Problems of Control and Diagnostics of a Cutting Tool Using a Vibroacoustic Signal

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ANNOTATION

The article deals with the problems of obtaining a vibroacoustic signal as an informative parameter for monitoring and diagnosing a cutting tool when creating high-performance technologies in automated production.

KEYWORDS: *detail, production, mechanical engineering, equipment, automation, technological process, metal cutting, control, methods, diagnostics, cutting tool, sensor, signal, research, measurement, system, machine tool, wear, signal, amplifier, analyzer.*

Trends in the development of world engineering production show that its distinctive feature is an intensive process of increasing productivity, reliability and durability of technological equipment, increasing the share of precision machine tools, increasing the level of automation and system integration of technological processes. In this regard, the task of building systems for automatic control and diagnostics of the cutting process, providing the required quality, high productivity, minimum costs for processing machine parts in a flexible automated production, remains a priority scientific and technical problem.

The existing systems for automatic control and diagnostics of the state of the cutting process have a number of significant drawbacks and do not fully meet the requirements of modern flexible automated production, since they do not provide high accuracy and reliability in real time. Among the methods for monitoring and diagnosing the state of a cutting tool, which makes it possible to carry out diagnostics in real time, the methods based on the registration of vibration acoustic emission (VAE) signals are considered the easiest to implement.

Experimental research is carried out when the sensor is located in the immediate vicinity of the cutting zone. In production, the installation of the sensor in the vicinity of the cutting zone is impractical, due to the negative impact of chips on it. Metal shavings, as well as other thermal and mechanical influences, can damage the sensor and the cables connecting it to the receiving equipment. With this removal of the signal, even at a small distance from the place of its registration, significantly changes the information content of the signal. Removing the sensor from the cutting zone raises the question of the reliability of the recorded signal.

When using a rotating tool, the problem of signal registration becomes more acute. Moving away from the cutting zone to the stationary machine node adds a large number of noise-like inclusions to the signal. These inclusions depend on elastic, thermal and other processes occurring at a distance from the cutting zone to the place of registration of the VAE signal. At present, these processes are difficult to describe mathematically or by models, and as a result, it is difficult to judge the processes occurring in the cutting zone from the received signal.

A number of researchers are conducting experimental studies of tool diagnostics using the VAE method, while the sensor is placed on the holder of a turning tool in the immediate vicinity of the cutting zone. However, in the conditions of automated production, there is a need for automatic tool change, which does not allow installing the sensor on the cutting tool holder. Also, there are no methods for monitoring the state of the tool and the stability of the cutting process, using VAE, for a rotating tool. To do this, only torque sensors installed between the drive and the spindle, strain gauges installed on the support, as well as measuring the electrical parameters of the engine, are currently known.

In the existing methods for analyzing the durability of a cutting tool, in order to be able to be introduced into production, the place where the sensors are attached must be removed from the cutting zone and the clamping place by at least 40 mm. Removing the sensor mounting location from the cutting zone will protect against metal shavings, but will lead to a loss of signal information at low frequencies. The length of the overhang of the cutting tool is more than 80 mm, which leads to a decrease in the rigidity of the technological system, an increase in the vibration of the cutter, and, as a result, a deterioration in the quality.

There is another method of recording the VAE signal: mounting the recording element of the sensor directly into the cutting tool under the cutting plate, which leads to an increase in the cost of the tool.

However, it would not be superfluous to note that the VAE signal receiver can be located at some distance from the cutting zone, since the tool and structural steel from which the cutting tool is made serves as a good conductor for elastic acoustic waves.

The disadvantage of the known methods of registration of VAE signals. is that they are applicable to a stationary tool fixed on the machine, which makes it difficult or impossible to use them on automatic machines and automatic lines where it is necessary to perform automatic tool change. In automated production, the tool is mounted in a turret. The change of the cutting tool is carried out by turning the turret about its axis, while the wires are wound, they break and, as a result, the impossibility of further measurement. At the same time, there are no methods for determining the most informative place for attaching the sensor, that is, the place at which it is possible to register from the cutting tool the most complete information about the processes occurring directly in the cutting zone.

The impossibility or inaccuracy of determining the numerical value of the wear of the cutting tool forces researchers to determine the period of wear of the cutting tool: running-in, normal, intensive. Each of the wear periods is accompanied by various processes occurring in the cutting zone and various values of these processes. It is also possible to diagnose the wear period of the cutting tool by determining the stability of the motion of the cutting tool tip, which depends on the stability of the cutting tool. Moreover, the assessment of the stability of the movement of the cutting tool is determined by indirect indicators.

A large number of noise components in the VAE signal makes it impossible to reliably diagnose the wear of the cutting tool, as a result of which it is necessary to develop methods for cleaning the VAE signal from extraneous noise.

The disadvantages of many methods for assessing the wear of a cutting tool are the lack of a method for cleaning the VAE signal. The analysis is carried out over the entire signal, when during the registration and analysis of the signal, its indicators can change significantly. At the same time, analysis over the entire signal will show the average value of the indicator and it will not be possible to reflect this sharp change, indicating the transition from one stage of work to another.

As is known, the VAE signal emitted during processing changes chaotically, which poses the problem for researchers to assess the stability of the signal by its diagnostic features. However, the stability of the parameters calculated on the length depends on the length of the signal. With a short signal length, the spread of values increases up to 5-10 times. Therefore, it is important to increase the length of the recorded signal to 128-512 Kb for the analysis of the working capacity of the cutting tool, which significantly increases the time from the onset of intensive wear to the time of registration of the onset of intensive wear. Also, with an increase in the length of the recorded signal, significant time is spent on analyzing the signal, writing it to the computer memory, and calculating the value of the diagnostic parameter.

The decision to replace the cutting tool must be made in real time, therefore, it is necessary to develop methods that build the dependence of the metal shavings formation frequency on time, and not on the observed implementation, which makes it possible to determine the value of the diagnostic parameter at different points in time.

An important place for increasing the reliability of diagnostics of the cutting process is the choice of: methods and means of recording the VAE signal, the location of the sensor, the applied method for cleaning the VAE signal from their noise components. The organization of the process of collecting information and selecting a diagnostic feature has an important aspect. How carefully these signs are selected depends on how effective the entire diagnostic process will be.

The operation of the measuring equipment is based on registering a series of periodically repeating, after a certain time, measurements of the input voltage value and recording it in the memory of the measuring equipment in order to transfer it for processing to a computer. The sampling period is selected based on the parameters of the received signal. It has been established that artificial piezoceramics, which have high strength and stability of properties, are most suitable for measuring VAE during cutting.

An analysis of the literature data shows that the spectrum of oscillations of the dominant frequencies of the sources lies in the range from 0 to 20 kHz. With a given spectrum of oscillation frequencies, it is sufficient to use a sampling period of the equipment of 100 - 1000 kHz. At the same time, the signal stored by the equipment does not lose information content, due to a fairly uniform distribution of measurement points along the curve of the output voltage level change.

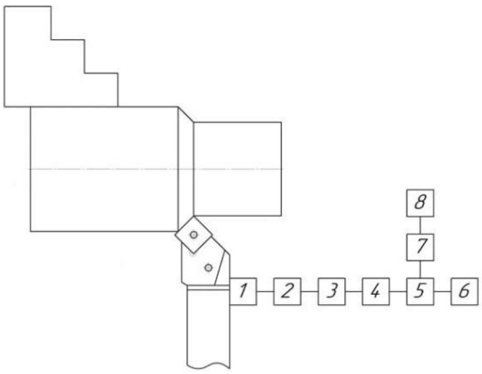

Fig. 1. Scheme of a typical set for measuring VAE.

1 - piezoelectric transducer; 2 - preamplifier; 3 - low pass filter; 4 - integrating amplifier; 5 - power amplifier; 6 - oscilloscope; 7 - amplitude analyzer; 8 - printer.

For the analysis of VAE, when cutting metals, multi-purpose sets of equipment are usually used, which can subsequently be upgraded to measure the informative parameters of VAE or their complexes and technological wave criteria, allow diagnosing one or another characteristic of machining (Fig. 1).

Vibroacoustic signal (VAS) are transmitted through the body of the tool cutter and form a piezoelectric transducer 1 of voltage waves, which are amplified by a preamplifier 2 and can be visually observed using an oscilloscope 6. In order to remove interference (signals with a frequency below 5 kHz), the signal is filtered using a frequency filter 3. Then the filtered signal is fed to an integrating amplifier 4, which allows you to get the VAS envelope. Further, the signal is again amplified by the power amplifier, and using the oscilloscope 6, the signal is visually controlled, and after the amplitude analyzer 7, using the recorders 8, the converted VAS is recorded on paper.

The VAE signal, when passing from the cutting zone to the place of its registration, undergoes numerous changes, leading to noise, distortion, and signal attenuation. These processes are difficult to calculate mathematically, due to the heterogeneity of the material, joints and shape of the measurement system components, however, these dependencies are constant, and they may be detected experimentally due to the constancy of the system parameters.

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