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Determination of the accuracy of the gear wheels of technological factors

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ABSTRACT: In this article, the results of the studies improve the accuracy of gears. A new system for counting the errors in the functional relationships of interfaces and kinematic pairs has been developed. It has solved the problems of determining errors, estimating the accuracy of the technological process, deviations in the standardized parameters of gears and operating parameters of gears

KEYWORDS: gear-honing, gear-milling, gear-drilling, gear-shaving, roll-on, gear wheels, cogwheels

I.INTRODUCTION

Increasing the accuracy of the gears can be carried out in various ways. However, each way to improve accuracy has its limits. For example, the accuracy of manufacturing gear-cutting machines, gear-cutting tools and devices is raised to practically and economically possible level. Even the rudest calculations can show that the geometrical errors of machines and tools, the errors of the base surfaces of the devices make no more than 10-15% of the error formed in the process of cogging. Thus, for example, when machining the teeth of cylindrical gears on gear milling, lathe and other machines, the accuracy of which is normalized in accordance with GOST 689-77, the geometric errors of the machine of accuracy class A when machining wheels up to 300 mm in diameter can introduce an error in the radial run out of the toothed ring within 15- 20 microns, which lies within the requirements for the gear wheel of the 4-5th degree of accuracy. However, when gear milling is performed, the accuracy of the gears lies in the range of 9-10, and sometimes the second degree of accuracy.

In this case, the error of the cogwheel along the radial run out is 100 ÷ 150 μm, which is much greater than the errors introduced by the geometrical errors of the machine, the adaptation and errors resulting from the influence of the error in the manufacture of the tool. The same phenomenon takes place when the gear wheels are also shaving in a new method and tool for finishing with a rolling tool (gear-shaving cutter roll-on) on the lathe. From the foregoing it follows that the main reserve for improving the accuracy of manufacturing gears lies in the process of gear cutting. Therefore, it was necessary to continue the study of the process of cutting and to distinguish between the errors of the gear crown and technological factors. The definition of such relationships can be realized only if the error reference system allows you to determine the feedback during the processing of parts. Such connections have found application at turning, milling and other operations when on change of the size of a processed detail it is possible to judge about this or that technological factor.

For cogwheels, the existing frame of reference for manufacturing errors does not allow us to characterize the technological factor that caused these deviations. Parameters of the gear wheel, normalized in accordance with GOST 1643-81, are interrelated. Therefore, the same technological factor can lead to the formation of deviations of several parameters.

It was necessary to search for a new frame of reference, which would allow one to uniquely determine the technological factor that caused the error of this parameter by deviating the parameter being investigated, and thereby expand the possibility of controlling the accuracy of gear processing.

Errors in the manufacture of gears have led to the study of errors in the gear crown during the process of gear processing, the analysis of methods and measurement schemes, the determination of qualitative indicators of gears.

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The development of functional interchangeability has made it possible to investigate the errors of gears based on the existence of continuity between three successive processes in which the gear wheel participates: machining, control and operation. Thus, the real wheel participates in a number of calls during processing, measurement and operation. The study of an object from the point of view of repeated treatment is called the "inversion principle" (65).

In this chapter, the main provisions for measuring the errors of gears, derived from the principle of inversion measurement schemes, are given, an evaluation of methods and schemes for measuring errors in gears during processing, control and operation based on the study of kinematic pairs of these processes. The study of kinematic pairs involves the study of the connections between the real and theoretical profiles of the involutes.

On the basis of the analysis as a criterion for assessing the accuracy of the process of gear processing and calculating the deviations of a single generalized parameter of a gear ring, the deviation of the in volute profile radii, which are normalized in accordance with GOST.

To study the relationship between the actual and theoretical positions, the profiles establish a reference frame in which the actual and actual error of the position of the real contour is distinguished from the nominal one (65).

II. SIGNIFICANCE OF THE SYSTEM

With reference to the study of errors in the gears, the direction of the actual error will depend on the following types of kinematic pairs: the cutting tool-the cogwheel, the cog-wheel-measuring tip and the controlled part-cogwheel. The numerical value of the actual error of the gear wheel is equal to the value of the segment between the points of the actual and theoretical profile formed by the intersection, the direction line of the movement of the part entering the interface with the gear wheel. The direction of the counting of the actual error coincides with the radius of the in volute and the line of meshing of the gear pair. The numerical value of the effective gear fault is equal to the value of the segment between the points formed by the intersection of the in volute radius with the theoretical and actual tooth profile of the wheel. This value can also be represented as the deviation value of the actual value of the radius of the in volute of the tooth profile of the wheel. Since the magnitude of deviation of the evolving radius is not standardized by the standards and GOST, we have introduced the designation V_{pr} – in our work - the deviation of the radius of the in volute of the tooth profile of the wheel. Consider the errors of the cogwheel in the first stage of inversion treatment during machining on gear cutting machines, as well as the processing of a turning tool (gear-shaving cutter-roll-on) on a lathe.

When investigating the errors of gears in the process of gear processing, we must consider a short-circuit technological system in which a tool-detail kinematic pair is formed.

If we consider the engagement of the tool and the profile as a mating of two parts in the technological system, then different kinematic schemes of profiling the gears will lead to different directions of counting the actual error of the actual wheel profile. The actual error will be measured in the direction of the tool's movement relative to the gear wheel provided by the gear cutting pattern. Consequently, the current values of the actual error characterize the kinematic error of the gear cutting in the direction of movements of the machine nodes and can be taken into account when adjusting the technological system.

III. LITERATURE SURVEY

In Table. 2.1 shows the actual errors of the wheel ring profiles for various wheel profiling schemes. It shows that, in the direction of the actual error, all the methods of cogging can be divided into four groups, the actual error being counted in one or two directions relative to the actual profile. Consequently, to control the technological process of gear cutting it is necessary and sufficient to have actual error values measured in only one direction (for the III and IV groups of gearing schemes), or only in two directions (for groups I and II).

The second process of inversion treatment of the cogwheel is the measurement process. When examining the errors of gears on gear-measuring instruments, one has to consider a closed system of the device, in which a measuring tip forms a kinematic pair with a gear wheel.

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Let's consider kinematic pairs a measuring tip - a cogwheel, on examples of schemes of measurements of deviations of parameters of the gear pairs normalized in GOST 1643-81.

Kinematic schemes of control and measuring devices provide for various prescribed laws of movement of the measuring tips with respect to the controlled toothed crown.

Table 2.2 shows the actual errors in the gear wheel rim profiles for various measurement schemes, from which it can be seen that in the direction of the actual error counting, all methods for determining the deviations of the toothed ring parameters can be divided into four groups. In each of the groups, the actual error will only be counted in one of the four directions.

Therefore, in order to determine the deviations of the ring gear of the wheel, as specified in GOST 1643-81, it is necessary and sufficient to have the displacement of the points of the actual profiles:

- Along the line of engagement (for the deviations of group I);
- Along an arc of a circle (for deviations of group II)
- In the radial direction (for the deviations of Group III);
- Along the axis of the gear (for the deviations of the IV group).

The third process of inversion treatment of the cogwheel is the process of exploitation. Thus it is necessary to consider the closed system of the mechanism, in which the gear wheel in gearing with a gear (or with another detail) forms a kinematic pair. In this pair, the direction of the counting of the actual error coincides with the direction of the count of the actual error of the actual profile of the tooth. The calculated values of the actual and actual error will be equal to the actual tooth profile of the wheel. The calculated values of the actual and actual error will be equal to the deviation value of the in volute radius V_{pr}.

IV. METHODOLOGY

To ensure the implementation of the principle of inversion, it is necessary to choose a single actual error, which most fully characterizes the processes of processing, control and operation.

Analysis of actual errors in the processing of gears (see table 2), schemes for monitoring the deviations in the parameters of the toothed wheel rim (see table 3) and the engagement schemes in operation make it possible to select deviations in the radius of the in volute profiles as the single actual error providing the inverse connection teeth of a gear wreath.

Investigations of the inverse couplings of cogwheels allowed the development of a new system for measuring the errors of gears. It is based on the functional relationship between the deviations of the gear crown parameters. The actual error-deviation of the evolving radius was chosen as the argument of the functional dependencies.
The development of a new frame of reference for the errors in the functional relations of interfaces and kinematic pairs has made it possible to solve the problems of determining errors, estimating the accuracy of the technological process, deviations of the normalized parameters of the gears and the operating parameters of the gears.

V. EXPERIMENTAL RESULTS

In theoretical and experimental studies, the criteria for evaluating the performance characteristics of gears are currently chosen for the deviations of the parameters provided for and standardized by GOST (3, 26, 28, 66). At the same time, the analysis of the kinematic pairs of the gears of the operation process shows that the actual and current there is only one error-deviation of the radii of the in volute gear tooth profiles. Therefore, to determine the performance characteristics of the gear pairs, it is necessary and sufficient to have a deviation value of only the radius of the in volute of the real surfaces of the tooth profile of the gears-the main parameter of the in volute.

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Table 2.1

Group	Under Group	Method of gearing	Directions for measuring the actual error	Error Indication
I	1	Hobbing with worm milling cutters	Radial	A_{Hr}
	2	Gear-milling module and worm cutters		
	3	Gearing		
	4	Stretching by a circular diagonal broach	By the arc of a circle	F_{ir}
	5	Stretching by milling		
	6	Thrust		
	7	Gear-grinding worm circles with forced obkatom		
	8	Gear-grinding by copying method		
II	1	Gear-cutting by the method of rolling	In the line of engagement	$V_{ρк}$
	2	Gear grinding by the method of rolling		
	3	Gear grooving by the method of rolling	By the arc of a circle	F'_{ir}
III	1	Shaving		
	2	Gear-grinding worm wheels without forced rolling		
	3	Gear-honing	Radial	A_{Hr}
	4	Gearing with multi-cutters		
	5	Pulling the teeth		
	6	Running in		
	7	Lapping		
IV	1	Running-in	In the line of engagement	$V_{ρк}$

Table 2.2.

Group	Under group	Term	Notation	Direction of measurement of actual error	Error Indicatio n
I	1	Kinematic transmission error	F'_{ivr}		
	2	Kinematic error of the wheel	F'_{ir}		
	3	Mesh step deviations	f_{pbr}	In the line of engagement	$V_{ρк}$
	4	Oscillation of the total normal length	F_{vwr}		
	5	Hard kinematic transmission error	f'_{ivr}		
	6	Rigid kinematic error of the wheel	f'_{ir}		
	7	Profile error	f_{fr}		

	8	Inaccuracy of the shape and location of the contact line	F_{kr}		
	9	Cyclic error of tooth frequency in gear	f_{zzor}		
	10	Cyclic error of the cogwheel	f_{zkr}		
II	1	Reject step	f_{ptr}		
	2	Accumulated error K steps	F_{pkr}		
	3	Accumulated step error by gear	F_{pr}	By the arc of a circle	$F_{ir}^{''}$
	4	Tooth direction error	$F_{\beta r}$		
III	1	Radial run out	F_{rr}		
	2	Offset of the source contour	A_{Hr}		
	3	Fluctuation of the measuring center distance		Radial	A_{Hr}
		a) the revolution of the cogwheel	$F_{ir}^{''}$		
		b) on one tooth	$f_{ir}^{''}$		
IV	1	Separation of axial steps along the normal	F_{pknr}	Along the sprocket wheel axis	F_{pknr}

VI. CONCLUSION AND FUTURE WORK

1. Existing system of counting errors in the ring gear does not allow to allocate a certain technological factor, leading to the formation of deviations in the parameters.

2. The technological factor in tooth processing can be determined by examining the relationships between the actual and theoretical position of the gear ring profiles of the wheel, characterized by the instantaneous values of the deviations of all the evolvent profiles formed at a given time.

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