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Issue Article

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THE KINEMATICS OF PINION AND GEAR WHEEL GEARING OF A HELICAL GEAR

***Abstract**: Analysis of the kinematics of pinion and gear wheel gearing of a helical gear was performed in the article. The result of the calculation were the contours of the pressure angle direction and the slip vector at contact point on the tooth of the gear wheel, represented by projections on the planes of a rectangular coordinate system.*

***Key words**: helical gear, gearing, gear wheel, pressure angle direction, slip vector at contact point.*
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1. Introduction

Comparing the kinematics of the links gearing of spur and helical gears, the following can be noted [1]:

1. In spur gears, contact occurs immediately along the entire length of the tooth, and in helical gears occurs gradually, as the driver link rotates.

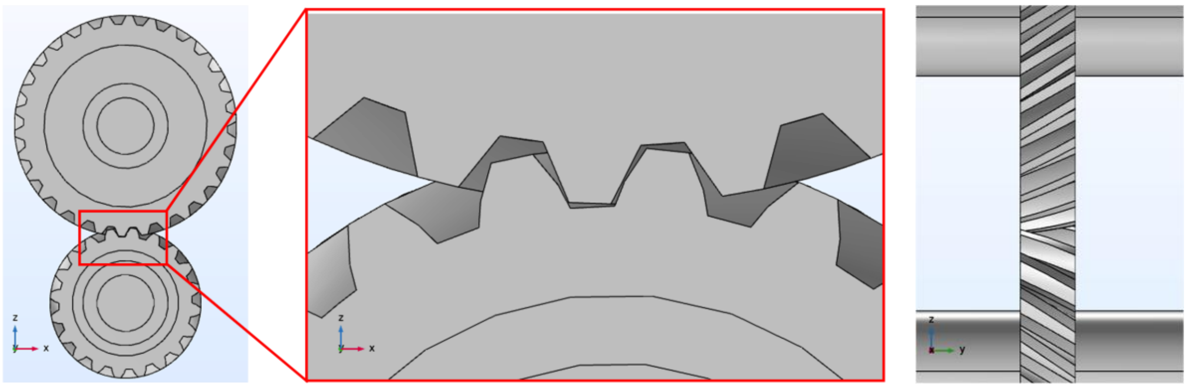
2. Since several pairs of teeth are simultaneously engaged in helical gears, the load capacity of such mechanisms is higher than that of spur gears.

Due to these advantages, helical gears can be used in medium-speed and high-speed modes. However, the high cost of manufacturing transmission links, the occurrence of axial force during operation, and low operational efficiency limit the use of these transmissions everywhere [2-5]. The analysis of the gearing process of the pinion and the gear wheel of helical gear, including through computer modeling, is presented in some works [6-9].

This article demonstrates the kinematics of the link gearing of the helical gear in the form of contour traces of the pressure angle and the slip vector at contact point of the teeth. These results will allow us to draw an expanded conclusion about the load characteristics and the value of the efficiency of the driver and driven transmission links [10].

2. Materials and methods

The pressure angle direction and the slip vector at contact point when the pinion and gear wheel gearing of the helical gear were calculated in the COMSOL Multiphysics program. To do this, the teeth of solid-state models of the pinion and gear wheel, which were mounted on the shafts, were engaged. The number of teeth of the pinion and the gear wheel was assumed to be 20 and 30, respectively. The pressure angle (alpha) and the helix angle (beta) of the pinion teeth and the gear wheel were assumed to be 25 degrees and 30 degrees, respectively. The gear mesh stiffness was set to 2×10^6 N/m. All the parts of the helical gear were given the properties of structural steel. The Fig. 1 shows the pinion and gear wheel gearing of the helical gear.



a ***b***

Figure 1. The pinion and gear wheel gearing of the helical gear: *a* – view on the XZ plane with a detail drawing and *b* – view on the YZ plane.

3. Results and discussion

The calculation results are represented by the characteristic contours of the pressure angle direction and the slip vector at contact point of the pinion teeth and the gear wheel (the Figs. 2 and 3). The contours were constructed relative to the face of the tooth of the gear wheel. The figures show the contours in three-dimensional form (thin black lines are the faces of the teeth of the gear wheel and pinion) and in two-dimensional form in the corresponding planes.

With a constant pressure angle, the force on the tooth of the gear wheel varies from a minimum value to a maximum value. The value of force along the tooth length increases 3.5 times. At the same time, the increase in force at the teeth contact occurs disproportionately.

The distribution of the slip vector at contact point of the pinion teeth and the gear wheel is almost uniform. The contours along the length and depth of the gear wheel tooth are characterized by the presence of sliding and friction effects on the faces of the teeth, which contributes to their uniform wear on the kinematic links of the helical gear on the one hand, and a decrease in useful work from a larger contact area (friction) on the other hand.

a

b

c

d

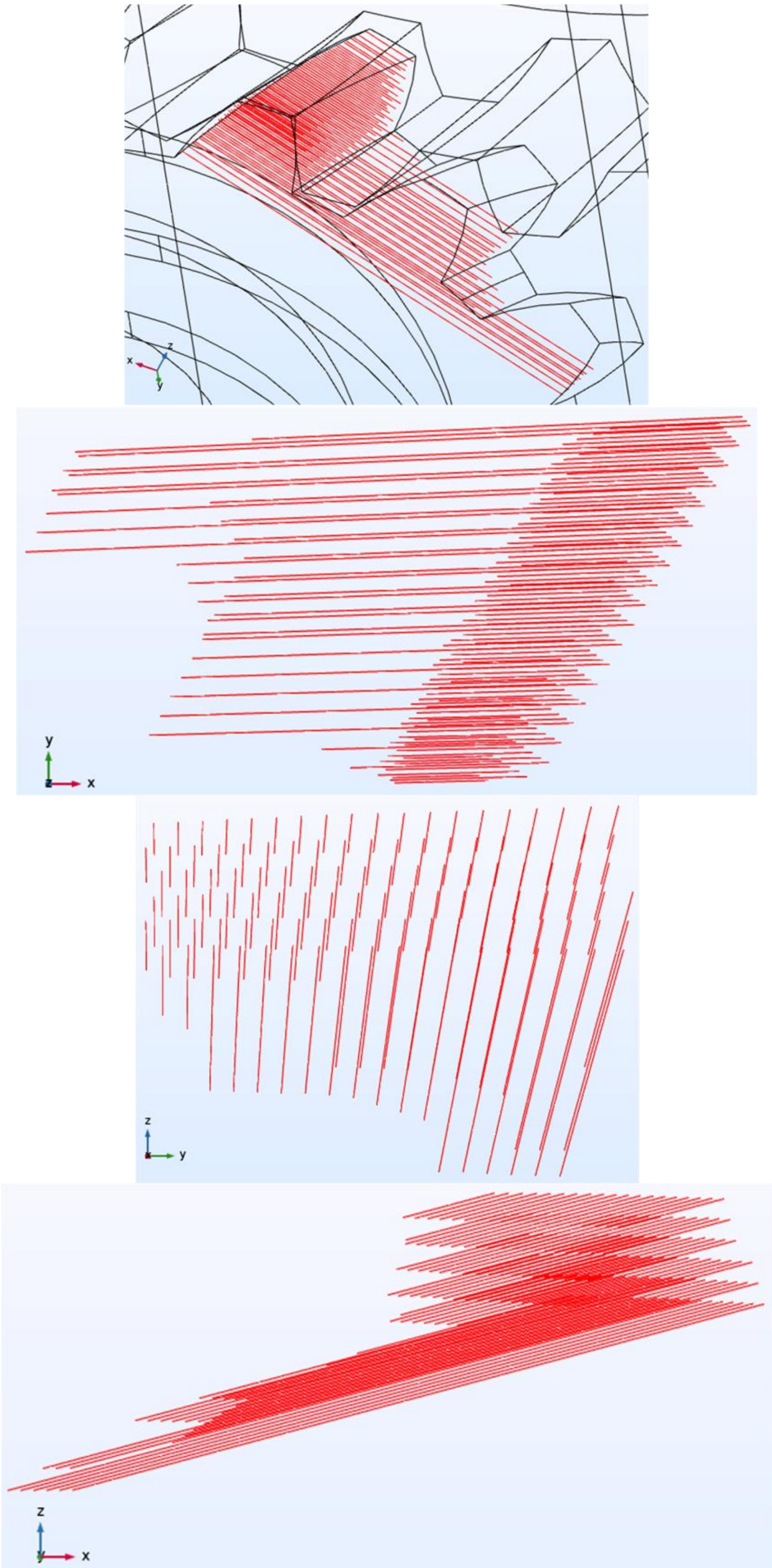


Figure 2. The pressure angle direction on the gear wheel tooth: *a* – isometric view; *b* – view on the XY plane; *c* – view on the YZ plane and *d* – view on the XZ plane.

a

b

c

d

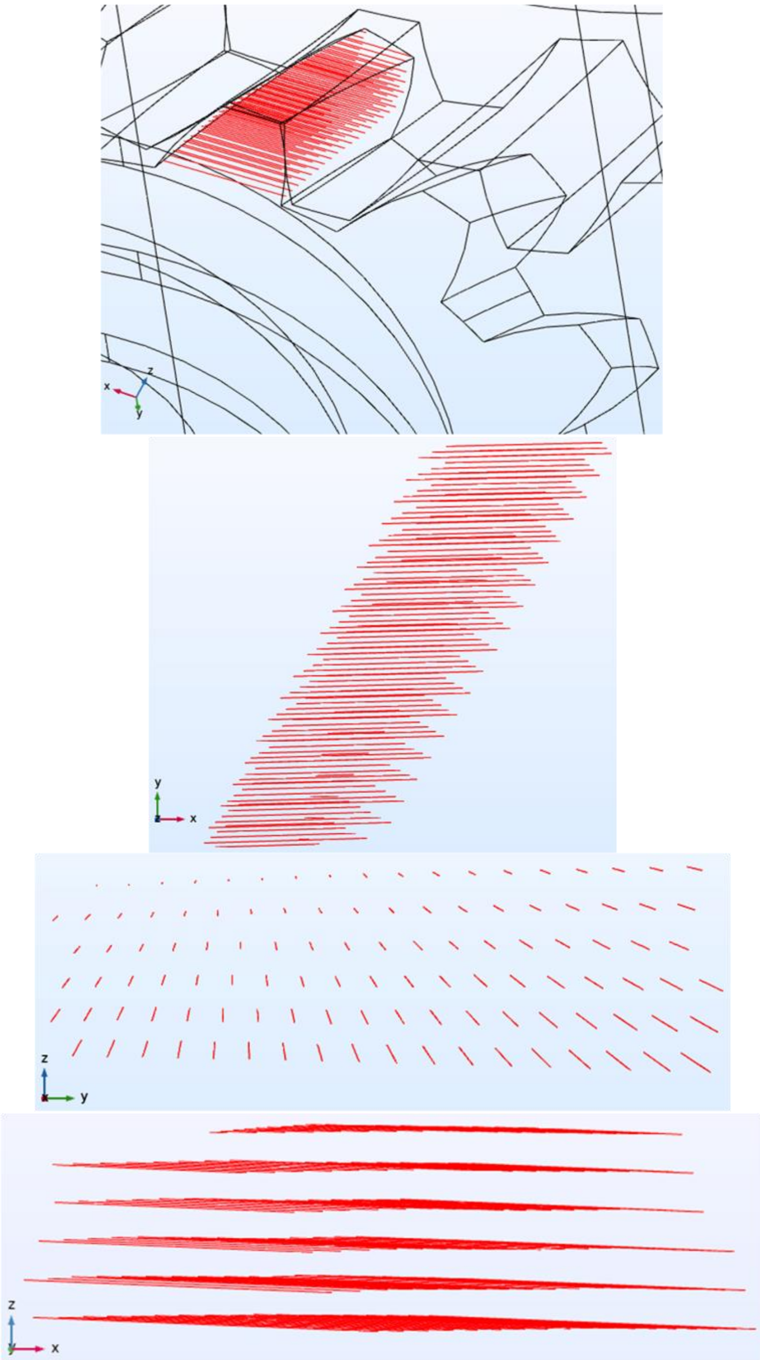


Figure 3. The slip vector at contact point of the pinion teeth and the gear wheel: *a* – isometric view; *b* – view on the XY plane; *c* – view on the YZ plane and *d* – view on the XZ plane.

4. Conclusion

The presented calculation of the contact parameters of gearing provides a visual representation of the motion kinematics of the helical gear. Using the example of a gear wheel tooth, the values and directions of the pressure angle and the sliding vector at contact point were determined. Volumetric and projection images of the kinematic parameters of the gearing will allow a critical analysis of the efficiency of the helical gear.

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