DOI:10.13434/j.cnki.1007-4546.2014.0306

Dynamic Simulation and Optimization Design of the Pendulum Ring Mechanism Based on ADAMS

WANG Zhi-peng, XIE Xun, LI He, YU Yong-chang

(College of Mechanical and Electrical Engineering, Agricultural University of Henan, Zhengzhou 450002)

Abstract: For pendulum ring mechanism, the working principle is analyzed by using the ADAMS software. Confirming the simulation to accord with the actual motion law, the main bars´ length is taken as the design variables in order to optimize the cutting speed. The optimization results show that the length of the pendulum rod increases by 3.22%, the cutting speed increases by 30.8%. It shows that the length of pendulum rod determines the cutting speed at a given pendulum angle. Designers can adjust the length of pendulum rod so as to select the appropriate cutting speed. The virtual prototype technology could the performance of the product is not only improved, and the design efficiency is also done.

Key words: pendulum ring mechanism; dynamic simulation; optimization; ADAMS

1 Introduction

The cutting device of combine-harvester can be divided into the reciprocating and the disc type. The drive of reciprocating cutter contains the crank-link mechanism, the pendulum ring mechanism, the planetary gear mechanism, the double crank mechanism and the double kick wheel mechanism, and so on [1]. It makes use of the reciprocating cutting motion of the moving, achieving the purpose of cutting grain. Comparing with the other mechanisms, the pendulum ring mechanism is the most widely used in agriculture and animal husbandry machinery. It has the advantages of compact structure, good mechanical performance, low noise, and light weight. But the research of virtual prototype of pendulum ring mechanism is deficient. In this paper, Adams software is used to virtual modeling, simulation and optimization for pendulum ring mechanism, so as to provide the basis for pendulum ring mechanism´s virtual design and research.

Received 25 August 2014

2 The structure and principle of pendulum ring

Pendulum ring mechanism is made up of main shaft, pendulum ring, pendulum cross, pendulum shaft, pendulum rod, connecting rod and cutter. Its structure is shown in Figure 1. As seen from Figure 1, a inclined hole cover is set on

the spindle. The inclined hole cover is set in the pendulum ring through balls. Pendulum cross is hinged by double pins on the pendulum ring. The spindle does the rotary movement, driving pendulum ring for reciprocating movement, so as to convert rotary movement into reciprocating movement. When pendulum ring does the swing movement, the pendulum shafts connected by pendulum cross drive the Pendulum rod, connecting rod, and cutter for reciprocating cutting motion.

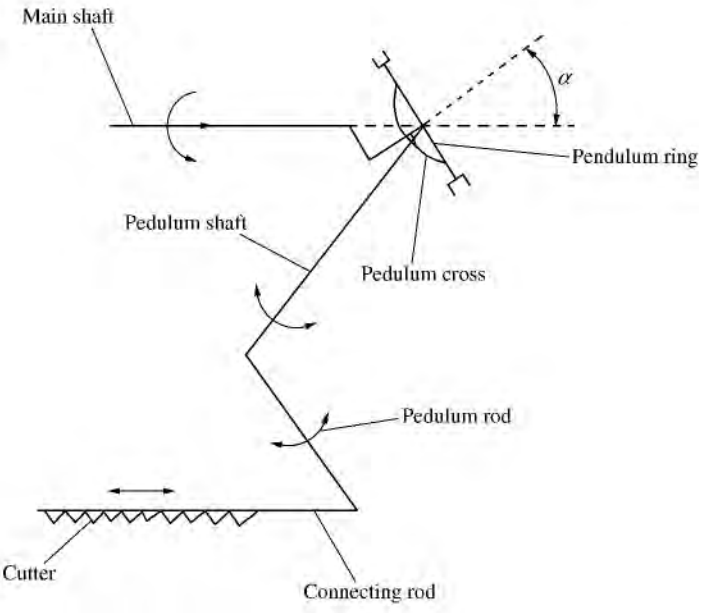

Figure 1 The diagram of pendulum ring mechanism

According to the Figure 1, there is an angle α between spindle axis and inclined hole cover axis, that is the pendulum angle. Pendulum angle α is an important structural parameter for pendulum ring mechanism, whose size directly affects the performance of whole mechanism. The greater the α, the smaller the inertia force is, and the biggest inertial force increase occurrences is disadvantaged, but it cannot reach the predetermined movement requirements if α is too small [2]. Generally the angle α is about 15 ° ~ 16 ° [3].

3 The modeling and simulation of pendulum ring

Before establishing the virtual prototype model of swinging ring mechanism, first of all, according to the principle of swinging ring mechanism movement, the parameters of each mechanism is preliminarily sets, and the coordinates of key points is determined, as shown in Table 1. Then modeling entities is called out in Adams/view are determined to establish movement for entity. After completing the entity, the

paper makes revolution constraints of Adams software is called out, according to the actual status of mechanism connect each components, including swinging ring mechanism replaced by universal joint. Finally, the speed to the crank is set[4]. The constraint conditions are shown in Table 2.

Table 1 The points´ coordinates

Points	*x*	*y*	*z*
Point 1	-165	0	0
Point 2	-60	0	0
Point 3	-50	0	13.39
Point 4	0	0	0
Point 5	0	0	200
Point 6	40.191	-150	200
Point 7	-60	-150	200
Point 8	-200	-150	200

Table 2 The constraint conditions

Joint_*i*	Constraint object	Constraint type
Joint_1	Spindle—earth	Cylinder joint
Joint_2	Spindle—pendulum shaft	Cardan joint
Joint_3	Pendulum shaft—earth	Cylinder joint
Joint_4	Pendulum shaft—pendulum rod	Rotation joint
Joint_5	Pendulum rod—connecting rod	Rotation joint
Joint_6	Connecting rod—cutter	Rotation joint
Joint_7	Cutter—earth	Movement joint

Before simulating, the virtual model using ADAMS software is verified, which the result is successful. Spindle´s angular velocity is 300 r/s, the simulation time is in set as 1.2 s. The pendulum ring can achieve a whole period of movement. Clicking button srart, the virtual model is shown in Figure 2.

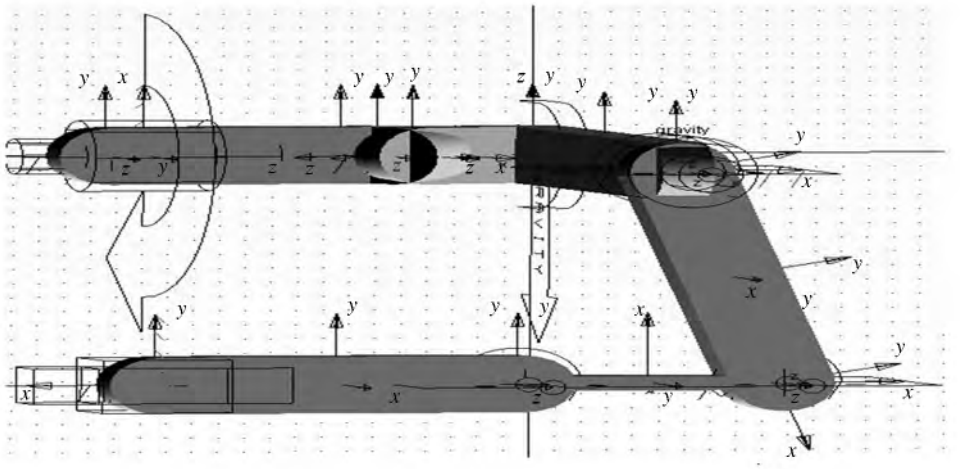

Figure 2 The virtual model of pendulum ring mechanism

4 The simulation analysis

Simulation analysis refering to the movement of objects in the real world is simulated in computer. Get the desired data for developing of the prototype[5]. Simulation, drawa from the post-processing module and outputa a series of simulation results of cutter[6]. The displacement, velocity and acceleration curves are shown in Figure 3.

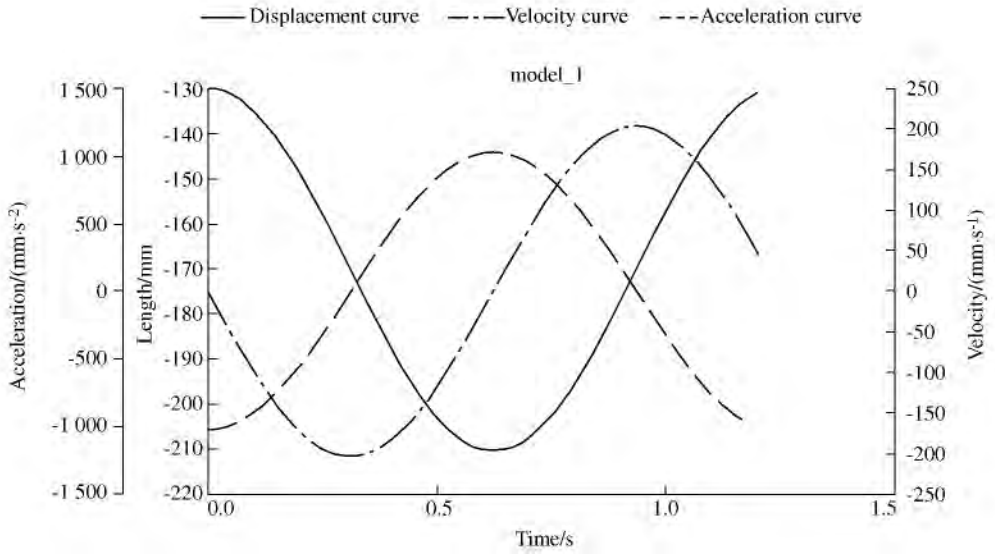

Figure 3 Movement parameter curves of the cutter

As shown in Figure 3, when the cutter is does reciprocating motion, the displacement, velocity and acceleration are doing simple harmonic motion. The speed of the cutter is 0 mm/s, when the cutter is in the end of left and right position that is 0 ~ 0.6 s, when the cutter´s speed is along the x axis negative direction, and the maximum speed is −210 mm/s, that is 0.6 s, when the cutter move to the leftmost position, reaching the maximum displacement of 80 mm, to reach the acceleration of maximum 1 000 mm/s^2, that is 0.6 ~ 1.2 s, when the cutter´s speed is along the x axis positive direction and the maximum speed is 210 mm/s. This is the movement process of cutter in a complete cycle. The above mention of analysis about the cutter´s movement is expected to reference [3], conforming to the law of motion. So this simulation is correct.

5 The optimization design

Cutting speed directly affects the quality of cutting. The qreater the cutting speed, the smaller the cutting resistance is in which its performance is better. But for different crops, the cutting speed is also different. Designers should choose the suitable cutting speed according to different crops. In order to achieve the change of cutting speed the paper use the ADAMS software to design, the lengths of bars as designed as the variables to achieve the cutting speed.

5.1 Institutions parameterized

Firstly, the length of main bars is set as variables. The variable dv_ab is the length of pendulum shaft, length of 200 mm ± 5 mm; The variable dv_bc is the length of pendulum rod, length of 155.44 mm ± 5 mm; the variable dv_cd is the length of connecting rod, length of 100.192 mm ± 5 mm; the variable dv_de is the length of cutter, length of 140 mm ± 5 mm.

Secondly, parameterize points in coordinate, after setting the variables. The parameterized points´ coordinates are shown in Table 3.

Table 3 The parameterized graph

Point_i	Loc_x	Loc_y	Loc_z
Point_1	−165	0	0
Point_2	−60	0	0
Point_3	−50	0	13.39
Point_4	0	0	0
Point_5	0	0	(.model_1.DV_ab)
Point_6	(SQRT(.model_1.DV_bc* .model))	−150	200
Point_7	((SQRT(.model_1.DV_bc* .model))	−150	200
Point_8	(.model_1.DV_de)	−150	200

5.2 Optimization calculation

The target is to increase the speed, in other word, make the speed of cutter minimum along the x axis negative direction. Add the variables dv_ab, dv_bc, dv_cd and dv_de, and optimize the solution. The optimization results are shown in Figure 4. Optimization results show that the optimized speed reach −257 mm/s, increasing by 30.8%. Variables dv_ab, dv_cd and dv_de almost don't have a change, but the final value of variable dv_bc is 160.44 mm, increasing by 3.22%. Thus, the length of the pendulum rod determines the speed of pendulum ring mechanism.

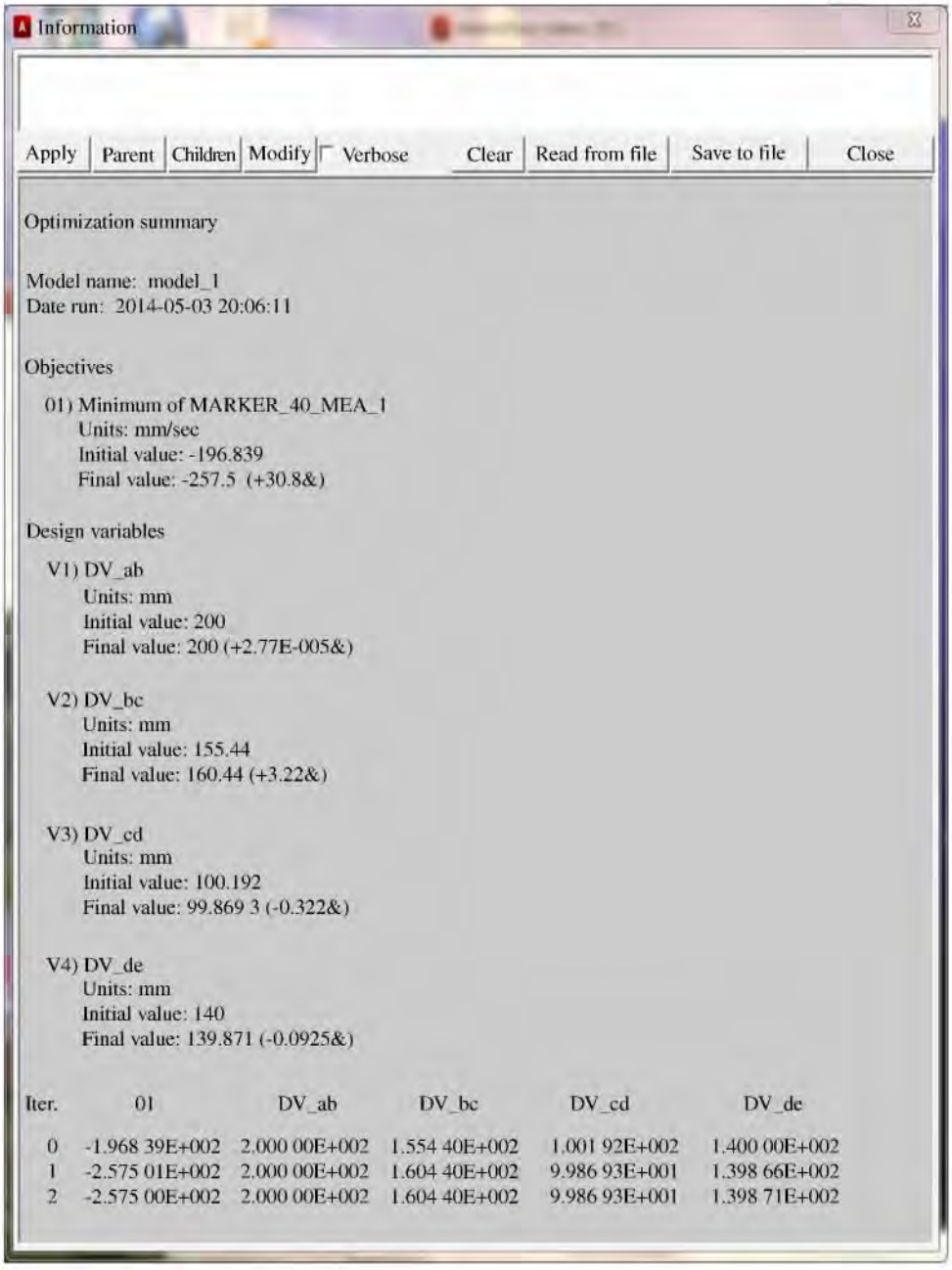

Figure 4 The graph of optimization

6 Conclusions

1) The virtual modeling and simulation to pendulum ring mechanism by using the Adams software were carried out. The key movement parameters including the displacement, the velocity and the acceleration were analyzed, and its motion law conforming to real movement was proved.

2) By measuring the key parameters of cutter displacement, velocity, acceleration, it was provided basis of the speed of cutter, cutting power, cutter´s type and size.

3) Under the selected angular, the speed of cutter has relationship with the length of pendulum rod. The pendulum rod length is reasonably adjusted, in order to achieve the appropriate cutting speed design method for designers.

4) Appvication of virtual simulation not only shortens the development cycle of product also improves the efficiency.

References

[1] Li J P. Modeling and movement simulation of pendulum ring mechanism [J]. Journal of Agricultural Mechanization Research, 2008, (6):31-33 (in Chinese)

[2] Wu X M. Kinematics analysis of pendulum ring mechanism in harvesting machines [J]. Journal of Agricultural Mechanization Research, 2010, (6):58-64 (in Chinese)

[3] Wang W J. Agricultural machinery design manual [M]. Beijing: Mechanical Industry Press, 2010:920-921 (in Chinese)

[4] Li J. The simulation of united harvest machine cutting mechanism based on virtual prototype technology [J]. Journal of Agricultural Machinery, 2006, (10):74-76 (in Chinese)

[5] Zhao W Y. Foundation and application example of ADAMS [M]. Beijing: Tsinghai University Press, 2011 (in Chinese)

[6] Guo W D. Virtual prototype technology and ADAMS application instance tutorial [M]. Beijing: Beijing University of Aeronautics and Astronautics Press, 2012 (in Chinese)

Brief Biographies

Wang Zhi-peng is now a Master´s degree student in the College of Mechanical and Electrical Engineering, Henan Agricultural University. His research interests include industrial engineering. 317614159@qq.com

Yu Yong-chang is now a professor/tutor in the College of Mechanical and Electrical Engineering, Henan Agricultural University. His research interests include agricultural machinery modernization. chungbuk@163.com