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Control of the process of pulsed laser thermal hardening based on emerging potential

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Abstract. The article studies the relationship between the time power distribution of pulsed laser radiation and the emerging electric potential in metals. It is shown that the emerging potential characterizes the shape of the laser pulse during processing and characterizes the penetration depth of the thermal influence zone. It is revealed if the energy of laser action pulse does not exceed 12 J and duration is less than 1 μs the form of the emerging potential is the same for all types of time distribution of laser action power.

1. Introduction
In engineering laser thermal hardening is applied to improve the wear resistance of the lay shafts, crankshafts, gear wheels, working surfaces of the valves, valve rockers, valve seats etc. The quality of the hardened layer depends on the parameters of the laser technological complex (the energy of the radiation pulse, focal length, pulse duration, gaseous atmosphere, external fields, etc.). Laser hardening of the working surface of the metal product at capacities close to critical, which do not allow melting, cannot give stable surface quality indicators which are required in the production process. Therefore, it is required to monitor the depth of the thermal influence zone in real time.

2. Results
In the course of this work a method for determining the parameters of the generated laser radiation and the depth of the thermal influence zone was developed. This method consists in removing the oscillograms of the emerging potential in the metal plate under the influence of a laser pulse in real time and their further processing to determine the required adjustments in the generation parameters.

Analyzing the data of the emerging potential graphs, the differences in the time distributions of energy in the pulse are traced. The graphs of regular and Gaussian distribution are similar and are characterized by a smoother increase and decrease of potential in time (Fig. 1, 2), in contrast to the increasing and decreasing distribution (Fig. 3, 4). The similarity of the graphs of regular and Gaussian distribution is explained by the absence in the distribution of sharp power jumps and regularity. However, it should be noted that at the same energy in the laser pulse with a regular time distribution of energy in the pulse, the emerging potential is greater as well as the depth of the thermal influence zone (Fig. 5).

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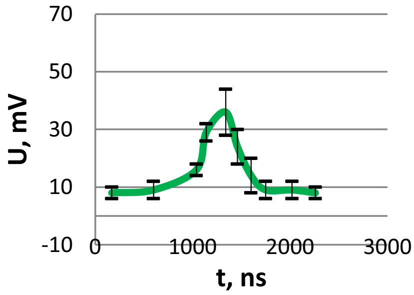

Fig 1. Graph of the dependence of the emerging potential on the time distribution of energy in the pulse: regular distribution, U = 300 V

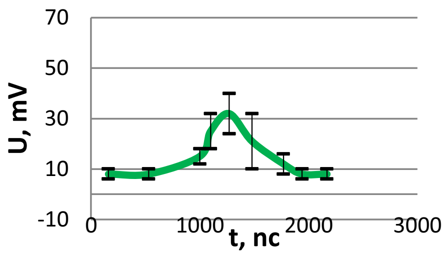

Fig. 2. Graph of the dependence of the emerging potential on the time distribution of energy in the pulse: Gaussian distribution, U = 300 V

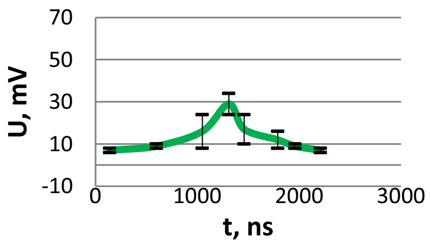

Fig. 3. Graph of the dependence of the emerging potential on the time distribution of energy in the pulse: increasing distribution, U = 300 V

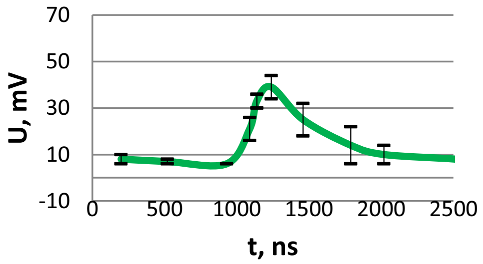

Fig. 4. Graph of the dependence of the emerging potential on the time distribution of energy in the pulse: decreasing distribution, U = 300 V

Increasing and decreasing distributions have graphical data which are characteristic of their time distribution of power in the pulse. Thus increasing distribution (Fig. 3) is characterized by a more gradual increase in potential, in contrast to decreasing distribution(Fig. 4), and a sharp decline to the average values with a further gradual decrease in potential. The decreasing distribution is characterized by a sharp increase in potential, followed by a very smooth decline.

We also carried out metallographic investigations with the aim of identifying the emerging features of the thermal influence zone influenced by of time power distribution and identify the relationship of emerging potential and depth of thermal influence zone.

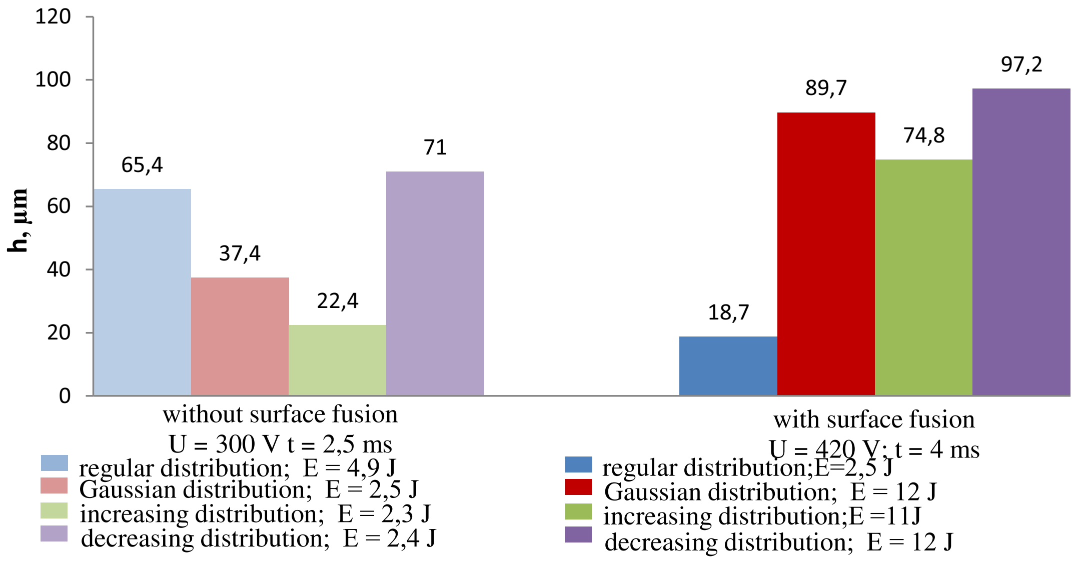

Fig. 5. Graph of the dependence of the depth of the thermal influence zone on the time distribution of energy in the pulse

The obtained values of the depth of thermal influence zone under the influence of a laser pulse with the surface fusion, except for the depth values under the influence of a regular time distribution of energy, have a smaller difference in values, while they are similar to the results of the influence without surface fusion. We can say that when the increases, the difference between the depth values, when exposed to different time distributions of energy, decreases.

In should be noted that on the graphs (Fig. 5) without surface fusion and with it, the greatest depth of thermal influence zone has pulses with decreasing time distribution of energy. The pulses with increasing time distribution have the lowest depth of thermal influence zone.

3. Conclusions

The identified relationship can be used to create a system of automatic control in real time. Such a system during processing will be able to accurately predict the depth of thermal influence zone as well as, if necessary, to adjust the power of laser radiation.

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