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INFLUENCE OF CERTAIN TECHNOLOGICAL PARAMETERS FOR LASER MARKING OF ARTICLES OF STEEL 08X13

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Abstract: *The influence of the frequency and duration of pulses on laser marking process of articles of steel 08X13 was studied. Has been used a disc laser – a contemporary laser, operating in the near infrared area. Dependencies on contrast of marking from frequency and duration of pulses for two power densities were received. The results are analyzed and summarized.*

Keywords*: disc laser, laser marking, steel 08X13, contrast, frequency, duration of pulses, power density.*

1. Introduction

The globalization of the production and trade sets new requirements for marking of the products which are marketed. Damage that to the products information must comply with the requirements of EU legislation and it is often associated with requirements for protection of consumer health, safety and environmental protection. In recent years, extremely increased role of the marking as a guarantee of counterfeits and protecting the intellectual property of the manufacturer. Basic requirement onto the marking is to possess the necessary contrast and store information throughout the exploitation. This largely applies to industrial products with applications in hydraulics - hydraulic pumps, hydraulic presses, pistons and others. In recent years for these products is used the laser marking - an innovative method with several advantages over other methods. This technological process is not yet fully studied for the different lasers and the materials from which products are made [1 - 4].
Purpose of the report is to examine the impact of the frequency and duration of pulses on process of laser marking by melting of steel 08X13 (EN 1.400) through disc laser and to determine work intervals for the frequency and duration of pulses for this steel.

2. Theoretical aspects

As is known, the main modes of work of the lasers are continuous and pulsed mode. Preferably is the lasers for marking is to work in pulsed mode. In it essential are pulse power P_p, pulse energy E_p, duration of pulses τ and frequency ν. They relate to the average power P of the laser with the expressions

$$P = P_p \tau \nu \quad , \tag{1}$$

$$P = E_p \nu \quad . \tag{2}$$

Contemporary lasers allow for conducting experiments in a very wide range of variation in the frequency and duration of pulses. There is a relationship between laser parameters from constructional character of certain lasers [2].

3. Material

Stainless steel 08H13 is with widely used in industry. It is used for making hydraulic pumps, parts with high ductility, subject to impact loads (valves of hydraulic presses, household items), as well as products that are exposed to slightly aggressive media (precipitation, aqueous solutions of salts of organic acids at room temperature, and others), blades of steam turbines, valves, bolts and pipes.
The hydraulic pumps manufactured from this steel, are used to transport wine, ethyl alcohol, methyl alcohol, strong alcohol, beer, vinegar, vegetable oil, viscous and foaming liquids, sludge, crushed grapes, grape mess, fruit purees, natural juices, nectars, syrups and others [8 – 10].
The chemical composition of steel 08H13 is presented in Table 1 [6]. It gives the impression the large chromium content, which is a alloying element. In Table 2 are given some basic parameters of steel 08X13 [6, 7]. It may be noted that the coefficient of thermal conductivity have not great value.

TABLE 1: Chemical composition of steel 08X13

Chemical element	**C**	**Si**	**Ni**	**Mn**
Content, %	< 0.08	< 0.80	< 0.60	< 0.80
Chemical element	S	P	Cr	
Content, %	< 0.025	0.03	12.0 ÷ 14.0	

TABLE 2: Certain parameters of steel 08X13

Parameter	**Value**
Thermal conductivity k, W/(m.K)	28
Specific heat capacity c, J/(kg.K)	462
Density ρ, kg/m^3	7760
Thermal diffusivity a, m^2/s	$7.81.10^{-6}$

3. Laser technological system

Laser technological system with disc laser, are used. It is a laser, operating in the near infrared region and is in pulse mode. This makes it suitable for the process of laser marking on metals and alloys. It has a number of advantages in comparison with much part of the lasers, used in industry. He has a very good quality of beam, small diameter of beam and high efficiency. Laser system is with extremely accurate positioning and good repeatability on the inscriptions. In Table 3 are given some basic parameters of the laser technological system [11].

TABLE 3: Certain basic parameters of the laser technological system

Parameter	Value
Wavelength λ, nm	1 064
Power P, W	16.0
Diameter of work spot in focus d, µm	30.0
Frequency v, kHz	5-50
Duration of pulses τ, µs	1.0 –10.0
Pulse energy E_p, mJ	0.32 – 3.2
Pulse power P_p, kW	0.032 – 3.2
Beam quality M^2	< 1.2
Positioning accuracy, µm	2.5
Efficiency, %	35

4. Experimental results and analysis

A great number of experiments to study the process laser marking by melting on stainless steel 08X13, were conducted. It was used raster method of marking. The test fields, consisting of squares with a side of 5 mm, were created. The squares were marked with different durations of pulses and different frequency.

Duration of pulses is changed in the interval τ Є [1.0; 10.0] µs with step 1.0 µs. Two graphs of the dependence on the contrast from the duration of the pulses for two power densities are shown in figure 1: q_{S1} = 1.95.10^{10} W/m^2 и q_{S2} = 2.26.10^{10} W/m^2 (fig. 1). Of them can draw the following conclusions:

- By increasing the duration of the pulses was observed weak and non-linear decrease the contrast. It is explained by the fact that with the increase of the duration of the pulses reduces the pulse power. Furthermore, it is increased the losses from heat conduction;
- The average fastness on reduction of contrast is

– 1.22 %/ µs for power density q_{S1} = 1.95.10^{10} W/m^2;

– 1.53 %/ µs for power density q_{S2} = 2.26.10^{10} W/m^2.

- The following work intervals for the duration of the pulses were determined

– τ Є [1.0; 4.0] µs for power density q_{S1} = 1.95.10^{10} W/m^2;

– τ Є [1.0; 10.0] µs for power density q_{S2} = 2.26.10^{10} W/m^2.

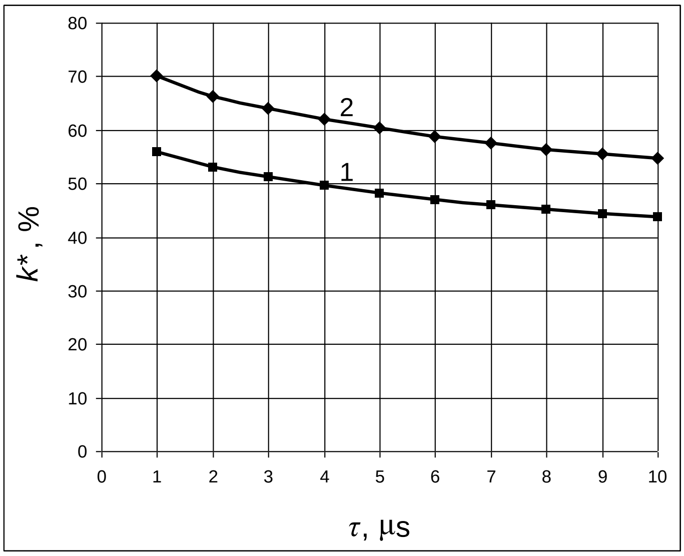

Fig. 1. Graphs on the dependence on the contrast from duration of the pulses for two power densities: 1 – q_{S1} = 1.95.10^{10} W/m^2; 2 – q_{S2} = 2.26.10^{10} W/m^2.

The frequency of repetition of the pulses is changed in in the interval ν Є [5.0; 50.0] kHz with step 5.0 kHz. Two graphs of the dependence on the contrast from frequency for two power densities densities are shown in figure 2: q_{S1} = 1.67.10^{10} W/m^2 и q_{S2} = 2.09.10^{10} W/m^2 (fig. 2). From their analysis follows:

- With the increase in frequency is observed nonlinear increase of contrast. In the interval ν Є [5.0; 20.0] kHz curve is steeper than in the interval ν Є [20.0; 50.0] kHz;
- The average fastness on increase of contrast in the interval ν Є [5.0; 20.0] kHz is

1.20 %/ kHz for power density q_{S1} = 1.67.10^{10} W/m^2;

1.41 %/ kHz for power density q_{S2} = 2.09.10^{10} W/m^2.

- The average fastness on increase of contrast in the interval ν Є [20.0; 50.0] kHz is

0.383 %/ kHz for power density q_{S1} = 1.67.10^{10} W/m^2;

0.351 %/ kHz for power density q_{S2} = 2.09.10^{10} W/m^2.

- The following work intervals for frequency were determined

ν Є [9.0; 50.0] kHz for power density q_{S1} = 1.67.10^{10} W/m^2;

ν Є [16.0; 50.0] kHz for power density q_{S2} = 2.09.10^{10} W/m^2.

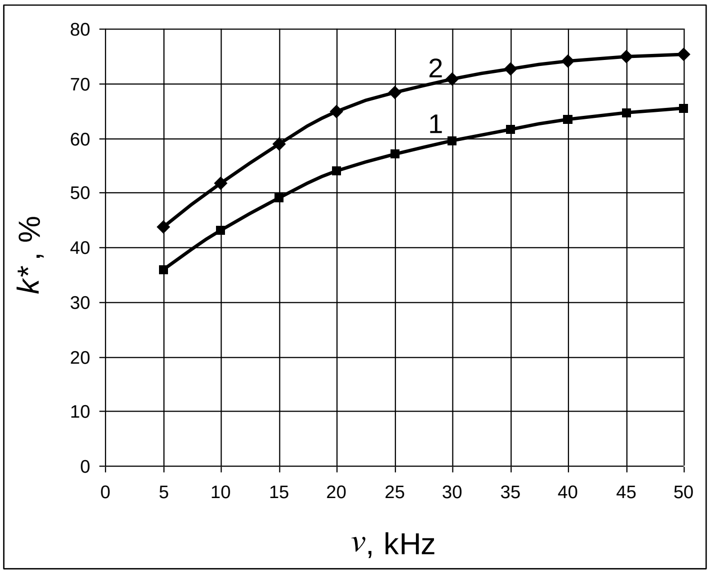

Fig. 2. Graphs on the dependence on the contrast from frequency for two power densities: 1 – q_{S1} = 1.67.10^{10} W/m^2; 2 – q_{S2} = 2.09.10^{10} W/m^2.

5. Conclusion

Laser marking is a stage from manufacture of the products. For optimization of the studies process for this steel it is necessary to investigate the influence of other important process parameters such as power density, speed, number of repetitions and defocusing. For this is necessary, experimental studies with disc laser to be continued. The results will help operators of laser technological systems, used in the industry.

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