# The methods of globoid surface modeling in CAD

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**ABSTRACT:** The three methods of the globoid surface modeling, using CAD systems – AutoCAD and CATIA were presented. The modeling was carried out on the example of the warm lateral surface of the globoidal worm gears. In the first presented method the external program, that generates the script commands for AutoCAD system and lets generate the points of the globoid helix, was used. In the following two methods to model helixes, the possibilities of CATIA were used: creating the graph of two-dimension functions and comprising them into tree-dimension function and kinematic simulation, as well. The worm gear development, including these atypical ones, requires looking for new solutions in their modeling. The described methodology is universal and allows to generate the globoid lateral-surface of worm on the basis of wormwheel constructional assumption and taken tooth profile. The proper modeling of worm gear geometry in CAD allows to analyse the geometric cooperation, strength (by the finite element method), or to make a prototype for the preliminary tests with using of the rapid prototyping techniques.

**KEYWORDS:** globoid surface, globoid worm gear, globoid worm, CAD

## 1. Introduction

The globoid worm gears are composed of a cylindrical or tori globoid wormwheel and the globoid worm, whose outline, in a longitudinal section, tightly touches to the wormheel [1, 3]. The wormwheel is positioned in the relation to the worm mostly at an angle of 90°. In comparison with the cylindrical worm gears, the globoid worm gears have lower operating wear and higher efficiency [1, 2]. Another advantage is more beneficial location of the contact lines and cooperation of more numbers of teeth [4]. Between of the worm meanders and wormwheel teeth there are high rubbing speeds not only along the contours of the teeth, but also along the tooth, which results from the wheels position in the relation to each other – axle rotating [2, 6]. When higher loads, the seizure of the teeth happens, because the sliding velocity increases with the increase of growth angle of worm meander line [5]. The disadvantages include technological difficulties and high sensitivity on the accuracy of these gears realisation.

Due to the construction and fulfilled functions the worm gears are a challenge for designers. There are few specialized applications to generate this type of gears. The software only to model worm gear wheels is not commonly available, therefore there is a need to base on the CAD system for general-purpose. The globoid surface modeling is a problem, as well. On the Internet it is possible to find examples of globoid screw surface modeling in CAD, but often they are not geometrically correct and do not reflect the actual geometry. For example, it is modeled on a helix with constant pitch and variable diameter only.

## 2. The Method No. 1: The globoid surface generating in AutoCAD

Globoid worm surface designing of the worm gear is the subject of intense analysis. Currently solutions are mostly reserved by the gear producers, therefore the presented way of modeling is innovative. The developed process of globoid worm lateral-surface modeling was carried out in four stages (Fig. 1): taking the wormwheel constructional assumption, generating the points of the globoid helix, export of the data in the points form to CATIA and the final worm shape modeling.

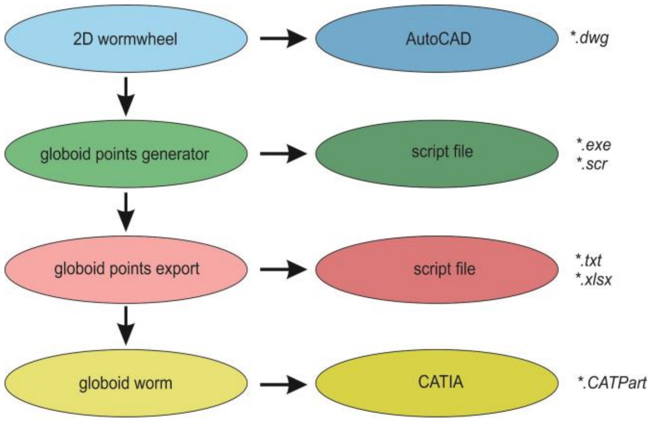


Fig. 1. The generating globoid worm steps

## 3. The Method No. 2: The laws in CATIA

In the second described method of the globoid helix modeling the laws (Law) in CATIA were used. The globoid helix can be modeled as a stretched spline on a set of points. Spline points can be determined using an external program (e.g., Matlab, Excel, C ++) based on the known mathematical relationships. Then the globoid helixes can be used to form proper surfaces between them.

The assumed constants:

H – a half of the globoid helix axial length,
a – the distance of the worm axis and the wormwheel,
r – the globoid radius, whereon there is a considered helix,
i – ratio.

In the Fig. 2 the diagram used to designate the parametric equations was shown.

A coordinate system $x_1, y_1, z_1$ associated with the end of the worm so that the $z_1$ axis is the worm axis, was taken. The worm wheel coordinate system $x_2, y_2, z_2$ was taken that the $x_2, y_2$ surface is set in the central plane of the worm. Then the two laws (Law) describing the mapping of cubic curve projection in the space of two mutually perpendicular planes. With two equations $x(z)$ and $y(z)$ of two-dimensional curves, based on them it is possible to create a $x, y(z)$ curve – Fig. 3.

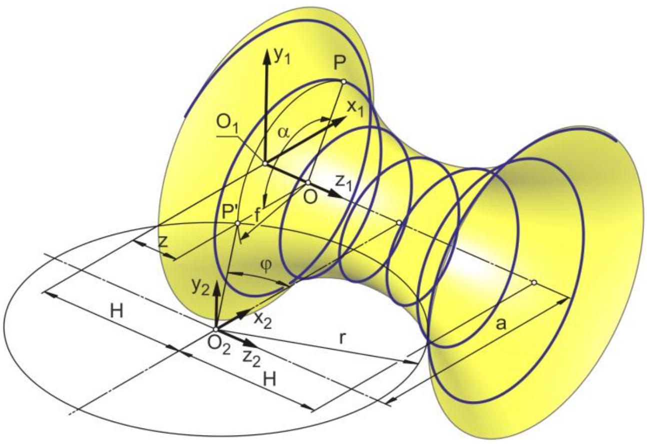


Fig. 2. The globoid helix – an auxiliary scheme

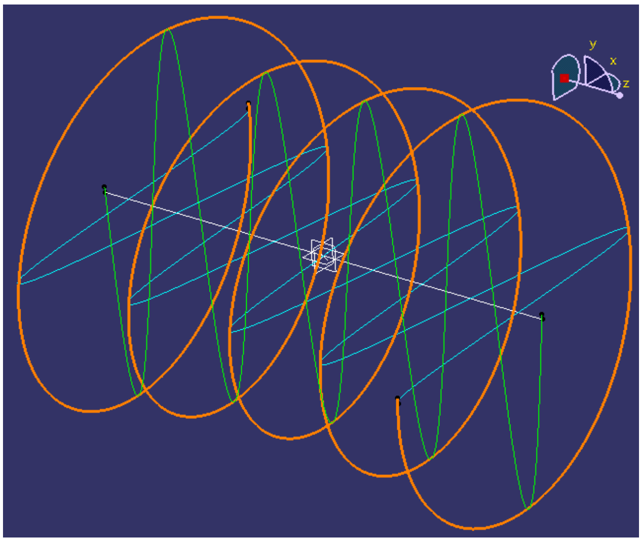

Fig. 3. The globoid helix $x, y(z)$ after the comprising of charts

## 4. The Method No. 3: The kinematic simulation in CATIA

To model of the globoid worm surface, the kinematic simulation in Digital Mockup Kinematics module can be used. The kinematic system consists of a tool model, the workpiece and the machine tools body. After the simulation to create the globoid helixes, the Trace command (Trace) was used. This command, on the basis of kinematic simulation, allows to trace the position of another points and lines. When the tracked object is a line, the result of the Trace command is a set of lines with points describing their ends. In both cases, for the track formed from both the points and the line (splines or cross- sectional lines), it is possible to create the meanders worm surface. The figure 4 shows the points and splines formed as a result of tracking points.

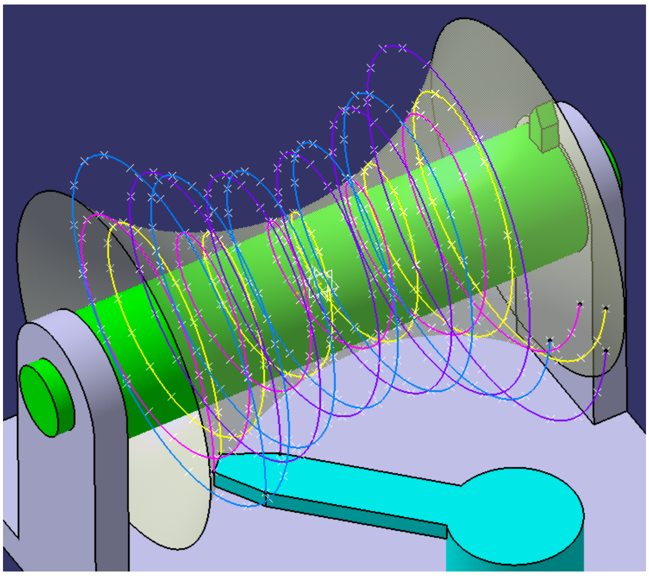

Fig. 4. The created points and splines

## 5. Conclusion

The globoid worm surface modeling is a difficult issue of complex surfaces modeling in CAD.
1) The conclusion of the method number 1: The developed methodology is universal, but it requires a lot of work.
2) The conclusion of the method number. 2: The presented method allows to create the expecting line in a simpler way than it was shown in the method number 1. The limitation is the length of the worm – the $H < r$ requirement must be fulfilled. Otherwise the $x(z)$ and $y(z)$ graphs are incorrect.
3) The conclusion of the method number 3: the use of kinematic simulation allows, in a relatively easy way, to create the complex surfaces that are the results of machining of the tools with straight-line cutting edge. The number of simulation „frames" is the limitation. For greater accuracy, the simulation should be divided into several segments. However, the problem, that happens then, is necessity to splines combine (for tracking the points).

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