

Wear of three-treads uncoated and coated integral hob milling tools

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Abstract. Tribological Processes in the gear cutting of cylindrical gears on cutting elements of hob milling tools develop under specific conditions. The particular requirements under which the contacts between the hob milling tools and the workpiece material are made, make it difficult to become familiar with the tribological processes on them so that today there is more knowledge about their consequences on the machined surface of the teeth and the cutting elements of the hob milling tool, and less about their nature. In this paper, based on the experimental investigations, the wear analysis of three-treads uncoated and coated integral hob milling tools in the gear cutting of cylindrical gears is given.

1. Introduction

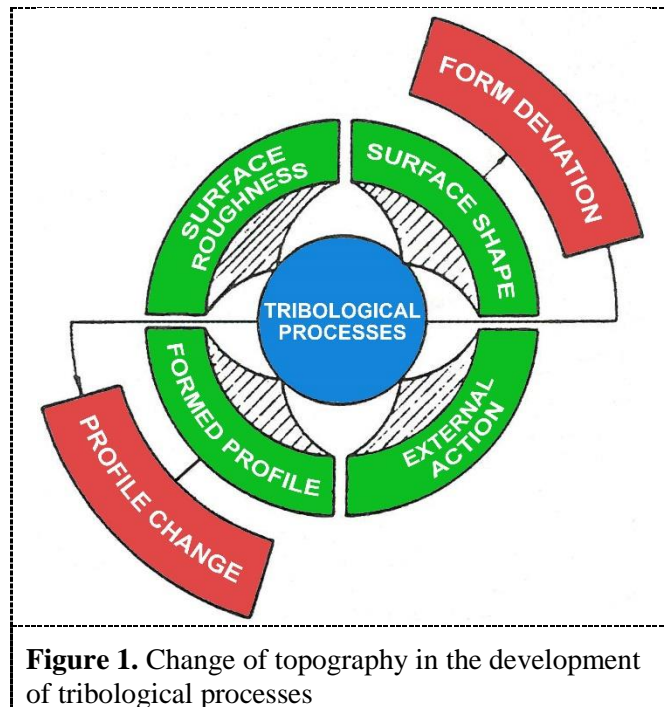
Tribomechanical systems for transmitting the energy of mechanical movement at a distance, as well as for modifying its parameters, also carry rotational movements. The elementary functions of the gearbox are energy distribution, reduction or increase of speed, change of type of action, start, stop, change of direction and more.

The functionality of toothed gears is based on a specific form of tribological- elements and appropriate conjugation laws of the contact surface.

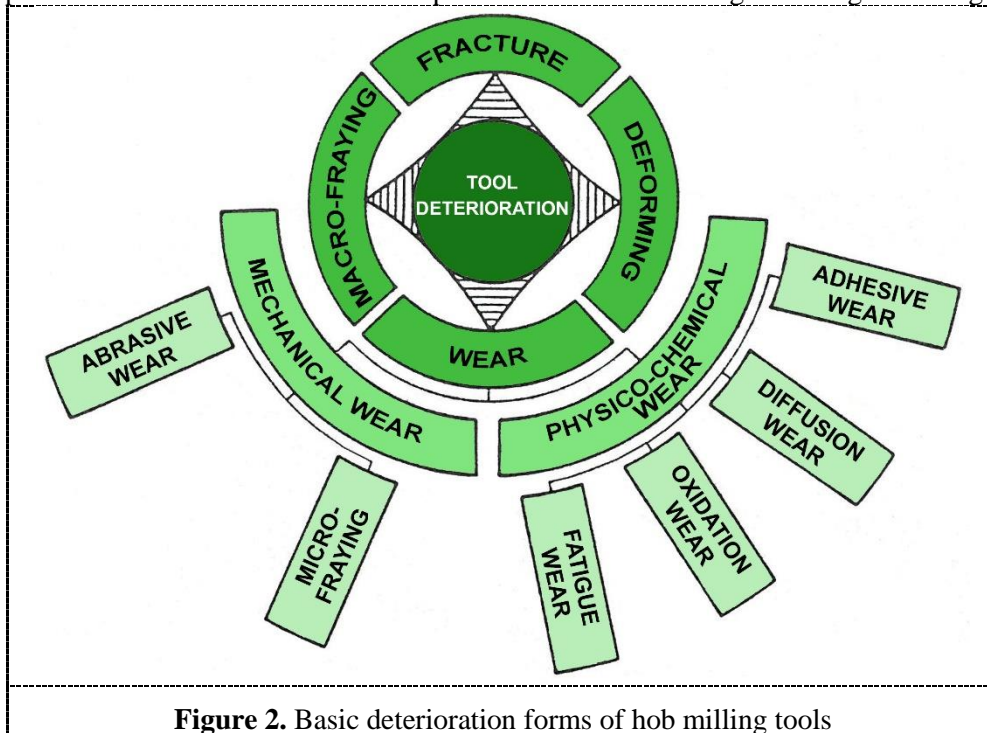
When gear cutting as a significant element of tribomechanical systems, it is very important to consider all tribological aspects, since errors made during machining cannot repair even perfectly organized maintenance.

2. Tribological processes, deterioration and wear

Tribological processes take place with the continuous destruction of parts of the surface of elements of the tribomechanical system and the emergence of new physically or topographically similar or completely different from the previous ones [1,2]. The destruction and formation of parts of the contact surface is temporally uneven and spatially discrete. Contact surfaces machined by hob milling always have irregularities. The connection between the contact surface topography and the development of tribological processes is extremely complex [3,4,5,6]. The change of topography in the development of tribological processes can be represented by the model as in figure 1 [2,3].



The deterioration of elements of tribomechanical systems in the process of gear cutting is one of the negative phenomena. The basic deterioration patterns of the hob milling tool are given in figure 2.



As can be seen in figure 2, wear is one form of deterioration of the hob milling tools.

In hob milling, all cutting elements do not play the same role in the process of gear cutting, that is, they do not remove the same amount of material from the workpiece [7]. For this reason, the wear of the cutting elements or the teeth of the hob milling tool is different. The teeth that take away most of the material when gear cutting wear the most.

3. Results of experimental research

This paper presents a part of the results of several years of research on the process of hob milling of cylindrical gears serration and the possibility of introducing into the production process of coated hob milling tools, which is related to the wear of three-treads uncoated and coated integral tools. Based on the experiment plan, tests were carried out, using hob milling tools from the same batch of HS-6-5-2-5 material, uncoated and coated with TiN.

During the test, the gear cutting of cylindrical gear was performed on the workpiece of the same material and characteristics with three-treads uncoated and coated integral hob milling tools. For these studies, an original form was developed to monitor the development of tribological processes in the gear cutting by hob milling. On this form, it is possible to enter information about: workpiece, hob milling tool, hob milling machine, technological process, sketch of workpiece in gear cutting, tooth wear, development of the wear process, wear distribution and more.

The paper provides data for the experiment with uncoated three-treads hob milling toll 1U (U-uncoated), and for all other experiments changes only the data for the tool mark 6U (U-uncoated), IVC (C-coated), VC (C-coated).

Workpiece data: outer diameter $d_k = 305$ mm, number of teeth $z_2 = 100$, module m , standard module 3 mm, angle of contact line $\alpha = 20^\circ$, angle of inclination of teeth $\beta = 0^\circ$, tooth width $b = 90$ mm, material HS-6-5-2-5, hardness HB = 180.

Hob milling data: integral 1U, diameter of hob milling tool $d_g = 120$ mm, length of hob milling tool $l_g = 115$ mm, module $m = 3$ mm, basic profile II, normal pitch $t_n = 9,42$ mm, coil angle $\omega = 10,4^\circ$, coil pitch $T = 91,2$ mm, direction of coil tread L , number of treads $z_1 = 3$, number of grooves $i = 10$, material of hob milling tool HS-6-5-2-5, hardness HRC = 65, accuracy class A, hole diameter $d = 22$ mm.

Machine data: hob milling machine MODUL-ZFWZ-250x5A, Cooling agent REZANOL EP40
Process data: number of revolutions $n = 200$ rev/min, axial feed $S_a = 6$ mm/rev.

The primary processes of wear are manifested in two basic ways as a flank wear and as a crater wear. Numerous technological parameters, i.e. conditions, influence which type of wear will be primarily dominant when gear cutting. During the experiment, only a part of which is presented in this paper, flank wear was the primary wear zone. In figure 3 wear process on inlet lateral flank, top flank and outlet lateral flank is shown. The wear of outlet lateral flank for pretreatment $VB_0 = 0,5$ mm is adopted as a wear criterion.

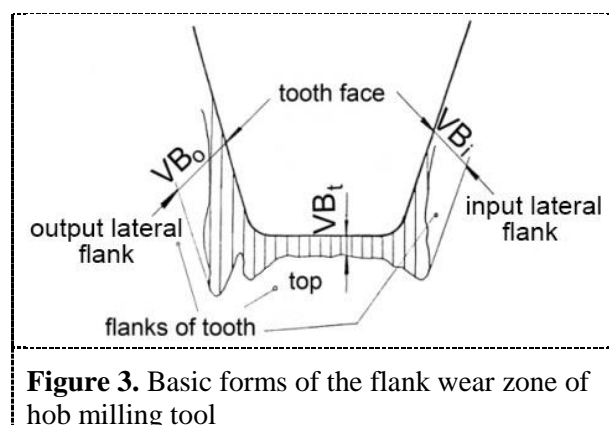


Figure 3. Basic forms of the flank wear zone of hob milling tool

In figures 4, 5, 7 and 8 characteristic examples of wear forms for two uncoated and two coated three-treads integral hob milling tools are given. The tooth wear forms of the uncoated three-treads integral hob milling tool 1U of HS-6-5-2-5 material on three combs (1,5,9) are given in figure 4. The wear distribution for this tool on the input lateral flank and output lateral flank is shown in figure 6. The tooth wear forms of the uncoated three-treads integral hob milling tool 6U of HS-6-5-2-5 material on three combs (1,5,9) are given in figure 5. The tooth wear forms of the three-treads integral hob milling tool

IVC of material HS-6-5-2-5 coated with TiN on three combs (1,5,9) are shown in figure 7. Figure 8 shows the tooth wear forms of the three-treads integral hob milling tool VC of material HS- 6-5-2-5 coated with TiN on three combs (1,5,9).

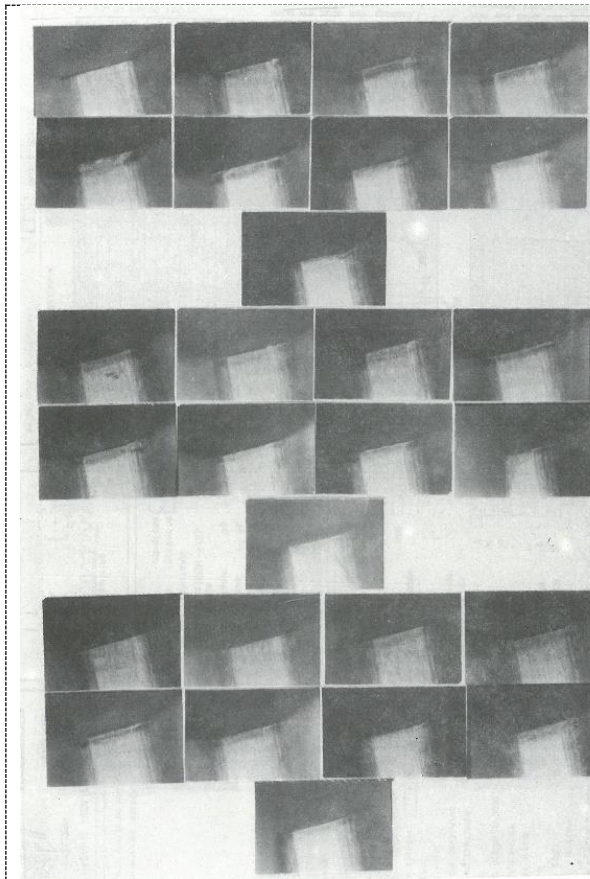


Figure 4. Records of the tooth wear form of the uncoated three-treads integral hob milling tool 1U

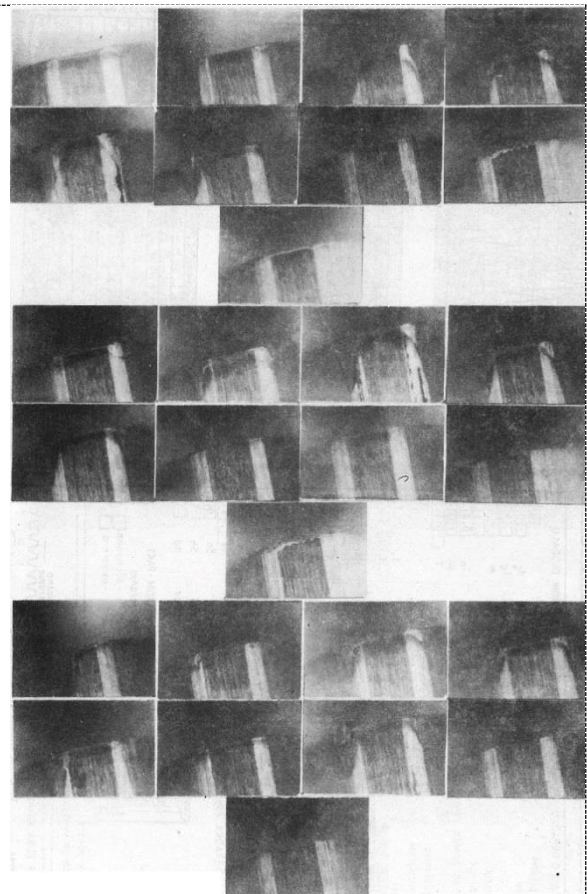


Figure 5. Records of the tooth wear form of the uncoated three-treads integral hob milling tool 6U

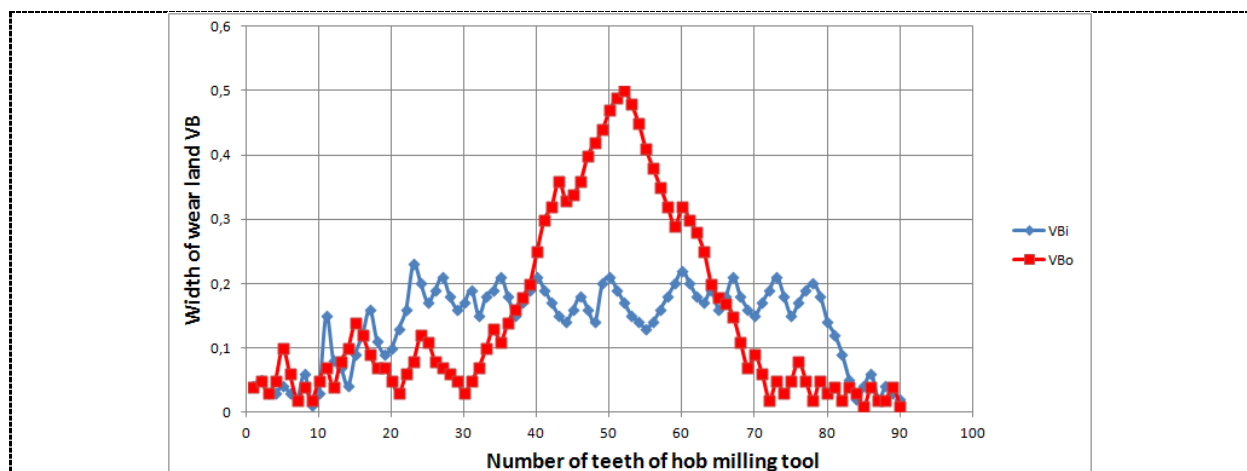


Figure 6. Wear distribution at the input and output lateral flank for uncoated three-treads integral hob milling tool 1U

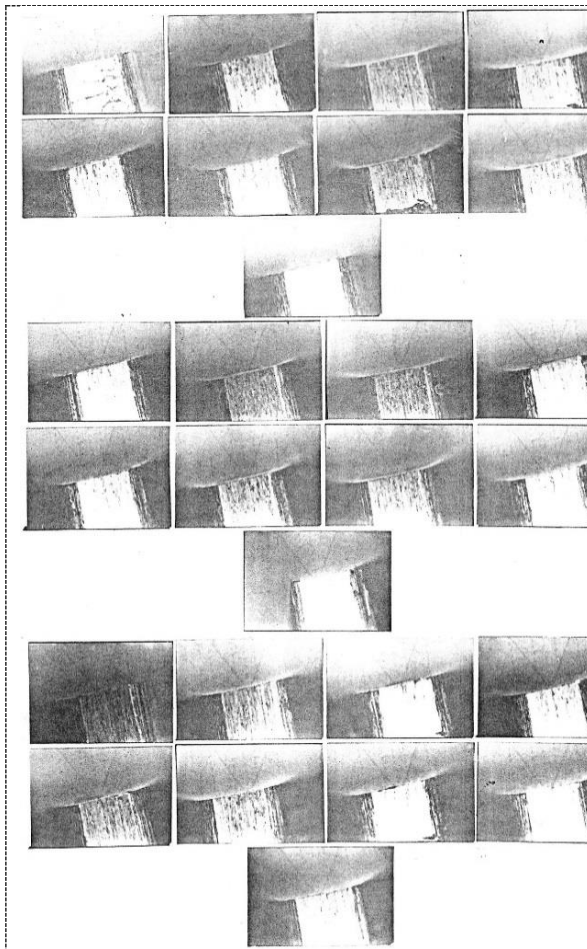


Figure 7. Records of the tooth wear form of coated three-treads integral hob milling tool IVC

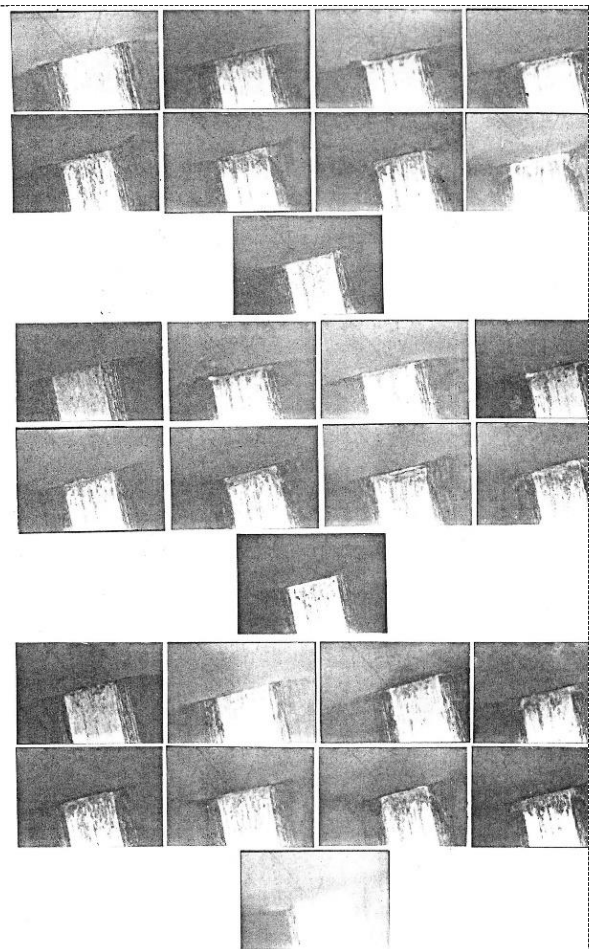


Figure 8. Records of the tooth wear form of coated three-treads integral hob milling tool VC

Comparative tests of uncoated three-treads integral hob milling tools and those coated with TiN were performed under real production conditions. Experimental studies have confirmed that there is concentrated wear of the cutting teeth of the hob milling tools. The morphology of the flank wear is characterized by the appearance of most often one groove on the input lateral flank and two grooves on the output lateral flank. The grooves are located in the zones of the transition of the top flank into the input and output lateral flank of the cutting elements of the hob milling tool.

Experimental studies have shown that three-treads integral hob milling tools process 2.46 more cylindrical gear teeth than three-treads uncoated integral hob milling tools.

4. Conclusion

Based on the presented in this paper, it can be concluded that the introduction of three-treads coated integral hob milling tool into the production process of gear cutting of cylindrical gears is justified, because significantly higher productivity is achieved and also better quality of machined surface is obtained.

5. References

- [1] Bouzakis K-D, Skoridatis G and Michalidis N 2008 Innovative methods for characterizing coatings mechanical properties, *Proceedings of International Conference 'The Coatings 2008'*, October 2008, Kallithea, Greece
- [2] Sovilj-Nikić I *Modeling and optimization of hob milling process (Modelovanje i optimizacija procesa odvalnog glodanja)*, Fakultet tehničkih nauka, Novi Sad, Serbia, Doctoral Thesis (unpublished)
- [3] Sovilj B 1988 *Identification of tribological processes during hob milling (Identifikacija triboloških procesa pri odvalnom glodanju)*, Fakultet tehničkih nauka, Novi Sad, Serbia
- [4] Sovilj-Nikić I, Sovilj-Nikić S, Sovilj B and Đokić R 2017 Analysis of roughness parameters of the tooth-face of model hob milling tool, *Machine design*, **9** (3), 99-106
- [5] Sovilj-Nikić I, Sovilj-Nikić S, Sovilj B and Blanuša V 2017 Topography of characteristics surfaces of model hob milling tools for machining of gear serration, *Proceedings of International Scientific Conference IRMES 2017*, 7-9 September 2017, Trebinje, Bosnia and Herzegovina, 241-246
- [6] Sovilj B, Sovilj-Nikić S and Juliana Javorova 2019 Tribological researches of triboelements topography of hob milling process of cylindrical gear serration, *Power Transmissions, MATEC Web of Conferences* **287**, 05003 (2019), p.13
- [7] Sovilj B and Sovilj-Nikić S 2018 Tribological researches of gear cutting processes of cylindrical gears, invited paper in *Proc. of 13th International Scientific Conference MMA 2018*, Novi Sad, Serbia, 107-116

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