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Mathematical modeling of the technological accuracy index deviation structure of the automobile parts

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Abstract. The technological components of the measured deviation of the accuracy index that arose during machining are ordered. Mathematical models have been developed to predict their magnitude during processing and also to find the causes of identified nonconformities in production, the components are ranked using the Pareto diagram.

1. Introduction

The world's leading automobile corporations have long since moved from a quality assurance based on alternative control to a constant reduction of quality indicators deviations value by regulating them. This approach may require the consideration of more factors.

Current International quality management standards require the development of systematic measurement of the most important (key) quality indicators, to build and analyze control charts [1], to apply methods for measurement systems of repeatability assessing and reproducibility. [2]. But identifying factors of instability and correcting planning takes time and reduces efficiency as soon as having processed. And there is no guarantee that the correction will reduce the deviation from the first attempt. Consequently, the effectiveness of management is lost.

2. Theoretical part

The proposed solution is shown on the example of the transition of longitudinal grinding (Fig. 1). In order to obtain the highest degree of adequacy of models, the process of forming in this paper is represented as the successive attachment of elementary areas to each other, caused by turning the workpiece by an angle $\Delta\varphi$ and axial movement of the tool by ΔS. To take into account all factors, the concept of a "pole" of the system is introduced. The blanking pole is the instantaneous position of the axis of rotation of the workpiece. The tool pole is the instantaneous position of the tool forming element [3-5].

Based on the definition of "products – the result of the process" (GOST R ISO 9000-08), the following basic principle is formulated: the measured deviation of the position coordinates of the elementary area of the treated surface from the given ideal value is a geometric sum of the technological components (procurement and tool) that arose in the preparation of the working stroke, in the processing of previous elementary sites and at the time of forming of this site.

The instantaneous radius of each site will be determined by the deviations from the ideal desired state of 2 poles: $\Delta\Pi_{Зi}$and $\Delta\Pi_{Иi}$. It is calculated in the operating technological coordinate system.

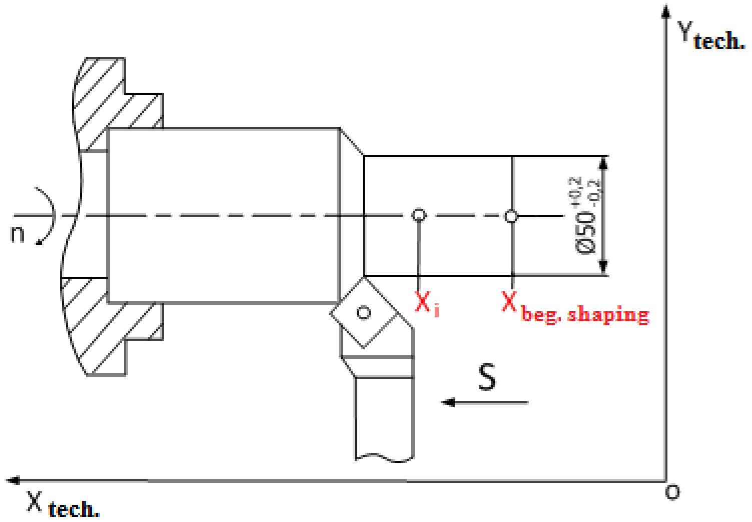

Figure 1. Technological scheme of the transition of external longitudinal grinding.

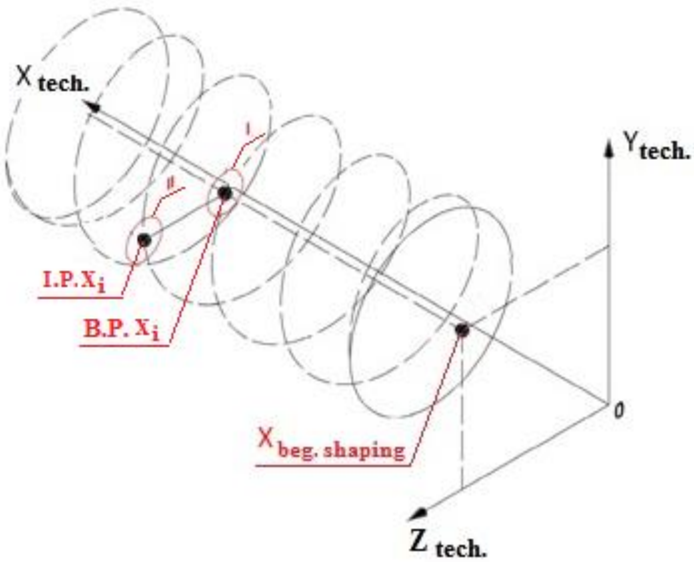

Figure 2. Ideal trajectories of poles movement in the transition of external cylindrical surface turning, I is the area of possible positions of the blank pole, II is the area of possible positions of the tool pole.

In the current X-coordinate of the position of the poles:

$$x_i = X_{pr.F.O.} - \sum_1^i \Delta\varphi_i * S \quad (1)$$

where $X_{pr.F.O.}$ – initial point of forming [mm.], $\Delta\varphi_i$ – the increment of the rotation angle [grade], S – submission amount [mm./turnover]

The actual distance of the elementary area from the instantaneous axis - R_i will be determined by the coordinates of the poles:

$$R_i = Y_{I.P.i} - Y_{ZP.i} \quad (2)$$

These coordinates of the poles are determined by geometrically summing of the coordinates of the point in their ideal position and technological components.

The Table shows a set of technological components that are relevant for this transition, in the order in which they occur.

General scheme of pole deviation factors

Table 1

№	Machine Forming Systems	Processes of the life cycle of the technological system				
		Equipment Characteristics	Setting up the task	Workpiece base	Figuration	Calculation point
1	Blanking branch	Position of the axis of rotation ΔY_{OCi}	---	The size of the allowance t_i and solidity HB_i	---	Deformation of the axis Δf_i
2	Tool Branch	Deprecation of the guide axis $\Delta Y_{Napr.i}$	Regulation of size $\Delta Y_{Nal.i}$	---	Accumulated dimensional wear Δh_{ri}	---

Thus:

The coordinates of the current position along the Y axis of the blanking pole:

$$Y_{Z.P.i} = Y_{ZPid.i} + \Delta Y_{0Ci} + f_i \quad (3)$$

where $\Delta Y_{0Ci} = \alpha * x_i$

The nonparallelism characteristic of the α-axis by the machine guide is determined by diagnosis.

The magnitude of the deformation of the axis at point i is calculated from known empirical relationships [2]. The coordinates of the position of the instrument pole are determined by:

$$Y_{I.P.i} = Y_{IPid.o} + \Delta Y_{Napr.i} + \Delta Y_{NAL} + \sum_1^{i-1} \Delta h_{ri} \quad (4)$$

$\Delta Y_{guide.}$ – the wear amount of the guide at the point

ΔY_{ADJ} – deviation of the coordinate of the adjustment dimension from the ideal value

Accumulated depreciation amount $\sum_1^{i-1} \Delta h_{r.i}$ is calculated from known empirical dimensions [6].

The accumulated instantaneous values R_i are added to the equation of the machined surface first in the machine coordinate system (2), and then it is converted to simulate the manufactured part in the measuring and construct coordinate systems.

The value of the identified components is ranked using the Pareto chart to plan the order of improvements.

3. Application of the developed modeling methodology

- To predict the deviation of key accuracy indicators during the development of production operations, including the use of virtual technologies.
- For automatic planning of the most effective corrective actions in case when an unacceptable amount of deviation is detected [6, 7, 8].
- To create a reliable information basis for effective preparation of production including innovative products, adding to the application of various methods of quality management [9].
- As a tool for comparative evaluation of the effectiveness of the methods used to control accuracy [5].
- As a basis for the effective diagnosis of machine system modules [10-12].

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