Motion simulation design of crank-connecting rod mechanism of automobile engine

Sui Zhang¹, Qiang Ma², Liang Zhang³, Hao-chuan Wan¹, Ren-qi He¹, Tun-xu Tan¹

¹. School of Robotics Engineering in Yangze Normal University, Fuling in Chongqing 408100;
². Chongqing Tiema Gearbox Co., Ltd. Jiulongpo in Chongqing, 404100;
³. Shaanxi Railway Passenger Transport Service Co., Ltd. Xi'an in Shaanxi 710016

Email address of the first author: 20140025@yznu.edu.cn

Abstract. In this paper, the crank-connecting rod mechanism of Santana 2000AJR automobile engine is modeled by UG8.0 software with CAD technology, and then the motion simulation module is used to create the motion drive. After pre-processing and post-processing, the motion simulation design of the crank-connecting rod mechanism is completed. In the development of automobile, the motion simulation technology can simulate the motion law of crank-connecting rod mechanism and replace the complicated physical experiments in practice, shorten the calculation cycle and cost, and lay a foundation for optimizing the design of crank-connecting rod mechanism.

1. Preface
Since 2008, China's automobile production industry has been the largest in the world, and the engine, as the core of automobile development, plays a very important role in the development of automobile industry. But technically, we are always restrained by others, whether it is engine, gearbox, chassis system, etc. The simulation design of crank-connecting rod mechanism is a key link in the development of automobile engine. CAD/CAE technology has been widely used in mechanical, aerospace and electronic industries, which plays a vital role in the design and motion simulation of crank-connecting rod mechanism.

2. Motion simulation technology based on UG
CAE module is a motion simulation analysis tool of UG, which is mainly used to predict and verify the motion characteristics of mechanism with software before prototype trial production. Through CAE module, we can analyze the interference of the mechanism, track the movement track of parts, carry out motion simulation and strength analysis, and optimize the movement mechanism by using the changes of displacement, coordinates, acceleration, speed and force of the graphic output parts. UG software is embedded with ADAMS system solver, which can conveniently simulate the motion of the model. UG motion simulation module is the main component of UG simulation analysis and an important tool for mechanical mechanism simulation. It can be used to simulate the mechanism motion principle, analyze the mechanism assembly interference, perform kinematic analysis on the mechanism displacement, velocity and force, and output the analysis results. Through the analysis and research of the output results, the mechanical structure design and functional design can be optimized.
3. Three-dimensional modeling of crank-connecting rod mechanism
UG NX software integrated with CAD/CAE function is used to model, and its general process is as follows:
(1) Entering the model drawing environment;
(2) Drawing a two-dimensional sketch;
(3) Based on two-dimensional sketch, create relevant three-dimensional features and get three-dimensional drawings of each part\(^3\).

3.1. Three-dimensional modeling of piston
Through a series of drawing steps, the piston three-dimensional model diagram in Figure 1 below is obtained.

![Figure 1. Three-dimensional model of piston](image)

3.2. Three-dimensional model of connecting rod and crankshaft (as shown in Figure 2 and Figure 3)

![Figure 2. Three-dimensional model diagram of connecting rod](image)
3.3. Assembly drawing of crank-connecting rod mechanism
As shown in Figure 4 below, it is the assembly drawing of crank-connecting rod mechanism.

4. Motion analysis of UG
UG (Unigraphics NX) has very powerful performance in motion simulation, which can directly apply the assembly files of the model and create motion simulation under different conditions without interfering with the assembly of the main model \cite{5}. The following is the process of motion simulation analysis of crank-connecting rod mechanism based on UG CAE module.

4.1. Analysis pretreatment
Pre-processing: (1) Creating connecting rods; (2) Create a cloud pair; (3) Defining motion drive; (4) Solving. In this stage, the input data information is processed by the settlement machine, so as to obtain the internal output data information, which is then transmitted to the motion simulation module.

Post-processing: in this process, the output information of the settlement machine is mainly interpreted by the motion simulation module, and then converted into animation, charts and reports.

4.2. Result analysis
Under the dynamic environment, the model detection results obtained by the solver (Recurdyn) have no errors or warnings. As shown in Figure 5.
Figure 5. Test report

Under unsteady driving, adjust the time to 30 and the number of steps to 600, which can be selected as the default value, and then click "OK" button to generate the name Solution 1. The specific information is shown in Figure 6.

Figure 6. Solution 1

As far as the movement situation is concerned, the movement is smooth without interference. The linear motion of the piston can be converted into the rotary motion of the crankshaft. It shows that the designed crank-connecting rod mechanism meets the requirements. Take the curve of parameters changing with time when the big end center of connecting rod moves around crank as an example.

The acceleration function is processed for the movement of the big end of the connecting rod and the rotating pair J001 of the crank. The process is shown in Figure 7 and Figure 8.
By processing the angular acceleration of the crankshaft, we can observe the movement of the connecting rod big end of the crank-connecting rod mechanism during acceleration and deceleration, as shown in the following Figures 9, 10 and 11.
Figure 11. Time image of angular acceleration

CAE module in UG can not only provide data analysis of the mechanism movement process, but also visually display the movement state of each part. The most important thing is that its interference checking function can quickly find out the interference phenomenon existing in the movement process of each mechanism, which provides a reliable and quick checking method for designers. Through the repeated operation of "simulating motion, modifying design and dynamic simulation", the mechanism design scheme can be continuously improved, the reliability of mechanism design is improved, and the work efficiency is greatly improved\(^{6}\)\(^{7}\).

5. Summary

This project is based on UG software to simulate the motion of crank-connecting rod mechanism of Santana 2000AJR engine, and its ultimate goal is to use virtual software technology to simulate the actual motion of crank-connecting rod mechanism of engine. Therefore, the physical experiment in reality can be replaced by the motion simulation experiment, which can save the cost and shorten the research and development cycle. With the continuous development of the automobile industry, there are more and more types of engines, which means that the motion of the crank-connecting rod mechanism of the engine and the motion environment become more complex. Therefore, this study also provides the necessary reference for the design of the crank-connecting rod mechanism.

References

[1] Lv Dong. Research on the development strategy of China's own brand automobile [D]. Hubei university of technology, 2011.
[2] Bai Xugui. Study on the formation mechanism of independent innovation capability of automobile manufacturing enterprises in China [D]. Jilin university, 2010
[3] Wang Haiyang. Modeling and Motion Simulation of Automobile Differential Based on UG [D]. North China Electric Power University, 2013.
[4] Mao Xingfei. 3D design and simulation analysis of automobile main reducer based on UG [D]. North China Electric Power University, 2011.
[5] Zhong Qi, Li Junwen, Xiao Shanhua, Han Lixi, Wang Jun. UG NX 8.0 Example Tutorial [M]: 2014.04
[6] Liu Peng. Application of CAD/CAE technology in large injection mold design [D]. Qingdao University of Science and Technology, 2009.
[7] Xiong Julu. Squeeze casting die design and motion simulation based on UG [D]. Wuhan University of Technology, 2005.