FEATURES CRATER MORPHOLOGY AFTER THE ACTION OF LASER RADIATION ON THE METAL SURFACE

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Abstract – Used plates of the alloy Fe-Si. Specimens irradiating by a laser source. When a pulse of radiation during at the surface formed crater with wavy-like relief. The appearance of a periodic wavy relief on the surface of the crater is connected, and thermocapillar phenomena that arise from the dependence of surface tension on temperature.

I. INTRODUCTION

Laser treatment of various details of metal commonly used in the industry (welding, cutting, and surface marking, etc.). For example, in laser marking process of stainless steel, the corrugated surface of the workpiece becomes. Reduction such kind surface defect is not yet unsolved problem.
The aim of this work was to study the morphology features of the surface characteristics of steel 40×13 when exposed by laser radiation of varying intensity.

II. EXPERIMENTAL TECHNIQUE

We used stainless steel plate 40X13 [1] with the dimensions 30×15×0,9 mm [2]. Samples were irradiated with a laser with an active element of YAG:Nd (1,064 mkm) (free generation). The pulse energy and time influence is 3 ± 0,1 J and 3 ms, respectively. The study was carried out using noncontact optical profilometer Wyko NT 9080 (Bruker AXS, USA). All experiments were performed at room temperature with a mixture of target blowing ambient air and argon (flow rate of 5 l/min.)

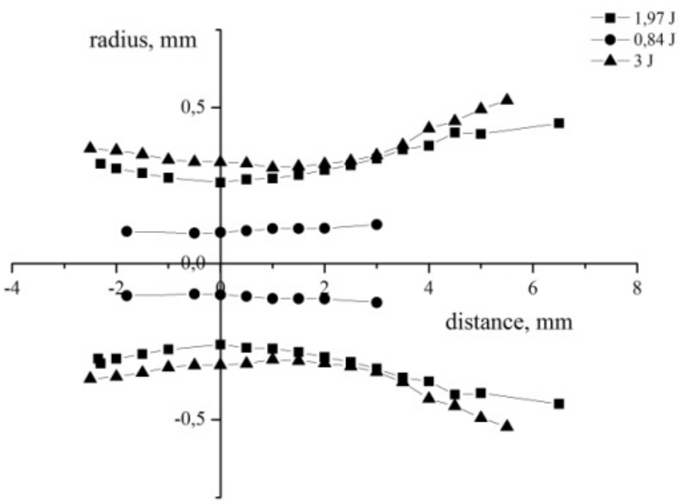

Figure 1 – Form caustics for different energies of the focused laser beam (t = 3 ms).

Calculation of power density (J) produced by the formula:

$$J = \frac{W}{\tau S},$$

where W – energy per pulse, τ – time of exposure and S – the area of the beam spot on the surface (the shape – a circle).

To vary the power density without changing the exposure time and energy radiation used caustic spatial laser beam (Fig. 1) by movement along which the radius incident beam solely changes, and hence power density (intensity) of the incident laser radiation. We used a caustic for energy 3 J.

III. RESULTS

The results are presented in Fig. 2. It is seen that by irradiating the surface with an intensity of $1{,}30 \cdot 10^5$ W·cm^{-2} (Fig. 2a) occurs slight melting. Besides, wavy-like relief not appears, that intensity may be regarded as a threshold for the formation of an wavy-like relief, while the crater diameter is 0,72 mm. When driving along the caustic (in the direction of reducing the diameter of the laser beam), with an increase in intensity is increased degree of fusion surface with simultaneous formation of a wavy-like relief, which is formed as a result of thermocapillary instability [2, 5]. Increased intensity above ~ $3{,}30 \cdot 10^5$ W·cm^{-2} leads to decrease amplitude of wavy-like relief in center by intensive removal of material target (though increase in the depth of the crater) at burning iron [2] and actions of vapors impact.

As one of characteristics of morphology of the crater was the degree of curvature surface on which can be qualitatively traced measure recoil effects of oxidation products at the surface of the molten iron during combustion. The degree of curvature of the surface varies with increasing power density. Practically all the craters (except Fig. 2a and b) the surface has a convex shape. At low intensities has a flat horizontal surface form (Fig. 2a), high - conical shape (Fig. 2g). It is also associated with the growing influence of the impact of oxidation products of the combustion of the metal.

Since, in this case, is the instability of thermocapillary convection [4], the other as a characteristic parameter of the crater morphology was spatial instability growth rate. This parameter allows us to characterize the degree of manifestation of this instability, depending on the laser power density (Fig. 3).

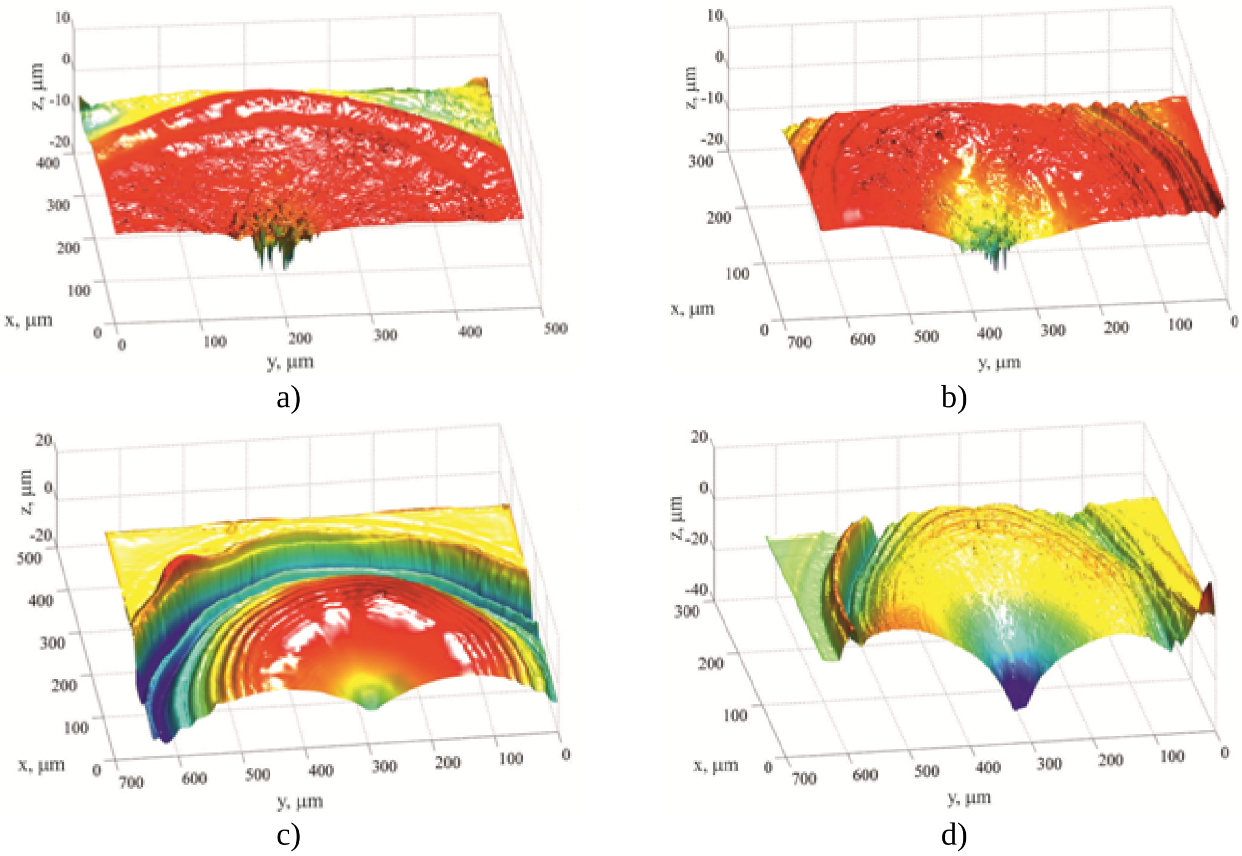

Figure 2 – View of the crater after laser irradiation with different power density on the surface of stainless steel: a) $1{,}30 \cdot 10^5$ W·cm^{-2}; b) $1{,}70 \cdot 10^5$ W·cm^{-2}; c) $2{,}64 \cdot 10^5$ W·cm^{-2}; d) $3{,}37 \cdot 10^5$ W·cm^{-2}

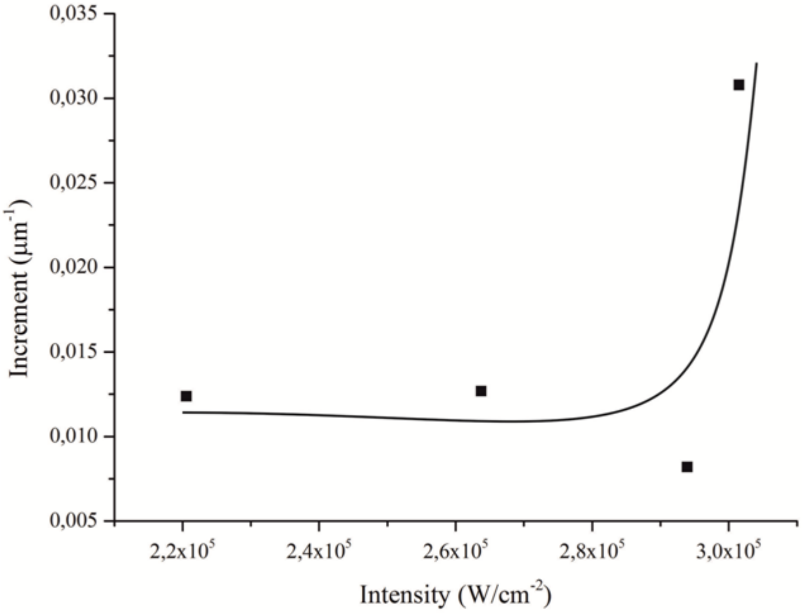

Figure 3 – The dependence of the spatial growth rate of the power density of laser radiation

As can be seen from Fig. 3 in the range of intensities of < ~ $3 \cdot 10^5$ W·cm^{-2} spatial growth rate is nearly constant, with a small excess of the specified intensity of a sharp increase in the spatial growth rate to ~ 0,03 m^{-1}. Growth spatial increment occurs mainly at the periphery of the crater which yet forming a wavy-like relief (Fig. 2g). Growth spatial increment, probably, by occurs due to an increase of mass transfer from the central portion to the peripheral crater under the pressure by combustion products at a target laser irradiation.

IV. Conclusion

Thus, at low intensities ($1{,}30 \cdot 10^5$ W cm^{-2}) forming the wave-like relief occurs. Abrupt growth increment associated with increased mass transfer of a central crater in the peripheral portion by the pressure of the vapor impulse. Thus there is an increase in the depth of the crater, as well as the change of curvature of the convex shape on a plane inclined.

References

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