SYSTEMATIC INVESTIGATION OF THE CONTACT SURFACE RELATIONSHIPS BETWEEN THE WORKPIECE AND TOOL IN GEAR GRINDING BY THE COPYING METHOD

Rasulov Nariman, Alakbarov Mursal
Azerbaijan Technical University, Baku, Azerbaijan,

Abstract: This study investigates the relationships between the technological and design parameters of shaped surface–tool interactions during the grinding of involute-profile gears. The mechanism of formation of the tool's design elements for ensuring high accuracy of the tooth working profile is analyzed. In addition, measures aimed at reducing the probability of errors caused by wear of the working profile of the grinding wheel during gear grinding are presented.
Keywords: gear grinding, generating method, tool, involute, profile, interaction.

Introduction. Achieving high technological and economic efficiency in the process of gear grinding by the copying method is possible only through the implementation of innovative technological measures based on a comprehensive system analysis rather than on the local optimization of an individual operation [1]. In this regard, the machining allowance before grinding is of particular importance. Such an integrated approach is considered one of the most rational and effective mechanisms for ensuring production efficiency through the control of technological processes and the development of optimal machining conditions.

Problem Statement. A systematic investigation of surface–tool interactions associated with the formation of gear working profiles, as well as the successful implementation of the positive outcomes obtained from these interactions into tool design and technological operations, represents an important aspect in improving product quality [1–4]. Therefore, the study of the interactions occurring between the tool and the surface is aimed at understanding their influence on the efficiency of the technological process and at ensuring high machining quality through effective control of these interactions.

Problem Statement. In profile grinding of involute gears by the copying method, the profile of the grinding wheel is transferred onto the workpiece. At Azerbaijan Technical University (AzTU), by arranging the tooth in an inclined position within the grinding zone, several negative factors expected in the case of vertical positioning during grinding-such as the non-uniformity of the actual cutting depth and the uneven wear distribution of the tool along the profile-have been partially reduced. In addition, favorable material removal conditions for surface grinding have been achieved.

In this study, the wear of the abrasive wheel is analytically determined and comparatively evaluated for both cases.

Discussion. At the same two compared points of the involute profile, the thicknesses of the material layer removed by the abrasive grains differ from each other ($t_a \neq t'_a$). On the other hand, due to the inclined positioning of the tooth, the actual cutting depth decreases, resulting in differences in the cutting path lengths traversed by the abrasive grains ($l_a \neq l'_a$), where this length is significantly reduced

for inclined teeth. At the same time, studies indicate that the wear of the abrasive tool is directly proportional to the volume of removed material. In the present case, the volume of material removed is identical for both grinding methods. However, when the tooth is positioned in an inclined manner during grinding, the grinding width and the actual cutting depth decrease, whereas the effective width of the abrasive wheel increases. Therefore, the wear intensities of the abrasive wheels should be characterized by the specific wear intensity. When grinding a vertically positioned tooth, the specific wear intensity of the tool is denoted by U_{sv}, whereas for an inclined tooth it is represented by U_{si}.

In both cases, the volume of removed material is equal. Furthermore, the coefficient k, which depends on the type of workpiece material, the abrasive tool, and the grinding conditions, is also assumed to be identical for both cases for the purpose of comparison. The coefficient representing the reduction ratio of the tool wear intensity can be determined from the following expression:

$$k_a = \frac{U_{sv}}{U_{si}} = \frac{\frac{kv}{L_v}}{\frac{kv}{L_i}} = \frac{L_i}{L_v}$$

Here, v is the volume of removed material; k is the coefficient expressing the relationship between the volume of removed material and the volume of tool wear; L_v is the working width of the abrasive wheel when grinding a vertically positioned tooth; and L_i is the working width of the abrasive wheel when grinding an inclined tooth.

Conclusion. In profile grinding by the generating-copying method, the relationships between the surface to be ground and the tool profiles, the wear of the tool, and its influence on machining accuracy are investigated. Furthermore, the issues related to grinding performance are resolved, and the directions for improving grinding efficiency are identified.

REFERANCES

1. Rasulov N.M, Shabiyev E.T., Damirova G.V., Alakbarov M.Z., Huseynov Y.E. Increasing the efficiency of forming complex rotating surfaces with the controlling of technological connections. Key Engineering Materials Vol. 979, april 2024, p. 55-62, Switzerland. https://doi.org/10.4028/p-jc7OVU
2. N.M. Rasulov, U.M. Nadirov, M. Z. Alakbarov, Improvıng the effıcıency of grındıng teeth by copyıng wıth the control of dynamıc technologıcal connectıons. / SOCAR Proceedings. Special Issue 1 (2022) 029-035. DOI: 10.5510/OGP2022SI100697. https://proceedings.socar.az/en/journal/85
3. N. Rasulov, et. al. (2025) "Issues of Increasing the Efficiency of Cylindrical Gear Grinding Using Copying Methods Through a Systematic Approach" Reliability: Theory & Applications, vol. 20, no. SI 7 (83), pp. 259-266. https://doi.org/10.24412/1932-2321-2025-783-259-266
4. Shipulin L.V., Yusubov, N.D., Frolov A.A. (2023). Study of the Microrelief Obtained During Single Abrasive Grain Cutting. In: Radionov, A.A., Gasiyarov, V.R. (eds) Proceedings of the 8th International Conference on Industrial Engineering. ICIE 2022. Lecture Notes in Mechanical Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-14125-6_97