ANNOTATION

Of the dissertation work of Tleuzhanova Gulnur Bolatkhanovna on the topic: "Development of an Automatic System for Monitoring Tool Overrun, Breakage, and Wear on a CNC Lathe" for the degree of Doctor of Philosophy (PhD) in specialty 8D07102 – Mechanical Engineering.

General Characteristics of the Work. The dissertation analyzes and confirms the possibility of increasing the efficiency of technological equipment, including CNC lathes, through the operational identification of emergency situations during their operation using technical means for automatic diagnostics of the condition of its functional units. The functional units necessary for creating diagnostic systems are identified, and the methods and algorithms of such systems for effective identification of emergency situations are considered. Variants of automatic technical diagnostic systems, including microprocessor-based ones, are considered, designed with the capability to interact with the machine's standard CNC system. To instrumentally support the functioning of automatic systems for monitoring tool overrun, breakage, and wear, a series of measuring transducers for diagnosing the condition of machine units have been developed. All developments are protected by patents of the Republic of Kazakhstan. Modeling various emergency situations during experimental research of the developed microprocessor system confirmed its operability, and acceptable operational and technical characteristics of the system were achieved.

Relevance of the Work. The experience of operating CNC lathes has shown that reliable and efficient operation of a lathe is impossible without additional equipping them with technical diagnostic tools and constructing automatic technical diagnostic systems based on them.

Analysis of technical and patent information has shown the limitations of such systems, and existing technical solutions have limited functionality and low technical characteristics. This primarily relates to the information support for the operation of such systems. Such measuring transducers must be reliable in operation and highly informative in their characteristics. Only measuring transducers embedded in the machine units can meet all these requirements.

The algorithm of such systems should have a minimal volume of computational procedures and ensure correct identification of emergency situations.

The most promising are automatic technical diagnostic systems of microprocessor execution with a wide range of operating modes. It is important to ensure the visualization of all stages of the technical diagnostic procedure.

Scientific research in solving these tasks is new, promising, and the only correct approach to increasing the efficiency of machine tool equipment.

This dissertation work, aimed at developing automatic technical diagnostic systems for CNC lathes, is relevant, and the scientific research itself is fundamentally new and has no analogues, which is confirmed by 15 patents of the Republic of Kazakhstan.

As a result of the dissertation research, the following results were obtained:

− An analysis of existing technical solutions for implementing automatic diagnostic devices for machine systems was conducted. It was established that prompt identification and elimination of potential emergency situations is only possible through the use of automatic technical diagnostic systems, including through the use of systems for monitoring tool overrun, breakage, and wear. Moreover, such systems must be suitable for CNC lathes, e.g., models TPK-125 VN2, 16K20F3, MTD-901, and others, and in training mode, it is necessary to determine the reference signal values for all possible emergency situations.

− Recognition of emergency situations in the operation of a CNC lathe is advisable in the mode of forming and recognizing the image of an emergency situation event. Unlike known diagnostic systems for machine unit conditions that implement current processing of a selected functional parameter, the use of binary parameters when forming an event matrix significantly reduced the volume of computational procedures. The originality of this approach is protected by RK Patent 36029.

− Further improvement of diagnostic systems for emergency situations in the operation of a CNC lathe is advisable through the use of a microprocessor control unit, which includes a central processor, address decoder, ADC, permanent and random access memory, and a character display block for visualizing the technical diagnostic process.

− For lathes with CNC class CNC, a microprocessor-based automatic system for monitoring tool overrun, breakage, and wear is needed, with a built-in measuring transducer for elastic deformations of the most loaded machine parts, a microprocessor control unit with a central processor, address decoder, analog-to-digital converter (ADC), permanent (ROM) and random access (RAM) memory,

while the visualization of the technical diagnostic process must be carried out through a character information display block (CIDB).
− For the functioning of the microprocessor automatic system for monitoring tool overrun, breakage, and tool wear, seven operating modes are necessary: "RAM Test", "Input", "Training", "CNC", "Graph", "Automatic", and "Wear".
− In the absence of deterministic dependencies of the measured parameters, for example, on tool wear, as well as in the presence of noise in the measured signal that prevents the establishment of unambiguous dependencies, the use of special algorithmic filtering methods and the apparatus of correlation function theory during the technical diagnostic procedure can achieve high efficiency of the technical diagnostic system.
− A range of non-standardized technical means of instrumental support (force measuring means – FMM) was developed. Their development used two new creation principles, namely, the principle of ensuring maximum information content and ensuring maximum sensitivity of the newly developed FMM.
− A faceted (multi-aspect) classification of FMM according to eleven classification features is proposed, which allowed assigning a unique code designation in the form of a sequence of eleven indices to each analyzed measuring transducer.
− Using the example of a dynamometric turret head (11100011010, RK Patent 36003), an analysis of measurement errors was performed, confirming the acceptable operational and metrological characteristics of this FMM identified by calculation and empirically. The found components of the measurement error are included in the certificate of the measurement procedure using this FMM.
− The possibility of technical diagnostics of the condition of CNC lathe units through the use of automatic systems for monitoring tool overrun, breakage, and wear implemented based on them, by introducing embedded measuring transducers into their composition, has been proven. Preventing emergency situations and breakdowns of functional machine units has increased their operational life, expanded functionality, and improved technical characteristics.
− Modeling various emergency situations during experimental research of the microprocessor automatic system for monitoring tool overrun, breakage, and wear on a lathe model 16K20F3 confirmed its operability, and acceptable operational and technical characteristics of the system were achieved.

The purpose of the work is to increase the efficiency of CNC lathes by equipping them with automatic systems for monitoring tool overrun, breakage, and

wear in microprocessor execution with the capability to interface and interact with standard machine control devices and with highly informative support for system functioning.

Research tasks:
− justify the use of automatic diagnostic systems to increase the efficiency of CNC lathes;
− determine the reference values of signals identifying various emergency situations;
− find ways to increase the reliability of emergency situation identification results;
− determine the composition and operating modes of the system for monitoring tool overrun, breakage, and wear in microprocessor execution with the capability to interface and interact with standard lathe control devices, as well as with visualization of the technical diagnostic process;
− develop reliable, highly informative measuring means for information support of automatic technical diagnostic systems;
− conduct modeling of various emergency situations during experimental research of the developed system under real operating conditions of a CNC lathe.

The object of the study is a CNC lathe equipped with a technical diagnostic system.

The subject of the study is the nodes of a CNC lathe equipped with embedded measuring transducers and the automatic system for monitoring tool overrun, breakage, and wear in microprocessor execution.

The scientific novelty lies in:
− the use of binary parameters when forming an event matrix to implement the algorithm for identifying emergency situations (RK Patent 36029) and the automatic system implementing this algorithm (RK Patent 36099);
− the composition and operating modes of the microprocessor automatic system for monitoring tool overrun, breakage, and wear on a CNC lathe;
− a range of new non-standardized measuring means (RK Patents 35906, 35907, 35908, 35924, 36003, 36141), faceted classification of these measuring means, and analysis of measurement errors for the dynamometric turret head (Patent 36003) with the compilation of a measurement procedure certificate;
− the results of experimental research of the microprocessor automatic system for monitoring tool overrun, breakage, and wear on a lathe model 16K20F3.

The practical significance lies in:
− the possibility of using invariant embedded measuring means for technological

machines   of   various   purposes;
− the possibility of applying algorithms for identifying emergency situations for technological equipment of various purposes.

The following scientific results are submitted for defense: − the algorithm for identifying emergency situations (RK Patent 36029) and the automatic system implementing this algorithm (RK Patent 36099); − the composition and operating modes of the microprocessor automatic system for monitoring tool overrun, breakage, and wear on a CNC lathe; − a range of new non-standardized measuring means (RK Patents 35906, 35907, 35908, 35924, 36003, 36141), faceted classification of these measuring means, and analysis of measurement errors for the dynamometric turret head (Patent 36003) with the compilation of a measurement procedure certificate; − the results of experimental research of the microprocessor automatic system for monitoring tool overrun, breakage, and wear on a lathe model 16K20F3.

Approbation of the work. The results of each stage of scientific research were reported and discussed at seminars of the department of EKTU named after D. Serikbayev.

Prototypes of invariant measuring transducers were tested at the testing ground of "Akmolapribor" LLP (Astana).

Publications. On the topic of the dissertation research, 18 scientific works have been published, including an article in a journal indexed in the Scopus database, in the scientific journal of Toraygyrov University "Science and Technology of Kazakhstan," and 15 RK patents for invention have been obtained.

Implementation of research results. Prototypes of flat-oscillating and sphere-rotating crushed stone distributors were accepted for use at the testing ground of "Akmolapribor" LLP (Astana).

Structure and volume of the dissertation. The dissertation consists of definitions, designations, and abbreviations, introduction, 4 sections, conclusion, and two appendices. The work is presented on __141_ typewritten pages, includes __88_ figures, _7_ tables, a list of used sources containing _62_ items.