Application of the group scheme of cutting when processing coarse-grain cogwheels

E V Artamonov*, V V Kireev and V A Zyryanov

Tyumen industrial university, Volodarsky st. 38, Tyumen, Russian Federation

*artamonovev@tyuiu.ru

Abstract. Today between the leading countries of the world there were difficult foreign policy relations. In the conditions of constant sanctions and refusal of delivery of various goods to the Russian Federation there is a question of creation of products of an own type in the conditions of import substitution. Against the background of these events in the Russian Federation the State program which has to give an impetus of the machine-building industry was developed and implemented and strengthen its influence in the world market. In particular, the large tool enterprises of Russia passed to developments of own designs of the metal-cutting tool for the machine-building industry. Now the perspective and effective tool can be considered assembly as its advantages were repeatedly proved by the leading Russian researchers [1-7].

In this work the possibility of creation of the combined tool for processing of coarse-grain cogwheels will be considered. Cogwheels entered our everyday life everywhere, their range of application is very wide and are used from clockworks to huge career excavators. For the Tyumen region, the being leading oil-and-gas and oil-extracting region of Russia requirement in processings of cogwheels is very big as they are applied in all process units. There is a set of methods of processing of cogwheels, but will stop by a copying method with use of worm mills. Tool firms in the Russian Federation do not offer designs of combined worm mills, in view of weak study of their possible designs capable to provide the high performance and cost efficiency at gear milling today. Also the design of the tool and its cutting elements have to maintain the high non-stationary loadings and tension arising in processing.

Creation of a combined design of a worm mill needs to be begun with creation of an initial contour of a tool rail (ICTR) and in the subsequent to have in it the cutting elements.

![Figure 1. Initial contour of a tool rail m=14.](image-url)
As an example we will consider ICTR for cogwheels of m=14 (fig.1). According to GOST 13755-81 the Kompas - 3D is made mathematical calculation and creation of an initial contour of a tool rail in the software. Further we pass to arrangement of the replaceable cutting hard-alloy plates (RHACB) in ICTR. As it was told above gear milling process very difficult and imposes huge requirements to the tool. Proceeding their it, in a design of the tool it is necessary to apply RHACB of such form which are capable to maintain high loadings and not to collapse.

Having carried out information search the attention to work [8] in which the author offered classification of RHACB by the directions of functional efficiency (fig.2) was paid.

![Figure 2. Classification of forms of the replaceable cutting hard-alloy plates.](image)

The author speaks about need of application of the cutting elements with the maximum corner $\varepsilon$ at top. Therefore as an example we will take 5-faced and we will make its arrangement in ICTR (fig.3).

![Figure 3. The layout of five the-faced replaceable cutting hard-alloy plate in an initial contour of a tool rail](image)

The same way we will make arrangement of round RHACB with the maximum corner $\varepsilon=180^\circ$ (fig.4).

![Figure 4. The layout of the round replaceable cutting hard-alloy plate in an initial contour of a tool rail](image)

However, these layouts of the cutting elements on a tool rail have the shortcomings. After processing by the tool with similar arrangement of the cutting elements in the housing of the tool the further processing with big sizes of the cut-off layer and an allowance for processing will be required. If to speak about a round plate with a corner $\varepsilon=180^\circ$, it is rather difficult to fix that in the tool housing.

Therefore an outlet from current situation is application of mills with new, more perfect, the scheme of cutting. In search of decisions [9-20] on creation of essentially new tool, for the purpose of search of an optimum way of fastening of the cutting plates, modifications of the tool and decrease in
loadings in processing deserve attention results of researches [21]. The author the idea about arrangement of the cutting elements in the tool housing tangentially moves forward.

In works [22-23] the combined layouts of RHACB in the tool housing were already offered. These layouts of the cutting elements in the housing of the cutting tool received the name group. Because of simultaneous application of the main - in the form of an ellipse (frontally located) and side - tangentially located RHACB. Thanks to it there is a division of shaving into simpler elements, by consecutive cutting of an allowance for processing (fig.5).

![Figure 5. The group layout of the replaceable cutting hard-alloy plates in an initial contour of a tool rail](image)

In work [24] researches on determination of cross-sectional areas of the cut-off layer and boundary conditions of loading of the cutting elements were already conducted. It allowed to determine by means of the software of ANSYS the arising main tension in the course of machining (fig.6).

![The cutting part of a standard worm mill](image)

![The cutting mill element with the group scheme of cutting](image)

| Size of the maximum and minimum main tension (Pa)*e^6 |
|-------------------------------------------------------|
| Standard worm mill                                    | 4.75        | 2.34        |
| Combined mill with the group scheme of cutting        | 2.34        | 0.78        |

![Figure 6. Pictures of isolines and distribution of dangerous tension m=14.](image)

The analysis of the received pictures of isolines of distribution of the main tension showed that sizes of tension of stretchings on a front surface of RHACB decrease this results from the fact that thanks to implementation of the group scheme of cutting there is a consecutive cutting by the separate cutting elements and each RHACB cuts off the part of the processed material. Also, application of a
plate in the form of an ellipse with the increased corner at top in comparison with tooth of a standard worm mill increases its durability and consequently sizes of dangerous tension $\sigma_1$. Thus, change of the scheme of gear milling influences distribution of tension in RHACB.

It is recommended to use the combined tool with the group scheme of cutting since the quantitative and qualitative analysis of calculation results showed that at it the best result when calculating is achieved by final elements to increase in efficiency of processing.

References

[1] Grechishnikov V.A., Grigoriev S.N., Maslov A.R., Skhirtladze A.G., Tool ensuring the integrated machine-building productions. – Stary Oskol: LLC Tonkiye naukoyemkiye technologii, – 348 s. 2018g.

[2] Semenchenko I.I., Matyushin V.M., Sakharov G.N., Design of metal-cutting tools. – Moscow: Mechanical engineering, – 952 s. 1963g.

[3] Boriskin O.I., Stakhanov N.G., Yakuschenkov A.V., An evolvent worm mill with hard-alloy rails. Domestic and foreign experience of quality assurance in mechanical engineering: All-Russian scientific and technical conference. Tula, pp. 116-118, 2019g.

[4] Chulin I.V., Increase in firmness of combined hard-alloy mills for processing of railway funnymen. Dissertation of candidate of technical sciences. Moscow, 2011g.

[5] Isaev A.V., Development of the national teams of mills with the replaceable many-sided hard-alloy plates located on a screw surface for processing of preparations with a shaped profile. Dissertation of candidate of technical sciences. Moscow, 2012g.

[6] Grechishnikov V.A., Isaev A.V., Romanov V.B., Method of forming of a profile of the forming initial tool surface of combined shaped mills with the cutting plates located along the screw line. Stankin MSTU Bulletin. Moscow, pp. 8-12, 2015g.

[7] Chevychelov S.A., Increase in efficiency of design of hyperbolic mills computer modeling of process of a reprofilirovaniye of rails. Dissertation of candidate of technical sciences. Oryol, 2005g.

[8] Artamonov E.V., Durability and working capacity of retrofittable hard alloy blades of assembly cutting tools. – Tyumen: TyumGNGU, – 192 s. 2003g. ISBN 5-88465-416-2

[9] Smirnov N.N., Gear milling by much screw worm mills with different schemes of cutting. Dissertation of candidate of technical sciences. Kiev, 1982g.

[10] Nichkov A.G., Shunaev B.K., Influence of the scheme of cutting at gear milling on wear of teeths of a worm mill. II NTK UPI, theses of reports of a conference. Sverdlovsk, 1968g.

[11] Nichkov A.G., Bases of a complex research of process of gear milling and optimization of its design and process parameters in the simple and combined schemes of cutting of cogwheels worm mills. Dissertation of the Doctor of Engineering. Tula, 1991g.

[12] Nichkov A.G., Firmness of a worm mill depending on the scheme of cutting. Theses of reports of a conference. Sverdlovsk, pp. 29-33, 1971g.

[13] Medvedickov S.N., High-performance gear cutting by mills. M.: Mechanical engineering, 106 s, 1981g.

[14] Nichkov A.G., Shunaev B.K., Influence of the scheme of cutting at gear milling on wear of teeths of a worm mill. II NTK UPI, theses of reports of a conference. Sverdlovsk, 1968g.

[15] T. Tokawa, Y. Nishimura, Y. Nakamura, High productivity dry hobbing system, J. Mitsubishi Heavy Ind. v.38(1). pp. 27-31, 2001g.

[16] T. Voschinobu, I. Naoga, V. Kuniharu, Stress analysis in cutting edge Fundamental study of Cutting edge chipping, J. I. Jap. Soc. Precis. Eng. v.10. pp. 1055-1061, 1973g.

[17] K. Bouzakis, E. Lili, N. Michailidis, O. Friderikos, Manufacturing of cylindrical gears by generating cutting processes, J. CIRP Annals - manufacturing Technology. v.2. pp. 676-696, 2008g.

[18] K. Bouzakis, S. Kombogiannis, A. Antoniadis, N. Vidakis, Gear hobbing cutting process simulation and tool wear prediction models, J. Manufacturing Science and Engineering. v.1.
[19] Fontaine M., Devillez A., Dudzinski D., *Analytical simulation of milling: Influence of tool design on cutting forces*. 12th IFToMM World Congress. Besançon (France), 2007.

[20] Agoston M. A. *Computer Graphics an Geometric Modeling*. Mathematics conference. London, 2005.

[21] Artamonov E.V., Pomigalova T.E., Tveryakov A.M., Uteshev M.H., *Fracture mechanics and durability of the replaceable cutting plates from solid alloys*. Tyumen : TSOGU, – 148 s. 2013.

[22] Artamonov E.V., Kireev V.V., Zyryanov V.A., *An interlocking side mill with retrofittable carbide blades for processing of coarse-pitch tooth wheels*. MATEC Web of Conferences 224. ICMTMTE – 2018. pp. 1-5, 2018.

[23] Artamonov E.V., Kireev V.V., Zyryanov V.A., *Modeling of process of gear milling for definition of the intense deformed state in replaceable many-sided plates of a worm mill*. MATEC Web of Conferences 298. ICMTMTE – 2019. pp. 1–8, 2019.

[24] Artamonov E.V., Kireev V.V., Zyryanov V.A., *Lay-out of cutting blades in an assembly basic rack of a counterpart rack for hob gears*. IOP Conference Series: Materials Science and Engineering 709. pp. 1-6, 2019.