International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

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THOMSON REUTERS

ISSN: 2277-9655
[Mammadov *, 7(10): October, 2018] Impact Factor: 5.164
IC™ Value: 3.00 CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

FORMATION OF ALLOWANCE WHEN THE GRINDING THE TEETH OF GEARS BY COPYING METHOD

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DOI: 10.5281/zenodo.1445943

ABSTRACT

The optimum value of the machining allowance is one of the sources ensuring the efficiency of the technological operation. The analysis of the technological parameters of the teeth of the wheels formed after cutting them with blade tools was made, their mechanisms of influence on the formation of the allowance for grinding the teeth by the copying method were identified and compared. The selection of the main significant parameters having direct functional connections with the allowance for grinding is substantiated. Analytical dependencies are presented to determine the minimum and maximum allowances for grinding.

Keywords: grinding, parameter, allowance, minimum, error, norm, accuracy, profile.

1. INTRODUCTION

In ensuring the effectiveness of manufacturing machine parts, the machining allowance takes a special place [1-5]. The optimum minimum and maximum allowance values for any chip-processing method are determined by calculation and analysis or are selected from the regulatory tables, agree to the processing condition. To grind the teeth of the wheels, it is recommended, usually 0.2 ÷ 0.3 mm of the allowance on the two sides of the tooth, and sometimes up to 0.6 mm [1.4.6-8]. However, these figures have no theoretical justification and are established on the basis of many years of experience in machine-building production. At the same time, studies of recent years have revealed that sometimes the values of the allowance for grinding teeth in the reference books do not allow effective provision of the required surface qualities, i. The optimality condition of the allowance is not ensured [1]. Thus, the development of a theoretical basis for determining the allowance for grinding teeth is an urgent task.

The peculiarity of complex tooth profiles is that their quality is evaluated by numerous parameters, in which the same output parameters of the technological process are repeated [4,7,8]. For example, the displacement of the original contour and the radial runout of the ring gear; the length variation in the general norms of the involute profile and the error in the profile; accumulated error in the pitch of the gear wheel and the greatest kinematic error of the wheel, etc. Therefore, it is recommended to control only one parameter, among the parameters included in each accuracy rate and the type of interface; even in this case, there is a repeat of the requirements for the quality parameter forming the teeth.

2. FORMULATION OF THE PROBLEM

I agree with the technique adopted in engineering, the minimum value of the machining allowance is determined on the basis that the defective layer and various spatial deviations of the surface formed on the previous pass (i.e, in this case, when cutting the teeth with blade tools: gearing, cutting the teeth with a worm cutter, etc.) and the installation error on the pass (in this case, when grinding) [1,2,4].

Ph.D., P.A. Kalashnikov proposed an analytical dependence for determining the allowance for gear grinding on two sides of the tooth [1]:

$$2z_{min}=F_{rri-1}\cdot\sin\alpha+2\left(R_{zi-1}+\sqrt{\left(F_{pri-1}\cdot\cos\alpha\right)^2+f_{fr(i-1)}{}^2+F_{\beta r(i-1)}}+\varepsilon_i\right) \quad (1)$$

Where,
F_{rr}-the radial beat of the crown,

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

F_{pr}- accumulated error of pitch of teeth,
F_{fr}- tooth profile deflection,
$F_{\beta r}$-the deflection in the direction of the tooth,
R_{Zi} - the height of the profile irregularities in the preceding operation,
ε_i- the error of setting the workpiece on the operation being performed,
i - the ordinal dimension of the passage,
α-angle linking.
Maximum allowance on both sides of the tooth

$$2Zmax_i = 2Zmin_i + T_{Wi}, \quad (2)$$

Where,T_{wi}- the tolerance for the oscillation of the length of the total normal on the operation being performed.

In the presented formulas (1) and (2) for determining the allowance for grinding, allowable limit values and tolerances for the parameters of complex involute tooth profiles provided by the relevant standards are taken into account. At the same time, the methodology of calculation, developed by Professor V.M. Kovanom, taking into account the theoretical analysis performed by Professor V.P. Ponomarev. However, analysis of formulas (1) and (2) shows that the set of overlapping parameters complicates the choice of the main ones, for inclusion in the allowance formulas. In addition, in (1) the depth of the defective layer of the surface after the dentistry is not taken into account, and in (2) the allowance for surface treatments on the previous pass is not reflected. In our opinion, if in the maximum allowance formula the allowance for the size of the machined surface on the previous pass is not taken into account, it means that the minimum allowance is taken into account in the formula. As a result, the minimum allowance value is not reasonably increased, its optimality is not ensured.

We believe that the diameter of the dividing circle can be taken as the most generalized and convenient parameter characterizing the quality of the teeth. The corresponding standard does not provide for a direct tolerance to this size, i.e. Its control and evaluation are not proposed. However, the most advantageous parameter expressing the accuracy of the dividing diameter is the tolerance provided for the accumulated step error. Based on the foregoing, to determine the maximum allowance for grinding, as tolerance for the size for the previous and performed passes, we select the accumulated error of the step, taking into account the mechanism of its effect on the allowance.

The purpose of the work is to analyze and select the parameters of the gears formed during zubnotrazanie and the development of analytical dependencies for determining the allowance for grinding teeth by copying.

In the paper, the wheel quality parameters are analyzed, as specified in GOST 1643-81, and the most significant of them are used to determine the allowance for grinding.

3. SOLUTION

The components of the allowance are mainly the output technological parameters of the surface formed on the previous working pass [4]. Therefore, we will analyze the relationships between the allowance for grinding teeth and the parameters of the quality of the teeth, provided by gear cutting. According to the standard, the quality parameters of the gears are normalized by four norms of accuracy [7,8]. Given the leakage mechanism with the allowance for grinding, you can divide them into three groups:

1. Parameters having generalized connections with allowance. They express the total connection of several elementary errors in the gears in a generalized form. For example, the greatest kinematic error of the gear wheel, the variation of the measuring center-to-center distance of the gear wheel, the cyclic errors of the gear wheel, and the like. Accounting them for determining the allowance is inexpedient. Application for this purpose, their elementary components is much more effective and will give more accurate results.

2. Parameters having indirect connections with allowance, inherent in gear cutting and gear grinding, formed for each tooth, mostly independently and randomly. For example, the deviation of the step, the accumulation of the error in the steps of the gear, the accumulated error of steps, the thickness of the tooth, the deviation of the total normal length, the displacement of the original contour of the profile, the error in the profile of the tooth, and so on. They can be listed to the same type, repeated errors and having almost the same mechanism of influence on the allowance. From these types of parameters, it is necessary to select the factors that significantly affect the size of the allowance and include them in the allowance formulas.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

3. Parameters that have direct, directed links to the allowance. At the same time, the connection between the function and the argument is to wear a regularly changing character along the circumference. The

main source of such errors is the errors made during the organization of the process of tooth-cutting and grinding, among the errors in setting the workpiece and setting up the technological system (for example, the error of alignment, the angular error in the installation of teeth and the adjustment of their position during tooth grinding). These parameters include the radial runout of the crown, the angle of the direction of the teeth. They are not repeated with other parameters, they are elementary components and therefore their use for determining the allowance for grinding is mandatory.

It is known that when grinding teeth by copying, the adjustment of the technological system is carried out to remove material from the surfaces of two adjacent teeth. Subsequent grinding of teeth is carried out with rotation of the wheel-workpiece by an angle corresponding to the pitch of the teeth [4,7,8]. Therefore, we believe that (and according to the standard) the accumulated step error is crucial for the formation of the allowance and covers other similar parameters. Consequently, it must be taken into account in the allowance formulas. In addition, the tolerance on it indirectly expresses the tolerance to the pitch diameter of the wheel and is the most significant in comparison with other similar ones.

The displacement of the original contour is of the same type as the radial runout of the crown and the error in the profile. We consider that it is sufficient to take into account the two last indices in the allowance formula, since they are prevailing.

The length of the total normal is combined from one end with the profile of the tooth, the limiting positions of which are limited by the tolerance. Therefore, taking into account the allowance for grinding tolerance for the profile error excludes the inclusion in it of the tolerance for the lengths of the total normal.

The diagram shows the formation of the allowance for the profile for grinding the tooth by the method of copying, without taking into account the direction of the effect of the parameters on the allowance (where $\varepsilon_i''$is the part of the error of setting the workpiece - the wheel entering the size of the allowance, $F'_{rr(i-1)}$- part of the radial runout of the crown, entering the size of the allowance).

Proceeding from the above, we propose formulas for determining the minimum and maximum allowances for tooth thicknesses for grinding:

$$2Z_{mini} = 2\left(R_{z(i-1)} + h_{i-1} + F_{\beta r(i-1)} \cdot cos\alpha + f_{fr(i-1)} + \sqrt{(0.5F_{rr(i-1)} \cdot sin\alpha\ )^2 + \varepsilon_i^2}\right) \quad (3)$$

$$2Z_{maxi} = 2Z_{mini} + T_{pr(i-1)} \cdot cos\alpha - T_{pri} \cdot cos\alpha \quad (4)$$

Where,

$T_{pr(i-1)}$- the tolerance of the accumulated step error in the previous pass,

T_{pri} - tolerance of the accumulated error of the step on the executed pass.

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

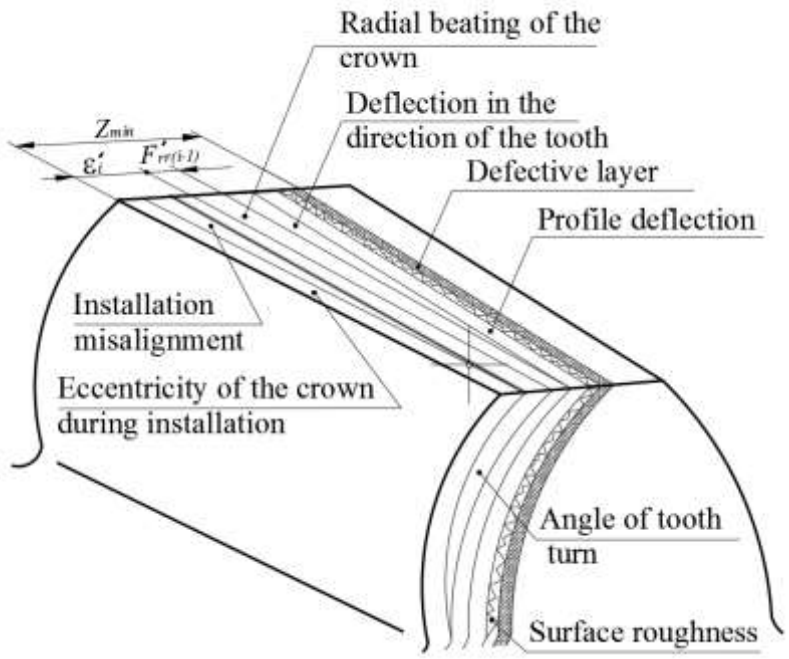

Fig. Scheme forming of allowance for profile for grinding a tooth by copying

The error in setting the workpiece-wheel during grinding can be determined by the formula:

$$\varepsilon_i = \sqrt{\varepsilon_{\delta e}^2 + \varepsilon_{\delta o}^2 + \varepsilon_{\delta y}^2} \quad (5)$$

Where,
$\varepsilon_{\delta e}^2$- the error of basing the crown on eccentricity,
$\varepsilon_{\delta o}^2$- the error of basing the crown on alignment,
$\varepsilon_{\delta y}^2$- the error of the angular position of the tooth.

It is taken into account that the directions of tolerance to the tooth directions and the tooth profile error coincide with the direction of the allowance for the thickness of the tooth, and the directions of the radial runout of the crown and the error of setting the workpiece are random.Thus, formulas (3) and (4) are proposed for determining the allowance for grinding. The error of setting the workpiece-wheel for grinding by copying can be determined by the formula (5).

4. CONCLUSIONS

- The analysis of the allowance connections for grinding the teeth of the wheels with the parameters formed after the cutting of the teeth was made and the significant ones were selected which were: radial runout of the crown, the profile error, the error in the direction of the tooth, and the accumulated error of the step.
- Analytical dependences (3) and (4) are proposed for determining the allowance for grinding teeth by the copying method, taking into account the direction of the links acting between the function and the arguments.

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CITE AN ARTICLE

Mammadov, A. S., Alakbarov, M. Z., & Rasulov, N. M. (2018). FORMATION OF ALLOWANCE WHEN THE GRINDING THE TEETH OF GEARS BY COPYING METHOD. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*, *7*(10), 1-5.