Research on influence of temporary distribution of power of laser radiation with a hybrid processing on a depth heat affected zone.

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Abstract. Investigations on the influence of the temporal distribution of the laser radiation power per pulse of hybrid processing on a depth heat affected zone. Recommendations on use of specific distribution of the laser radiation power in the combined laser and plasma processing for decrease in energy consumption.

1. Introduction
One of the most effective methods of treating metal alloys is to use hybrid processing methods using plasma and laser radiation flux [1]. The main criterion for assessing the quality of the process parameters of the hybrid hardening serves temperature distribution in the interaction zone of concentrated energy flows, and from it has, in turn, depend all the other indicators of the quality of the hardening [2, 3].

In practice there is often a question of depth heat affected zone (HAZ), particularly for machine parts operating on an abrasion. Surface treatment of parts using hybrid laser-plasma method in the critical energy density of the laser beam, do not give stable quality indicators, which leads to the inability to use these technologies in the industry.

For ensuring high-quality management of technological processing of a product, it is necessary to study more fully the processes proceeding at influence of laser radiation [4]. In this work research of influence of temporary distribution of power of laser radiation to depth of a zone of phase transformations in metal at influence of the laser is conducted.

2. Experimental study
For carrying out experiments with a research objective of interaction of laser radiation, with various temporary distribution of power, with metals experimental installation on the basis of the laser technological complex LRS-150A was designed (figure 1).
The used laser technological complex allows to generate pulse laser radiation with various
temporary distribution of power in an impulse. For carrying out experiment were used the most
widespread and encountered in using in the industry of distribution of power of radiation in time:
uniformly, Gaussian, evenly increasing and evenly decreasing. To achieve the correct measurements,
energy input to the pulse was the same, which is achieved by the same voltage capacitor charging
power supply system of the laser technological complex.

For completeness of consideration of the processes proceeding during radiation on a detail were
two operating modes which are characterized various voltage of a charge condensers $U_K$ and time of
pulse influence $t$ are picked up: $U_K = 420 \ \text{V}, \ t = 4 \ \text{ms}$ и $U_K = 300 \ \text{V}, \ t = 2,5 \ \text{ms}$. Steel 45
microstructure, when processing with use of the modes described above, are presented in figures 2 and
3.

3. Results of experiment
In figures 2 and 3: a – uniform distribution, b – Gaussian distribution, c – the increasing distribution, d – the decreasing distribution.

The analysis of the processed samples at $U = 300 \ \text{V}, \ t = 2,5 \ \text{ms}$ showed to the following
dependencies which are possible to distinguishing: at the uniform and decreasing temporary
distribution of power in an impulse of laser radiation almost identical depth of the zone of thermal
influence.

Figure 1. Experimental laser technological machine.
Under the influence of the Gaussian and the increasing temporary distribution of energy, depth of HAZ is much less, in difference from the uniform and decreasing distribution.

The values obtained for the depth of the HAZ when $U_K = 420$ V, $t = 4$ ms (Table 1) are similar in nature to the results of the impact when $U_K = 300$ V, $t = 2.5$ ms, but the difference in the depth of the HAZ impact at different temporal distribution of power laser pulse is reduced.

We will note that the samples processed with the decreasing temporary distribution of energy have the greatest depth of HAZ, and the samples processed with the increasing temporary distribution have the smallest depth of HAZ.

**Figure 2.** Microstructure of a zone of laser influence $U_K = 300$ V, $t = 2.5$ ms, x200
Figure 3. Microstructure of a zone of laser influence $U_k = 420$ V, $t = 4$ ms, x200

Table 1. The dependence of the depth of HAZ of temporary power distribution in the laser pulse.

| Temporary power distribution | $U_k = 300$ V, $t = 2.5$ ms | $U_k = 300$ V, $t = 2.5$ ms |
|-----------------------------|-------------------------------|-------------------------------|
| Uniformly                   | 65.4                          | 18.7                          |
| Gaussian                    | 37.4                          | 89.7                          |
| Evenly increasing           | 22.4                          | 74.8                          |
| Evenly decreasing           | 71                            | 97.2                          |

4. Conclusions
Thus, at hybrid laser and plasma processing of materials, for decrease in energy consumption of technological installation and management of stability indicators of quality processing, it is necessary to strive for the absence of increasing laser power during the whole cycle of continuous exposure to
laser radiation. In case of pulse laser influence in the combined power source, it is necessary strives for the falling characteristics of power in an impulse of laser radiation.

References

[1] Israphilov I H, Bashmakov D A, Galiakbarov A T, Mandrik P A and Ganiev M M 2014 Russian Physics Journal 57 3/3 148

[2] Grigor’yants A G, Shiganov I M and Misyurov A I 2006 Technological processes of laser processing (Moscow: Bauman Moscow State Technical University) p 664

[3] Israphilov I H, Galiakbarov A T, Israphilov D I, Gabdrahmanov A T and Samigullin A D 2012 Proceedings of the Tula State University. Technical sciences. 6 90

[4] Israphilov D I 2007 Management of a plasma technological complex for heat treatment of parts with specified strength characteristics (Naberezhnye Chelny: Kama state engineering and economic academy) p 141