Finite Element Analysis of Static Linkage of Engine Connecting Rod Based on Algor

Chunming Xu1,2 Bowen Luo 1,a *

1 Key Laboratory of Metallurgical Equipment and Control Technology, Ministry of Education, Wuhan University of Science and Technology, Wuhan 430081, China.
2 Hubei Key Laboratory of Mechanical Transmission and Manufacturing Engineering, Wuhan University of Science and Technology, Wuhan 430081, China.
342430046@qq.com
378401869@qq.com

Abstract. The finite element static analysis software Algor is used to simulate and analyze the engine connecting rod, and the distribution diagram of the change of stress and displacement is obtained. Theoretically, the force analysis of engine connecting rod is carried out, which provides a necessary theoretical basis for further structural design and optimization of engine connecting rod.

1. Introduction

Algor is a world famous large-scale finite element simulation software, is widely used in product design and development of various industries, it can simulate all kinds of phenomena, such as the structure of static and dynamic, fluid, heat conduction, electromagnetic field, pipeline process design, can also help the design analysis of various personnel forecast and test in the real under the condition of high speed and low cost, complete the design project is safer and more reliable[1]. Algor has a good reputation for its complete analysis, easy operation and low requirements for hardware.

It is well known in the design and analysis of science and technology workers. As one of the representatives of CAE analysis tools, Algor has been widely applied in many fields, such as ship, automobile, aerospace, machinery, electronics, medicine, daily necessities, military, petrochemical industry, large scale building, MEMS, and many other fields. In this paper, I take the engine connecting rod as the research object, and through the Algor finite element analysis software, the static finite element analysis of the engine connecting rod is carried out.

2. Static theory analysis of engine connecting rod

The description of the problem: Working load: exerting force along the axial direction of the connecting rod at the center hole of the connecting rod D4; boundary condition: the constraint is imposed on the D2 hole formed by the connecting rod and the connecting rod cover. The purpose and content of the analysis - static analysis: stress and deformation under load, strength checking and stiffness analysis. Model creation process. The geometric model can be done by Solidworks[2], and the model can be simplified properly to simplify the holes, to reverse the corner and to the right angle, and to simplify the model. Write the whole process of modeling in detail, including the commands used. It shows the characteristics of stress and displacement distribution, the maximum stress value and its location, the maximum
3. The force analysis of the connecting rod

3.1 The acceleration of the crank connecting rod mechanism.

Figure 1 shows a schematic diagram of the crank linkage mechanism[4-5]. From Figure 1, it can be seen that the piston displacement formula is:

\[ X = R + L \cos \beta - R \alpha \]

\( \alpha \) is the crank angle; \( \beta \) is the angle at which the connecting rod axis deviates from the cylinder centerline in its oscillating plane. At the same time, let the ratio of the crank radius to the length of the connecting rod be \( \lambda \), That is \( \lambda = \frac{R}{L} \). The equation (1) can be transformed into

\[ X = R (1 - \cos \alpha) + L(1 - \sqrt{1 - \lambda^2 \sin^2 \alpha}) \]

The acceleration of the piston is obtained from the displacement formula. According to the binomial theorem, take the first two steps to simplify the original equation:

\[ a = R \omega^2 \cos \alpha + R \omega^2 \lambda \cos 2\alpha \]

4. Finite Element Analysis of Connecting Rods

I first draw the part drawing of the connecting rod with SolidWorks 2013[6-8]. The connecting rod body is shown in Figure 2, and the connecting rod cover is shown in Figure 3.
Assemble parts drawing to get 3D model entity assembly drawing. Three-dimensional model entity assembly diagram shown in Figure 4.

Algor provides a good file association, which can be directly entered into Algor software through SolidWorks and select linear static stress analysis. Define the attributes[9-10], select the "block" unit type, and select material AISI4310 (40CrMo). Through look-up table, we can see that the elastic modulus $E=206840 \text{ N/mm}^2$, Poisson's ratio $\nu=0.3$, shear modulus of elasticity $G=79565\text{ MPa}$, the density is $7822\text{ kg/m}^3$. As shown in Figure 5.
Figure 5 Attribute definition
Mesh division, connecting rod and cover division results, as shown in Figure 6.

Figure 6 Linkage meshing Constraints and loads applied to the finite element model
Load F=1500N is applied to the axis of the connecting rod and Impose constraints. The resulting model is shown in Figure 7.
Figure 7 Load and constraint imposed model

Enter the analysis module, and the analyzed displacement cloud is shown in Figure 8. As can be seen from the figure, the maximum displacement is 0.007968681 mm and appears at the right end of the shaft. According to the material mechanics, it can be judged that the maximum displacement should appear at the right end, indicating that the analysis result is reasonable.

Figure 8 Displacement cloud chart of connecting rod

The von Mises stress cloud is shown in Figure 9.
The direction of the maximum principal stress trace is shown in Figure 10.

5. Conclusion
The yield strength of the connecting rod material 40CrMo is 420MPa. Through material mechanics analysis and finite element analysis, it is concluded that the displacement cloud map and stress cloud map of the working shaft are reasonable. The maximum displacement is 0.007968681mm, and the maximum stress is 13.0594MPa. Therefore, the structure of the connecting rod can meet the requirements of the work.

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