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Methods for Determining the Life and Reliability of Cutting Tools During the Drilling Process Using Vibroacoustic Signal

Fayzimatov Shukhrat Numanovich, Fayzimatov Bokhodir Numanovich, Abdullayev Shuhrat Makhmutjonovich

Doctor of technical sciences, Professor, Fergana Polytechnic Institute
Candidate of technical sciences, docent, Andijan Machine building Institute
Doctorate student of Fergana Polytechnic Institute

ABSTRACT: The article presents methods for determining the resource and durability of a cutting tool when drilling using a vibroacoustic signal.

KEYWORDS: drilling, acoustics, wear, cutting, oscilloscope, filter unit, cutting zone, power spectrum, cutting speed, depth, feed, material being processed, diagnostic parameter.

I.INTRODUCTION

In the field of science of today's world, it is necessary that the development of processing technology based on the vibroacoustic signal generated in the cutting zone to increase the accuracy of the geometric parameters of their surfaces, to ensure the flatness of the surface, and to increase the quality and service life of machine and automotive parts.

Increasing the accuracy of the product and reducing its cost in processing based on the vibroacoustic signal is one of the important tasks that determine the quality of the machine and equipment. In this regard, the research centers of developed countries, including the USA, England, Germany, Russia, Japan and other countries, have developed processing technologies based on vibroacoustic signals, which ensure the corrosion resistance of drills and increase the accuracy indicators of the processed hole surfaces when making holes for details. special attention is paid to the output.

A number of scientific works are being carried out for the integration of the elements of technological equipment, including the monitoring and diagnostics of the state of the devices.

II.LITERATURE ANALYSIS AND METHODS

The level of technological development of countries is determined by many aspects. Analysis of studies on diagnostics of the state of the cutting tool by scientists such as N.V. Talantova, A. Ostafsva, G.L. Kufareva, V.K. Starkova, A.S. Vereshchak, V.A. Grechishnikov, V.S. Kushner, V.I. Vlasova, A.A. Mirzayev, Sh.N. Fayzimatov [8] shows that during the operation of CNC machine tools, the operator intervenes in the operation of the machine tool in accordance with the control program in order to eliminate the malfunctions in order to maintain the current performance, on average, every 6-22 minutes. Operator-correctable cutter failures range from 23% to 63%. Research by Takeyama [9] in Japan shows that the failure rate of CNC equipment is 39% to 50% due to failures detected by cutting tool wear and breakage in different machining operations. Downtime due to equipment failure is only 4 ÷ 6%.

III. RESULTS

Further development of ideas about the mechanisms of propagation of the vibroacoustic signal between the cutting zone and its recording site, and experimental confirmation of the established methods of construction of the acoustic path, as well as the determination of diagnostic parameters for the monitoring of decay. The cutting tool can only be based on complex semi-experimental studies of vibroacoustic signal transmission processes [2].

The following equipment was used for the experiments: a contact, direct, combined piezoelectric sensor KD35, an infrasound sound level measuring device was used as a measuring conductor [3].

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An analog data acquisition and processing board with the following features is used as a data acquisition board: 8-bit ASP, 2 synchronous channels, maximum sampling rate 100 MHz, programmable gain, 640 kB RAM. The data acquisition board is designed as an expansion board for an IBM-compatible PC.

LA-nYu two-channel storage oscilloscope is used as an analog filtering unit. This model has eight-bit high-speed ASP and 640 Kb of its own random access memory. The oscilloscope has its own clock generator, but can also be connected to an external clock generator. Structurally, the oscilloscope is designed as an expansion module for personal computers such as IBM PC AT and allows information exchange with a personal computer through the ISA bus.

The stand includes a personal computer, such as an IBM PC Pentium-3/128 Mb, with a data acquisition board installed; Connection of sensors, analog filtering unit and data acquisition board is done through coaxial cable [7].

Work with the data collection board is carried out using a program developed on the basis of the Department of Mechanical Engineering and Automation Technologies, which allows you to record the electrical signal of the vibroacoustic signal in two channels using three synchronization modes (internal, on). To determine the dependence of the cutting tool wear on the vibroacoustic signal, it is necessary to determine the level of stability and stationary signal of the vibroacoustic signal recorded in the immediate vicinity of the cutting zone.

A test bench was developed on the basis of 2L450A benches for conducting experiments on the stability of vibroacoustic signals.

The measurement of statistical properties of processes has taken a firm place in the practice of modern acoustic research. The scientific basis of such measurements is the theory of random functions, and their methodology was developed within the framework of the theory of statistical measurements.

The random functions of the recorded vibroacoustic signals are due to the stochasticity of the cutting tool wear processes [1], because the wear during cutting is influenced by many factors and it is difficult to predict the influence of all these factors.

For stability analysis, the power spectrum is recorded at least 20 times under equal conditions. Signal recording is repeated under different cutting conditions: cutting speed, depth, thrust and material being processed. According to the vibroacoustic signal recording, the diagnostic parameter is calculated and the change of one of the parameters is drawn from the implementation number. By changing one or another diagnostic rule, the stability of the vibroacoustic signal is evaluated.

Signal analysis is performed according to several diagnostic rules, namely:

• by the value of the maximum component of the vibroacoustic power spectrum;
• by the frequency value of the maximum component of the vibroacoustic power spectrum;
• by the size of the signal noise components;
• on the fractal dimension;

The degree of stability of the signal is evaluated by changing the diagnostic parameters depending on the number of measurements.

The stand developed on the basis of the 2A135 machine is designed for registration and processing of VAE signals during drilling and processing, the general view of the stand is shown in Fig. 1.

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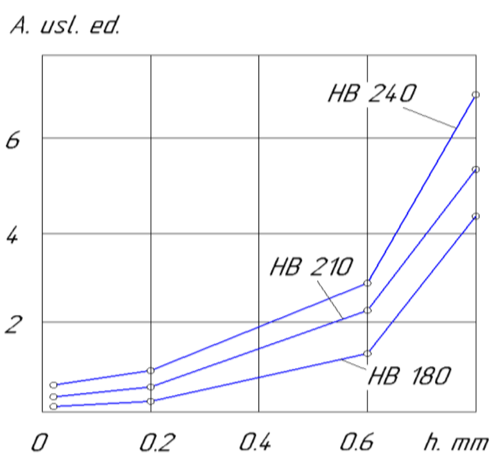
Figure 1 – stability analysis of the vibroacoustic signal based on the 2A135 bench.

When studying the stability of the vibroacoustic signal: A sweep is performed, a continuous signal is recorded from two sensors at the same time. The sensor mounted on the spindle of the machine tool is attached at a distance of 30-40 mm from the cutting zone and at a distance of 30 mm from the attachment point of the cutting tool to the front surface. The latter is attached to the receiver using a mounting bracket.

In this method, a connection is established between the amount of wear and an acoustic signal, which allows monitoring the position of the cutting tool during the drilling process (table 1).

Table 1

Machine model	Cutting tool material	Drill diameter, mm	Workpiece material	Number of spindle revolutions, rpm	Wear, mm
2A135	P6M5	31,5	Steel 35,40,45.	250	0.1÷0.5



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Its main component is the vibration of the cutting tool insert. Due to the risk of chip damage to the sensor housing and connecting wires, do not approach the sensor mounting point to the exit plate. At the same time, the strong fixation of the wave receiver in the vicinity (Fig. 2) or on the cutting plate increases the reliability of the decision about the need to replace the cutting tool.

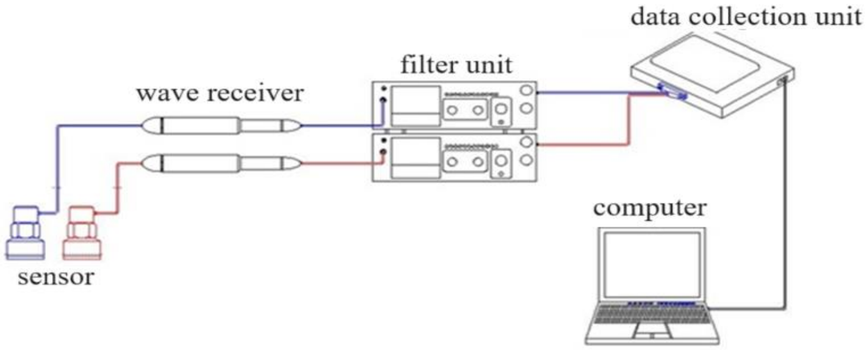

Figure 2. Schematic diagram of a stand for studying signal stability based on the 2A135 machine

In studying the stability of the VAE signal recorded from a rotary cutter it is important to know why cutting is done, a continuous signal is recorded from two sensors connected to the wave receiver. One of the transducers is mounted on the spindle head body and vibrates freely. Another wave receiver is attached to the spindle body at one end, and rests on the rotating spindle at the other end.

The recorded VAE signal enters the data acquisition board through an analog filtering unit, where analog-to-digital conversion is performed, after which the signal is sent to the computer center for processing.

In this stand, the vibrations of the drill are transmitted to the wave receiver mounted on the body of the spindle. The tip of the wave receiver rests on the protrusion cutter and records the vibrations caused by its penetration and exit from the protrusion zone, as well as the vibrations caused by the formation of segmental cracks.

The signal to another wave receiver mounted in the housing and freely oscillating enters the shaft head housing through the support, shaft and bearings.

When recording the vibroacoustic signal from a transducer mounted on a wave receiver facing the drill, it is compared to the signal attenuation coefficient and the best signal-to-noise ratio compared to a free vibrating resonator mounted on a smaller spindle body.

Fig. 3 - installation of sensors on the drill in the analysis of signal stability based on the 2A135 machine: 1 - sensor, 2 - wave converter

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The power spectrum is obtained from the sensor installed on the wave receiver made in the form of a plate, at least 20 times under equal conditions (Fig. 3). Signal recording is repeated for different cutting conditions: cutting speed, depth and thrust. According to the vibroacoustic signal recording, the diagnostic parameter is calculated and the change of one of the parameters is drawn from the implementation number. By changing one or another diagnostic rule, the stability of the vibroacoustic signal is evaluated.

IV.CONCLUSION

1. Communication between the amount of feed and the acoustic signal was established, which allows monitoring the position of the cutting tool during the drilling process.
2. The dynamic state of the cutting tool during the drilling process was determined using the magnitude of the acoustic signal.
3. Using the vibroacoustic method to determine the criteria for cutting tool wear during milling allows to monitor the condition of the cutting tool.
4. A method for determining the service life and durability of a cutting tool during drilling using a vibroacoustic signal has been developed.

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