the standard. If the main text is in Bulgarian or Russian, the titles in Cyrillic come before those in Latin. If the main text is in English, the titles in Latin come before those in Cyrillic. The paper cited should have: for the first author – surname and first name initial; for the second and other authors – first name initial and surname; title of the paper; name of the publishing source; number of volume (in Arabic figures); year; first and last page number of the paper. For a book cited the following must be marked: author(s) – surname and initials, title, city, publishing house, year of publication.

10. **The author(s) and the reviewer, chosen by the Editorial Board, are responsible for the contents of the materials submitted**.

Important for readers, companies and organizations

1. Authors, who are not members of the Union of Scientists - Ruse, should pay for publishing of materials.

2. Advertising and information materials of group members of the Union of Scientists – Ruse are published free of charge.

3. Advertising and information materials of companies and organizations are charged on negotiable (current) prices.

Editorial Board

ISSN 1314-3077