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Simulation and Experimental Study on Dynamic Response of Crank-Slider Mechanism with Clearance Joints of Different Materials

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Abstract: **From the simulation and experiment, the dynamic characteristics of crank-slider mechanism with clearance joints of different materials are studied. The dynamic simulation of the crank-slider mechanism with clearance joint is carried out by using three-dimensional simulation software. The effect on the dynamic response of the mechanical system of clearance joint with different materials is studied. The dynamic characteristics of crank-slider mechanism with different materials are studied by using the physical experiment platform. The results show that the clearance joint of different materials has an influence on the dynamic characteristics of the crank-slider mechanism.**

Key words: Crank - Slider Mechanism; Dynamics; Experiment; Material

1. INTRODUCTION

With the rapid development of science and technology, modern machinery develops towards high-speed and high-precision. The requirements of the mechanical system also develops toward functional diversification and task complexity. Therefore, the factors that need to be discussed in depth are increasing. High-precision, high efficiency, high reliability and high service life and other issues of the mechanical system has become the focus on research to improve and develop machinery manufacturing equipment.

In the mechanical system, due to processing, installation and other factors, the clearance is inevitable. And because of the existence of the clearance, there are line or point contact between two contact bodies besides the ideal surface contact, which makes the ideal low-hinge hinge connection probably become a vice-hinge vice. Thus the accuracy, efficiency, reliability and service life of the mechanism are affected. Therefore, the study of the clearance joint problem has important theoretical and engineering value. Flores [1-3] designed and built a crank-slider mechanism test rig, and studied the effects of the clearance size and the crank speed on the dynamic response of the joint by means of calculation and experiment. And a new constraint method was proposed to analyze the dynamic characteristics of the mechanical system with a clearance lubrication joint. Xu [4-5] analyzed the effect of the joint clearance on the dynamic response of mechanical system, and took the crank-slider mechanism for example to analyze the dynamic response of the mechanical system with clearance joint when both joints are non-ideal hinges. Mukras S [6-8] deduced the dynamic model of the clearance hinge under wear, and the crank-slider mechanism was used as an example to make a testing machine to validate the prediction of joint wear.

This paper takes the crank-slider mechanism as an example to analyze the dynamic response of the crank - slider mechanism with clearance in different materials and study the influence on the dynamic characteristics of the crank-slider mechanism with clearance joints with different materials by the combination of simulation analysis and physical experiment.

2. SIMULATION ANALYSIS OF THE CRANK-SLIDER MECHANISM

The three-dimensional model of the crank-slider mechanism is established and the model is imported into the three-dimensional simulation analysis software to simulate the crank-slider mechanism dynamics. The parameters of the crank slider mechanism are shown in the following table. By changing the material of the connecting rod in the crank-slider mechanism, the influence of the clearance joint with different materials on the crank-slider mechanism is analyzed.

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Table 1 The parameters of crank-slider mechanism

Parameters	Value
The length of crank	50mm
The length of connecting rod	220mm
The radius of joint pin	10mm
The radius of joint bushings	10.1mm
Joint clearance	0.1mm
Material of crank	Steel
Material of connecting rod	Steel Aluminum
Elastic Modulus	210GPa、71.7GPa
Poisson's ratio	0.29、0.33
Contact stiffness	7.981×10^{10}N/m

As shown in the following figure, it is the dynamic simulation result of the crank-slider mechanism with clearance. Fig.1 shows the acceleration of the slider at different crank speeds when the material of the connecting rod is steel. The speed of the crank in Fig(a) is 100rpm and the speed of the crank in Fig(b) is 150rpm. Fig.2 shows the acceleration of the slider at different crank speeds when the material of the connecting rod is aluminum. The speed of the crank in Fig(a) is 100rpm and the speed of the crank in Fig(b) is 150rpm.

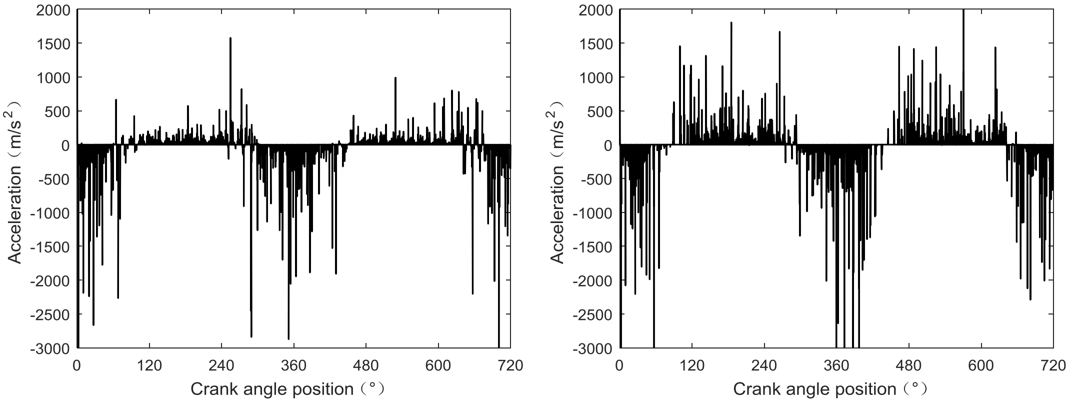

Fig.1 The acceleration of the slider at different crank speeds when the material of the connecting rod is aluminum (a)100rpm (b)150rpm

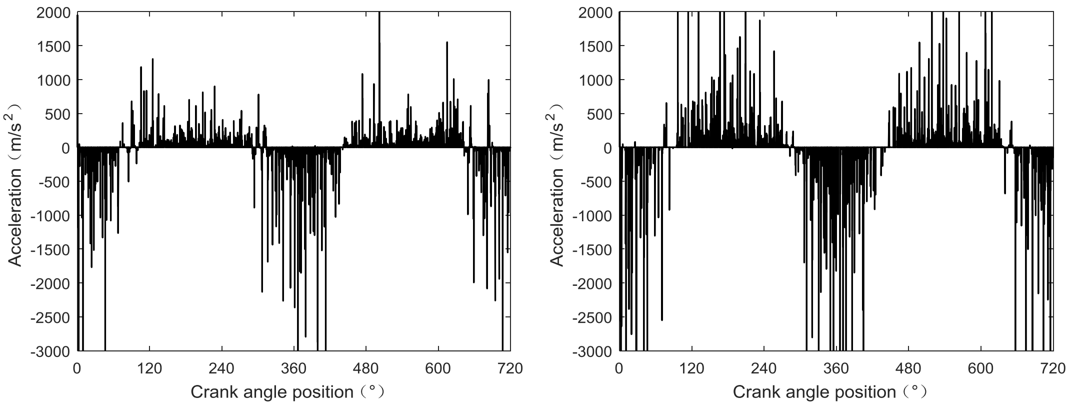

Fig.2 The acceleration of the slider at different crank speeds when the material of the connecting rod is steel (a)100rpm (b)150rpm

As can be seen by comparing Figures 1 and 2, it can be found that the crankshaft impact in Fig. 2 is large in Fig. 1, that is, when the connecting rod material is aluminum, the motion stability of the crank-slider mechanism is worse than that when the connecting rod material is steel. The crankshaft impact in Fig. (a) is smaller than that in Fig. (b), that is, the rotational speed has an influence on the dynamic response of crank-slider mechanism. The higher the crankshaft speed is, the worse the kinematic stability of the mechanical system is. And the dynamic response law of crank slider mechanism of different materials is consistent.

3. EXPERIMENTAL STUDY OF THE CRANK-SLIDER MECHANISM

By using the crank-slider mechanism test rig, the dynamics experiment of the crank-slider mechanism with clearance joint was carried out. By changing different materials of the connecting rods, the effects of clearance joint with different materials on the dynamic response of the crank-slider mechanism are studied.

As shown in the following figure, it is the dynamic simulation results of the crank-slider mechanism. Fig.3 shows the acceleration of the slider at different crank speeds when the material of the connecting rod is steel. The speed of the crank in Fig(a) is 100rpm and the speed of the crank in Fig(b) is 150rpm. Fig.4 shows the acceleration of the slider at different crank speeds when the material of the connecting rod is aluminum. The speed of the crank in Fig(a) is 100rpm and the speed of the crank in Fig(b) is 150rpm.

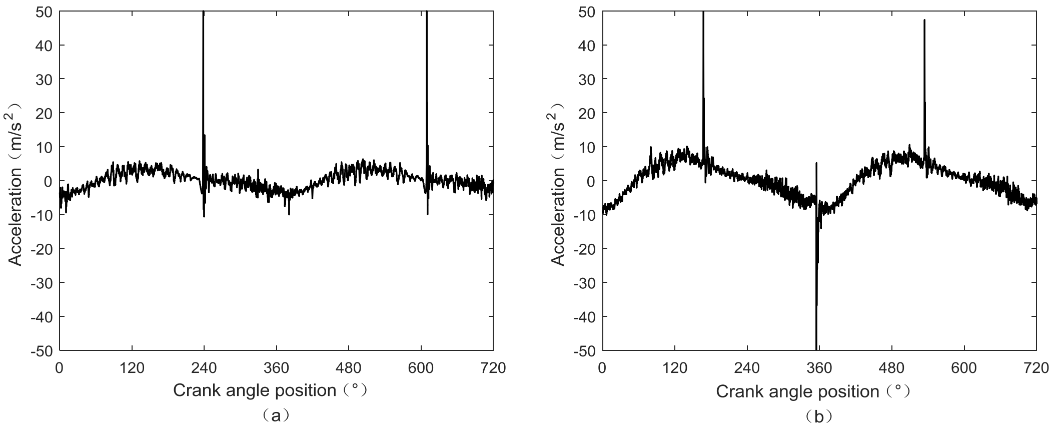

Fig.3 The acceleration of the slider at different crank speeds when the material of the connecting rod is steel (a)100rpm (b)150rpm

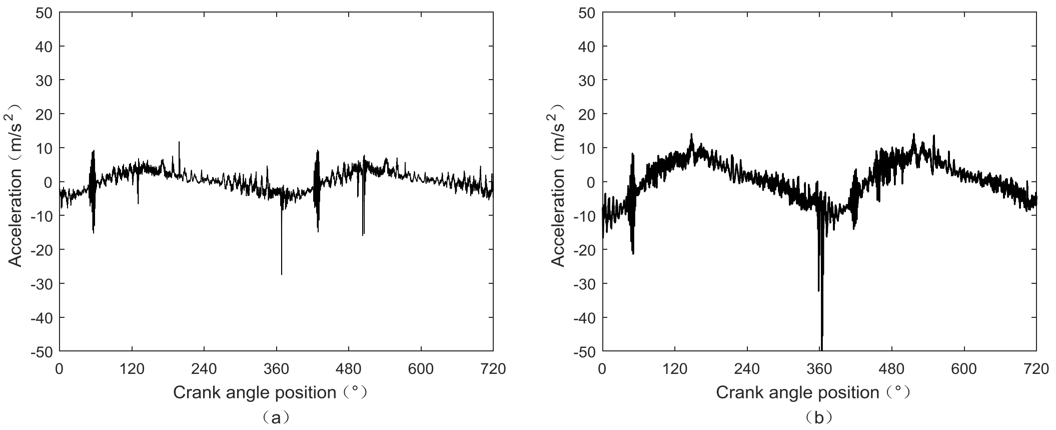

Fig.4 The acceleration of the slider at different crank speeds when the material of the connecting rod is aluminum (a)100rpm (b)150rpm

It can be seen from Fig. 3 and Fig. 4 that the peak value of the curve impact in Fig. 3 is higher than the curve in Fig. 4, but the overall fluctuation of the curve in Fig. 4 is larger than that in Fig. 3, that is, when the connecting rod material is aluminum, the motion stability of the crank-slider mechanism is lower than that when the connecting rod material is steel. The crank acceleration curve at 150rpm is larger than that at 100rpm, that is, the crankshaft speed has an effect on the dynamic response of the mechanical system. The higher the rotational speed is, the worse the stability of the mechanical system is. And the dynamic response law of crank-slider mechanism with different materials is the same. The experimental results are in agreement with the simulation results, that is, the material of the connecting rod and the speed of the crank have an influence on the dynamic response of the crank-slider mechanism.

4 CONCLUSION

The presence of clearance joint can affect the accuracy, reliability, and service life of mechanical systems. This paper takes the crank-slider mechanism as an example to study the dynamic response of crank - slider mechanism with different materials by simulation and experiment. The simulation and experimental results show that the material of the connecting rod and the speed of the crank have an influence on the dynamic characteristics of the crank-slider mechanism.

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