ADAMS simulation analysis of the planetary transmission system of electric wrench used for equipment installation

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ADAMS simulation analysis of the planetary transmission system of electric wrench used for equipment installation

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Abstract: The electric wrench is widely used in the screw connection of the equipment installation, their transmission system usually use the planet gears. In view of the problems existed in the dynamic simulation of planetary gear system trains, the virtual prototyping technology is used to simulate the dynamic of electric wrench. Firstly, the three-dimensional model of the planetary transmission trains is established by using SolidWorks software. Secondly, the model is introduced into the ADAMS software to carry out the dynamic simulation analysis, the dynamic force of the X axis and the Y axis direction are obtained. The dynamic force is synthesized by using the Matlab software and the dynamic circle force is obtained. Finally, using the model and formula of gear static calculation, the circle force in the static state is obtained. Comparison of the both, the result shows that the dynamic circle force fluctuates around the value of the static circle force according to the rotation period, which fits the characteristics of dynamic changes for acting force. The work lays a foundation for the analysis of the dynamic characteristics of planetary transmission train in the next step.

1. Introduction

Threaded connection is a widely used detachable fixed connection. In some precision machinery, the ratio of threaded fastening is approximately 42%. Electric wrench is a hand-held power tool that fastens or disassembles threaded parts, it provides greater tightening force and higher reliability than manual operation, and improves production efficiency at the same time. Therefore, electric wrenches have been widely used in threaded connections (Figure 1 shows the electric wrench in the fastening sheet metal parts).

Figure 1. Electric wrench fastening sheet metal parts.

Planetary gear trains have the advantages of compact structure, large transmission ratio and high transmission efficiency. As the main transmission part of the electric wrench, it can ensure the small size and light weight of the electric wrench. At the same time, the torque of the electric wrench can be measured and controlled based on the theory of the planetary gears' power splitting [1]. The electric wrench transmission system mainly adopts planetary gear train with multi-stage series 2K-H type (NGW type). Figure 2 is a schematic diagram of an electric wrench drive system.

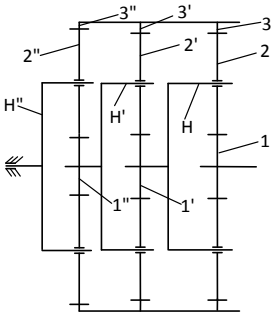


Figure 2. The schematic diagram of an electric wrench drive system.

The dynamics simulation analysis of planetary gear trains is of great significance for studying the dynamic characteristics of it. Scholars at home and abroad have done a lot of research on the dynamic characteristics of planetary gear trains, and get a great many achievements in this field [2-4]. Because of the fact that the dynamic simulation analysis of planetary gear trains is simple and feasible by using virtual prototyping technology and it is widely adopted in research [5-10]. It can be seen from the above introduction that virtual prototype technology has become an effective method for dynamic simulation analysis of planetary gear trains. Using virtual prototype technology, the dynamics simulation analysis of various planetary gear trains was carried out by the researchers. In the current research, there are two main problems. (i)The research methods used by different researchers are basically the same, but the results obtained are quite different. (ii)At present, most of the research results are lack of verification. Although some studies have made a certain comparison, but there is no necessary explanation for the selection of comparative value types.

Problems caused by dynamic simulation analysis of planetary gear trains based on Virtual Prototyping Technology. The object of this paper is the planetary transmission system in the electric wrench, and the dynamic simulation analysis is carried out by the virtual prototyping technology and compared with the static calculation results. The research results will provide guidance for dynamic simulation analysis of planetary gear mechanism. Figure 3 is the analysis process in this article.

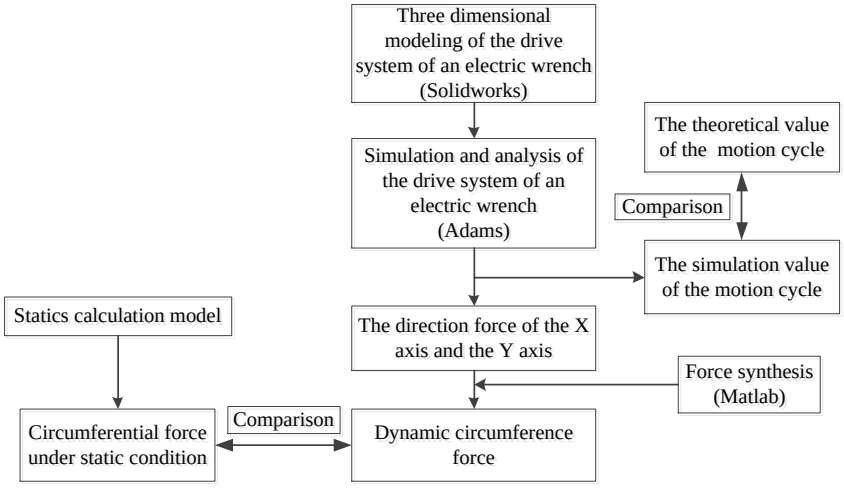


Figure 3. The analysis process in this article.

2. 3D Model of electric wrench planetary transmission system

The electric wrench transmission system mainly adopts planetary gear train with multi-stage series 2K-H type (NGW type). This article takes a model of an electric wrench as an example. Its transmission system is made up of three stages 2K-H planetary gear mechanism. Its key components mainly include the center wheel, planetary gear, planet carrier and internal gear housing. 3D model of parts and transmission systems were built by Solidworks. As shown in Figure 4.

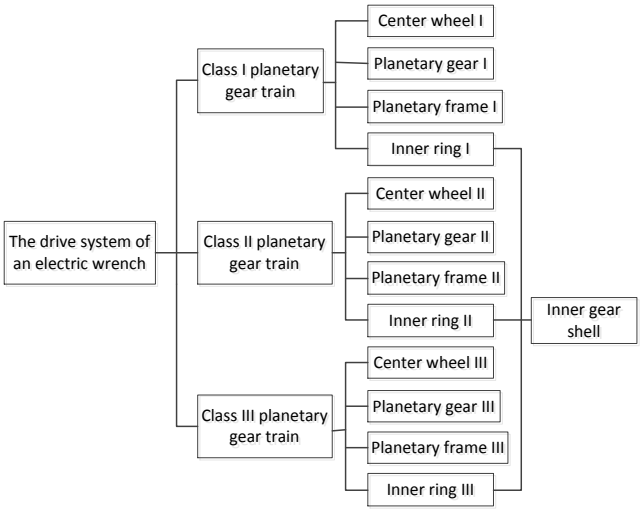


Figure 4. Main component.

3. Dynamic simulation analysis of planetary transmission system of electric wrench.

3.1. Importing and simplifying 3D models

Three-dimensional models of planetary gear transmission system built in Solidworks software is imported into ADAMS (Figure 5). In order to improve the efficiency of simulation, the model is simplified and the bearings and other bearings are removed. But its inertia, mass and other attributes are included in the simulation model.

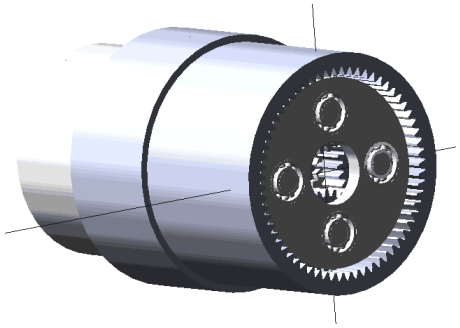


Figure 5. Model after importing ADAMS.

3.2. The exertion of constraints

(i)The planetary frame establishes a rotating pair relative to the frame.

(ii) The sun wheel, planetary gear and inner gear ring are applied with rotating pairs between the planet carrier components, so that they can rotate relative to the planet carrier.

(iii) A pair of gears is applied between the sun wheel, the planetary gear, the planetary gear and the inner gear ring. It is necessary to point out that if gear pairs are applied between three pairs of planetary gear and sun gear and three pairs of planetary gear and inner gear ring, it will lead to

redundant constraints. Therefore, the following treatment: one of the three planetary gears is applied to two gear pairs with the sun wheel and the inner ring; the remaining two planet wheels, respectively, apply a pair of gears to the sun and inner rings, so that the excess constraints can be avoided.

3.3. Dynamic simulation analysis

3.3.1.Operating mode

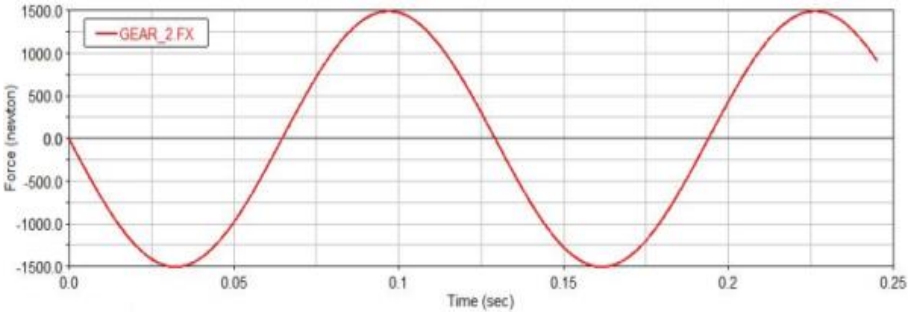
The technical parameters of the electric wrench selected in this paper are shown in Table1. The maximum output torque is 1200N.m, and the output speed is 14rpm. According to the output torque, the system transmission ratio and the transmission efficiency, the input torque of 10N.m is applied on the first stage of the sun wheel, and the speed of 463.8rpm is applied on the first stage of the planet frame.

Table1. Technical parameters of an electric wrench.

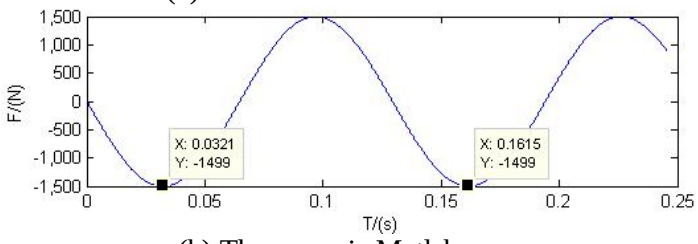
Voltage	Max current	Max power	Frequency	Max torque	Speed	Net weight	Fit bolt	Transmission efficiency
230V 115V	12A 24A	2800 W	50~60 HZ	1200 N.m	14rp m	7.1 KG	M16 (5/8") M20 (3/4") M22 (7/8") M24(1")	62.8%

3.3.2. Dynamic simulation analysis

Taking the first class drive as an example, the force between the planetary gear I and the sun wheel I is analyzed. The direction force of the Y axis and the X axis is shown as shown in Figure 6 (a) and Figure 7 (a). To facilitate the display of its period of motion, the data is drawn and synthesized by Matlab. The results and the dynamic circle force after synthesis are shown in Figure 6 (b), Figure 7 (b) and Figure 8.

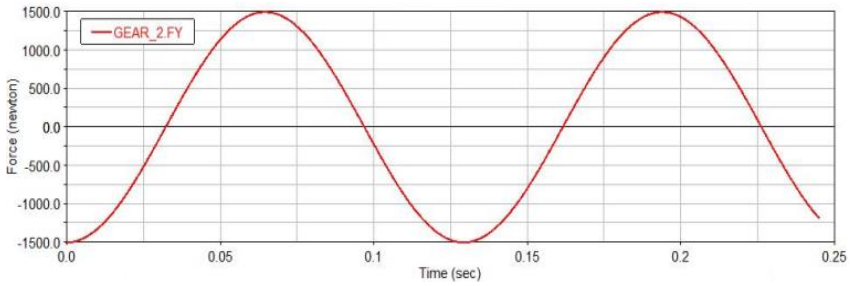


(a) The curve in ADAMS

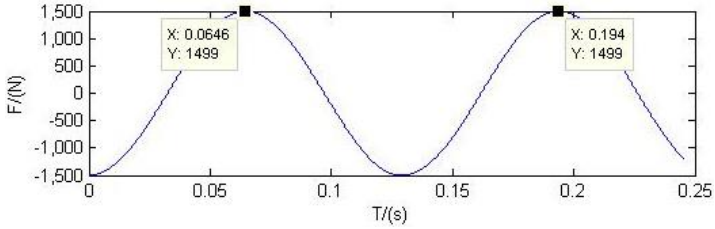


(b) The curve in Matlab

Figure 6. Direction force of X axis.



(a)The curve in ADAMS



(b) The curve in Matlab

Figure 7. Direction force of Y axis.

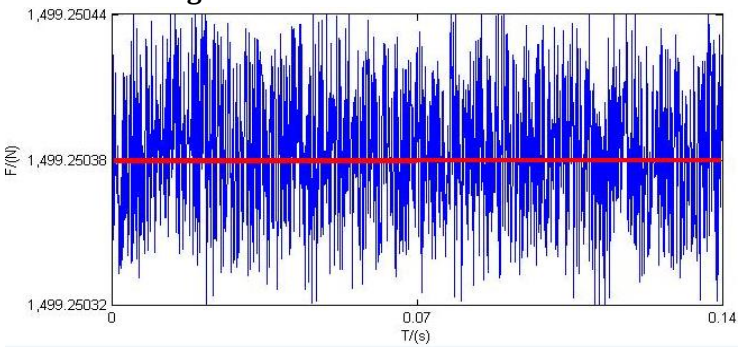


Figure 8. Dynamic circumference force.

3.4. Statics calculation

Using the gear static calculation model [11] (Figure 9 and formula (1)), the circumferential force in static state is calculated.

$$\begin{cases} F_t = 2T_1 / d_1^{'} \\ F_r = F_t \tan\alpha \\ F_n = F_t / \cos\alpha \end{cases} \quad (1)$$

In the formula, The Meshing force, the circumference force and the radial force are respectively Fn, Ft, Fr, T1 is the transfer torque; D1 is the pitch diameter and the alpha is the meshing angle.

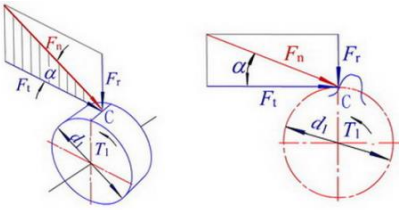


Figure 9. The force of spur gear drive.

According to the requirements of installation, the central distance between the first stage planetary gear I and the sun wheel I is a 19.49mm. According to table 1, the main parameters of the electric spanner planetary gear transmission system and the calculation chart of the pitch diameter of the spur gear (Figure 10). It can be obtained that the pitch diameter of the sun wheel I and planetary gear is D1 '=13.34mm. We have given the input torque T1 of the first stage sun wheel as 10N.m

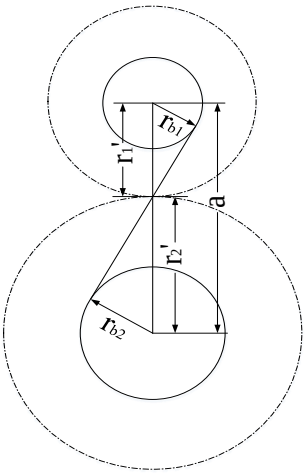


Figure 10. The calculation chart of spur gear' Circle size.

By drag-in the above values into (1), the circumferential force in static state can be obtained.

$$F_t = 2T_1 / d_1 \approx 1499.25038 \text{ N} \quad (2)$$

3.5. Calculation of the motion cycle

According to the speed of the output and the transmission ratio of the transmission system, the speed of stage I planet carrier can be calculated to be 463.8rpm.Therefore, the motion cycle of the first stage planetary gear and the sun wheel is calculated as follows:

$$T = 60 / n = 0.1294 \text{ S} \quad (3)$$

Compared with the result of ADAMS software analysis (the time periods in Figure 6 and 7), the period of theoretical calculation coincide with the period of simulation analysis.

3.6. Comparison of the circumferential force

From Figure 8, it can be seen that the dynamic circle force fluctuates up and down the 1499.25038N, which is in accordance with the 1499.25038N size of the static force calculated by the static force, which is the characteristic of the dynamic change of the cooperative force.

4. Conclusions

Taking the planetary transmission system of the electric wrench as the research object, the dynamics simulation analysis is carried out.

(1) Taking an electric wrench as an example, the composition of the electric wrench is analyzed, and the three-dimensional model of the planetary transmission system of the electric wrench is established by using Solidworks.

(2) The simplified model is imported into ADAMS software, and constraints are imposed according to their matching relationship. According to the load and speed of its working condition, kinematics simulation is carried out to get the dynamic force of X axis and Y axis. The force of these two directions is synthesized by Matlab software, and the dynamic circumferential force is obtained.

(3) The circumferential force in static state is obtained by using the gear static calculation model

and formula. The period of theoretical motion is calculated. The results are compared with the results of dynamic simulation analysis. The results show that the period of theoretical calculation and the period of simulation analysis are consistent. The dynamic circle force fluctuates around the cycle of the static circle force according to the movement cycle, which is in line with the dynamic change of the force.

This study laid the foundation for the next step of the dynamic analysis of the electric spanner planetary transmission system.

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