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Analysis of acoustic oscillations dependence on the process parameters in laser treatment

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Abstract

Comparative analysis of various modes of metal laser processing based on the analysis of acoustic vibrations from the machining area requires interpretation of the original signal which allows revealing the interrelation of the data received with indicators of the parts quality.

The nature of acoustic signal oscillations from the area of laser radiation interaction with the metal is connected with its spectral function of the Fourier transform. This transformation describes the relationship between time and spectral characteristics of the acoustic signals of the same process.

The article describes the method of acoustic oscillations analysis and achieving the comparative parameters in laser heat treatment: duration of the laser radiation pulse, width of signal spectrum, minimum and maximum values of spectrum function, frequency rates of harmonic components, energy of signal. Experimental research and analysis of the data showed that frequency of acoustic signal is weakly dependent on density of laser energy, and change of pulse laser energy density in parts processing directly affects the increase of output signal amplitude.

The revealed dependencies of the signal frequency and amplitude on the energy density correspond to the theoretical research in this direction and allow using the data obtained in the future to automate the control laser machining process.

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Keywords: laser radiation, energy density, the Fourier transform, ultrasound, amplitude, frequency, spectrum.

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1. Introduction

The amplitude of audio signal during pulse laser processing of parts carries the excessive amount of information about parameters of technological processing directly from the zone of impact in real time. The amplitude of the acoustic signal characterizes the density of laser pulse energy unit and its absorption coefficient [1].

Comparative analysis of the output signal at different processing parameters requires identification of time and frequency characteristics based on the original acoustic signal. These characteristics include time function of the signal, spectral density of the signal, power spectrum [2]. These characteristics make it possible to determine the signal parameters affecting the quality parameters of the process: duration; width of spectrum, singular points of the spectrum function, frequency rates of harmonic components; and energy of the signal.

2. Identification of comparative parameters of the signal

The amplitude spectrum of the typical acoustic signal from the processing zone is shown in figure 1. Above the source signal the discrete Fourier transform has been performed, as well as the transition to the frequency domain of the signal has been done.

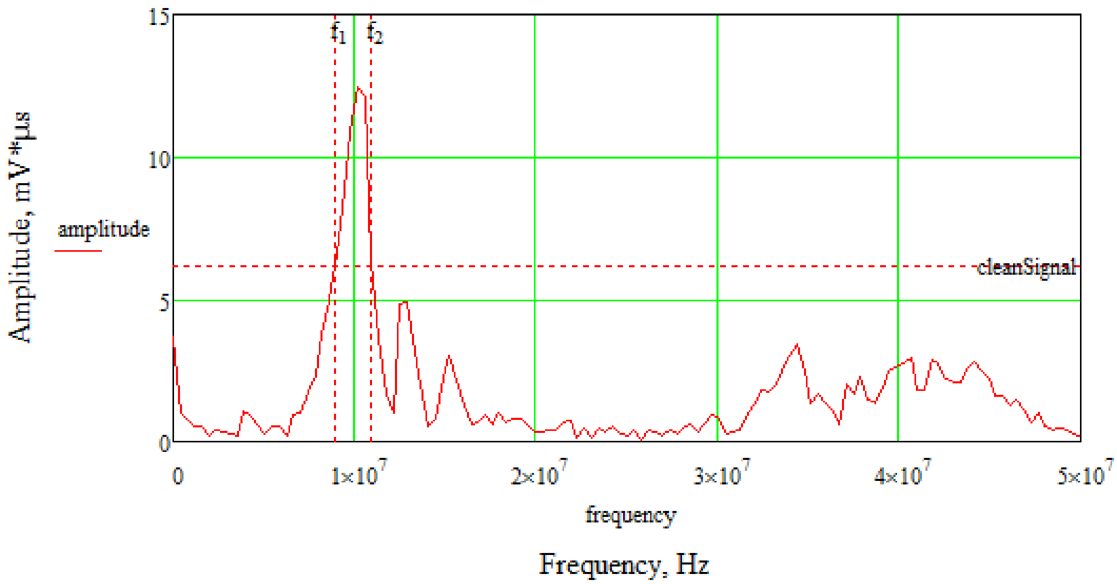

Fig. 1. Amplitude spectrum of the signal.

The amplitude spectrum of the signal has the appearance of a damped function with the main lobe containing the major part of the signal energy as compared to other signals in the spectrum and noise [3].

The signal obtained from the treatment zone has a finite duration, which is limited to the time interval determined by duration of the laser pulse, and its spectral function is limited to the Fourier transform on the frequency axis [4]. The width of the signal spectrum is chosen based on the ratio of Us to Un. Thus the characteristic feature of the information signal is the effective width of spectrum which determines the information content and the quality of control system.

When analyzing the signal from the processing area the main requirement is to reveal the informative signal which contains the information about the process quality [5].

To restore the signal based on its spectrum in the effective bandwidth it is necessary to carry out the inverse Fourier transform, and, therefore, to do the transition from the frequency domain into the time domain. The original and filtered signal on the frequency range which contains much of the energy is shown in fig. 2.