Analysis on Involute Gear Dynamics Simulation Based on the ADAMS/Engine

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Abstract-**Taking involute spur gear as the investigation subject, the parametric model of involute gear is established by module of ADAMS/Engine, which is set up with oil film fluid dynamics theory. According to the simulation result on the model, the relationship between minimum oil film thickness and gear meshing force is obtained. The relationship between the rotating speeds and the average meshing force is obtained by data compilation in Matlab, and so on to the relationship between the rotating speeds and the max meshing force. It resolves the inadequate of the static calculation method, which did not take into account lubrication and did not reflect relationship between gears meshing force and rotating speeds in time. The results provide references for the accurate checking for gear strength.**

Keywords-ADAMS/Engine, minimum oil film thickness, gear meshing force, Matlab

I. INTRODUCTION

The gear drive is an important aspect in the whole mechanical transmission field. It is developed towards heavy load, high speed, miniaturization, high reliable. Therefore, the gear's bearing capacity needs to be accurately computed. At present the check for the gear strength is resolved by statics theory and contact mechanics, or by the contact finite element method to non-linear contact question.[1] The gear contact model is used to be simulated with the view module in the ADAMS. However, these methods that is based on impact penalty function do not take into account lubricate influence. In the gear drive, especially under having tooth face friction condition, this factor is not neglected.[2]

In this paper, the parametric model of involute gear is established by the ADAMS/Engine module, which is set up with oil film thickness dynamics theory. According to the simulation result on the model, the relationship between minimum oil film thickness and gear meshing force are obtained. Under different rotating speeds the average , max meshing force curve and relation equation are got by the data compilation in matlab.

II. PRIMARY ALGORITHM PRINCIPLE FOR GEAR MESHIING FORCE

In the elastic fluid dynamic lubrication theory, gear meshing force has two parts: gear meshing force rigid part and damping part.[3-5]

$$F = F_g + f_c \tag{1}$$

$$F_g = \frac{4K_g(x - h_0 + h_1)^3}{27h_1^2}$$

$$h_0 - h_1 \le x \le h_0 + 0.5h_1 \tag{2}$$

$$f_c = -Cv \tag{3}$$

Where K_g is the meshing rigidity, h_0 is the total tooth side clearance of two meshing tooth, which is decided by manufacture precision, x is the distance between two meshing tooth face. h_1 is 2 times of single tooth face lubricant oil film thickness , $h = 2h_1$,h is the lubricant film thickness of single tooth face. C is meshing damping, v is gear speed, Figure 1 shows the computation principle for gear meshing force.

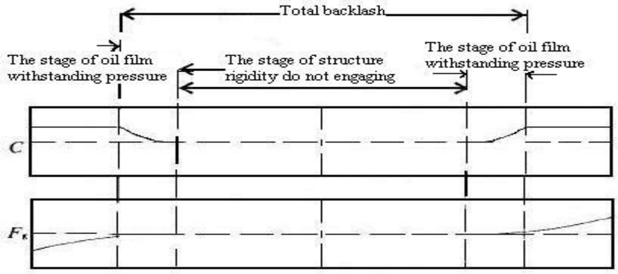

Figure 1. Computation principle of gear meshing force

III. BUILDING MODEL

A. building Gear model

It is generally that the basic Hard Point is established by ADAMS/engine's Template Builder. For the sake of convenient reference Hard Point is as the origin of coordinates. Gear's fixed mount is set up on this foundation, then gears module is established, gear's basic parameter could be corrected in the standard template, like modulus, tooth number, pressure angle, tooth width and so on.

In order to achieve parametric center distance of two gears is set up a function of position which is 0.5*(gear1.pitch_diameter+ gear2.pitch_diameter)[6-7].The distance between two gear's center is adjusted automaticly when the modulus and teeth number have a chang. After model is build, the mutual force between gears is defined as three Phase Gear Force, which decided by Engaging Stiffness, Engaging Damping, Oil-film Thickness. The module function is defined as Major Role.

B. building Drive shaft model

Input Communicator must be set up correctly, Output Communicator must match with Input Communicator. Only in this way, the position of shaft will change along with the gear center distance. And a power dyno1 is defined on a shaft. This template's function is typed as TESTRIG.

C. Gear and axis assembly

As shown in Figure 2, the gear and shaft are assembled in the Engine standard interface and the assembly type is set up as General Assembly

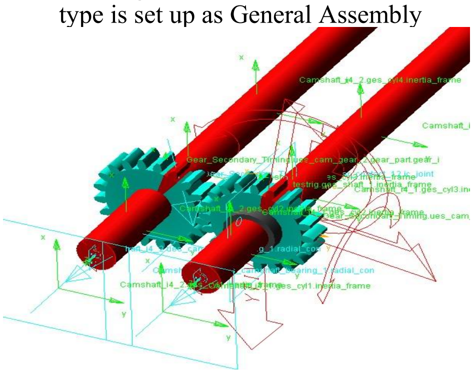

Figure 2. Assembly modeling of gear and shaft

IV. SIMULATIING AND DATA PROCESSING

In setting menu Unit is selected as millisecond, then parameters of simulating type and time are set in toolbar. As shown in Tab.1, two gear parameters were set in order to facilitate calculates.

Simulation steps is set up as 720, simulation time is limited to 60ms, and rotational speed is set up as 4000 rpm, As shown in Figure 3,the gear meshing force changes with obvious cycle.

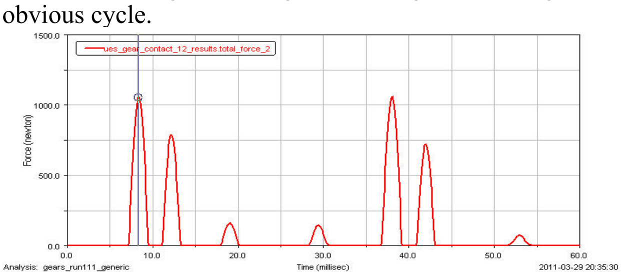

Figure 3. Periodic change curve of gear engaging force

Viewing the results under the postprocessor,it can be seen from Figure 4, in the case of a certain film thickness(from0.02mm to0.1mm), the meshing force changes little, while in the stage of engaging-out, meshing force changes obviously.

Viewing the results under the postprocessor, it can be seen from Figure 5，with the speed increases from 3000 to 5000 rpm , the meshing force has a trend of increase. This is because, with the speed increases, the rotation torque becomes larger, and it is proportional to the tooth surface normal force. However, the curve equation cannot be obtained in the Postprocessor module of ADAMS to quantitatively describe the relationships, it can be fitted in the matlab.

The average meshing forces of different speed are fitted by Quadratic curve in the matlab to get the curve as shown in Figure 6,which shows the relationships between the average meshing force and the rotation speed. The fitting equation is

$$Y=(4.8068e\text{-}005)X^{\wedge}2-0.3274X+641.4631 \quad (5)$$

The maximum instantaneous meshing forces of different speed are fitted by Cubic curve as shown in Figure 7,which shows the relationships between the average meshing force and the rotation speed. The fitting equation is

$$Y=(4.9186e\text{-}008)X^{\wedge}3-(5.3475e\text{-}004)X-1.5949e+003 \quad (6)$$

It can be seen from Figure 6 and Figure 7, with the rotational speed changes, the maximum instant meshing force has a bigger fluctuation than the average meshing force. The gear meshing forces of different speeds can be approximately obtained by these two equations, which is beneficial for the check of the strength of the gear and the improving of the accuracy of calculation. Certainly, the relation equations are different under different modulus, the number of teeth and the angle of pressure.

V. SUMMARIES

(1)A method was explored in this paper. The equation curve of average engaging force and the biggest engaging force with the different rotational speed were obtained by this method based on the elastic fluid dynamic lubrication theory. And this method feasibility is confirmed.

(2) Through analyzing the simulation results, with the different rotational speed, the equations and the relational curves about the average meshing force of gear and the instant max meshing force of gear are obtained in Matlab. This method plays an auxiliary checking role in dynamics calculation.

REFERENCES

[1] Zhou Qin-Yuan. Based on Pro/E and ANSYS gear contact stress finite element analysis [J] Journal of Shenyang Institute of Aeronautical Engineering, 2007.8

[2] Wei Shu-Hua. Study on the design of cylindrical gear reducer based on virtual prototyping technology [D]. Shandong Scientific and technical university, 2006.6

[3] Li Run-Fang, Wang Jian-Jun. Gear systems dynamics ---vibration, impact, noise [M]. Beijing: Scientific Publishing house,1997.

[4] Zou Huai Wu, Shi RuiQiu. Dynamic simulation of Five-Stage Reducer for Ship-Lift with steel rope at Three Gorges project [J]. Journal of Three Gorges college, 2002.10 P434-435

[5] Zhao Yan-Tao, Fan Wen-Xin. Based on ADAMS/ENGINE crankshaft bearing lubrication analysis[J]. Journal of diesel engine design and manufacture, 2009.2 P66-69

[6] Wu Shi-Jin, Hu Jian-Zheng, Wang Xiao-Sun. Simulation Design of axis-fixed transmission gearbox based on ADAMS [J]. Journal of Construction Machinery, 2003.8

[7] Wang Xiao-Sun, Wu Shi-Jing, Hu Zheng-Jian. Parameterized Dynamic Modeling And Simulating of Planetary Transmission [J], Journal of Refrigeration Air Conditioning and Electrical Power Equipment, 2003.2 P58-61

TABLE.1 GEAR'S GEOMETRIC PARAMETER

Gear name	Teeth number (Z)	Module (m)	Gear width (b)	Tooth angle (α)	Addendum factor (ha^*)
gear 1	20	4	20	20	1
gear2	20	4	20	20	1

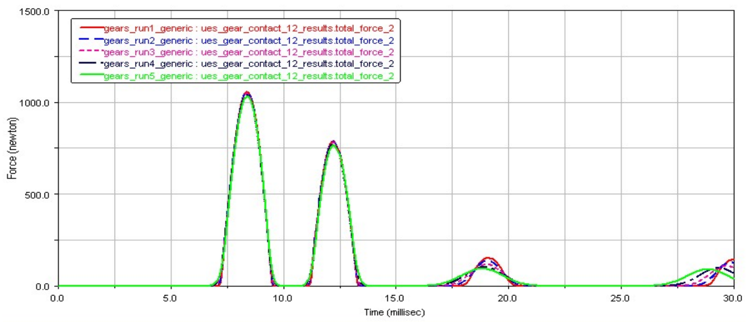

Figure 4. Curve of gear engaging force under different lubricant film thickness

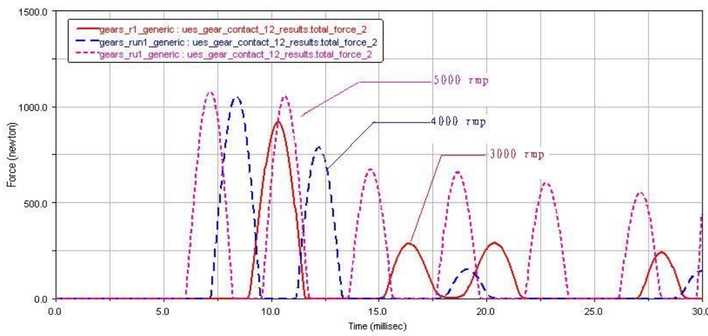

Figure 5. Curve of gear engaging force under different rotational speeds

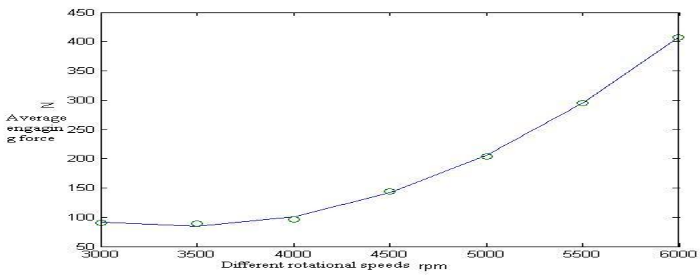

Figure 6. The curve of gear dynamic meshing force

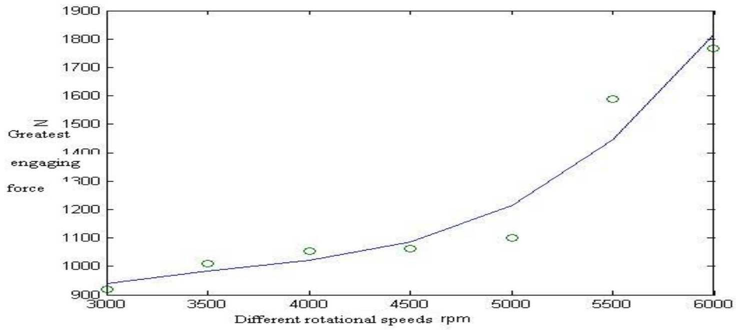

Figure 7. The curve different rotational speeds gear instant max meshing force