The process control for improving the durability of the cutting edge of the teeth of the cutter at their recovery

V V Zvezdin, R M Hisamutdinov, R R Rakhimov, R R Saubanov and I H Israfilov

Kazan (Volga) Federal University (KFU), Naberezhnye Chelny, Russia
E-mail: irmaris@yandex.ru, rafisih88@mail.ru

Abstract. The features of the technology of laser deposition of wear-resistant powders on the cutting edge of the cutter tooth with control of the positioning of the focus of laser radiation are considered. The stabilization of the parameters of the laser technological complex and the positioning of the focus of the laser radiation makes it possible to increase the efficiency of the technological process of restoring the instrument, with its specified quality indicators.

1. Introduction

Analysis of the development of modern engineering shows the widespread introduction and use of automated laser processing complexes (ALPC) metal processing as one of the effective methods to improve production efficiency by increasing the productivity of technological processes (TP) [1-4].

The efficiency of production is characterized by increased productivity, the most complete use of production capacity, raw materials and material resources, achieving the best results at the lowest cost [1, 2]. The main role in the development of industry belongs to tool production, which determines the level of productive forces of the entire industry.

Modern technologies of development of tool production are: use of powder metallurgy; automation of technological processes, application of automatic lines by laser technological complexes; application of methods of thermal and thermochemical processing, wear-resistant coatings; expansion of the field of application of thermal processing methods. These directions, ultimately, contribute to the solution of the main tasks of increasing the efficiency of production and quality of products. One of the methods of reducing costs in the manufacture of products is the restoration of worn edges of tools by laser surfacing of wear-resistant powders.

2. Theoretical and experimental studies

The wear edge of the tool is the result of changes in the operating conditions that is characterized by an increased notching and cutting force when high temperatures [3, 4] (Fig. 1). When implementing laser technology in the processing of tool steels, it is necessary to take into account the quality of laser radiation (LR) [1-2, 5-7], the purity of the surface layer, the physical and chemical parameters of the applied surfacing powder, etc. The quality of the LR determines the parameters of laser technological complexes (LTC) and the quality of the TP surfacing. The question of the influence of the energy intensity distribution in the spot of LR the quality of the surfacing remains relevant.

Process control to improve the durability of the cutting edge of the teeth of the TP surfacing cutting edge of the teeth of the cutter is acutely in front of the tool production. Studies have shown the instability of the parameters characterizing the quality of the TP (Fig. 2). That characterized mainly by the mismatch of the center of the spot with the center of the top of the tooth of the cutter, as well as the
surface roughness, heterogeneity of the chemical composition and microstructure in depth. A significant effect on TP deposition rate provide stability and the values of the parameters of LTS. It is necessary to consider the LTC as a set of interacting links of a complex system [5, 8-10]. It is an optical quantum generator, optical system (OS), LR interaction medium with metals, workpiece and the mechanism of its precision movement.

According to the results of experimental and theoretical studies on laser cladding, the main factors affecting the quality of the TP are the stability of the set value of the power density, the quality and precision positioning of the focus LR the cutting edge of the cutter teeth [1, 3, 8, 11].

Figure 3 shows the location of the reflected radiation from the cutter tooth to the sensitive areas of the matrix photodetector (OP). Precise positioning is provided by the developed system of automated control of the position of the focus of LR when surfacing the teeth of the cutter [1]. Figure 4 shows a fragment of the tooth after laser welding with a precise positioning of the focus of LR.

For fast process of laser surfacing it is necessary to provide automated control of LTC with feedback on the parameters measured in real time of course of TP surfacing [8-11].

An experimental setup was developed, the block diagram of which is shown on the figure 5.
Control of the LTS parameters and their stabilization is carried out due to the negative feedback on the measured parameters from the interaction zone with the metal. This is achieved by analyzing the position of the focus of LR to the cutter tooth and the angle to the normal plane of the workpiece surface. The structure of the ACS LTC is a system that is characterized by a large number of feedbacks and is nonlinear. [1, 5, 10, 11].

The technology of restoring the cutting edge of the tool consists of a sequence of operations: cleaning the surface of the tooth cutter; surfacing powder; sharpening; application of titanium nitride [1]. Cladding and hardening of the vertices of the surface of the teeth powder brand BoroTec - Eutalloy® 10009 was carried out with a fiber ytterbium laser LS-2, with a wavelength of 1.06 µm (Fig. 4). Surface protection against oxidation is carried out with argon supplied through a special nozzle.

3. Conclusion
Experimental studies of the impact LR on the steel cutter R18K5F2 show the possibility of optimizing the energy parameters of the LTC for surfacing to obtain the required quality indicators, which leads to increased durability of the cutting edge of the cutter teeth in their recovery. The developed ACS LTC meets the requirements for the accuracy of positioning relative to the edge of the cutter, provide stable quality indicators TP surfacing.

References
[1] Zvezdin V V, Khisamutdinov R M, Rakhimov R R, Israfilov I H and Akhtiamov R F 2017 Method of control position of laser focus during surfacing teeth of cuttersš IOP Conference Series: Materials Science and Engineering Volume 240, Issue 1 Article number 012072.
[2] Rakhimov R R, Saubanov R R and Israfilov I H 2017 Analysis of the impact of informative heat
treatment parameters on the properties of hardening of the surface layers Journal of Physics: Conference Series Vol 789 Is 1 012040

[3] Gabdrakhmanov Az T, Israphilov I H, Galiakbarov A T, Samigullin A D and Gabdrakhmanov Al.T 2016 Improving the efficiency of plasma heat treatment of metals Journal of Physics: Conference Series Volume 669 012014

[4] Valiev R A, Bochkov V E, Bashkirov Sh Sh, Romanov E S and Chistjakov V A 1991 Mössbauer study of surface layers of high-speed steel after laser treatment Hyperfine Interactions 69 (1-4) pp 589-92

[5] Grigoryants A G, Perestoronin A V, Portnov S M, Zvezdin V V and Israfilov I H 2015 A system for automatic control of precision laser welding in engineering Welding International T. 29, number 10 pp 801-4

[6] Zvezdin V V, Klochkova K V, Rakhimov R R, Saubanov R R, Israfilov I H and Pesoshin V A 2018 Technology ability of laser bonding of compacted graphite iron IOP Conference Series: Materials Science and Engineering Vol 412 Issue 1 012084

[7] Zvezdin V V, Hisamutdinov, R M, Rakhimov R R, Israfilov I H and Saubanov R R 2018 Technology of overlay laser welding of durable powdery into blade edge of miller IOP Conference Series: Materials Science and Engineering Vol 412 Issue 1 012083

[8] Bashmakov D A and Zvezdin V V 2018 Control of laser-field technological complexes for tool hardening ARPN Journal of Engineering and Applied Sciences 13(8) pp 2979-82

[9] Rakhimov R R, Zvezdin V V, Israfilov I H, Nabiullina G I Saubanov R R 2014 Modeling of the laser heat treatment News of the Tula State University (Technical science) number 11-2 pp 476-84

[10] Zvezdin V V, Israfilov D I, Portnov S M, Saubanov R R, Rakhimov R R and Zvezdina N M 2015 Automatic control system of high-precision welding of preparations by the laser radiation at influence of the plasma torch Proceedings of the higher educational institutions (Physics) Vol 58 ed Siberian Physico-Technical Institute (Tomsk) pp 51-54

[11] Zvezdin V V, Rakhimov R R, Saubanov R R, Israfilov I H and Akhtiamov R F 2017 Management of laser welding based on analysis informative signals IOP Conference Series: Materials Science and Engineering Vol 240 Is 1 012073