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LOAD CHARACTERISTICS OF THE HELICAL GEAR: SHAFT CALCULATION

Abstract: *Shafts serve as load-bearing elements in gear transmissions. The accuracy and durability of the gear transmission during operation depends on the degree of their loading (deformation). Computer calculations and subsequent analysis of the simulation results made it possible to make recommendations about the condition of the helical gear shafts when exposed to loads and the centrifugal force generated in them.*

Key words: *helical gear, pinion, gear wheel, shaft, load, centrifugal force.*
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1. Introduction

The use of a gear transmission with straight or spiral teeth is determined by the operating mode of the mechanism. Helical gears have a priority advantage, in the form of a gradual gearing of several pinion teeth and a gear wheel, which allows these mechanisms to be used at medium and high shaft speeds [1-2].

During the operation of the gear transmission, forces in various directions act on the elements of the mechanism, which cause the corresponding types of deformations of the material [3]. Since the shaft has a supporting function in the mechanism, it is important to investigate its possible deformations. Some achievements in improving the operation of helical gears can be found in the works [4-10].

The rotation of the shaft at a certain constant or variable speed is accompanied by the appearance of centrifugal force. The nature of the distribution of centrifugal force will allow us to conclude about the equilibrium of the rotating shaft.

The article provides a visualization of the distribution of force acting on a driven shaft and the resulting centrifugal force during rotation of this shaft. Thus, it is possible to predict vibrations and deformations of gear transmission elements based on contour traces in the shaft volume.

2. Materials and methods

To calculate the load characteristics of the helical gear shafts, models of a pinion and a gear wheel with pitch diameters of 100 mm and 150 mm, respectively, and two shafts with diameters of 40 mm were built. The gear ratio was 1.5. At the same time, 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 bearing stiffness on the shafts was set to 1×10^7 N/m. The driver shaft rotated at 500 rpm, and the resisting torque on the driven shaft was 100 N×m. All models of the helical gear (shafts, pinion and gear wheel) were given the properties of structural steel: density – 7850 kg/m³, Young's modulus – 200×10^9 Pa and Poisson's ratio – 0.3. A general view of the electronic model of the helical gear is shown in the Fig. 1.

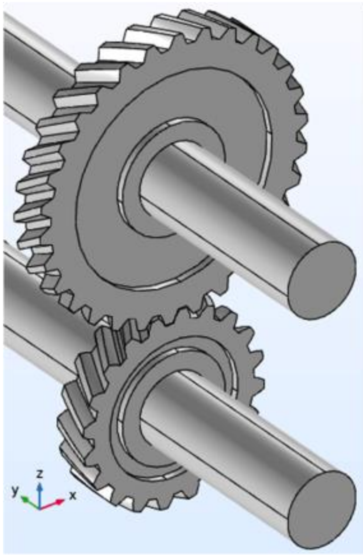


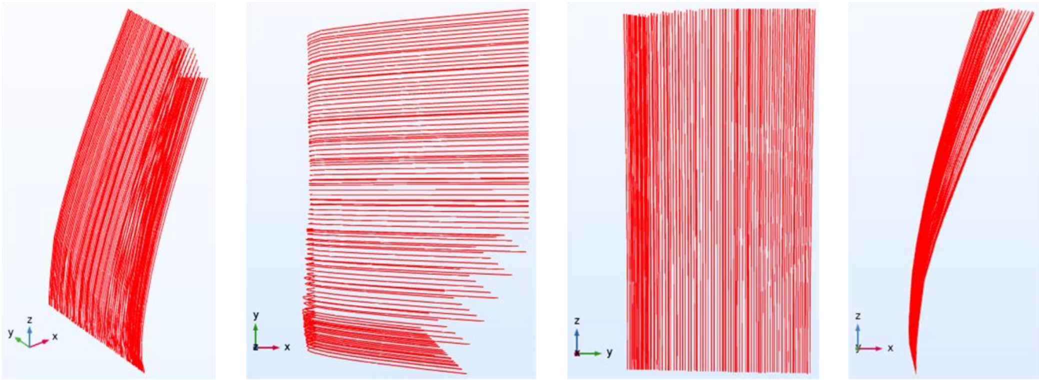
Figure 1. A general view of the electronic model of the helical gear.

3. Results and discussion

The result of the calculation was the contour traces of the load distribution on the shaft at the junction with the gear wheel and centrifugal force generated by the shaft rotation. For a detailed visualization of the shaft loading, contours of the same color in the amount of 100 pieces were adopted. The contours are presented in isometric form and in two-dimensional orientations in the Figs. 2 and 3.

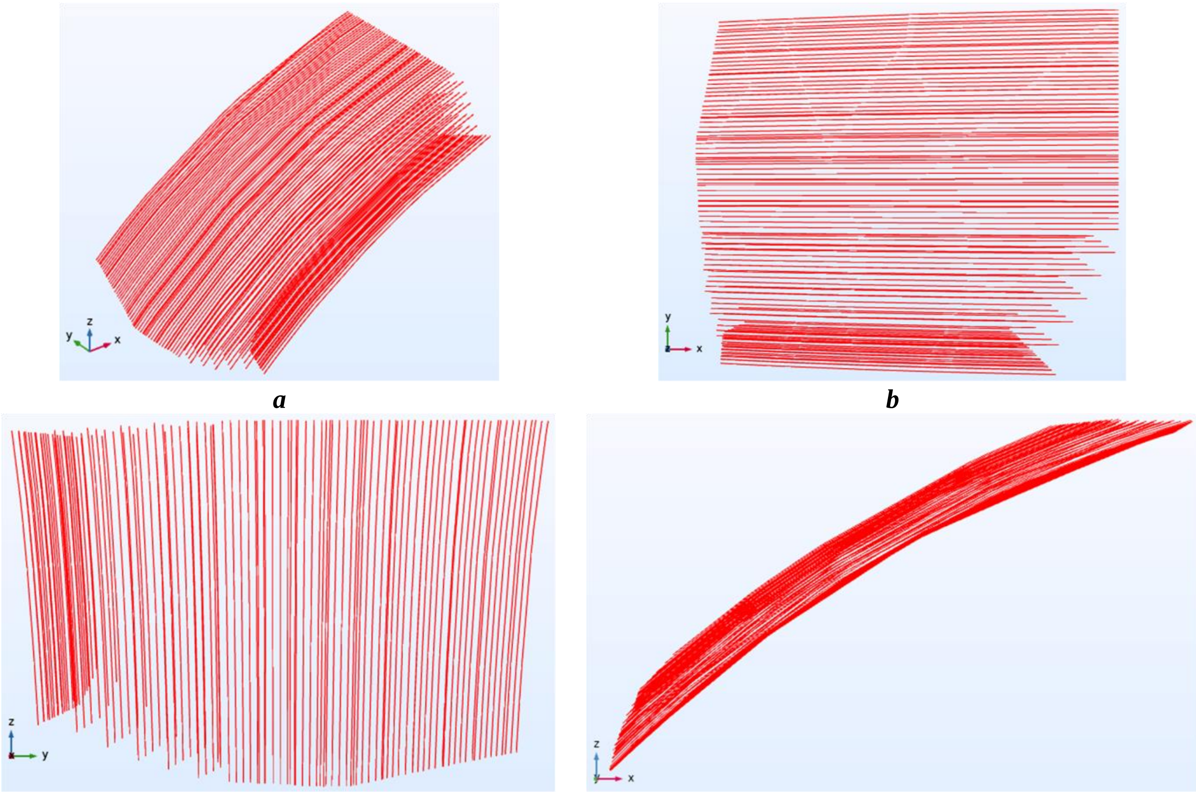
Since the Y-axis determines the thickness of the gear wheel, when superimposing contours on a three-dimensional model of the shaft in accordance with the presented views, it can be noted that there is no load on a certain contact area (from the end of the gear wheel), which may be a consequence of vibrations in the gear transmission parts. In the shaft cross-section, the load increases in the direction of shaft rotation, which is observed in the Fig. 2, d.

At the same time, when rotating, the centrifugal force arises from the middle of the shaft and is distributed diagonally (see the Fig. 3, d). As in the case of a load, the centrifugal force contours do not have a symmetrical profile.



a *b* *c* *d*

Figure 2. Load distribution on the shaft: *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. Distribution of centrifugal force on the shaft: *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 load distributions on the rotating shaft of the helical gear and the resulting centrifugal force from shaft rotation in various projections are demonstrated. According to the contour trace, it is noted that during the operation of the gear transmission at the junctions of the shaft with the pinion, the force is distributed somewhat unevenly due to vibrations in the elements of the kinematic pair. At the same time, the intensity of the load action increases in the direction of shaft rotation. Similarly, it is possible to judge the probable vibration by the contour traces of the distribution of centrifugal force, which acts diagonally across the shaft in cross-section.

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