

Study on the Effect of the Modification on the Contact Characteristics of Bevel Gear for Sino Mold

Humin Dai

Guangdong Mechanical & Electrical Polytechnic Guangzhou, Guangdong, 510515, China

Keywords: Profile modification, Axial modification, Sino mold, Bevel gear.

Abstract: Bevel gears are used in the development of industry and various machinery and equipment to provide strong power and load capacity between two intersecting axes. Bevel gear, as a key transmission part, plays a very important role in noise reduction and stabilization during machine operation and optimizes the performance of the whole machine and equipment. Modification is as important as bevel gears. In the process of gear die modification, according to the different technology, there are unstable factors, which make the bevel gear misalignment and deviation in the contact process between the gear dies. In this paper, through the introduction of modification and die, the application status of gear die by profile modification and axial modification is summarized. The influence of modification on contact stress, bending stress and meshing impact of bevel gears used in dies is summarized. Through parameters, dynamic characteristics and other aspects, the influence of optimizing modification on contact of bevel gears for dies and molds can be provided with more valuable reference for the application of bevel gears in industrial processes, machine equipment and modification and dies.

1. Research Background

1.1 Literature review

Sino mold refers to the dies and tools needed to obtain a product through extrusion, die casting or forging and smelting in industrial production. Sino mold is not only a tool for making molding articles, but also a tool for making the shape of objects according to molding materials. Wu Xiaochun and Xie Chen and others, combined with the "12th Five-Year Plan" and the requirements of steel products market for cold-working dies, analyzed the development path and direction of domestic cold-working dies steel in the future. In addition, compared with foreign steel material dies and summarized the development status of cold-working steel dies at home and abroad in the past five years, introduced the problems that should be paid attention to in the practical application of cold-working die steel, and provided a reference for the future development of steel die enterprises and cold-working dies(Wu et al,2013).At the same time, Wu Xiaochun and Zuo Pengpeng, based on the connotation of hot-working die, introduced the current development status of hot-working die steel market and products, and the difficulties faced by hot-working die in the development process. Some problems of hot working dies at home and abroad were solved, and the development and research direction of hot working dies in the future were predicted, which provided reference for the follow-up development of hot working steel dies at home and abroad(Zuo et al,2013).Modification can be divided into profile modification and axial modification. Bevel gears provide power when two axes move according to the different modification. Zhu Caichao, Chen Shuang and Ma Fei outlined the basic structure and principle of megawatt wind power gearbox, and analyzed the dynamic characteristics and various parameters of gear tooth modification for megawatt wind power gearbox. Relevant experimental data show that reasonable gear modification can ensure the improvement of dynamic performance of megawatt wind power gearbox and the reduction of negative problems(Zhu et al,2013).Wang Jian and Zhang Jun outlined the connotation, current situation and relationship of gear tooth modification and helical gear, analyzed the improvement and reduction of both forces and transmission, reduced noise and vibration of transmission, which had a strong help for gear tooth modification and helical gear

transmission improvement(Wang et al,2018).

1.2 Purpose of research

The influence of modification on contact characteristics of bevel gears for die is to improve the fit and give full play to the role of die in industry. Mold is known as the “mother of industry”. The plasticity characteristics of the mold lay the foundation that it can be effectively combined with any machine and equipment in any form, so it is widely used in industrial production. According to the different forming materials, the molds can be roughly divided into hardware, plastic and special molds. Moreover, according to the modification form of the die, the technological measures of gear tooth surface modification are all different. Modification can be divided into tooth profile modification and axial modification, so the effect is different. Tooth profile modification is characterized by reducing the impact and noise between the teeth, preventing gluing damage, etc. The effect of profile modification is worse than that of axial modification, but it plays a certain role in improving the load-carrying capacity of gear and the uneven distribution of load. Modification can make the tooth surface of the gear die even and make the fit between the gears reach a better standard. Bevel gear is a kind of gear, which has fixed bevel teeth, spiral bevel gear and base bevel and other forms. Bevel gears are mostly used in industrial transmission equipment, vehicle variables and other equipment. They have the characteristics of noise reduction, shock reduction and low cost (Song et al, 2017). Bevel gear die is mostly used in machine equipment to increase the contact power between die and die. Modification can promote the close movement of two intersecting axes by dressing the tooth surfaces of different parts. Based on the overview of the connotation and development status of modification and die, the contact characteristics of bevel gear and modification to die are analyzed. The influence of tooth surface modification on tooth surface contact force, root bending stress and meshing impact force is discussed. Modification and bevel gear dressing are used to optimize the gear die by optimizing the processing parameters, secondary optimization and reducing the dynamic contact characteristics, which can provide more innovative reference and reference for the subsequent modification and the diversification of the development of the model.

2. Development Status of Modification in Die Bevel Gear

Modification refers to the technological measures to adjust the gear tooth surface slightly and make it deviate from the theoretical tooth surface. According to the different parts of modification, modification can be divided into profile modification and axial modification. At present, gear manufacturing enterprises at home and abroad regard tooth surface modification as the core of improving tooth surface contact characteristics and optimizing transmission performance. Therefore, axial modification technology is one of the key research technologies in gear manufacturing enterprises. Bevel gears are beveled gears used to drive between intersecting axles, which can change the direction of transmission. It is usually made by machine tools. Bevel gears require high precision, so mold bevel gears are often constructed to meet the requirements of high precision. At the beginning of the 20th century, Grison Company created the first bevel gear end cutting machine. In the middle of twentieth Century, a machine with a rocker mechanism and a knife tilting mechanism was launched, so that the advanced engagement theory of bevel gears could be realized on gear pairs. In 1978, Grison Company officially published the principle of bevel gear tooth surface contact analysis. Based on this principle, Professor Zheng Changqi of China deduced the calculation formula of bevel gear tooth surface contact analysis. China has been devoting its efforts to the numerical control of bevel gear machine tools (Zhang et al, 2018). YK2260, developed by China Hunan Zhongda Chuangyuan CNC Equipment Co., Ltd., can process two kinds of bevel gears with Grison and Olikang teeth, and the processing accuracy reaches GB5 level. Tianjin Jingcheng Machine Tool Manufacturing Co., Ltd. takes YH60 series of four-axis coordinate axis CNC spiral bevel gear milling machines with complete specifications for large, medium and small sizes as its leading product, and has developed YH9150 type CNC spiral bevel gear milling machine in recent years, realizing free grinding of all tooth surfaces. China's bevel gear machine

tool industry is developing towards high precision, functional composite, full CNC and automation.

3. Effect of Modification on Contact Characteristics of Bevel Gears for Dies

3.1 Modification on Contact Stress of Die Tooth Surface

In the process of transmission, bevel gears realize power transmission through point engagement along the contact track of gears. In the contact process of point meshing of different teeth, the stress between the tooth surface and the tooth surface is caused by friction, which is called the contact stress of the tooth surface. The wear of gears will occur under the action of contact stress for a long time, and the meshing degree of gears will be affected, resulting in contact fatigue. Therefore, improving the contact stress of the tooth surface will greatly improve the service life of the gear (Yao, 2012). The main influence of modification on contact stress of tooth surface is that in the process of gear meshing, smaller gears act as active meshing wheels, and the bottom contacts with the top part of larger gears, which results in excessive stress and damage to gears.

3.2 Influence of Modification on Bending Stress of Die Teeth

Tooth root bending stress can lead to fracture of gear root, which is the main reason for high damage rate in gear transmission. The meshing process of gears is cyclic meshing. The root of gears will be subjected to large bending force in the meshing process, and the root of gears will be damaged under the action of long-term bending force. The influence of profile modification on the bending stress of tooth root mainly comes from radial force and stress concentration (Yang et al, 2016). Without gear surface modification, it is impossible to control real-time stress and deformation during gear meshing. At present, gear strength checking is still the basic strength design based on the cantilever beam theory. Finite element analysis strength is carried out by modification to ensure that the root bending stress is not too large, which is the main research direction to reduce the root bending stress.

3.3 Effect of Modification on Impact Force of Die Meshing

In the process of power transmission, most gears of different sizes engage continuously to realize power transmission. The meshing impact force will be produced when the teeth and teeth mesh instantaneously. Many scholars have shown that meshing impact force is the main cause of gear vibration and noise. The meshing impact force in bevel gears can not be directly obtained by finite element dynamic analysis. The meshing impact can only be adjusted by adjusting the meshing position and the relative speed of the driving wheel. The fluctuation of gear meshing speed is an important factor to determine the meshing impact force. Modification will affect the speed fluctuation in the process of meshing, and increase the impact force of gear meshing due to elastic deformation.

4. Contact Characteristic Optimization Strategy of Bevel Gear for Die Based on Modification

4.1 Optimizing Machining Parameters and Reducing Contact Stress on Tooth Surface

In order to optimize the contact characteristics of bevel gears for die modification, the first step is to optimize the processing parameters to reduce the contact stress on the tooth surface. The commonly used modification is circular tool modification, which can effectively reduce the tooth surface contact stress in bevel gears. In the actual production process, circular production tools are expensive and difficult to manufacture, which makes it difficult to realize batch application to achieve the purpose of shape modification. Based on this, it is a feasible and more practical method to optimize the parameters by computer technology and to realize the modification optimization in the manufacturing process. The essence of numerical optimization based on processing parameters is to optimize the parameters by approximating the tooth surface so that the generated tooth surface has the same data as the pre-produced tooth surface. By programming the corresponding tooth surface approximation program with computer technology, the closer the manufacturing parameters

of the gear are, the less the corresponding resistance is during the point meshing process between the gear and the gear, thus achieving the purpose of reducing the contact stress of the tooth surface.

4.2 Secondary optimization of processing parameters to reduce bending stress of tooth root

By approaching the tooth surface of bevel gears, the processing parameters are optimized, and the contact stress between the tooth surface and the tooth surface is reduced. In order to ensure the quality of the root, it is necessary to optimize the processing parameters twice to reduce the bending stress of the root. In the process of parameter quadratic optimization, the installation cone angle, the basic cutter inclination angle and the basic cutter rotation angle of the machine tool have great influence on the bending stress of the tooth root. Based on this, the above parameters are taken as priority optimization parameters. Finite element analysis in computer technology can realize secondary optimization of processing parameters, so as to regulate and control two key influencing factors, namely radial force and stress concentration, to ensure that the bending stress of the tooth root is in a stable state and the root of the gear will not fracture due to excessive stress, thus prolonging the service life of the gear.

4.3 Verify dynamic contact characteristics and reduce meshing impact force

The contact stress on the tooth surface and the bending stress on the root of the tooth are reduced by twice optimization of the processing parameters. The meshing impact force of the gear can be verified by dynamic contact characteristics. According to the dynamic contact performance of gears, the contact stress of different gears and the bending stress of the root will be reduced and stabilized after reducing the contact stress of the tooth surface and the bending stress of the root. Based on this, the phenomenon of edge contact will be greatly alleviated. As the bending stress of the root decreases, the bending strength of the root also increases. To some extent, the essence of strength increase is to deal with meshing impact. In the process of gear work, it makes gear work safer and more reliable, and reduces the noise between gear meshing, which brings greater economic benefits to enterprises and society.

5. Conclusion

With the increasing number of transmission parts and requirements of modern machinery, it is particularly important to improve the performance of bevel gears in noise reduction and stability. Starting from the theory and development direction of bevel gears, this paper studies the role of bevel gears in the application of industrial machinery and equipment. In the above research process, two aspects of modification are introduced, including the production process, principle, performance, current situation and Prospect of the die. The influence of modification on the contact characteristics of bevel gears for die is analyzed, and then the tooth surface is optimized to improve the fit between the tooth surfaces. It provides thinking path and improvement direction for improving bevel gear performance in the future. In this paper, the effect of modification on contact characteristics of bevel gears used in dies and its optimization are discussed. The modification of bevel gears and the application of bevel gears in dies and molds are also discussed. In order to better promote the development and utilization of bevel gear and profile modification technology, there are still places to be improved. For example, the number of experiments, data, equipment and other basic upgrades and other theoretical support, and so on.

Acknowledgement

This research has been financed by The Natural Science Research Project in 2019 of Liaoning Provincial Department of Education "Analysis on air distribution of air-conditioning system in the CRH" (LJKY2019112)

References

- [1] Wu X.C., Xie C., et al.(2013). Domestic and Foreign Cold Mold Steel Development Dynamics Mold Industry,44(12),1-11.
- [2] Zuo P.P., Wu X.C.,(2013). The Current Situation and Trend of the Development of Hot Mold Steel at Home and Abroad. Mold Industry, 44(10),1-9.
- [3] Zhu C.C., Chen S., Ma F., et al.(2013). Teeth Trim on the Dynamic Characteristics of the Megawatt Wind Gearbox . Vibration and Shock,32 (7),123-128.
- [4] Wang J., Zhang J.(2018). Comparative Analysis of the Effect of the Wheel Tooth Trim on the Oblique Gear Transfer Error. Vibration and shock, 37 (2),254-260.
- [5] Song C.S., Weng Y.X., Zhu C.C., et al,(2017). Consider the Dynamic Meshing Performance of the Wheel-toothed Electric Vehicle Rim Reducer. Vibration and Shock, 36 (20),254-260.
- [6] Zhang W.Q., Ma P.P., Guo X.D. et al,(2018). Spiral Cone Gear Contact Characteristic Control Method Aased on Conjugate Differential Surface . Journal of Beijing University of Technology, 44(7),1024-1031.
- [7] Yao T.Q., Wang L.H., Tan Y. et al,(2012). Arc Tooth Cone Gear Contact Dynamics Analysis Vibration and Shock,31(9),128-134.
- [8] Yang Z., Zhang J., Zhang Y.M., et al,(2016). The Gear Wheel Tooth Repair Volume Based on the Robust Design of Reliability is the Amount of Shape Repair . Journal of Northeastern University (Natural Science Edition),37(3),368-372.