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MODELING OF MACHINING OF NON-INVOLUTE GEARS

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Abstract: *In this article, the relevance of the study of gears with a complex non-involute profile of the tooth flanks is justified. For the subsequent study of non-involute gearings, the task of mathematical modeling of the profile of a gear-cutting rolling tool for machining of non-involute gear wheels is solved. A method for geometric analysis of the process of surfaces shaping by rolling gear cutting tools has been developed.*

Keywords: *shaping of gear wheels, non-involute tooth profile, kinematic curve.*

Introduction

The most common mechanical transmissions which are used in mechanical engineering are gears with an involute profile of the teeth flanks. Transmissions composed of such wheels differ in a number of advantages. However, along with certain advantages, involute gears have a number of significant disadvantages. These include: a large pressure coefficient between the teeth, low coefficient of overlap of the wheels and hence the insufficient smoothness of engagement.

Therefore, one of the current trends is the study of gears with a complex non-involute profile of the teeth flanks, which in some applications have advantages over involute gears and are deprived of some of their disadvantages.

There are two methods of cutting the teeth of cylindrical gear wheels: the copy method and the rolling method. The profile of the tool working by the rolling method does not depend on the number of teeth of the machined wheel, therefore, with the same tool, you can cut gear wheels with any number of teeth. The accuracy of the wheels made by the rolling method is significantly higher than the accuracy of the wheels made by the copy method.

In this paper, we solve the task of mathematical modeling of the profile of a gear cutting rolling tool for machining of non-involute gear wheels.

Geometric modeling of plane kinematic curves

The authors of the article previously solved the task of geometric modeling of plane kinematic curves as potential profiles of the teeth flanks of gear cutting tools for shaping of non-involute gear wheels [1, 2].

To generalize the geometric modeling of curves, the mathematical apparatus of multi-parameter mappings of space was used, developed for solving the issues of surface shaping by cutting by Dr. Eng., Prof. of NTU «KhPI» B.A. Perepelitsa [3], as well as a generalized unified mapping structure for working and machine gearings, proposed by PhD, Sen. Staff Scientist of ISM NASU (Kiev) A.V. Krivosheya [4]. In this case, the kinematic curve was considered as a continuous trajectory of the complex motion of a point in a three-link gearing shown in Fig. 1.

The use of a generalized unified structure and methods of multi-parameter mappings made it possible to model the field of various plane curves shown in Fig. 2 by the structural method without deriving their specific analytical equations [1, 2].

Formation of the initial contour of a rack tool for the machining of non-involute gear wheels

The task of mathematical modeling of the tooth profile of a gear-cutting tool for machining of non-involute gear wheels is solved.

In the process of cutting of gear wheels by a gear rack with a standard profile, the involute profile of the wheel teeth is reproduced [5]. In the general case, not only sections of straight lines, but also other arbitrary types of curves (for example, kinematic) can be considered as a profile of a rack tooth flanks [1, 2]. The use of such a tool allows to cut the wheels with a more complex non-involute teeth profile.

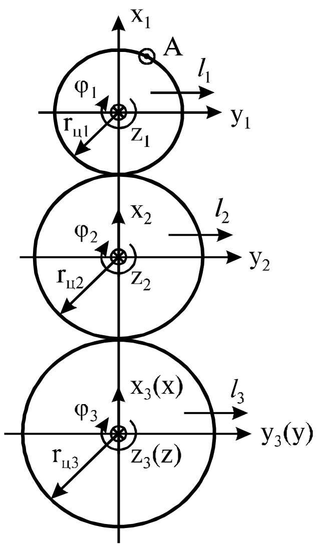
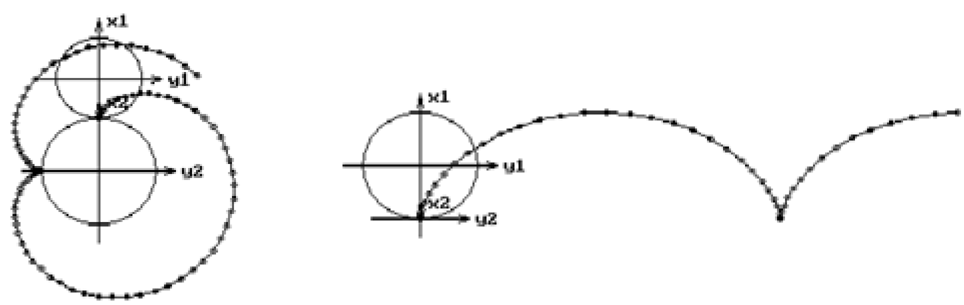


Figure 1 – The scheme of a three-members rack gearing



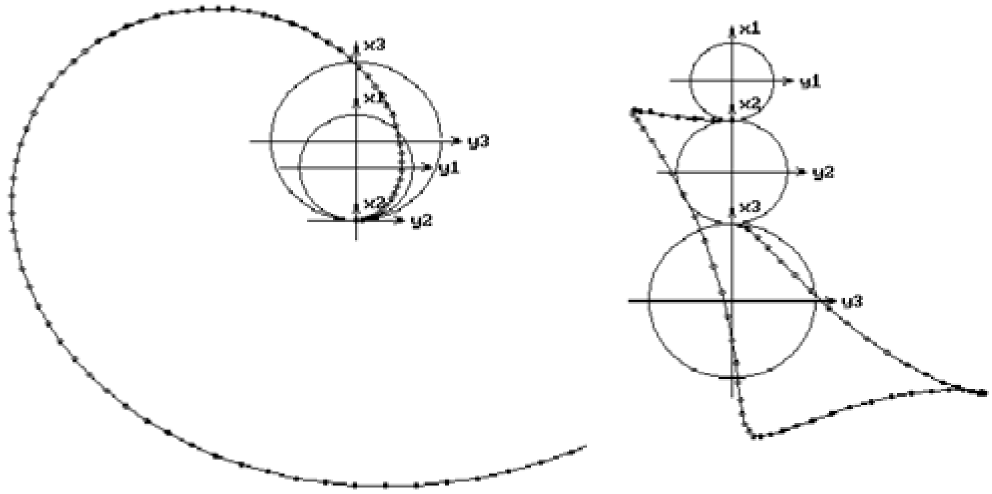


Figure 2 – The examples of plane kinematic curves

Let's consider some section of one of the previously modeled flat kinematic curves as a profile of the rack tooth flank.

The initial producing rack contour with the profile of the tooth flank in the form of a certain kinematic curve is shown in Fig. 3.

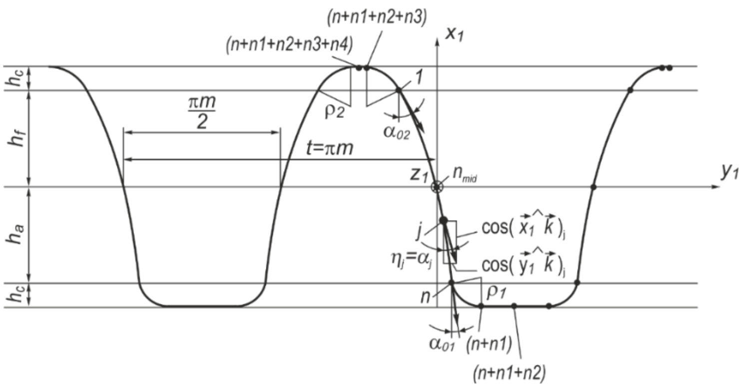


Figure 3 – The initial producing contour of a rack tool for the machining of non-involute gear wheels

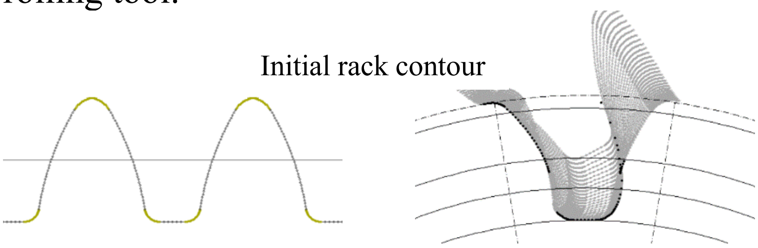
Geometric analysis of the surfaces shaping process by rolling gear cutting tools

Based on the previously developed algorithm for calculating the profile of envelope surfaces [6], a method for geometric analysis of the process of surfaces shaping by rolling gear cutting tools has been developed. In this case, a new structural approach to find the formable and tool surfaces as envelopes, which does not require the derivation of specific analytical equations, is used [7, 8].

Using computer graphics, the sequential shaping of the space between the teeth of the gear wheel is studied. A plane geometric task is being solved. The workpiece and the shaping tooth of the tool (for example, tool rack) can be considered as geometric figures, i.e. bounded subsets of plane points. As noted earlier, the boundaries of the tooth of the tool can be not only straight line segments, but also various other types of curves. In motion relative to the workpiece, the tool tooth as a geometric figure sweeps on the plane a region representing a set of trajectories of points. The boundaries of this area. which is swept, are either the trajectories of single points of the tooth, or the envelopes of certain curves that bound the tooth.

In Fig. 4, a, b the initial profile of the tool rack with a concave profile of the tooth flanks and the successive shaping of the space between the teeth of the gear wheel with the module *m*=5 and the number of teeth *z*=20 is shown. In the figures, the workpiece points, in which, at the current time, the condition of touching the surfaces is fulfilled, are highlighted. The combination of these points represents the envelopes of certain curves that limit the tool tooth. They are marked in Fig. 4, c. Fig. 4, d images the boundaries of the desired space between the wheel teeth. Fig. 5 and 6 represent the space shaping between the teeth of gears with *m*=5 and *z*=20 by tool rack with a convex and concave-convex profile of the tooth flanks, respectively.

The proposed method allows to analyze the process of shaping the surface of the gear wheel, detect the appearance of undercuts, and also determine the range of gear wheels which can be obtained using a specific rolling tool.



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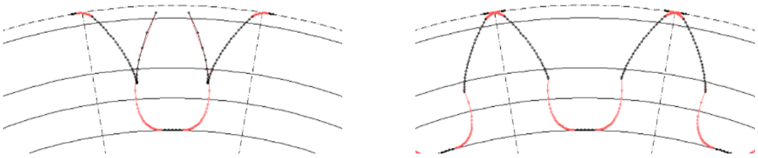
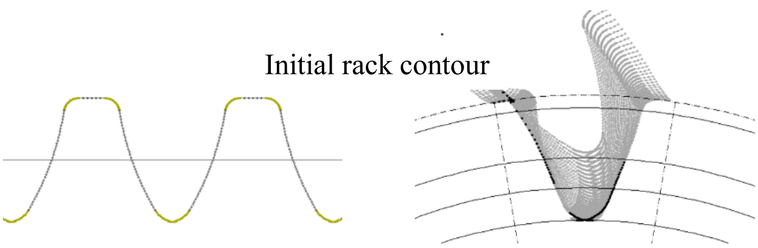


c d

Figure 4 – The shaping of the space between the teeth of the gear wheel with m=5 and z=20 by tool rack with a concave profile of the tooth flanks



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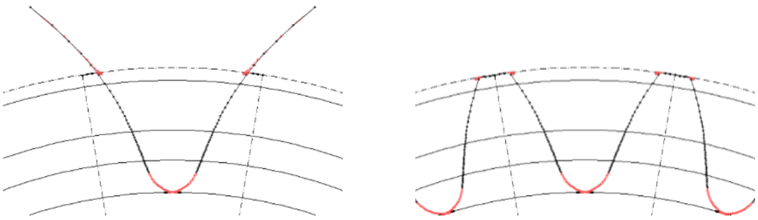

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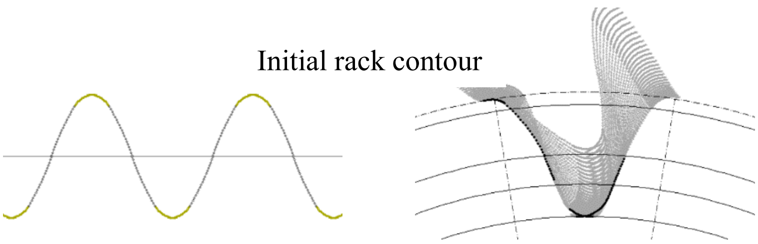
Figure 5 – The shaping of the space between the teeth of the gear wheel with m=5 and z=20 by tool rack with a convex profile of the tooth flanks



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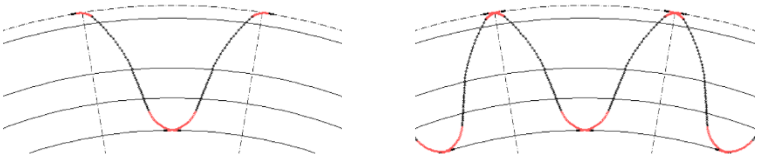

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Figure 6 – The shaping of the space between the teeth of the gear wheel with m=5 and z=20 by tool rack with a concave-convex profile of the tooth flanks

Conclusions

1. A mathematical model for calculating the tooth profile of a gear-cutting tool for machining of non-involute gear wheels has been developed. As a profile of the rack tooth flank, a certain section of one of the modeled kinematic curves is considered.

2. Based on the algorithm for calculating the profile of envelope surfaces, a method for geometric analysis of the process of shaping surfaces by rolling gear cutting tools has been developed.

3. Using computer graphics, the sequential shaping of the space between the teeth of non-involute gear wheels processed by rolling-in gear-cutting tools with a given tooth profile has been investigated.

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E-LEARNING MULTIDISCIPLINARY DEVELOPMENTAL ENVIRONMENT BASED ON NEW EUROPEAN RESEARCH PARADIGM

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