The Structure and Principles of Work Intellectual Processing Control System on CNC

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Abstract. The high rate of technological progress imposes stringent quality demands of engineering production. The main requirement is dimensional accuracy of metal-cutting equipment with a minimal needed operating costs during the period of operation. The article considers the problem of increasing the accuracy of processing engineering products on CNC. The authors have proposed a solution of the problem by providing entering operational adjustment to the control of the trajectory of the executive bodies of the machine. The necessity of creation of mathematical models of processes in an automated process system operations (APSO). Based on the research, authors had proposed that a generalized scheme of diagnosis and operation input of corrections and approximate mathematical models of the individual processes of diagnosis.

Introduction

Currently, the processing engineering products implemented on equipment that uses computer numerical control (CNC), has been some marginal level of precision machining, so the minimum discrete movement of the executive bodies of most modern machines, is 1 micron, and some of them are able to carry out moving in quantities less than one micron. Further increases the accuracy of processing implemented on CNC equipment, is due to a decrease minimum possible discrete movement of executive bodies is not possible to restrictions imposed by both the physics of metal cutting on the micron and submicron level and the actual condition of the equipment. For example, in the micron and submicron level becomes critical influence of errors caused by the influence of the equipment: power loads, the heat flux and wear of the cutting tools that change the shape and spatial position as the executive bodies of the machine as workpiece.

In almost all cases the development of control programs for CNC equipment is carried out either with the use of computer-aided design (CAD), or with built-in simulation directly on the CNC control panel. Should be noted that in this case, and CAD and CNC panel working with a mathematical model of the workpiece, cutting tools and equipment, and any mathematical model is a kind of idealized object affected by a greater or lesser degree of simplification. In this case, simplified physical and mechanical properties of objects which appear to CAD as absolutely rigid, not exposed to heat fluxes not undergo wear. Therefore, errors occur in the technological system in the implementation of control programs (CP), created by means of CAD or CNC control panel, will be inherited by the workpiece. Prevent the occurrence of errors in the processing system, at realization of CP is impossible due to the...
physical nature of the objects. In this case it is necessary to implement conversion of the control trajectory (CT), in a way that errors of processing system will be compensated.

2. Methods of Research

Widespread CNC lathes in modern machining production leads to appearance another problem - reducing the quality of products manufactured by the technological system during exploitation, that requires a decision. The point is that any material object is exposed to the phenomenon of ageing, i.e., gradual deterioration of its original characteristics. Technological system is no exception to this rule, it is also susceptible to deterioration in their operational characteristics of over time, and this process as faster, as more intense use of technological possibilities. One of the major operational characteristics of technological system is its ability to ensure the desired dimensional accuracy and surface quality at minimum production costs. The deterioration of the ability of technological to ensure the required dimensional accuracy, is connected with many physical phenomena occurring during exploitation.

The main factors causing the aging of technological system the following:
– wear in use friction surfaces of the elements technological equipment
– error of the spatial position of the individual elements of technological equipment;
– thermal deformation ;
– changes in the geometric parameters of the cutting tool;
– various kinds of breakdowns.

These factors do not influence individually and independently of each other, but operate simultaneously, thereby significantly degrading the performance of technological system.

With an ever increasing requirements, placed on scientific and technical progress to the quality of product engineering production, it is necessary to ensure the minimization of the impact, exerted by the unfavorable factors in the technological system. In spite of the revealed problem of reducing the dimensional accuracy during the operation of equipment, CNC lathes are an essential part of a technological system of modern engineering production. Therefore it is necessary look for ways to solve this problem. In order to improve the dimensional accuracy of processing on CNC lathes, it is proposed to provide operational input corrections in CT movement of executive bodies of the machine, which allows to compensate the system error appearing in work. From the definition of the technological system implies that a complex of functionally related technological equipment, the production of objects and performers to execute regulated conditions of production. This definition gives us a generalized representation of what is a technological system, to the same from the definition is not entirely clear degree of automation, performed by the system processes or operations. So it is important to differentiate definitions technological systems, where used universal equipment and where used CNC lathes.

We introduce the concept of an automated system of technological operations (ASTO). ASTO – it is a complex of functionally related technological equipment, the production of objects, executors and intellectual control system processing on CNC lathes to execute in regulated production conditions specified of technological processes of or operations in the shortest possible machining time and at the least cost of material and human resources.

The general form of structure automated ASTO can be represented as a neural graphic pattern illustrated in figure 1.
The proposed structure of ASTO is not a full and complete (elements that make up the ASTO shown in Figure 1), but enough to approach the question of mathematical modeling and the development of mathematical models of various processes occurring in it and necessary for the development of intellectual control system processing on CNC lathes.

**Table 1.** The elements constituting ASTO.

| Symbol | Name of element ASTO |
|--------|----------------------|
| $M$    | Automated system of technological operations (ASTO – ISDU) |
| $P$    | Subject of production (labor) |
| $P_1$  | Variety of physical and mechanical properties of the material object of production (labor) |
| $P_2$  | Variety geometrical parameters of the object of production (labor) |
| $W$    | Workers on engineering process |
| $W_1$  | Mechanical technician of engineering process |
| Symbol | Name of element ASTO |
|--------|---------------------|
| $W_2$  | Technological equipment operator |
| $A$    | Variety of technological equipment |
| $A_1$  | Technological equipment |
| $A_{11}$ | Variety of technological equipment |
| $A_{12}$ | Variety of tool support |
| $A_2$  | Technological equipment |
| $A_{21}$ | Cutting machine |
| $A_{22}$ | Variety means of maintenance of working capacity tool |
| $B$    | Technical equipment and automated system control of engineering process (TEASC EP) |
| $B_1$  | System diagnostic aids |
| $B_{11}$ | System of aids preliminary diagnosis of subsystems and elements of technological system |
| $B_{12}$ | System of aids operative diagnosis of subsystems and elements of technological system |
| $B_2$  | System of forming and operational input of corrections |
| $B_{21}$ | System processing data of the preliminary diagnosis of the technological system |
| $B_{22}$ | System processing of operative diagnostic technology system |
| $B_3$  | System determining the correction parameters |
| $B_{31}$ | System determining the correction parameters according to the preliminary diagnosis |
| $B_4$  | System of numerical control machine (CNC) |
| $B_{41}$ | System of forming and operational input of corrections |
| $B_{42}$ | System operational data during processing |
| $B_{43}$ | System of numerical control of lathe (PCNC) |

As part of the study on an experimental setup shown in Figure 2, the possibility of creating intellectual control system processing on CNC machines, exercise power loading of the executive bodies to simulate the errors occurring in the technological system from the impact of the cutting forces, leading to the rejection of the surfaces to be treated details reversal of the turret and a change in spatial position the caliper.

It was found, that the results obtained during the research of deviation of the elements of technological system leading to the formation of error processing, are correlated with applicable cutting forces.
The study also noted that the processes of diagnosing the state of technological systems and drives, it is advisable to divide the preliminary and operational, that reduces the complexity of setting up specific technology systems and meets the requirements for the implementation of flexible processing technologies.

From this graphic can be seen that the three basic groups of parameters stand apart:
- parameter group 1, a preliminary diagnosis of the parameters used to define values of operative correction in the processing for all the various parts and tools.
- parameter group 2, a preliminary diagnosis of the parameters used to define values of operative correction in the processing of specific parts and tools.
- parameter group 3, a current operational parameters of the diagnosis used to define the values of the input sum and surgical correction in the processing of the path of the tool and cutting conditions.

This generalized scheme of diagnosing the state of the technological system allows to come close to the issue of mathematical modeling of diagnostics.

Mathematical model of automating the process of diagnosis is not adequate diagnostic process performed by a man. The mathematical model contains features inherent in the machine process, and saves the basic features of the process performed by a man. This article presents mathematical models and their verbal description, diagnosing the state of the technological system, written using the language of mathematical logic and predicate logic. In this article, as an example, the mathematical model (1) diagnosis of deviations of surfaces of structural elements of a part under the influence of the cutting forces arising in ASTO during the processing of written with the help of mathematical logic and its section of predicate logic.

\[
\forall M \exists B_i^{2} \in \left( \left( P \subset A_i^{1} \right) \rightarrow \left( B_i^{2} \ni B_i^{3} \right) \right) \rightarrow \left( B_i^{4} \ni B_i^{5} \right)
\]

\[
M = \left( A \ni P \ni W \ni B \right)
\]

\[
B_i^{3} = \left\{ x \in N, F \left( x \right) \right\} ;
\]

\[
F \left( x \right) = x_i \cdot q^{-1} ;
\]

Read: for a variety of ASTO (M), including multiple of technological equipment (A), a multiple of items of production (labor) (P), a lot of workers (W) and a multiple of means of automated process control systems (B) - there are many systems diagnostics changes in the spatial position.

(\(B_i^{2}\)) the subject of work (\(P\)), established in technological equipment (\(A_i^{1}\)), loading using a device (\(B_i^{2}\)) a variety of weights (\(B_i^{3}\)), measured by device (\(B_i^{3}\)), including feeler (\(B_i^{4}\)), registered device (\(B_i^{2}\)) a lot of deviations (\(B_i^{3}\)) spatial position.

Or, from the perspective of an engineer: diagnostics automated technological system operations consisting of technological equipment, the subject of production (labor), contractors and equipment of automated process control system, by definition, changes in the spatial position of the workpiece relative to the OZ axis when it is loading component of cutting force PZ is as follows: on the blank mounted in the fixture affected by a device that simulates the action of cutting force component PZ, the measuring device disposed at the opposite side, comprising a probe, determines the amount of deflection recorded recording unit.

The proposed approach to the mathematical modeling of processes in ATCO allow to solve the problem of intellectual control system processing CNC and, consequently, reduce the dimensional accuracy machining with CNC machines as a result of the phenomenon of aging. The solution to this problem provides a reduction in production costs associated with the manufacture of technological engineering products.

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