The method of diagnosing machine systems by measuring the accuracy of manufactured parts

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Abstract. The main provisions of the technique allowing to create a diagnostic complex of the technical state of the machine system, which is informative at the same time of several diagnostic complexes - geometrical accuracy, strain gauge, technological accuracy, the influence of technological heredity - are revealed.

1. Introduction

The Republic of Tatarstan is characterized by a developed automotive industry. Here are concentrated large-scale production of heavy-duty cars. In this case, the issue of the car is provided not by one plant, but by a whole chain of enterprises supplying auto components. Today, suppliers are subjected to stringent requirements for product quality and delivery times. Expensive equipment, often leased. Absence of highly qualified personnel and working capital. An important condition for the competitiveness of an enterprise is the ability to ensure the release of quality products throughout the entire operation cycle of equipment [1].

As the output of products is inevitable wear and tear of the machine components, the displacement of individual modules, and hence the loss of accuracy. This requires a low-cost, simple and effective system for diagnosing the main modules of the technological system.

Requirements for the accuracy of machines and their individual components are set by manufacturers in the passports on the machine. To diagnose various parts of machine systems for compliance with the requirements is carried out by various methods. The diagnostic methods can be internal - built into the CNC machine system and external, for the implementation of which it is necessary to perform measurements with the help of special diagnostic complexes. The most applicable of them are the following: checking the moving nodes for geometrical accuracy, measuring the tensile forces of cutting forces and checking for technological accuracy. For example, the complexes of Renishaw - Ballbar QC20-W, laser system (C-ALS), Kistler 9129AA, etc. These complexes, although accurate, but their cost is comparable to the cost of the machine system. In order to use the complexes it is necessary to readjust the machine system, ie interrupt the technological process. The reason for the use of these systems are the indices of the suitability of technological processes, calculated in accordance with [2].

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2. Theoretical part

For a comprehensive assessment of the technical state of the machine system, simultaneous application of several types of diagnostics is necessary, which further increases the cost of this process. The goal of the project is to develop a hardware and software complex for diagnosing the technical accuracy of machine systems, which reveals a set of factors, based on measurements of the accuracy of the machined parts to quickly identify the most significant deviations that affect the quality of manufacturing machine parts.

The diagnostic complex allows:

1. Identify a set of factors recorded by three different methods of diagnostics - geometric accuracy, strain gauges, technological accuracy and calculates the degree of influence on the quality of the detail of the technological inheritance of the error transfer to the part.
2. For measurements, there is no need to reconfigure the equipment,
3. To work with the complex, it is enough to have the skills of personnel who have workplaces.
4. In comparison with foreign with foreign manufacturers, the lower cost of the complex and its operation.

The procedure and results of the experiments are given in [3-6]. The workpiece before processing and the processed part after processing are measured in a single measuring coordinate system from the same measuring bases. An obligatory condition for the calculation is the registration of process conditions. These include:

1. The coordinates of the base of the workpiece when installed in the tool.
2. The values of feed and cutting speed.
3. Status of the cutting edges of the tool.
4. Beating clamping elements rigging.
5. Limit values of key quality indicators of a part.
6. As a result of the complex's work, two 3D models are formed: the workpiece model and the part model in a unified coordinate system related to the coordinates of the position of the workpiece being machined in the machine coordinate system.

According to the 3D models, the actual distribution of the allowance is calculated, which, in the presence of recorded data on the conditions of the cut-off process, calculates the indices for a variety of directions - geometric accuracy, strength, stiffness of the machine system nodes, technological accuracy with calculation of the indices of convergence and reproducibility of the technological process, heredity of indicators of accuracy of preparation. The simultaneous presence of all this set of indicators allows us to formulate what is especially valuable for small enterprises - the content of corrective actions to improve the quality of the workpiece.

Thus, the effectiveness of the work of the complex is much higher, in comparison with the nearest imported analogues. Figure 1 shows a constructive solution of the hardware-software complex for diagnosing technical accuracy.
In this constructive solution, the complex is intended for diagnostics of lathe group machines processing rotating bodies with a diameter of not more than two hundred mm and a length not exceeding four hundred. The machines of this group are most common in the processes of manufacturing parts at machine-building enterprises. For automated measurements, the part is installed in the center, one of which is driven by a stepper motor through a belt drive. The construction of the mathematical models of the workpiece and the workpiece is carried out from measurements taken simultaneously from three capacitive probes. To increase the accuracy of measurements in the design of the complex, it was decided to get rid of moving parts from the sensors. The sensors have a range of readings that is greater than the depth of cut in the machining transition of the part being measured. The sensor holder is able to rotate about a vertical axis, which allows measurements not only of the outer cylindrical surfaces but also of the end and conical surfaces. Stepper motor control and data processing from the sensors is carried out using a measuring computer.

3. Application of the diagnostic technique

Based on these studies the methodology of diagnostic measurements was defined for accuracy indices. Contrary to the traditional statistical control it is planned to measure in pre-defined points of the machined surfaces. The mathematic treatment allows to define the contribution of each significant factor to the accumulative value of the measured deviation with the reasonable degree of accuracy.

The patents on the methods of measurement, diagnostics and diagnostic systems [7-9].

The experimental comparison of effectiveness and efficiency for a new procedure [2] was performed in the same manufacturing environment as the analysis of statistical methods.

In the nonmachining elements of two work pieces from the experimental sample the coordinate system was placed, the measurements were performed in the specified points before and after machining and the locating coordinates were recorded for each work piece in the manufacturing system.

At the first step of measurement data analysis it was established that the critical accuracy indices of products are shaft and bushing circularity deviations and runout. The second step revealed limiting diagnostic constituents of these deviations. The biggest contribution to runout deviation is made by
axis misalignment of boring bar and chuck. Therefore, during data analysis the specific corrective action has been already planned.

The technique of diagnosing according to the accuracy indicators of the processed ones was successfully tested in the existing technological processes for processing parts of various automobile units at the KAMAZ enterprise, and small suppliers.

4. Conclusion

For the practical application of established to measurement system. It consists of measuring the plate on which the measuring device linked to a computer and accessories to base parts [18-21]. Calculation of technological components is conducted with the registration in the database, automated issuance of the report on the need for corrective action.

Costs of such a measurement system will cost much cheaper buying any measuring machine, and efficiency will be higher, since the measurements can be performed in the workplace. Such a method of diagnosis is automatically embedded in the process of monitoring the quality of output. Diagnostic measurements performed adjuster with any change process (set-up, change of party preparations and so on.), As well as planned in relation to the respective modules based cycles.

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