Technical science/8.Processing of materials in Machinery Industry.

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LASER SURFACE HARDENING

The use of laser made it possible to change significantly the technology of product manufacturing [1]. Laser beam high energy concentration and its locality allow to treat only a proper part of the material without heating the whole volume of it and without damaging its structure and features. This minimizes the deformation of parts. Also high concentration of energy allows to heat and cool the processed materials swiftly with a very low duration of thermal influence. As a result of laser treatment it’s also possible to get qualitatively new properties of materials due to forming of nanostructure in them.

By now the most advanced technological instrument is fiber laser. Among the number of its benefits we should list an energy efficiency (up to 50%) which reduces operating costs. Small size of the unit allows easily mount them into existing systems of manufacturing. However high cost of fiber lasers holds back their wide use. Previously it was shown that surface thermal hardening could be resulted not only by continuous wave mode but also by pulse mode. [2, 3]. Usage of pulse emission allows to reduce the power of laser units up to 5-10 W.

The purpose of the article is to justify a possibilities to use low power lasers in pulse mode for laser hardening of instruments’ surfaces or some of their parts.

For surface laser hardening was used a solid YAG-laser with its power 5 W (diode pumping, emission wavelength λ=1,064 micron, pulse mode). Two modes were examined: treatment by single pulses (duration 0,1...0,4 msec) and multipulse treatment by short (30...70 msec) pulses. Scan speed was 8…2 mm/sec. Pulse energy was detected by photoelectric method. Thermal hardening was performed on instrument steel У12, which previously was quenched and low-temperature tempered. У12 steel is used for instruments with increased wear resistance at medium and high unit are pressure (without heating of cutting edge); files, shaving blades and knifes, sharp surgery instruments, scrapers, engraving instruments and so on. The structure of the steel in initial condition is tempered martensite and carbides. The hardness of samples was R_z=20 micron, therefore there is no need to reduce the surface reflectance.

Short pulse duration and ability to focus the beam into spot of small diameter allow to create the power density which is enough to heat the surface to more than phase transformation temperature.

While heating materials with a help of laser there could be released the following processes: 1) laser heating of the surface layer to the temperature which is not higher than flowing temperature, holding at this temperature and further cooling; 2) heating the material to more than flowing temperature, crystallization and cooling of crystallized material; 3) heating the material to more than its evaporation temperature, plastic deformation as a result of shock wave, heating of surface by plasma which resulted by action of laser on material [2].

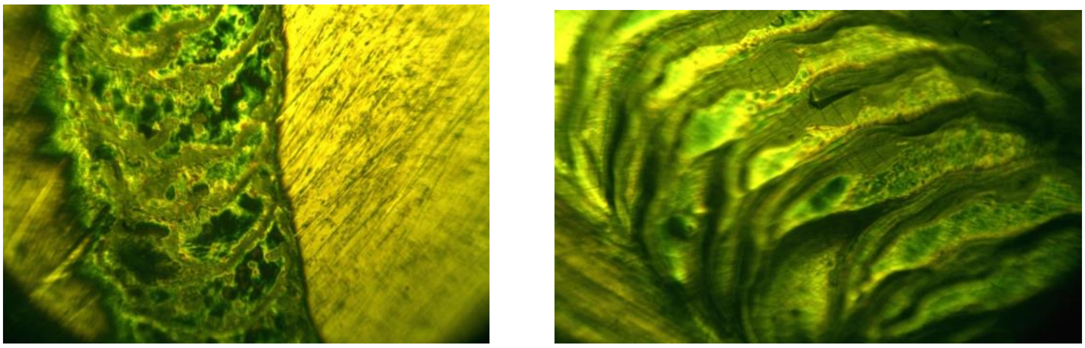
The result of pulse laser radiation depends on intensity (*q* – density of power) and time of influence (*t* – pulse duration). Therefore the effective release of every technological process in only possible for limited intervals *q* and *t* [2]. Low-power solid-state laser allows to get short duration pulses with great energy density (table 1), which allows to release the process №2 – heating with fusing.

Table 1 – Calculation of power density at single-pulse and multi-pulse treatment

Parameters	Multi-pulse treatment			Single-pulse treatment
Pulse duration, ms	40	50	60	400
Pulse energy, J	0,7	1,45	2,38	3,55
Power density, W/m^2	$7,3 \cdot 10^8$	$12,1 \cdot 10^8$	$16,5 \cdot 10^8$	$21,1 \cdot 10^8$

On the ground of calculations it could be concluded that with increase of pulse duration the value of power density increases (for multi-pulse treatment). For single-pulse treatment the power density is by an order more. This data perfectly agree completely with macroanalysis of hardened samples surfaces. Treatment at all modes causes heating of treated surface to temperature above its flowing point. While single-pulse treatment it happens melting and foaming of metal which could cause micro-cracks while crystallization (Fig. 1, a). Multi-pulse mode also causes melting which in some cases is not welcome but still provides higher quality of the surface (Fig. 1, б).

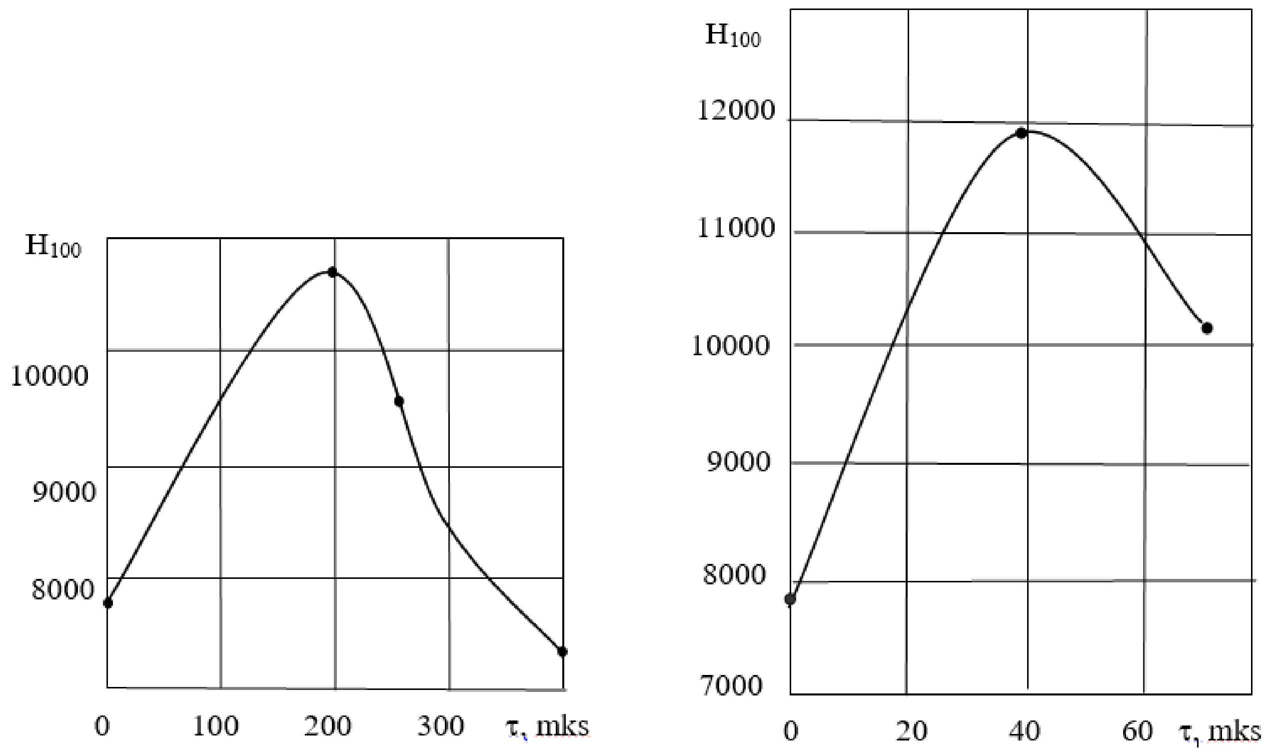
Comparison of these two modes shows that after treatment by series of short pulses the hardness of steel У12 is higher (Fig. 2, b), than after treatment by single pulses (Fig. 2, a).



a b

Fig. 1. Area of laser influence: a – single-pulse treatment, b – multi-pulse treatment

It is fair to assume that while multi-pulse treatment due to short influence of laser beam and due to fast speed of heat dissipation, diffusion processes, which are associated with dilution of carbides during smelting, are not completely finished. Hence secondary cementite is persists, continue further grain refining, increasing of dislocation density, increasing of internal strain, which leads to increasing of harness. The curve of micro-hardness dependence has got its maximum at some certain value of pulse duration. For У12 steel exists optimal value of pulse duration which allows to get maximal hardness of surface layer of the steel.



a b

Fig 2. Dependence of micro-hardness on pulse duration: a – single-pulse treatment, b – multi-pulse treatment

As a result of investigation held it was detected that in spite of low power of fiber laser the pulse mode provides thermal surface hardening. There exists optimal pulse duration which enables the most effective laser influence.

Literature

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