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DESIGN, MODELING, AND MOTION SIMULATION OF VEHICLE WINDSHIELD WIPERS

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ABSTRACT

Analyzing the working principle of automotive windshield wipers, designing and calculating the crank rocker mechanism, and modeling and assembling using Solidworks. Importing the models created in Solidworks into ADAMS software for motion simulation. Through observing the simulation process, it was found that there was no interference between the two wiper blades during the simulation and the operational conditions met the design requirements. The left wiper blade achieved a wiping area of 0.198m^2, while the right wiper blade achieved a brushing area of 0.297m^2. The simulation provided motion data for the wiper blade, including centroid velocity, acceleration, angular velocity, and angular acceleration, revealing the periodic motion characteristics of the wiper blade. (10pt Times New Roman, Justified).

KEYWORDS: Wiper, Modeling, ADAMS, Motion Simulation

1. INTRODUCTION

Whether the windscreen is convenient for the driver or not is essential for the safe driving, thus the windscreen wiper is one of the important equipment of automobile [1]. The main function of windshield wipers is to sweep away rain, snow, dust, and other obstacles on the windshield and rear window that obstruct visibility, in order to ensure a clear view and maintain driving safety.

The windshield wiper mechanisms are vehicle-specific systems [2], which includes components such as an electric motor, worm gear reducer, planar four-bar linkage, wiper arm pivot shaft, and wiper blade assembly. For planar four-bar mechanism, when the sum of shortest and longest rod is less than or equal to the sum of other two rods, the mechanism exists crank [3]. Crank rocker mechanism is a common mechanism, widely used in sewing machine, mixer, adjustment mechanism on the radar, shaper and other equipment, which can make the whole week rotary motion into reciprocating swing, also can make reciprocating swing into rotary motion [4].

Because the crank rocker mechanism with large bearing capacity and the use of the quick return characteristics can improve the production efficiency and other advantages, it has been widely used in mechanical engineering [5]. In mechanism design, the requirements of follower mechanism must satisfy a certain motion law, which requires the necessary analysis of mechanism motion [6]. There are many ways to analyze the mechanism motion law, and common analysis method is a graphical method and analytical method. However, the graphic method design has characteristics of low precision and time consuming, and computing workload of analytical method is big, which must deal with the aid of computer programming [7]. When addressing the motion of machine parts, machines and equipment, it is first necessary to create a kinematic model [8].

ADAMS (Automatic Dynamic Analysis of Mechanical Systems) is a mechanical system dynamic analysis software based on virtual prototyping technology, which integrates modeling, simulation, and visual post-processing techniques. With the help of ADAMS software, it is possible to conduct kinematic analysis on completed mechanical systems, obtaining parameters such as motion trajectory, velocity, acceleration, and more. In this paper, using the ADAMS simulation software platform, the kinematic simulation analysis of the crank rocker mechanism in the planar four-bar linkage mechanism of the car windshield wiper is carried out. Detailed

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motion parameters of the wiper blade are obtained, and the existence of interference phenomenon is analyzed and observed. The goal is to achieve a reasonable design structure, increase the wiping area of the windshield wiper, and improve the safety and comfort of driving in rainy conditions.

2. DESIGN OF CRANK ROCKER MECHANISM

The introduction of the windshield wiper model mainly focuses on the linkage mechanism. The most commonly used and relatively simple linkage mechanism is the four-bar linkage, of which the windshield wiper utilizes a type called the crank-rocker mechanism. When the car windshield wiper is in operation, it is powered by an electric motor that drives a worm gear mechanism to reduce speed. The worm wheel then drives the crank, which in turn drives the crank-rocker mechanism. The motion law of four-bar mechanism is totally dependent on the length ratio of four bars [9]. By conducting dimension structural design and motion analysis of the crank-rocker mechanism, it can be determined whether the windshield wiper meets the requirements of use.

According to the design requirements of the windshield wiper, the initial position of the rocker arm should meet a certain angle. A too small starting angle can cause interference between the two wiper arm supports. The swinging angle of the wiper should not be too large, as an excessively large wiper angle would exceed the area of the windshield. At the same time, the swinging angle should not be too small, as a too small swinging angle would result in a smaller wiping area of the wiper, which does not meet the usage requirements.

Assuming a swinging angle of 80° and an initial angle of 15° for the wiper arm. According to the installation dimensions of a certain car, the distances between the crank and the left and right rocker arms of the wiper are 200 mm and 240 mm, respectively. The length of the left wiper blade is 400 mm, while the length of the right wiper blade is 600 mm. Both the left and right wiper blade supports measure 360 mm. The connecting rod length between the left and right wiper blade supports is 440 mm. When the crank turns around, there will be two particular positions for the crank and the rocker [10]. These are the two limit positions of the motion of the crank rocker mechanism, namely the collinear positions of the crank and connecting rod, which are the dead points of the mechanism. The location map is shown in Figure 1.

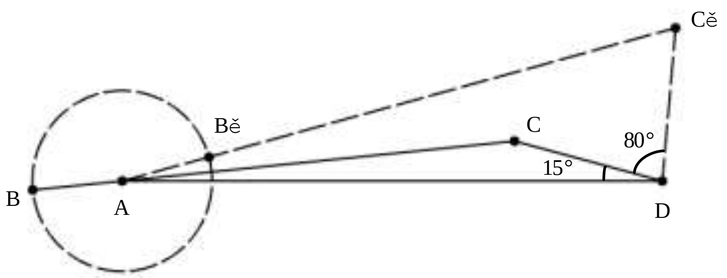

Fig.1 Schematic diagram of the extreme positions of the crank rocker mechanism

Assuming the crank as the active component to do constant velocity rotation, rocker as the follower to swing back and forth, the crank is strictly shortest [4]. Take the crank AB as 40mm, and calculate the parameters of connecting rod BC and rocker CD according to the position of the mechanism in Figure 1. According to the law of cosines for triangles, the following equation can be obtained:

$$cos\ 15^{\circ} = \frac{240^2+CD^2-(BC-40)^2}{2\times240\times CD} \quad (1)$$

$$cos\ 95^{\circ} = \frac{240^2+CD^2-(BC+40)^2}{2\times240\times CD} \quad (2)$$

In conclusion, according to the calculation, the length of the connecting rod BC is 215mm and the length of the rocker CD is 68mm. The overall dimensions of the windshield wiper's crank-rocker mechanism are chosen as shown in Figure 2.

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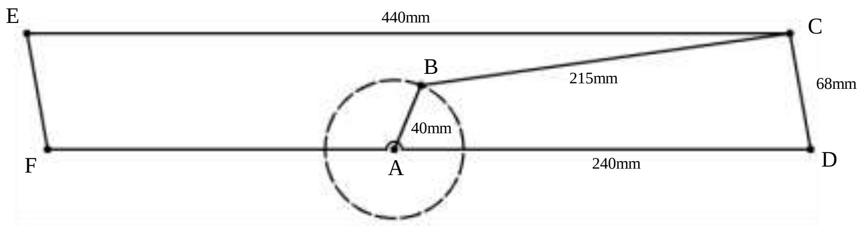

Fig.2 Dimension diagram of the windshield wiper

3. ESTABLISHMENT OF PHYSICAL MODEL

2.1 Model establishment and simulation settings

Create simplified 3D models of various components of the wiper in SolidWorks, including the frame, crank, connecting rod, right rocker arm, right wiper, left rocker arm, left wiper, and middle rod. Assemble the 3D models of the components and apply constraints. Import the simplified 3D model into ADAMS software and convert the view mode of the wiper. The resulting graphics are shown in Figure 3.

Fig.3 Wiper model

2.2 Adding constraints and drivers

Before conducting the simulation, it is necessary to add motion constraints and drivers to the geometric model imported into ADAMS. The specific steps are as follows:

Adding motion constraints: First, add fixed constraints between the chassis and the ground, the left rocker arm and the left wiper, and the right rocker arm and the right wiper. The ground is a part automatically created by ADAMS. Then, create rotational constraints perpendicular to the geometric plane between the chassis and the crank, the crank and the connecting rod, the connecting rod and the right rocker arm, the connecting rod and the middle rod, the right rocker arm and the chassis, the left rocker arm and the middle rod, and the left rocker arm and the chassis.

Adding drivers: In this crank-rocker mechanism, the driving component is the crank, so add a rotational driver in the vertical geometric plane for the crank.

The model after adding constraints and drivers is shown in Figure 4.

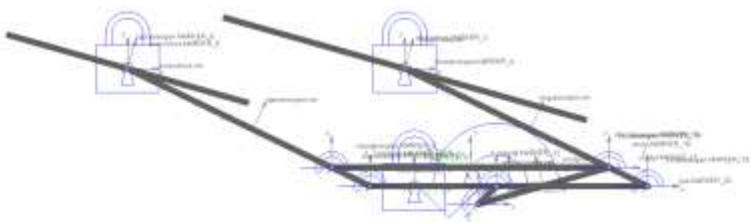

Fig.4 Constraint graph of crank rocker mechanism

2.3 Conduct simulation

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After adding constraints and drivers, the simulation settings are configured with a simulation time of 8 seconds and a time step of 0.001. Click the start button to observe the simulation motion process. By using the function calculation, the sweeping area of the left wiper blade is determined to be 0.198m^2, and the sweeping area of the right wiper blade is 0.297m^2. The sweeping areas of the wiper blades are shown in Figure 5, with the gray area representing the sweeping area of the left blade and the black area representing the sweeping area of the right blade.

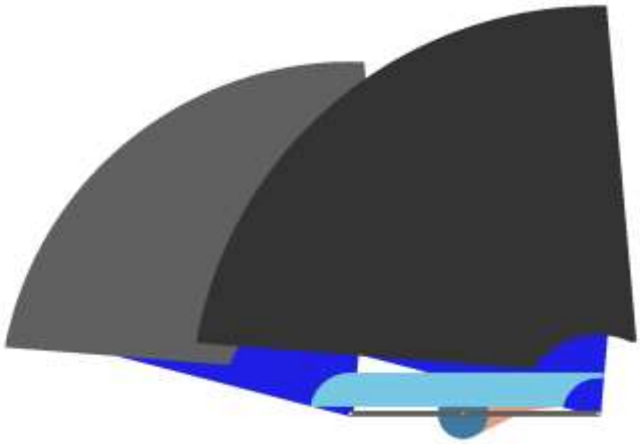

Fig.5 Diagram of the wiping area of the wiper blade

After the motion simulation is completed, enter the post-processing module.

4. ADAMS result analysis

By conducting kinematic simulation of the wiper, the ADAMS post-processing module can be used to obtain the changing characteristics curves of the velocity, acceleration, angular velocity, and angular acceleration of the wiper blades in three axes, as shown in Figures 6-9. By analyzing these characteristic curves, we can determine the trends of various motion parameters and assess the rationality of the mechanism design.

During the observation of the simulation process, it is important to check whether there is any motion interference when the wiper operates in real-world conditions. Motion interference can lead to component damage, so determining if interference occurs is a crucial criterion for evaluating the rationality of the mechanism design in question.

As shown in Figure 6, the maximum velocities of the wiper blade's center of mass in the positive and negative directions of the x-axis are 551mm/s and 535mm/s, respectively. In the positive and negative directions of the y-axis, the maximum velocities are 537mm/s and 399mm/s, respectively. There is no movement in the z-axis direction for the wiper blade. The magnitude of the combined velocity ranges from a maximum of 658mm/s to a minimum of 0mm/s.

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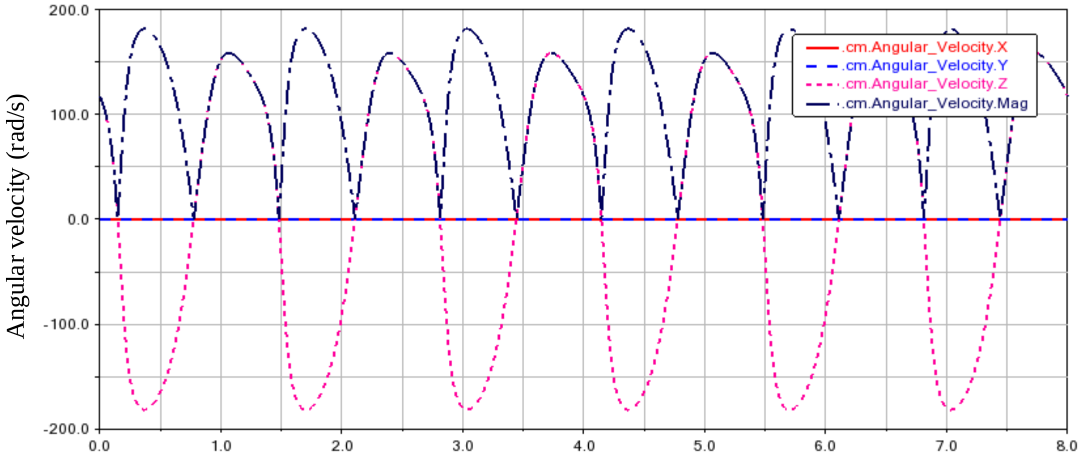

Fig.6 Wiper blade center of mass velocity curve

As shown in Figure 7, the maximum accelerations of the wiper blade's center of mass in the positive and negative directions of the x-axis are 2364mm/s² and 3450mm/s², respectively. In the positive and negative directions of the y-axis, the maximum accelerations are 6659mm/s² and 1967mm/s², respectively. There is no acceleration in the z-axis direction for the wiper blade. The magnitude of the combined acceleration ranges from a maximum of 6911mm/s² to a minimum of 1297mm/s².

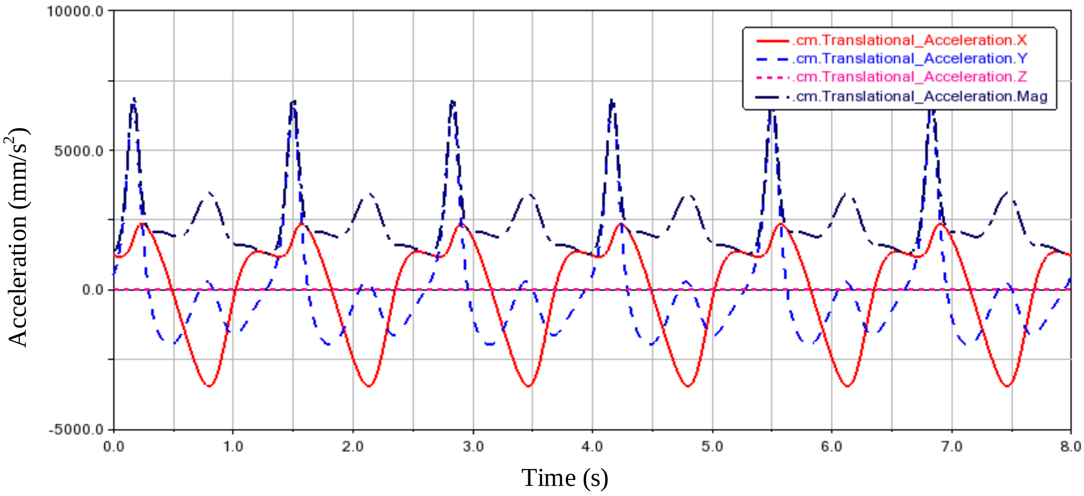

Fig.7 Wiper blade center of mass acceleration curve

As shown in Figure 8, the center of mass of the wiper blade has angular velocities of 0rad/s in both the positive and negative directions of the x-axis and y-axis. In the positive and negative directions of the z-axis, the maximum and minimum angular velocities are 159rad/s and 182rad/s, respectively. The maximum combined angular velocity is 182rad/s, while the minimum is 0rad/s.

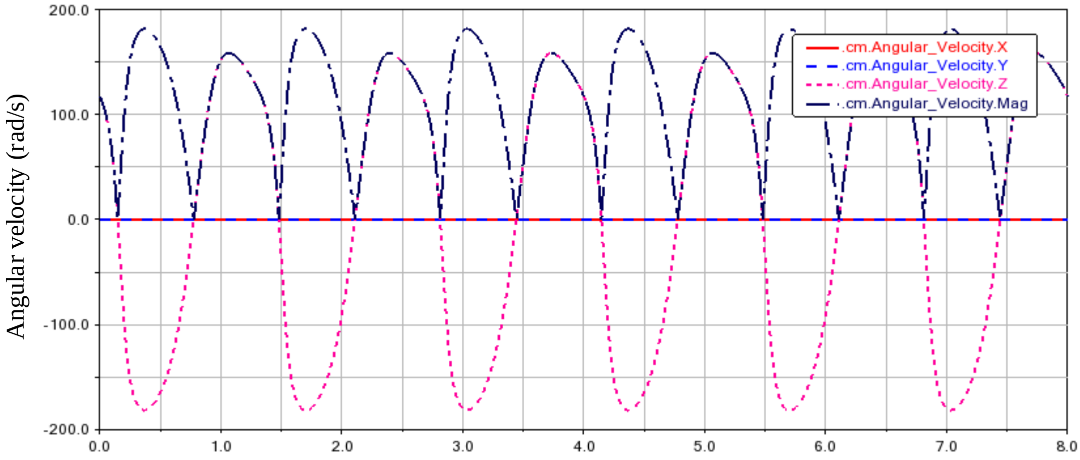

Fig.8 Wiper blade center of mass angular velocity curve

As shown in Figure 9, the center of mass of the wiper blade has no angular acceleration in the x-axis and y-axis directions. In the positive and negative directions of the z-axis, the maximum and minimum angular accelerations are 956rad/s² and 1909rad/s², respectively. The maximum and minimum values for the combined angular acceleration are 1909rad/s² and 0rad/s², respectively.

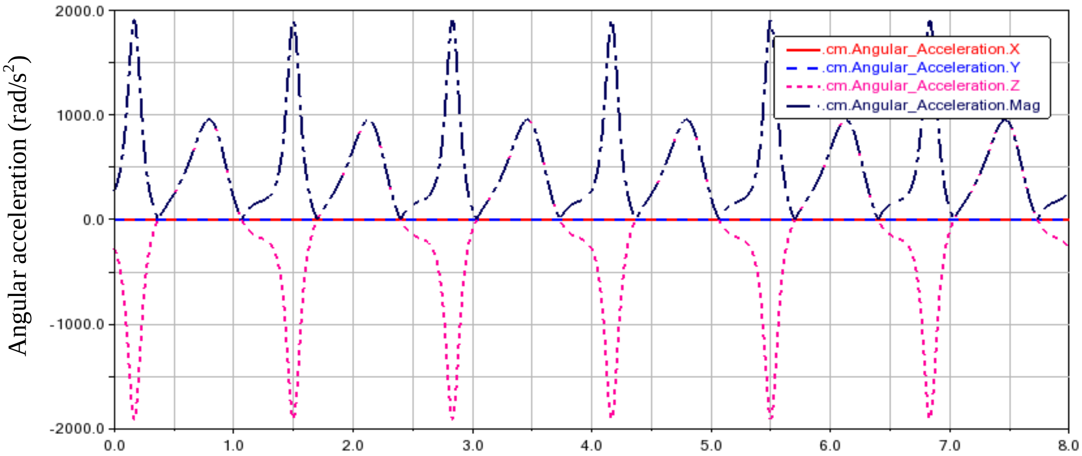

Fig.9 Wiper blade center of mass angular acceleration curve

Through the analysis and observation of the motion process in ADAMS simulation, it can be concluded that there is no interference phenomenon between the two wiper blades, and they satisfy the normal operating conditions as predicted by theoretical calculations. The various motion parameters of the wiper blades exhibit periodic motion characteristics.

5. Conclusion

The windshield wiper of a car is crucial for driving safety in rainy conditions. In this article, the crank-rocker mechanism model of the car's windshield wiper is calculated and established using SolidWorks to create a simplified model. By utilizing ADAMS kinematic simulation software for motion characteristic analysis of the established crank rocker mechanism model, analyzing key kinematic parameters is beneficial for verifying the rationality of the mechanism design, making the entire crank rocker mechanism design more intuitive, improving the efficiency of the mechanism design, and reducing design costs. With the windshield wiper meeting the usage requirements, the sweeping area of the left wiper blade is achieved as 0.198m^2, and the sweeping area of the right wiper blade is 0.297m^2. Through observation of the simulated motion process, it was found that there is no interference between the two wiper blades. The velocity, acceleration, angular velocity, and angular acceleration of the wiper blades' center of mass during motion were analyzed as motion parameters. The wiper blades exhibit periodic motion characteristics during their movement.

6. ACKNOWLEDGEMENTS

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REFERENCES

[1] Sun Xiaobing, Wang Desheng, Liu Haibo. Total Internal Reflection Infrared Rain Sensor. Instrument Technique and Sensor, 2010(09):96-98.
[2] ALEXANDRU C,POZNA C. Dynamic Modeling and Control of the Windshield Wiper Mechanisms. WSEAS Transactions on Systems,2009,8(7/9).
[3] X. Long. Design Analysis and Simulation of Crank-rocker Mechanism in Packaging Machinery. PACKAGING ENGINEERING, vol. 35, May. 2014, pp. 76-79.
[4] Y. Jinhu. Research of the Transmission Angle Function of Offset Crank Rocker Mechanism. Journal of Mechanical, vol. 38, Aug. 2014, pp. 43-46.
[5] Z. Fei, H. Zhichao, and L. Jie. Design approach for crank rocker mechanism with specific rod length. JOURNAL OF MACHINE DESIGN, vol. 31.
[6] L. Hongliang, H. Yuemin, and H. Min. Determination of the Connecting Rod Length of the Crank-rocker Mechanism. Mechanical Engineer, Feb. 2014, pp. 20-22.
[7] Sun J. Analysis and Optimization of the Transmission Angle of Crank Rocker Mechanism. Proceedings of the 2015 International Conference on Mechatronics, Electronic, Industrial and Control Engineering, 2015.
[8] Delyová I, Hroncová D, Frankovský P, et al. Kinematic Analysis of Crank Rocker Mechanism Using MSC Adams/View. Applied Mechanics and Materials, 2014, 3354(611-611).
[9] Tang Yinghong, Liu Zhongwei, He Bing. Optimization Design for Crank-rocker Mechanism Based on Genetic Algorithm. 2012 International Conference on Intelligent System Design and Engineering Application, 2012.
[10] Shutong C, Xiushi S, Chuwei Y. Kinematic and Dynamic Characteristics in a Crank-rocker Four-bar Linkage. Journal of Physics: Conference Series, 2021, 2029(1).

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