Impact Factor: 9.9 ISSN-L: 2544-980X

Changes in Tooth Micro-Geometry

Ishmuratov Hikmat Kakharovich [1], *Abdurakhmanov Azamat Erkinovich* [2]

Annotation: This paper discusses methods for optimizing the micro-geometry of the teeth of hypoid and bevel gears to improve their operational characteristics. Due to manufacturing errors and changes caused by operating conditions, the teeth of these gears are often not ideally meshed with theoretical profiles, leading to increased wear and localised contact. One effective solution is the modification of the micro-geometry of the teeth, including changes to the tilt angles, pressure angles, and spiral angles. The studies show that the precise adjustment of parameters such as the distances between the elements of the gear meshing helps to improve load distribution and increase the durability of gears. The results of this work are important for improving the performance and reliability of gear drives in various mechanisms, including automotive transmissions and industrial equipment.

Keywords: micro-geometry of teeth, hypoid gears, bevel gears, tooth modification, tilt angles, tooth wear, load, optimisation.

Introduction

Gears, especially hypoid bevel gears, play a key role in mechanisms subjected to high loads, such as automotive transmissions and industrial machinery. However, due to manufacturing errors and variations caused by operating conditions, the teeth of these wheels cannot be perfectly mated to theoretical profiles. This can lead to localised contact, increased pressure and accelerated wear. To ensure stable and effective contact under various operating conditions, modification of tooth micro-geometry is essential. This can reduce contact loads, increase durability and improve the performance of mechanisms, including noise and vibration reduction. The relevance of this topic is to improve the reliability and performance of gears.

Theoretical basis

Theoretically, ideal gear tooth profiles, called mating profiles, imply their perfect interaction during force transmission and motion, which minimises wear and increases the efficiency of the mechanism. However, in real conditions, due to manufacturing errors, wear and external loads, the teeth cannot be perfectly mated, which leads to changes in their shape and location. This causes localised contact, increased pressure and wear on the tooth surface.

Tooth micro-geometry plays an important role in improving the performance of gear mechanisms. Micro-geometry refers to small changes in the shape and orientation of the teeth that can significantly affect the contact characteristics between them. In particular, by changing the inclination angle, height or radius of curvature of the teeth, an optimum distribution of contact pressure and a reduction in friction losses can be achieved.

For hypoid and bevel gears, an important aspect is the change in their micro-geometry in response to load-induced deformations. These changes can affect the mutual position of the gears in the transmission, which in turn changes the contact characteristics. Modelling and analysing these processes can optimise the performance of gears, improving their efficiency and durability.

[1] PhD., Associate Professor, Tashkent State University technical university
[2] Senior Lecturer, Tashkent State University technical university

The theory of tooth micro-geometry change is based on modelling the deformations that occur during the operation of mechanisms. These deformations can lead to changes in contact points, resulting in reduced wear and noise. In order to fine-tune and optimise mechanism performance, advanced modelling and numerical analysis techniques are required to predict and correct tooth behaviour under different operating conditions.

A typical corrective intervention used in bevel gears is bombing. These are changes that can affect both the tooth's lateral surface and its profile. Figure 1 graphically depicts two possible types of bombing: profile bombing and lateral surface (or rim) bombing.

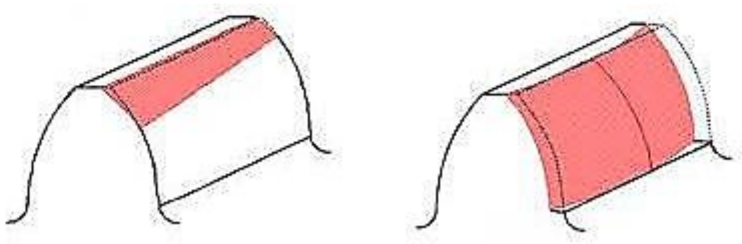

Figure 1 - Types of gear tooth bombing: profile and side bombing

Methodology. To optimise the tooth micro-geometry of hypoid and bevel gears, methods were used to improve tooth contact and reduce wear. The basic approach involved tooth shape modifications such as tooth angle and other corrections aimed at improving load distribution.

Modification of tooth micro-geometry. One effective method is to modify **tooth inclination angles** and **profiles** to help improve load distribution and reduce the likelihood of wear. These corrections are necessary to compensate for changes in the contact area and to compensate for deformations that occur after heat treatments.

Changes in pressure and helix angles. Important corrections are **changes in the pressure angle and helix angle of** the teeth. Changing the pressure angle improves the load distribution across the tooth, while changing the helix angle aims to optimise tooth contact and improve tooth durability. These changes help to achieve a more even pressure distribution on the tooth surfaces and reduce the risk of damage.

Optimisation algorithms

To fine-tune tooth micro-geometry, special algorithms have been developed to simulate various variations in tooth angles and profiles. These methods help to select optimal parameters to improve gear reliability and durability under realistic operating conditions.

Results and Discussion. During the study, the dependence of the change in the contact pattern on various parameters such as the distances H and V was evaluated, which is confirmed by the results presented in Fig. 2. This diagram shows how changes in these distances affect the contact position between the gear teeth.

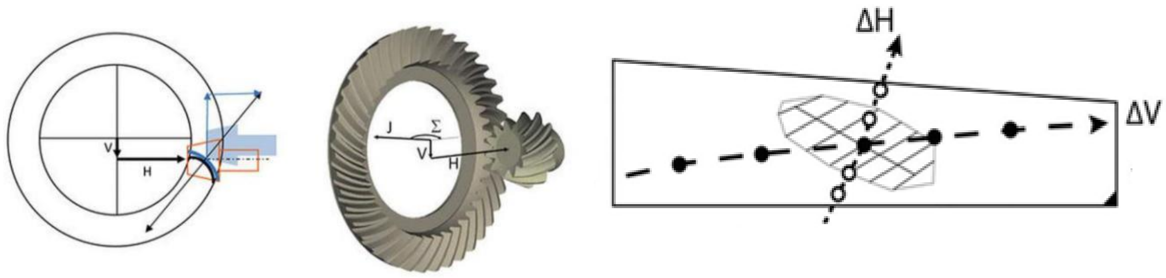

Figure 2 - Change of contact pattern as a function of distances H and V

The effect of changing distances on the contact pattern. When the distance **H** (ΔH, as shown) is increased, the contact on the lateral surface of the crown moves closer to the tooth crest, which moves it slightly away from the outer diameter (heel). At the same time, increasing the mounting distance **V** (ΔV, as shown in the figure) causes the contact to shift to the inner diameter (toe), bringing it closer to the top of the tooth (crest). These changes affect the distribution of contact loads, allowing them to be distributed more evenly across the tooth surface, reducing localised high pressures and improving performance.

Changes on the lateral surface with increasing distances. On the lateral surface that is released from the contact, increasing the distance **V** (ΔV positive) brings the contact closer to the outside diameter, which improves the load distribution across the tooth. In turn, increasing the distance **H** (ΔH positive) shifts the contact towards the tooth ridge, bringing it closer to the outer diameter. These changes also improve contact stability and reduce tooth wear.

Practical significance of the changes. These results show that fine-tuning the H and V distances can significantly affect the contact load distribution and improve gear durability. Variations in these parameters allow the contact pattern to be optimised in response to actual operating conditions, which in turn reduces wear and improves gear performance.

Conclusion. The study investigated the optimisation of tooth micro-geometry of hypoid and bevel gears to improve their performance. Modifications such as changing the inclination angles and pressure angles can improve load distribution and reduce wear.

The results showed that the fine tuning of parameters such as H and V distances significantly affects the contact load distribution and improves the durability of the gears. These modifications can improve performance stability and reduce wear under real-world operating conditions.

Thus, methods for optimising tooth micro-geometry contribute to improving the performance and durability of gears, which is particularly important for automotive transmissions and industrial equipment.

Literature:

1. Ishmuratov H.K... Wear resistance of gear teeth, when rolling without participation in the wear process of abrasive particles // International Scientific and Practical Conference "Automobile and Tractor Engineering". -Minsk, 2019. C. 16-20
2. Ikramov U.A. Calculation methods of abrasive wear estimation. -M.: Mashinostroenie, 1987.-288 p.
3. Ishmuratov H.K. Wear resistance of open gears of gear teeth. Wear resistance of open gears of gear teeth. // Vestnik TashGTU, -Tashkent, 2019. №2.-C.175-182.