Actualization of the quality of production assessing problem at machining processes

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Abstract. The article analyzes the existing approaches to assessing the quality of mechanical processing products using inprocess gages with the actualization of the problem of improving such systems, by improving the hardware and software of statistical data analysis.

Keywords: product quality; production; mechanical processing; automotive industry.

1. Introduction

Modern conditions of competitiveness are high demands on the quality of products. With regard to the machine-building and automotive industries, as well as a number of related industries, and especially with the large-issue and mass character of production, quality products imply products manufactured with high dimensional accuracy, minimal shape error, and no surface defects [7, 8]. High precision manufacturing of individual parts allows for the proper functioning of each node, to achieve high reliability and durability of the finished product. The dimensional accuracy of the geometric parameters and the shape of the part steadily increases with time due to the modernization of the existing and the creation of new processing equipment, the introduction of new materials, processing modes, as well as the improvement of measurement and control technology. In this case, the decisive role in terms of achieving high quality indicators is played not only by the control of an already processed part, the so-called postoperative control, but by the control performed directly in the process of manufacturing the part — active control. Until now, a large number of high-precision parts in machine-building production are processed on metalworking machines (grinding and honing), including the active introduction of multi-purpose machines (the so-called machining centers). Multipurpose machines are capable of complex processing of parts of complex shape, consistently performing various machining operations, combined with a change of the cutting tool [1-3].

2. Main part

Inprocess gage (IG) have been developed for quite some time, from the moment of the need to obtain mass-produced products of engineering production of high dimensional accuracy at machining operations. IG is installed directly on the machining machine, measures the size of the workpiece and as it changes during processing issues commands to the machine control system to change processing modes, and when it reaches the required size, it issues a command to complete processing. This principle of operation is used regardless of the variety of grinding processes, design features of a particular grinding machine. In special cases (the impossibility of placing the sensors in the treatment area or the high complexity of the auxiliary equipment, and, consequently, its increased cost. Or when the size of the workpiece is provided by a fixed installation of the processing tool relative to the part), the part is not monitored during processing, but immediately after its endings According to the results of control, teams are formed for the sub-adjustment of the processing tool.
At the same time, regardless of the type of grinding operation and the IG used, all other components of the technological process also impose strict requirements:

- to the processing tool (grinding wheel), on which the frequency of edits depends on its blunting, the period of its durability, the duration of the processing operation;
- blanks (stability of material properties, amount of allowance before processing), on which the duration of a machining operation depends (with an unstable range of variation of the size of blanks, even within a small batch)
- coolant-cutting fluid (CCF), the composition and temperature of which determine the efficiency of heat removal from the part and the quality of its processing;
- rigidity of the technological system of the machine.

In this regard, the achievement of high quality, while maintaining the required performance, as well as low cost for the implementation of such activities is a difficult task [1, 2, 4-6].

One of the main areas to achieve greater opportunities in improving the efficiency of machining operations, and in particular in grinding, is the development of new means of active control along with the improvement of algorithms for managing grinding modes.

It is known that one of the main indicators of product quality (in terms of geometrical parameters), in particular, the size of parts, at the time of finishing a part is determined by the values of the final removal rate of the allowance and the time of removal of the grinding wheel $V_{MK}$ from the workpiece from the moment the end processing command is triggered $t_G$:

$$ L = f(V_{MK}, t_G). $$

(1)

Since the time of removal of the grinding wheel varies within relatively small limits, its value can be assumed constant under certain assumptions, and the value itself can be compensated for as a systematic error. In this case, the error in the size of the workpiece in the transition to small increments can be represented as:

$$ \Delta L = C_1 \Delta V_{MK}, $$

(2)

where $C_1$ - constant for a particular equipment coefficient characterizing the processing conditions [3].

It is also known that the quality of microgeometry (roughness) of the machined surface of a part $R_a$ is a function of the final removal rate $V_{MK}$:

$$ R_a = C_2 V_{MK}^n, $$

(3)

where $C_2$, $n$ - constant for a particular equipment coefficients, characterizing the processing conditions [7].

From expressions (2) and (3) it follows that the quality of machining the part, and in particular the geometrical parameters and the quality of microgeometry, can be assessed directly at the moment when the part is finished machining on a grinding machine. Due to the presence of disturbing factors that have a randomly functional nature, an error occurs during manufacture. As a result, at the output of the machine, parts are obtained whose size varies in a certain range, whereas the optimal (in the ideal case) is to obtain a nominal size $- L_{HOM}$. 

In this regard, the deviation of the size of the part from the nominal - the error in the manufacture of the $i$-th part $\Delta L_i$ can be represented as:

$$ \Delta L_i = L_i - L_{HOM}, $$

(4)

where $L_i$ is the size of the $i$-th part after finishing the treatment; $L_{HOM}$ - nominal size of the part.
The error in the manufacture of the part $\Delta L_i$ in this case is due to the variation of the final rate of removal of the allowance at the time of completion of machining the part with the grinding wheel $\Delta V_{MKi}$:

$$\Delta V_{MKi} = V_{MKi} - V_{MK Hom},$$  \hspace{1cm} (5)

where $V_{MKi}$ - the final rate of removal of the allowance at the time of completion of processing the $i$-th part;

$V_{MK Hom}$ - the value of the final rate of removal of the allowance at which the nominal size of the part is achieved [6].

Thus, using expressions (2–5), it is possible to obtain information on the quality of manufactured parts directly at the time of finishing the processing, providing the machine operator with data on the size deviation from the nominal value directly in the processing cycle, as well as the roughness value [7–12].

3. Conclusion

Figure 1 shows a typical three-interval control algorithm for the cross feed of the grinding machine, where the shaded area $V_M(S)$ shows the trajectory of the metal removal rate in the machining process at different stages of grinding - roughing, finishing and grooming depending on the size of the allowance.

As can be seen from the figure, due to the presence of disturbing factors, the gamma trajectory of the removal rate of the allowance takes a certain range, which ultimately leads to a variation in the final size and quality of the microgeometry at the end of the part processing. In this case, the information obtained at the inspection stage of the finished part can only confirm the real value of the size of the manufactured part, i.e. information about the size deviation from the nominal value arrives with a delay. This can lead to the release of parts or even a small batch with a fairly large variation in size.

Thus, the further improvement of existing IG systems is associated with the improvement of active and postoperative control tools based on a two-loop active control system, as well as the implementation of automated software systems for recalculating large arrays of statistical data on the course of the machining process.
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