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VIBROACOUSTIC MONITORING FEATURES OF RADIATION-BEAM TECHNOLOGIES BY THE CASE STUDY OF LASER, ELECTRICAL DISCHARGE, AND ELECTRON-BEAM MACHINING[1]

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Modern trends in the development of technologies suggest the presence of automatic monitoring systems to control the flow of manufacturing processes and provide information about deviations of the current conditions from the optimal modes, warn about developing defects and emergencies. Simultaneously, there is a multiplicity of approaches to the algorithms for diagnosing and selecting diagnostic parameters.

But there is not enough information about monitoring methods implemented in processes related to radiation-beam technologies (RBT), based on the impact on the product's surface by concentrated heat flows of energy with a high-power density. For example, such technologies include exposure to plasma jets, laser radiation, electron or ion beams. A feature of this technologies is similar processes: the transfer of thermal energy, heating of the volume, the development of melting, evaporation, ionization and vapor expansion during evaporation, cooling after the end of the energy impact. These processes accompanied by phase transformations and chemical reactions that cause changes in the volume of matter and, as a result, by the release of vibroacoustic energy that propagates through the flexible system of technological equipment in the frequency range up to 50 kHz. This range is characterized by a lower attenuation rate when transmitting over long distances. The use of relatively low-frequency ranges is essential for monitoring processes in places where the installation of vibration measuring equipment near the high-intensity treatment zone is impossible.

It experimentally shown that the amplitudes of the vibroacoustic (VA) signal accompanying the RBT processes increase with the increasing power density and process performance. It shown that this relationship is inherent in a wide range of frequencies of the VA signal, but the rate of change of these parameters with a change in the intensity of the thermal effect is different for different frequency ranges. From a comparison of experimental data and data from literature sources, it assumed that the accelerated growth of the high-frequency components of the VA signal with an increase in the intensity of the energy flow is associated with the activation of the processes of volumetric boiling and evaporation the processed material.

The K_f parameter introduced as the ratio of the effective amplitudes of the low-frequency and high-frequency ranges of the VA signal to monitor the results of the impact on the material by high-energy energy flows in the direction of vaporization. It shown that the tendency to decrease the K_f parameter shows an increase in the proportion of the substance evaporated and in the boiling stage during laser treatment.

Experimental studies have allowed us to establish that with an increase in the concentration of erosion products during electric discharge machining (EDM), the intensity of the energy flow generated by the discharge current decreases. Part of the energy spent on the destruction of the particles of the products of erosion. This phenomenon increases the size of the energy impact area and, accordingly, reduces the power density. As a result, the proportion of vaporization and release of the material into the working fluid decreases and reflected in the increase in the K_f parameter. Control of the K_f parameter allows to indicate the short-circuit moment at EDM with a free electrode to increase the productivity and reliability of the technological process. This fact fits into the general scheme of the relationship of the K_f parameter with the intensity of the high-energy impact on materials during RBT.

Monitoring of electron-beam alloying processes can allow evaluating the performance of the operation in real-time by monitoring the parameters of the VA signals, introducing the necessary correction of processing modes, and even optimizing them. Monitoring of the K_f parameter makes it possible to estimate the proportion of the substance in the state of volumetric boiling and evaporation, to select rational treatment modes, not allowing excessive evaporation of the applied coating, but providing the necessary intensity of the impact power to trigger the necessary chemical reactions.

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