Finite Element Analysis of Three-ring Reducer

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Abstract: The tricycle reducer is widely used in many fields such as mining, petroleum and building materials because of its characteristics of large transmission ratio, compact structure and wide application, as well as its excellent carrying capacity and low cost. In order to understand the force of three-ring reducer, the finite element analysis method should be adopted. This paper, starting with the structure and working principle, carries out the multi-tooth meshing effect and the whole machine statics analysis, aiming to provide a reference for the optimization and perfection of the products.

Keywords: three-ring reducer; Finite element analysis; Force conditions

1. Introduction

The three-ring gear reducer is a new type of transmission, which is developed on the basis of the research and development of ordinary planetary gearbox with few tooth difference. Due to its relatively complicated force conditions, the deformation of the components will be affected by the system movement or when the dynamic performance changes. However, at the present stage, the research on tricycle reducer is not deep enough, and the mechanical properties are still not well understood. In order to get the accurate research results, this paper will carry out the finite element analysis of tricycles reducers.

2. Composition of the three-ring reducer

The main components of the three-ring gear reducer are input shaft, support shafts, bearing bases, output shaft and annular plate. In order to effectively overcome the dead point position in the foundation structure of the three-ring reducer, the splicing phase angle of each ring plate is set to 120 degrees and the three ring plates are arranged side by side.

3. Driving principle and transmission form of three-ring reducer

3.1. Driving principles

The transmission mechanism of the tri-ring reducer is composed of a gear mechanism and a parallelogram mechanism: there is a dead point in the system movement, which is an indeterminate position where the movement between the parallel quadrilateral mechanisms and the crank common line is 0?? and 180? angles. In order to overcome the uncertainty of the tri-ring reducer operating at the dead point, the phase angle between the various base structures is

usually set to 120 degrees and the three-phase parallelogram is arranged. When a phase parallelogram mechanism runs to a dead point in the drive system of a tricycle accelerator, the transmission power to overcome the dead points is generated, which is transmitted by other two-phase mechanisms.

3.2. Form of transmission

There are two different transmission forms of three-ring reducer, i. e. symmetrical transmission and offset transmission. The former is based on the input shaft and bearing shaft of the three-ring reducer to set the output shaft into a relative position, while the latter will be set into the same side at the position of input axis and supporting shaft. Under different transmission forms, the mechanical properties of the three-ring reducer are not consistent. Based on the same technical parameters, the mechanical properties of the two transmission modes are determined. The results show that the symmetrical transmission mode has more ideal mechanical behaviors. The deviation type dynamic form will appear more obvious vibration, and the noise is relatively poor mechanical performance.

4. Finite Element Analysis of Three-ring Reducer

4.1. Construction of FEM Model for Gear Pairs

4.1.1. Selection of analytical modules

In the process of finite element analysis of three-ring reducer, multi-tooth engagement is a kind of contact problem, which belongs to the strong nonlinear problem. To analyze it, the high standard of computer hardware is required, and a large amount of resource loss will be produced in the calculation. For a three-ring reducer, both the inner and outer

gears are cylindrical straight teeth. If the 3D body contact problem is simplified and converted into 2D plane contact problems, the calculation process can be simplified, and more accurate analysis results can also be obtained. Due to the relatively complex shape of the gear pair model of three-ring gear reducer, this paper selects two units, PLAN EL 83, 2 D contact unit CONTAl 72 and TARG EL 69, after integrating several influencing factors.

4.1.2. Delimitation of grid elements

In order to save computation time and improve calculation accuracy, more intensive and detailed mesh cell division is usually needed in the area where the stress concentration is relatively high. Relatively sparse for minor areas. For this reason, the stress in this area is relatively concentrated when the gearbox model is divided, so a fine mesh method is needed for the two positions of contact surface and tooth root angle transition.

4.1.3. Analysis of influencing factors of multi-tooth meshing effect of three-ring reducer

Through analysis, it is found that the input torque and the position change of theoretical meshing point will influence the multiple-tooth mesh effect of the three-ring reducer.

(1) The larger the input torque value, the smaller the proportion of the load to which the teeth carrying the primary load are allocated, and the higher the ratio of those bearing the secondary loads to the loads carried.

(2) The higher the input torque, the greater the stress variation on the gear pair, and the positive correlation between the two.

(3) The greater the input torque, the smaller the change in the load ratio of the teeth, and the inverse relationship between them.

(4) The load bearing teeth of the input torque and the three-ring reducer have a positive correlation with the number of teeth, i.e. the greater the value of that torque, the more teeth are required. When the input torque is 25 % of the maximum theoretical torque, five pairs of bearing teeth are required.

(5) The theoretical maximum load torque for the three-ring reducer selected in this paper is 2180 Nm, but the maximum Mises stress of the gear pair still does not reach the material ultimate stress when the input torque is increased to 2.55 times the theoretic maximum.

4.2. Construction of finite element model for the whole machine

4.2.1. Selection of analytical modules

Considering that the surface of the three ring reducer inner gear plate, eccentric sleeve and other entities are surfaces and the entity shape is not very regular, the selected unit type is SOLIDl 86 unit, which is a high order entity unit with 2 displacement modes and 20 nodes (with middle contacts), and is well suited for dividing irregular entity model and has high computational accuracy.

4.2.2. Delimitation of grid elements

In dividing the mesh, in order to get the element of shape rules, this paper selects another noncomputational element MESH200, which is a unit provided by ANSYS for dividing mesh and does not have any arithmetic function. This paper mainly uses it to divide mesh to each solid surface of three-ring reducer, and then obtains the unusual regular solid unit through the "stretching" of the surface element, which ensures the accuracy of statics finite element analysis for the whole machine on one hand.

4.2.3. Comparison of Finite Element Analysis and Test Results

Through analysis, it is found that the torque of the inner gear plate to the output shaft has the characteristics of periodic variation. The maximum fluctuating torque is measured by the test, and only about 2.4 % error exists between them when the finite element analysis and the experimental results are compared.

4. Summary

The innovation of this paper is to use finite element method to realize the three-ring reducer gear and the construction of the whole FEM model, and then to analyze the efficiency of multi-tooth meshing and static force. Due to the limitation of length of the article, the research in this paper is not comprehensive enough. In the future, it is necessary to focus on the influence of inertia force on three-ring reducer, analyze the distribution of stress of each structure part under inertial force, understand the constraint reaction force of traditional system, and take into account all transmission elasticity, so as to analyze vibration characteristics of triring reduction.

References

[1] Pivovarenko Y. (2020) Negative Electrization of the Sargasso Sea as the Cause of Its Anomaly. American Journal of Electromagnetics and Applications, 8 (2), 33-39.

[2] Deepening the Core Architecture of Linux, by Guo Xuxue, People' s Postal and Telecommunications Publishing House, June 2010

[3] Han Xiaojuan, Hu Pioneer, Guo Hui, et al.. Finite Element Analysis of the Exterior Tooth Plate of Internal Gear Reducer[J]. Mechanical Transmission, 2017 (11): 126-130.

[4] Xu Feng Ping, Wang Qiang, Du Wentao. Simulation analysis of flexible body dynamics of three-ring reducer[J]. Mining Machinery, 2018, 46 (2): 59-63.

[5] Andy FZ, Paymon R, Kevin CC. (2018). Advances in Proximal Interphalangeal Joint Arthroplasty: Biomechanics and Biomaterials. Hand Clinics. 34 (2): 185-194.

[6] Gossling, S., Scott, D., & Hall, C.M. (2020). Pandemics,

tourism and global change: a rapid assessment of COVID-19. Journal of Sustainable Tourism, 29, 1 - 20.

[7]   Emanuel, E., Persad, G., Upshur, R., Thome, B., Parker, M., Glickman, A., Zhang, C., Boyle, C.W., Smith, M., & Phillips, J.P. (2020). Fair Allocation of Scarce Medical Resources in the Time of Covid-19. The New England journal of medicine.

[8]   Das K K (2018). "A Study on Evolutionary Perspectives of 'Emotions' and 'Mood' on Biological Evolutionary Platform". Psychology and Behavioral Sciences; 7 (5): 89-96.

[9]   Piya AK, Raihan MM, Hossain MA. (2020). Effect of

Osteoblasts Cell Adhesion Behavior on Biomaterial Surfaces by Atomic Force Microscope. Advances in Applied Sciences. 5 (1): 1-10.

[10]   Connors, J., & Levy, J. (2020). COVID-19 and its implications for thrombosis and anticoagulation. Blood, 135, 2033 - 2040.

[11]   Baig, A.M., Khaleeq, A., Ali, U., & Syeda, H. (2020). Evidence of the COVID-19 Virus Targeting the CNS: Tissue Distribution, Host–Virus Interaction, and Proposed Neurotropic Mechanisms. ACS Chemical Neuroscience, 11, 995 - 998.