Simulation analysis of reducer transmission gear based on ANSYS Workbench

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Abstract

With the continuous development of gear industry, gear research is more and more in-depth, and gear is the most important mechanism in the reducer. In this paper, through three-dimensional modeling and finite element simulation analysis, the reducer gear static analysis and modal analysis, obtained the simulation needs of deformation nephogram and stress nephogram, and the resonance frequencies of the first three orders provide a basis for future gear design and optimization.

Keywords

Gear; Workbench; Static analysis; Modal analysis.

1. Introduction

Gear transmission is the most widely used in mechanism and transmission device. At present, the indexing circle diameter of gears can be from 50 um to more than 100 meters, and the number of teeth can be from 1 to thousands. The efficiency is 99.5%, and the temperature inside the box can reach 538 degrees Celsius. According to the data published by National Bureau of Statistics and China Gear Professional Association, the overall scale of the global gear industry gear transmission is an important part of mechanical equipment, with the transfer of power, variable speed commutation function[1].

During the Tenth Five-Year Plan period, China's gear industry has developed rapidly. In 2005, the annual output value of the gear industry increased from 24 billion yuan in 2000 to 68.3 billion yuan, with an annual compound growth rate of 23.27%. It has become the largest industry in China's machinery infrastructure. In 2006, China's total industrial output value of all gear, transmission and drive parts manufacturing enterprises reached 1026,283,000 yuan, an increase of 24.15% over the same period last year. In January-December 2007, China's total industrial output value of all gear, transmission and drive parts manufacturing enterprises reached 136,541,000 yuan, an increase of 30.96% over the same period last year; in January-October 2008, the total industrial output value of all gear, drive and drive parts manufacturing enterprises increased by 30.96%. In January, China's total industrial output value of all gear, transmission and drive parts manufacturers reached 1445,29138,000 yuan, an increase of 32.92 percent over the same period last year. At the end of the Eleventh Five-Year Plan, the annual sales of China's gear manufacturing industry could reach 130 billion yuan, with per capita sales rising to 650,000 yuan per year, ranking second in the world. In recent years, with the rapid development of science and technology, new methods and technologies have emerged in some disciplines, especially the development of computer and information technology, which have brought new vitality and new ways to gear research, and made some previously unimaginable contents possible. Many experts and scholars have done a lot of work in various fields involving gears, such as the research and application of new tooth shape, new structure, new theory, new materials, new technology, new products and so on. Many achievements have been made. In this paper, tooth shape and gear structure, the application of new theory in gear research, computer software should be adopted. The three parts are sorted out so as to provide reference for further research.

2. Model Establishment

At present, the main three-dimensional modeling software are creo, Solidworks, UG and so on. This paper uses the general three-dimensional modeling software Solidworks to model the reducer gear. The main parameters used in this paper are the number of teeth Z=10, pressure angle a= 20 degrees, modulus M = 4.5, indexing circle diameter D = 45mm [2-3]. In order to reduce the weight of the gear, lightweight gear is carried out. The design is carried out in the vicinity of the drive shaft space, and the three-dimensional model is shown in Fig. 1.

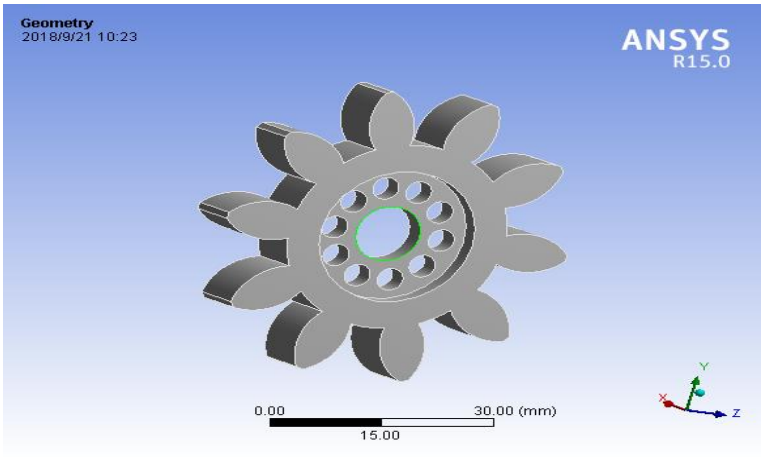

Fig.1 Three-dimensional model

3. Finite Element Model Division

3.1 Grid Partition

Because of the powerful excuse ability of Workbench and Solidworks, the size of simulation data depends largely on the mesh fineness when the three-dimensional model is saved in (.x_t) format and imported into Workbench[4]. However, too fine mesh may lead to too long computing time and too coarse mesh may affect the accuracy of the results. In this paper, the mesh size is 2.5mm, 6096 units and 10845 nodes are generated. The partition form is shown in Fig 2.

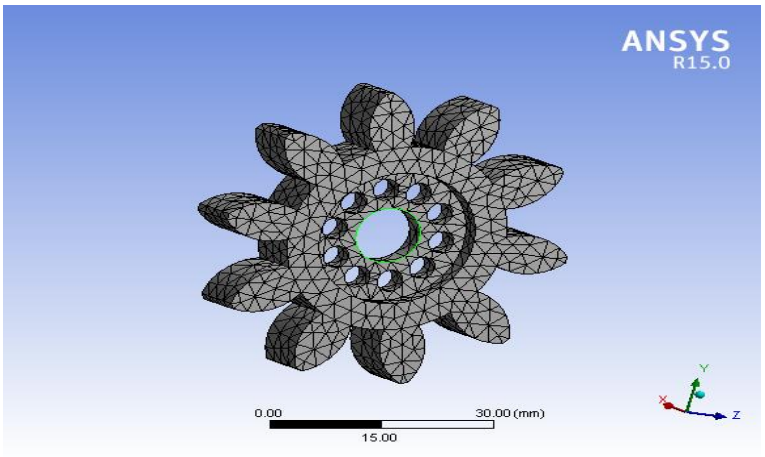

Fig.2 Mesh generation model

3.2 Loads and Constraints

In order to reduce the calculation time, this paper uses only one gear to simulate the working condition of a pair of gears meshing transmission. When the gear rotates, the gear can be regarded as fixed and non-rotating, so a fixed constraint is applied at the hole of the gear shaft, and the force of the gear transmission is transferred to the meshing place of the fixed gear and the gear is located at the meshing place of the fixed gear. The meshing point is loaded with a concentrated force, loading and restraint are shown in Fig. 3.

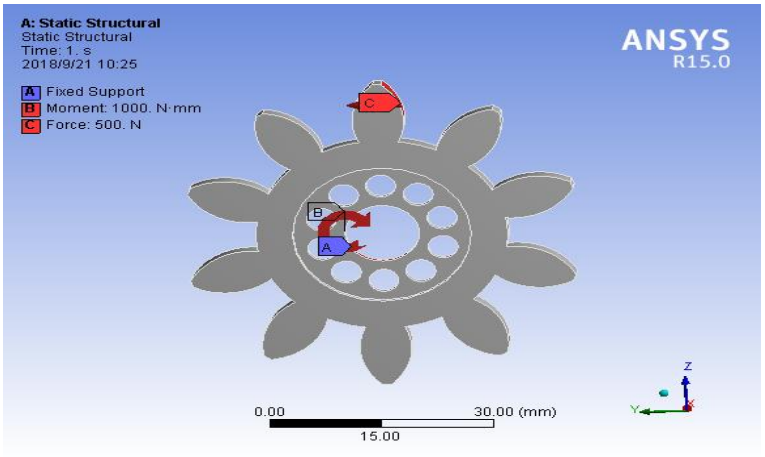

Fig.3 Load and constraint model

4. Finite Element Simulation

4.1 Static Analysis

The displacement nephogram and stress nephogram as shown in Fig. 4 and Fig. 5 are obtained after the finite element model is loaded and solved. It is shown from the figure that the maximum deformation of the gear occurs at the meshing point of the gear, and the maximum deformation is 0.072156 mm. The maximum stress of the gear occurs at the position of the axle hole in the meshing place, and the maximum stress is 291.59 MPa[5].

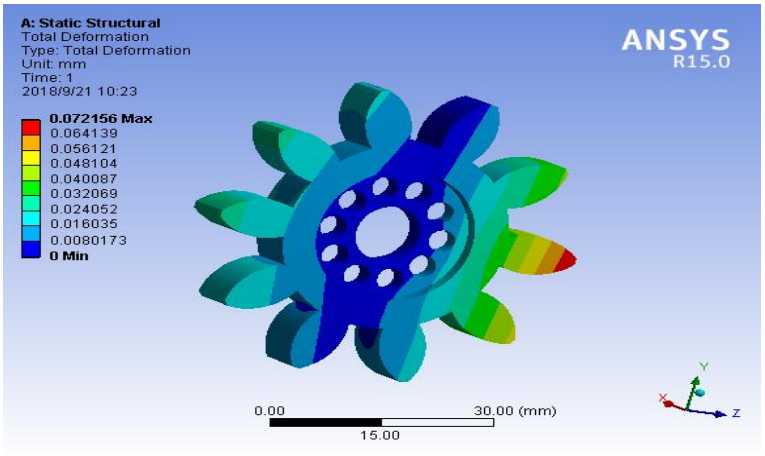

Fig.4 Displacement cloud map

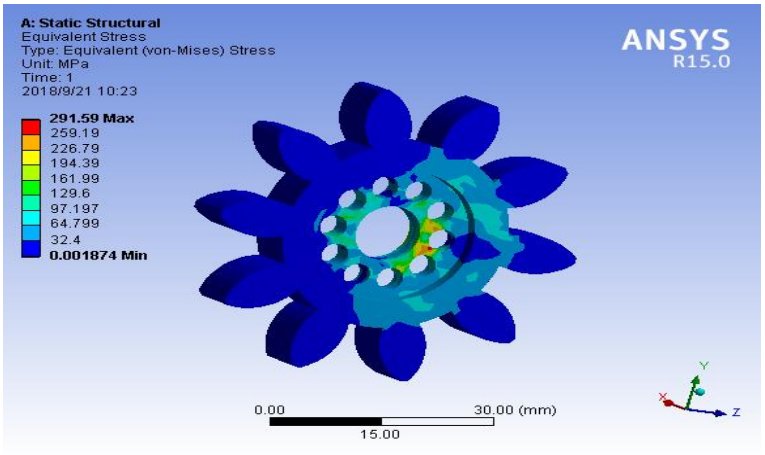

Fig.5 Stress cloud map

4.2 Modal analysis

Modal analysis is a method to study the dynamic characteristics of structures, and is generally applied in the field of engineering vibration. Among them, modal is the natural vibration characteristics of mechanical structure, each modal has a specific natural frequency, damping ratio and modal vibration mode. The process of analyzing these modal parameters is called modal analysis. Through modal analysis, the natural frequency and mode shapes of the structure can be obtained. The optimum design of the structure can be achieved by means of the vibration frequency[6]. The first three modes of the structure can be analyzed by modal analysis. The first three vibration frequencies of gear reducer simulation are extracted in this paper. The data are shown in Table 1.

Table.1 Resonance frequencies and characteristics of various orders

Order	resonance frequency /Hz	Vibration characteristics
1	0	The vibration on the right is greater than the left.
2	3.5615e-3	Left and right vibrations
3	8.144e-3	The left side vibration is greater than the right side.

5. Conclusion

Through the static simulation analysis, it can be concluded that the gear reducer at the meshing point has the most obvious force, which provides the foundation and guarantee for the future gear design and optimization; through the modal analysis, it can be concluded that the vibration frequency of the gear reducer studied in this paper is less than 1e-2 Hz, so it can be used in the future gear design. Avoid resonance frequency and improve the service life and strength of gears.

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