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CONTROL SYSTEM FOR THE PART PROCESSING PROCESS IN A CONDITOINS OF UNMANNED PRODUCTION

Annotation. The article presents a method of measuring the gradual wear of cutting tools during turning operations with the use of ultrasonic diagnostics, measuring the torque and power measurement on the machine spindle motor, measured with wattmeter for CNC machines directly during the cutting process. The measurement scheme is presented.

Keywords: instrument wear, ultrasound, torque, wattmeter, automated production.

INTRODUCTION

Information about condition and expected tool suitability time is a necessary source of information for determining best processing parameters, so control systems of cutting process are being implemented in the production sector based on measuring the level of tool wear [1]. Such systems allow to provide necessary accuracy of processing and quality of a surface, and also to increase productivity in the conditions of unmanned technology.

As the working surface of the cutting tool is affected by mechanical loads, high temperature and cooling liquid, the efficiency of the cutting tool is being decreased due to continuously deformations of the cutting edge.

The aim of this work is to develop a system for monitoring the process of processing parts on CNC machines in the conditions of "unmanned technology", that based on the measurement of this signals: ultrasonic echo-signal, torque on the machine spindle and power on the machine spindle motor.

METHODS OF MEASURING SIGNALS

Ultrasonic method allows to monitor of the condition of the cutting tool edge in real time. It is based on measuring the time, that ultrasound wave travels through the tool body, so it allows to calculate the length of the cutting edge. Knowing the speed and time of ultrasound propagation in the medium, it is easy to determine the desired path of the ultrasonic wave.

Ultrasonic vibrations in the medium in the form of pulses are emitted by a piezoelectric source, which is installed in the caliper of the machine. If these pulses collide with an obstacle, then reflected part of the energy of the emitted wave creates the echo pulse, which then returns to the radiation source. At this point in time, the piezoelectric element switches from radiation mode to receiver mode.

The time between radiation and echo pulse receiving is the time that the ultrasonic pulse travels the path "transmitter-reflective surface-receiver". It is can be measured with an accuracy of one nanosecond. It was found that the path difference can be measured by ultrasound control with an accuracy of ±2 microns [2].

For measuring, a mark is being created near the cutting edge, using an electrical discharging machining. It has constant dimensions: 1.2 mm deep and 1.2 mm thick. The ultrasonic wave that transmitted to the tool body travels through the tool body and reflects from the mark, front surface and back surface of the cutting edge.

The echo signal consists of three parts. The first part is a reflection from the mark, which is the same for all instruments, the second part is an echo signal from the back surface, and the third part is a signal from the front and side surfaces. The wear of the cutting edge is calculated by the time difference between the mark and back surface reflections.

This system also measures power on the machine spindle motor, using a digital wattmeter and the torque that is measured using bearings with strain gauges that are installed on the machine spindle. These parameters determine the degree of wear of the cutting tool and prevent defects during production.

It is known that the torque and power increases with increasing tool wear [3], therefore, these parameters can be used as a source of information, for monitoring of the condition of the cutting tool edge in real time, as well for the developing a system for monitoring the process of processing parts on CNC machines.

The block diagram of the wear monitoring system of the cutting tool edge is presented in Fig. 1.

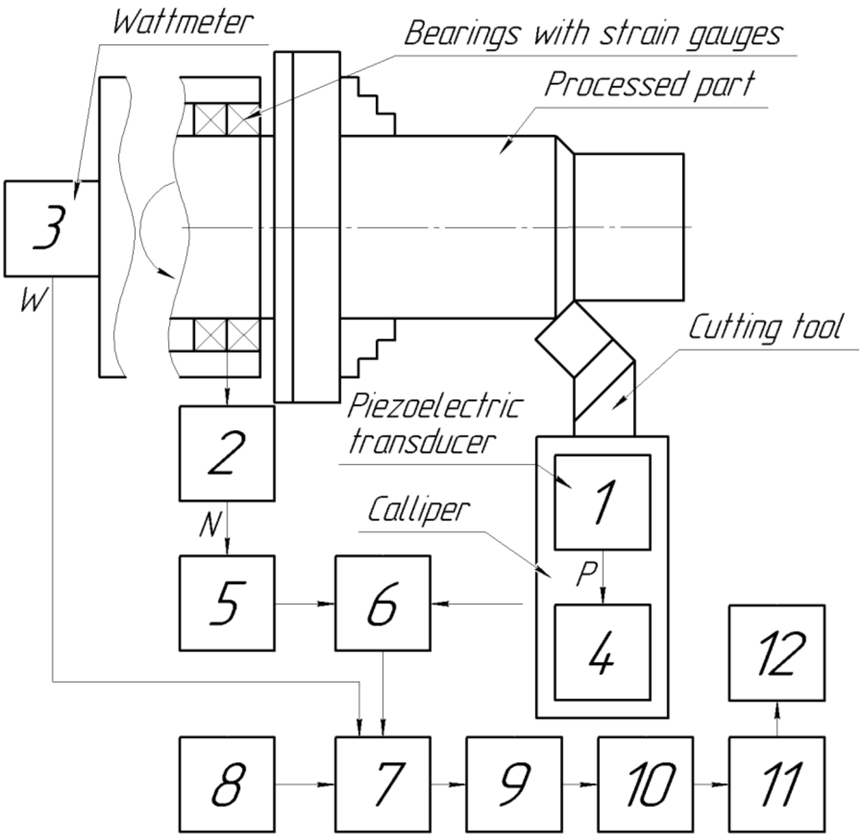

Fig. 1. Block diagram of the control system of the turning process

In this block diagram: Block 1 is a piezoelectric transducer that generate and radiate ultrasonic waves in pulse form and receives reflected echo-signals. Block 2 measures the torque on the machine spindle using bearings with strain gauges. Block 3 is a digital wattmeter, that connected to the machine spindle motor. It measures voltage and current, multiplies them, and outputs power. Accordingly, the received signals are amplified and filtered in blocks 4 and 5, from where they enter the analog-to-digital converter (Block 6). The digital wattmeter has its own analog-to-digital converter, and the signals it provides do not require filtering and amplification so information from it goes directly to Block 7, where all received signals are processed and compared with those stored in the database (Block 8). Based on this comparison, Block 9 calculates wear rate and actual wear of the cutting tool and sends this information to the control unit (Block 10). The control unit evaluates which of the cutting parameters (feed, speed, etc.) can be changed and generates corrected control signals that are entered in the CNC machine program (Block 11). The program processes the signals and transmits them to the machine's actuators (Block 12).

During the processing of the part, the wear area of the cutting edge of the tool increases, respectively, the amount of reflected ultrasonic energy increases in direct proportion. The time difference between the echo signal of the mark and the back surface of the cutting edge also decreases. Also, the greater the tool wear, the greater the force required to remove chips from the surface of the workpiece, and the torque on the machine spindle increases accordingly. Similarly, the level of acoustic emission increases.

CONCLUSION

The developed control system can be used in turning operations in CNC machines in the conditions of "unmanned technology" to create the most optimal processing mode, decrease the number of defective parts and, accordingly, increase production efficiency.

The cutting process monitoring system, which is based on measuring the torque on the machine spindle, the power of machine spindle motor and ultrasonic measurements, will allow you to measure the level of wear of the cutting tool in real time during processing in conditions of unmanned technology, assess the degree of wear under specified cutting modes and improve the reliability and accuracy of the processing process.

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