Directed Formation of Quality, as a Way of Improving the Durability of Conjugated Parts of Friction Pairs

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Abstract. In the article the research of possibilities of directed formation of indicators of quality is given, by selecting technological operations and appointment of corresponding processing regimes. Studied approach directed formation of quality, based on the elements of theories of technological inheritance and interference of quality, which can reduce the role of random factors and their complex combinations in the process of providing regulated quality indicators, which in turn reduces the field of dispersion values performance and improves the quality of processed details. It is noted that for implementation of directed formation it is necessary to determine technological parameters, with the help of changing the values of which, it is possible to control the values of their indicators, which evolve in the process of mechanical processing. This will completely eliminate or reduce the impact of those indicators that worsen the performance properties of parts. It was revealed that the nature of manifestations of technological heredity is influenced by the conditions of implementation and the type of technological operations. It is advisable to apply this approach in the initial machining operations in order to initialize the manifestations of those indicators that improve the performance of the parts in general.

Keywords: Analysis · Manufacturing · Coefficient · Matrix · Model

1 Introduction

The sequence of stages of the process of composition and use technological approaches characterized the technological history of manufacturing parts. In its turn, it is determined by a number of quality indicators of new details. Knowing the patterns of their formation, it is possible at the stage of technological preparation of production to provide for measures to ensure the regulated values that provide directional forming quality.

Directed forming elements based on theories of heredity and technological interference of quality, thus reducing the role of random factors and their combinations in the provision of quality, which reduces the dispersion values of field and improves the quality of machined parts. Each stage of the manufacturing process should be

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considered as the interaction of various manufacturing facilities that define the processes of transformation of quality, appearance phenomena of inheritance and interference [1–4].

Technological support of quality indicators begins with the selection of material parts with certain physical and mechanical properties, taking into account changes in these properties over time, possible defects and impurities in the material, as well as the choice of the method of obtaining blanks.

The next stage—the selection methods and calculation parameters processing modes are to receive at least regulated performance technology and further cost adjustments in a production environment. The choice of sequence processing techniques is originally based on technological principles that ensure consistent increase of accuracy and reduction of the size of high-altitude performance surface roughness of machined workpiece. When calculating the parameters regimes, it is necessary to use theoretical and empirical indicators of quality blanks depending on the conditions of processing. Then you need to analyze the possible effects of technological inheritance and interference indicators of quality in the manufacturing process as a trend change indicator may not coincide with other changes directions. This analysis will allow to determine the conditions of the process flow, in which there is no negative impact of material properties, surface layer, design blank forms, its technological bases for formed parts quality [5].

To make a directed formation, it is necessary to determine the parameters by changing the values of which can control values of the indicators evolving in the course of treatment. This will eliminate or reduce the impact indicators that degrade the operating properties of parts, primarily for the procurement or initial machining operation and initialize displays indicators that provide improved performance properties parts in general.

2 Literature Review

The analysis of the nature of the relationships between regulated technology and quality indicators of the obtained blanks with parameters of treatment showed that the accuracy and deviations can be controlled when cutting machining; undulation—with abrasive cutting; roughness parameters—for all methods of treatment; physical and mechanical surface layer—at strengthening the cutting surface plastic deformation (SPD).

Management indicators of quality are provided by varying the parameters of technological systems and processing modes intended for some process operations, namely in the case of cutting edge cutting the accuracy of the size and shape workpieces main impact exercise machine precision, rigidity of technological system and cutting tool material; undulation—system rigidity and precision of the machine; for roughness parameters—supply (supply at a value greater than or equal 0,1 mm/rev) the mechanical properties—lubricating fluid (LF) and machining technology features work areas (TMWA) (zone of direct contact tool and workpiece, LF availability, processing temperature zones), the geometry of the cutting tool parameters and modes of treatment [6, 7].

Given the accuracy of abrasive cutting to size and shape pieces affect the accuracy of the machine, the rigidity of technological system, cutting depth and the number of working strokes; on undulation—technological system stiffness, precision machine, the number of working strokes; in roughness—granularity, the number of working strokes and feed; on physical mechanical properties—cutting depth, grain, LF and TMWA.

If the SPD accuracy size and shape of pieces depends largely on their baseline values, partly on the strength of deformation, the number of working strokes and yield strength of the material; undulation, in addition to these options, depending on the shape of the working tool; roughness—from its initial value, strength deformation, supply and yield strength of the material [8, 9].

In the application of SPD there are manageable physical and mechanical properties that depend on the strength of deformation, the number of working strokes, filing, form tools, the yield strength of the material and the LF and TMWA (Table 1).

Table 1. The impact of technological parameters on quality systems.

Quality parameters	Technological system settings and modes of treatment (in descending order of the degree of influence)		
Turning processing			
Precision	PM	RTS	MTC
Waviness	RTS	PM	–
Roughness	TM	–	–
Physical and mechanical properties	LTE	CTG	TM
Abrasive processing			
Precision	PM	RTS	TM
Waviness	RTS	PM	TM
Roughness	MTC	TM	LTE
Physical and mechanical properties	TM	MTC	LTE
Treatment of SPD			
Precision	IQ	TM	YSM
Waviness	TM	YSM	CTG
Roughness	IQ	TM	YSM
Physical and mechanical properties	TM	YSM	LTE

PM precision machine; *RTS* rigidity of technological system; *MCT* material cutting tool; *TM* technological modes; *LTE* lubricating technological environment; *CTG* cutting tool geometry; *YSM* yield strength of the material; *IQ* indicators of quality

The nature of the technological manifestations of heredity conditions affects the implementation process and nature of exposure. In one case related to technological transitions manufacturing process technology, heredity may be such as the Quality of the workpiece is transferred completely or becomes more pronounced. For other pair of adjacent passages, the same process technology heredity has significant or no manifestations at all. Similarly, the degree of interference appears differently on different technological transitions [10].

After determining the transformation coefficients of quality indicators in the manufacture of parts with known structure of the process, it is possible to determine the desired distribution of performance between technological operations and transitions. On the other hand, the known range of variation values of quality and original piece set values of a number of indicators of quality parts, the most efficient workflow can be developed that will provide conversion quality indicators in the workpiece indicators of quality parts.

3 Research Methodology

In order to describe the transformation of the quality parameters during technological preparation of production processes in the design, mathematical tools.

There are several basic approaches to describing and modeling parts indicators of quality from the standpoint of the theory of technological inheritance. The most appropriate form of presentation changes of quality, as shown in recognized linear

$$K_{ij} = K_{i(j-1)}(1 + k_i) \quad (1)$$

where K_{ij}, $K_{i(j-1)}$ is quality score K_i logging on technological transitions j and $(j - 1)$ in accordance; $i = 1 \ldots n$, where n is the number of quality indicators workpiece; k_i is technological heredity factor for a given indicator.

Changing the index according to Formula (1) is illustrated in (Fig. 1).

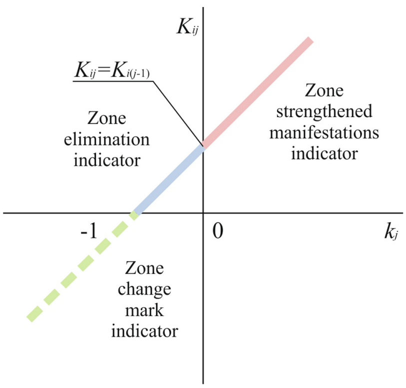

Fig. 1. Change K_i quality score details when changing technological heredity factor k for the transition j.

This form of representation allows to avoid uncertainty at the time of formation rate and changes in the sign of the coefficient. In this case, if during the process the quality score has become zero, the future may be "restoration" of its non-zero value.

The basic mathematical tools of transformation of quality indicators are based on the following assumptions:

1. Quality parts formed during the production cycle. Quality components and their values are the result of technological history;
2. Any (technological or related) effects on the workpiece changes all the quality of the workpiece;
3. Any quality score, changing, changing all the other quality billets.

Given these preconditions values of quality in certain technological transition in general can be represented by (2):

$$[K]_j = [K]_{j-1} + [\Delta K]_T + [\Delta K]_y + [\Delta K]_p \tag{2}$$

where $[K]_{j-1}$ is the set quality values that characterize the state of the workpiece after the previous $(j-1)$ transition; $[\Delta K]_T$ is change of the set quality values billet due to the direct impact of technological method of the jth transition; $[\Delta K]_y$ is change of the set quality values of the workpiece under the influence of the conditions of implementation of the process method jth transition; $[\Delta K]_p$ is change of the set values of quality blanks related to the technological history.

The set change of quality values $[\Delta K]_T$, $[\Delta K]_y$, $[\Delta K]_p$ can be represented as the product quality values after the jth switch to the corresponding coefficients:

$$[K_i]_j = [K_i]_{j-1} + [K_i]_j \cdot [K_i]_{j-1} + [u_i]_j \cdot [K_i]_{j-1} + \Sigma[k_{il}]_j \cdot [K_i]_j \tag{3}$$

where $[k_i]_j$, $[k_i]_{j-1}$ are vector-column values ith quality score blank after the conversion j and $(j-1)$ in accordance; $[k_i]_j$ is coefficient matrix values of quality changes in the jth move, describing the impact of technology (machining mode settings); $[u_i]_j$ is matrix coefficients change values of quality-related conditions of implementation of the jth transition (effect of errors in installation, configuration, stability, temperature control); $[k_{il}]_j$ is matrix coefficients that describe the interplay of quality, prevailing at different stages of the process.

Under the mutual influence one should understand the changes of i quality score based on l indicator of quality that occur during the execution of the jth transition and change lth quality score based on the ith indicator, which appears on the same transition, with $i \neq$ l; and, $l = 1, \ldots, n$, where n is a number of quality indicators blanks formed to make the transition j, but also affect the quality generated in this transition.

The set of coefficients of the quality indicators, obtained after the transition $(j-1)$ can be represented by multiple factors prompt succession $[m_i]_j$, defining change indicators of a product because of the direct impact of technological method to transition j, where $m_i = 1 + k_i + u_i$.

Then the formula for determining the number of quality indicators will be as follows:

$$[K_i]_j = [m_i]_j \cdot [K_i]_{j-1} + \Sigma[k_{il}]_j \cdot [K_i]_j \quad (4)$$

4 Results

The most active group of the factors that determine the value of options are m_i modes of treatment. The number of possible combinations of parameters is large, but each method can define a set of values for providing regulated native implementation method, a medium processing mode, which consistently evaluated the method.

As stated in [11], elements of the matrix $[k_{il}]_j$ may be determined only experimentally. Because of different physical parameters as properties of the coefficients of mutual influence will differ. First of all, it refers to the stability of these ratios over time. Matrix $[k_{il}]_j$ may include permanent elements k_{il} = const and especially, $k_{il} = 0$, and logical variables over time $k_{il} = k_{il}(\tau)$.

To assess the relative impact indicators as details, it is necessary to solve two main tasks:

(1) to obtain quantitative impact assessments and their statistical characteristics in a fixed time interval;
(2) to determine the conditions and the time of display patterns of influence.

The study matrix elements $[k_{il}]_j$ should perform a preliminary analysis of the set of quality indicators and allocate separate blocks of influence, such as "waviness–geometry", "residual stresses–geometry", "mechanical properties of the material–roughness". Such links are presented in Table 2.

Table 2. Matrix interference indicators of quality parts on interoperable transitions.

The final quality score, *i*	The indicator that provides *L* impact on operations:							
	Turning processing							
		Abrasive processing						
			Treatment of SPD					
	GF	W	GF	W	GF	W	GF	W
GF	+	+	+	+	+	+	+	+
W	+	+	+	+	+	+	+	+
R	+	+	+	+	+	+	+	+
SR	±	±	±	±	±	±	±	±
RS	+	±	+	±	+	±	+	±
S	+	+	+	+	+	+	+	+
SS	±	±	±	±	±	±	±	±
MMP	+	+	+	+	+	+	+	+

GF geometric form; *W* waviness; *R* roughness; *SR* sub-roughness; *RS* residual stresses; *S* strengthening; *SS* structural state; *MMP* mechanical material properties; + direct communication; ± mediated communication; – missing bond

Followed experimentally determine the necessary constants and variables for regression coefficients. Thus, a reliable and versatile model of quality indicators suitable for practical use in the design processes of manufacturing parts.

5 Conclusions

The process of stable work of parts, which is based on complex mechanical, physical and chemical processes, determines its overall wear resistance. Prior to this process, the physical and geometric characteristics of the surface, such as roughness, microhardness, magnitude and sign of residual stresses, structure metal, friction coefficient and others, acquire optimum values, respectively, of operating conditions and wear. It is determined that optimum performance characteristics during normal wear and tear are supported, evolutionary, and they are continuously reproduced in the same values that are manifested by technological heredity.

Establishing the facts of technological inheritance of quality indicators from previous moves to the next and their mutual influence and quantification of these effects will form information provision to describe and study the processes of change and preservation of quality indicators detail of practical calculation of the indicators, as well as automated systems design and simulation technology of production. It should be noted that the determination of many coefficients as a matrix of specific values for various combinations of methods, materials, types, sizes of parts, etc. rather laborious process. Necessary conducting numerous experiments, which greatly complicates the use of this approach.

To reduce the complexity of the present rates offered in the form of mathematical relationships that describe the impact of technological factors on the quality and technological inheritance and mutual influence performance. These dependencies allow an idea of the mechanisms of formation, inheritance and mutual influence of quality, as well as the possibility of regulating these phenomena. Thus, for example, setting the parameters of the process (including the cutting parameters, equipment) can determine the future values of quality.

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