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Technological complexes of laser welding and hardening tool

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Abstract. The control system of the automated laser technological complex for the technology of surfacing and hardening the cutting edge of the teeth of the mill with the positioning of the focus of laser radiation on the tooth is considered. Automating the process of laser hardening and surfacing of parts in mechanical engineering makes it possible to increase the efficiency of the technological process of tool restoration, with its specified quality indicators.

1. Introduction

Analysis of the development of modern engineering on the principles of industry 4.0 and robotics in the automotive industry [1] shows the widespread use of automated laser technology complexes (ALTC) surfacing, hardening, welding, cutting, etc. with the required quality of processing, as one of the effective methods to improve production efficiency by improving the productivity of technological processes (TP) and optimizing production resources [1-4].

An important factor in reducing the cost of production is a qualitative improvement in the technical level of production of mastered products in engineering [2-5]. With the advent of fiber lasers there was a sharp increase in demand for high-tech industrial equipment. [1-3].

2. Theoretical and experimental studies

A question of the process of automation welding and hardening the cutting edges of the teeth of the cutter facing tool is very important for production. Studies have shown the instability of the parameters characterizing the quality of TPs. Which are characterized by surface roughness, uniformity of chemical composition and microstructure in depth. A significant role in this is played by the stability and parameter values of laser technological complexes (LTC).

According to the results of experimental and theoretical studies on laser cladding and quenching, the main factors affecting the quality of the TPs are the stability of the set value of the power density, the quality and precision positioning of the focus laser radiation (LR) the cutting edge of the cutter teeth [1-2, 4].

In the course of research, a block diagram of ALTC was developed that meets the requirements for technological complexes (Fig. 1).

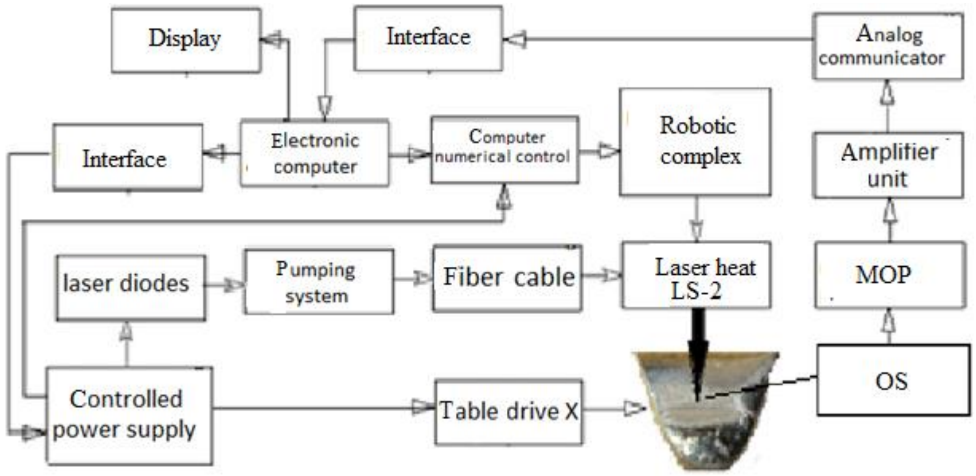

Figure 1. ALTC Structural Diagram:
when OS – Optical system, MOP – matrix photodetector

LR is fed by the optical head of the fiber ytterbium laser LS-2 to the top of the tooth surface, fixed on a robotic complex,and the focus of LR moves along the y, Z coordinates of the tooth. Moving the cutter on X is carried out by the drive of the desktop. Precision positioning of the focus on the cutting edge of the cutter teeth is provided by the elements of technical vision (ETV). It is an optical system, a matrix photodetector, an amplifier unit, an analog switch that converts parallel code into a serial and a communication interface with the control computer. An error signal according to the ratios of the irradiated squares MOP is supplied by converters on the computer where the developed algorithm is evaluated and issued on a rack CNC signal, adjustment of focus or for Y,Z. a controlled power source (CPS) receives a signal of the displacement X. [6-8].

The calculation of the active resistance of the photosensitive layer of AF shows its dependence on the area of illumination:

$$R_{pl} = \frac{\rho_н \rho_o l^2}{dl\left[(x-\Delta x)\rho_н + \Delta x \rho_o\right]} = \frac{\rho_н \rho_o l^2}{d\left[(S_п - S_н)\rho_н + S_н \rho_o\right]} \qquad (1)$$

when R_{pl} – resistance of the photosensitive layer, ρ_H, ρ_O – resistivity of the respectively unlit and illuminated areas of the photodetector (OP); l – length of the photosensitive layer; $S_П$, S_H – the area of the photosensitive layer, respectively, full and unlit surfaces of the OP.

Correction for the drive Y remote change in the position of the focus of LR, taking into account the displacement of the orientation angle between the optical axis and the tangent surface of the tooth at the point of interaction of LR with the metal is determined by the expression [6]:

$$\Delta\varphi = f\left(R_{OPп} - R_{OPн}\right) \qquad (2),$$

when Δφ – is the increment of the angle of displacement between the optical axis OP and the tangent of the tooth surface at the point influence of LR to metal; $R_{OPп}$, $R_{OPн}$– resistance of the photosensitive layer respectively, the total and unlit surfaces OP.

Figure 2 shows the location of the sensitive areas of the MOP relative to the top of the cutter tooth. The photoresistive matrix sensitive in the near LR region was chosen as the MOP.

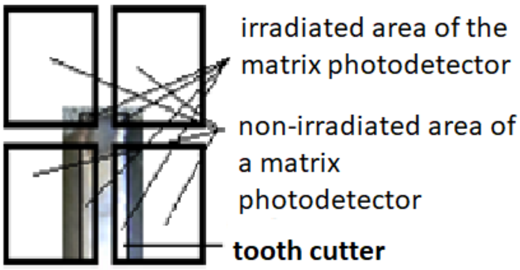

Figure 2. The location of the sensitive areas of the MOP relative to the top of the tooth cutter

Carried out laser cladding of powder brand BoroTec - Eutalloy® 10009 steel R18K5F2 using flux brand AN-43.

The technology of restoration of the cutting edge of the tool consists of a sequence of operations: cleaning the surface of the tooth of the cutter; surfacing powder; sharpening; laser hardening in the mode without melting and applying titanium nitride [2, 9]. Surfacing and hardening were carried out on a fiber ytterbium laser LS-2, with a wavelength of 1.06 µm, the top of the tooth surface was treated (Fig. 3.4).

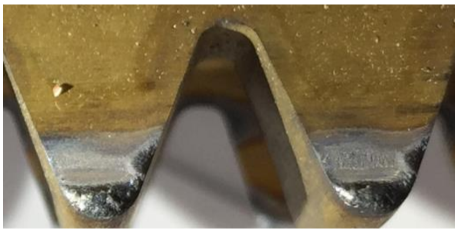

Figure 3. Picture of surfacing powder on milling cutter teeth

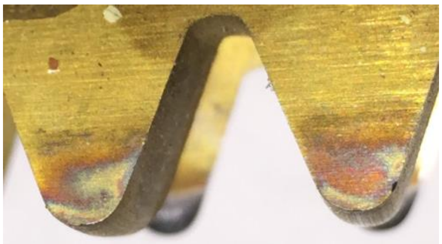

Figure 4. Picture of hardening milling cutter teeth

The microstructure of the hardened layer on the tops of the teeth LR a latent martensite and carbides. Carbide heterogeneity in the structure of the cutter satisfies GOST 19265-73. A graph of the dependence of microhardness on the depth of the layer shown in fig. 5.

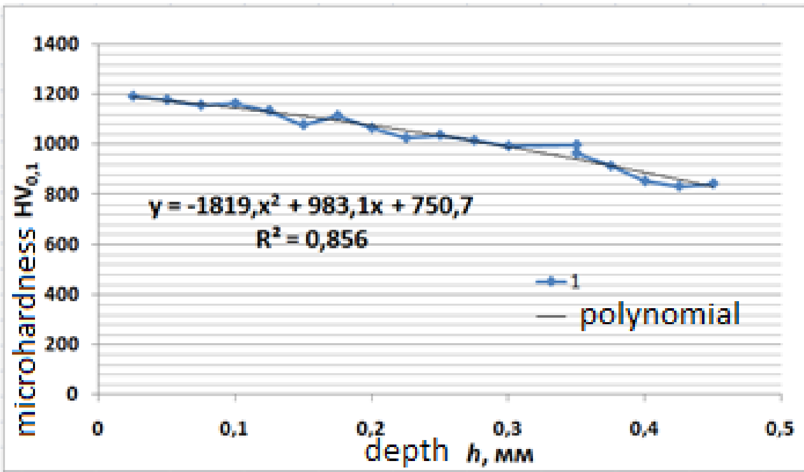

Figure 5. Microhardness versus hardened layer depth

The results of the chemical analysis of the metal of the sample correspond to the metal R18K5F2 GOST 19265-73.High hardness ($HV_{0,1}$ 1192) of the hardened layer increases the wear resistance of the cutter.

3. Conclusion

Tool edge wear is a consequence of changes in operating conditions, which is characterized by an increase in cutting and cutting forces at high temperature [1-4]. When implementing laser technology in the processing of tool steels, it is necessary to take into account of the quality LR [10]. The quality of LR defines parameters LTC and the quality of TP hardening and surfacing. The question of the impact of the distribution of intensity of energy in the spot, LR the quality of hardening and welding is still urgent.

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