Lay-out of cutting blades in an assembly basic rack of a counterpart rack for hob gears

E V Artamonov, V V Kireev and V A Zyryanov*
Tyumen industrial university, Volodarsky st. 38 , Tyumen, Russian Federation

*zyrjanovva@tyuiu.ru

Abstract. Nowadays many Russian tool-making facilities which produce a metal-cutting tool for a processing of coarse-pitch tooth-wheels do not offer constructions of assembly hob gears with replaceable hard-alloy carbide blades. Creation of the assembly constructions for machine-building enterprises with the replaceable hard-alloy carbide blades (RHACB) is an effective solution for the processing of tooth wheels. Thanks to it productivity existing equipment increases many-fold, economical effectiveness caused by implementation of the high-capacity tool allows to purchase modern equipment and make work of machine operators more effective and less labour-intensive. In this paper we offer a radical technical solution which allows to increase production efficiency of mechanical processing by a tool with lay-out of the hard-alloy carbide blades in the assembly basic rack of the counterpart rack in hob gears. Implementation of a group scheme in the assembly counterpart cutting rack is reached by means of usage of big amount of basic and side carbide blades on an Archimede’s tool worm that allows to cut away surplus consecutively and decrease depth of cut on the carbide blades. Also it allows to provide evenness of cutting and also decrease a value of blow stresses on cutting elements of the assembly tool. Due to usage of the replaceable hard-alloy carbide blades resistance and reliability of the assembly gear hob increases.

Russian Federation program aimed at development of the industry and increase of its competitively of perfection of created construction of assembly tools for processing of the coarse-pitch tooth-wheels equipped with the replaceable hard-alloy blades (RHAB) with the purpose of significant increase of their working capacity is up-to-date nowadays. In many countries where production of the metal-cutting tool is organized active economic growth is observed. Nowadays the metal-cutting tool made a long perfection way from a complete one up to an assembly one with usage of replaceable hard-alloy elements. And that is a great step for development of the machine-building enterprises. The process of the tooth-wheels process is very complex and labour-consuming and it specifies a lot of requirements to the metal-cutting tool because of originating transient loads and tensions. As a result of it premature wearing out or destruction of hob gears teeth happens (fig.1).
That is why creation of the assembly constructions of hob gears for hobbing of the coarse-pitch tooth-wheels is both a necessary and economically efficient because of the tool hard alloy saving by means of the replaceable hard-alloy blades.

The purpose of this study is to create the radically new assembly tool with the replaceable hard-alloy carbide blades and decrease of originating loads during the processing.

There are a lot of papers dedicated to development and creation of new and modified tool constructions for processing of the tooth-wheels. [1-10]. A number of scientists offered different technical solutions, for example:
- usage of assembly hob gears
- usage of assembly hob gears with revolving racks
- usage of standard conical cutters
- usage of multiple-thread hobs
- usage of hob gears with special layout of cutting grooves
- usage of hob gears with a changed cutting scheme
- usage of hob gears with uppermost cutting edges of teeth
- hob gears with a conical lead-in
- hob gears with a top-loaded cutting scheme
- hob gears with a progressive cutting scheme
- hob gears with alternately loaded side edges of teeth
- usage of hob gears with chip separating concave grooves on a tooth top
- hob gears with a progressive cutting scheme with a wavy profile of a tooth
- hob gears with a progressive cutting scheme with chip separating bevel edges on a tooth top
- hob gears with a progressive cutting scheme with an inclination of uppermost cutting edges of a tooth
- hob gears with positive front and extended back angles
- hob gears with a flat front surface and straightforward cutting edges
- hob gears with a flat front surface of teeth and cambered cutting edges
- hob gears with a concaved front surface

Of course, all listed technical solutions have their benefits and disadvantages, which come from concrete conditions of their usage and operation of hob gears. In search of solutions concerning creation of new constructions of the assembly metal-cutting tool and optimal way of replaceable hard-alloy carbide blades fastening with the purpose of originating stresses reduction and consequently of dangerous main stresses during the processing we paid attention to the following paper [11-13].
In this paper the author studied influence of geometrical dimensions of blades on a value of dangerous main stresses originating. This suggests that thickness of the hard-alloy carbide blade is more important than its length. But, a simple increase of the hard-alloy carbide blade in thickness during mechanical processing of the coarse-pitch tooth-wheels will lead to additional economical expenditures within the frameworks of production. That is why most effective solution for this problem may be tangential lay-out of cutting elements in a case of assembly gear-making hobs [14-15]. This lay-out of RHACB allows to provide firm fastening and positioning in a tool case, lighten chip flow and its outlet from a cutting zone. Also free access to mounting screws is provided in case of the blade disruption or its replacement.

During realization of the tangential lay-out of hard-alloy cutting elements in the tool case we made a decision to separate machine-finish allowance and decrease cross-sectional areas of a cut away layer by means of realization of the group cutting scheme with usage of basic – elliptic blades placed in front and of sided ones – tangentially placed RHACB. By means of program software “Kompas – 3D” we developed and projected the construction of the assembly hob gear with 5 different tool racks, released in the group cutting scheme (fig.2).

**Figure 2. Group cutting scheme**

For checking purposes of this hob functioning efficiency we made a decision to conduct an imitative modelling of a standard hob gear mechanical processing (fig.3) and the developed assembly hob gear with the group cutting scheme m=14 (fig.4). Processing modes and base data: standard gear - Z(gear teeth)=25. m=14, S=3 mm/rot, Sz=0,3 mm, Zw=32; assembly gear – Z (gear teeth)=25; m=14; S=3 mm; Sz=0,12 mm/rot; Z (wheel teeth)=32.

**Figure 3. Imitative modelling of a cutting process by the standard hob gear**

**Figure 4. Imitative modelling of a cutting process by the assembly hob gear with the group cutting scheme**
On the results of the imitative modelling we determined the cross-sectional areas of the cut layer on the front surface of teeth for the standard and assembly hob gear. (fig.5).

The diagram of a dependence of the cross-sectional area of the cut layer on the cutting depth by the standard hob gear (m=14)

The diagram of a dependence of the cross-section areas of the cut layer on the cutting depth by the assembly hob gear with the group cutting scheme (m=14)

Figure 5. The results of the imitative modelling.

Thanks to usage of the cutting scheme we managed to receive more simple fragments of the cross-section areas of the cut layer in comparison with the standard hob gear. These fragments exclude originating of a three-element chip during the mechanical processing of the coarse-pitch tooth-wheels. The diagram of the cutting elements stress showed pressurizing stability and consequently decrease of the cross-section areas during processing.

Therefore on the basis of the conducted studies it was found that usage of the group cutting scheme with the offered lay-out of the carbide blades in the case of the assembly gear will allow to decrease level of wear and tear of the hob gear by applying of consequential cutting away of surplus on the area
of the tooth wheel profile by cutting hard-alloy elements. Thanks to it the chip changes into more simple form that will allow to decrease dangerous main stresses which influence on the main carbide blade of the tool. Usage of big amount of the cutting elements in the construction of the assembly tool and increase of rotation frequency in comparison with the standard hob gear contributes to decrease of the tooth depth of penetration and decrease of wear and tear rate and possibility of cutting edges destruction. All abovementioned data allows to increase efficiency of gear-tooth milling by means of increase of processing efficiency twice-thrice.

References
[1] Smirnov N.N., Gear milling by much screw worm mills with different schemes of cutting. Dissertation of candidate of technical sciences. Kiev, 1982g.
[2] Nichkov A.G., Shunaev B.K., Influence of the scheme of cutting at gear milling on wear of teeth of a worm mill. II NTK UPI, theses of reports of a conference. Sverdlovsk, 1968g.
[3] 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.
[4] 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.
[5] Medvedickov S.N., High-performance gear cutting by mills. M.: Mechanical engineering. 106 s, 1981g.
[6] Shunaev B.K., Petra S.P., The combined schemes of milling of cogwheels with radial incision of a worm mill. Progressive designs and methods of processing in tool production. Perm, 1975g.
[7] Artamonov E.V., Kireev V.V., Zyryanov V.A., Improving the Efficiency of Hobbing Mills, ISSN 1068-798X, Russian Engineering Research, 2017, v.37, No. 5, pp. 447–449. Allerton Press, Inc., 2017. DOI: 10.3103/S1068798X1705057
[8] Egorov S.B., Kapitanov A.V., Loktev D.A., Modern Methods and Technological Solutions for Effective Processing of Gear Wheels. Materials Science Forum, ISSN:1662-9752, v.870, pp. 397-403, Trans Tech Publications, Switzerland 2016g. DOI: 10.4028/www.scientific.net/MSF.870.397
[9] Papsheva N.D., Akushskaya O.M., Improving the efficiency of the process of gear cutting, Engineering journal of Don. 36 (54), 2015g.
[10] Srinivasan N., Shunnugam M. S., Limiting conditions in gear shaping for corrected involute gears. International Journal of Machine Tool Design and Research. v.23, Issue 4, pp. 227-235, 1983g.
[11] W. Liu, D. Ren, S. Usui, J. Wadell, T. D. Marusich, A gear cutting predictive model using the finite element method, J. CIRP. v.8 pp. 51-56, 2013g.
[12] S. Steina, M. Lechthalera, S. Krassnitzera, K. Albrechta, A. Schindlerb, M. Arndta, Gear hobbing: A contribution to analogy testing and its wear mechanisms, J. CIRP. v. 11(1) pp. 220-225, 2012g.
[13] T. Tokawa, Y. Nishimura, Y. Nakamura, High productivity dry hobbing system, J. Mitsubishi Heavy Ind. v.38(1). pp. 27-31, 2001g.
[14] Artyomov 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
[15] Artyomov 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, 2018g.