Simulation Analysis of Manual Hydraulic Crane Based on ADAMS

Li Zheng, Zhu Jiangfeng, Wang He, Yu Lanhao, Wu Guoliang

College of Mechanical and Electronic Engineering, Shandong University of Science and Technology, Qingdao, 266590, China

Abstract: Use solidworks to establish the manual hydraulic crane three-dimensional model, use ADAMS software to kinematics and dynamics simulation. Obtain the force value curve at main hinge points , acceleration value curve and velocity value curve during lifting process, which provides reference for manual hydraulic crane design and optimization.
Keywords: simulation; manual hydraulic crane; ADAMS

1. INTRODUCTION

Manual hydraulic cranes are widely used in occasions need to lift and handle small or medium-sized goods, such as workshops, factories, and so on[1]. They have important application values in the automobile repair industry and are mainly suitable for hoisting, handling during engine repair. Manual hydraulic crane mainly includes base, hydraulic system and arm structure. There is a chain hook at the end of the arm. The maximum lifting load is mainly 1t, 1.5t, 2t and other specifications. If you want to drop the heavy objects, you can slowly open the hydraulic value to make the arm slow down under the action of gravity. Some folding types can fold the front foot tube to reduce the floor space, and convenient storage. You should use it on flat ground so that all wheels are in good contact with the ground. Wheels are casters and easy to turn around when advancing.

Han Guangxin[1] et al. use ANSYS software to analysis manual hydraulic crane stress distribution and analysis fatigue life under the repeated loading condition. However, the existing literatures have little research on force changes of the hydraulic cylinder of manual hydraulic crane. ADAMS software is abbreviation of Automatic Dynamic Analysis of Mechanical Systems [2]. Users can use ADAMS to build and test virtual prototypes on their computers, enable to simulate to obtain the motion performance of complex mechanical system designs. This paper use ADAMS to kinematics and dynamics simulation and provides reference for manual hydraulic crane design and optimization.

2. BUILD MANUAL HYDRAULIC CRANE THREE-DIMENSIONAL MODEL

The manual hydraulic crane can adjust different holes on the arm to obtain different length of the arm. The maximum arm length hole rated load is 1t, the hydraulic rod stroke is 500mm. We choose the largest arm length of the arm as working condition to analyze the force during the lifting process.

We use solidworks establish the manual hydraulic crane three-dimensional model. We simplify the model according to the size and structure, ignoring the structure that has less effect on strength, such as wheels, the hand-push handle, the hook and so on. Use solidworks to establish manual hydraulic crane three-dimensional model as shown as figure 1.

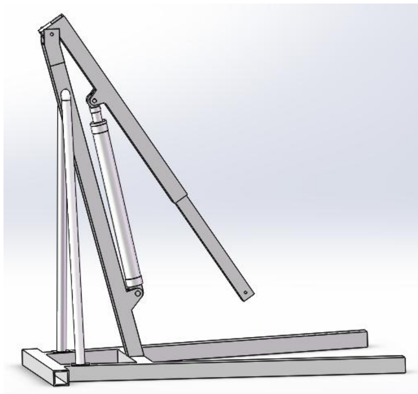

Figure 1. manual hydraulic crane three-dimensional model

3. ADD CONSTRAINTS AND DRIVERS IN ADAMS

Use solidworks to create a manual hydraulic crane three-dimensional model, save as parasolid format into ADAMS for kinematics and dynamics analysis [3,4]. Add constraints, load, drive, the gravity acceleration and so on. In the place of the arm and the hook hinge to add a vertical load 9800N, add each part density 7.85E-006kg/mm^3, add fixed constraint between the base and the ground, add revolute pair in the relative rotation between rotating components, add sliding pair between the hydraulic cylinder and piston rod. The movement of the manual hydraulic crane is driven by the hydraulic cylinder. Add step displacement drive function in the slip of the hydraulic cylinder to make the movement of the mechanical system coincide with the actual work [5], the drive function is step(time,0,0,25,500), and constraints and drive have added in ADAMS as shown in figure 2.

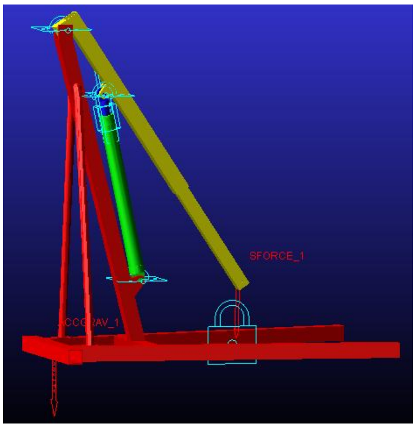

Figure 2 Add constraints and drivers in ADAMS

4、ADAMS KINEMATICS AND DYNAMITICS ANALYSIS

Analysis hydraulic rod along the axial force changes during manual hydraulic crane lifting process has an important reference value for the hydraulic system design and optimization. The axial force variation of the hydraulic rod can be analyzed by analyzing the force variation of the hydraulic cylinder-base articulation point JIONT_2 or the piston rod and arm articulation point JIONT_3. Due to the influence of piston rod, hydraulic cylinder, value of force in JIONT_2 and JIONT_3 are slightly different, but compared with the force of lifting heavy objects is very small, in this paper neglect the influence. Figure 3 is with the arm rise, JIONT_3 force variety curve, the curve shows that with the arm rise, hydraulic rod force gradually reduced except the last. Analysis of the gradual decline reasons, in order to facilitate analysis, neglect the weight of the arm, piston rod, hydraulic cylinder and other light weight components. Due to the hinge point JIONT4 between the arm and the base, JIONT_3 at the hinge point of the piston rod and the arm, and the hinge points of the hook and the arm are almost in the same straight line. During the progress of lifting of the arm, the value of the distance from the hinged point of the hanger and the arm to JIONT4 divided by the distance from JIONT_3 to JIONT_4 is basically unchanged. And the gravity of the load is always the same, the direction is vertical downward. Therefore, the decomposition of the force at JIONT_3 along the vertical direction is basically unchanged. The angle between the hydraulic rod and the vertical direction gradually decrease, so the force along the hydraulic rod gradually decreases. Table 1 is JIONT_3 force variation table, due to limited space, we intercept the force dates of 0s to 0.2s and 24.7s to 25.0s, the maximum force is 69445.112N and the minimum force is 31922.2756N. Due to the value of the distance from the hinged point of the hanger and the arm to JIONT4 divided by the distance from JIONT_3 to JIONT_4 is not strict unchanged value and increase at last, the force increase at last, which is the geometry size reason.

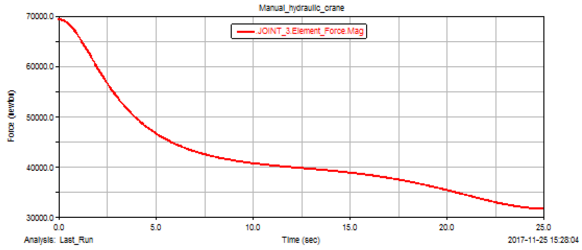

Figure 3 force changes curve of JIONT_3

Table 1 force changes table of JIONT_3

Manual_hydraulic_crane			
Time	.JOINT_3.Element_Force.Mag	24.7	31942.8034
		24.75	31936.3788
0.0	69445.112	24.8	31931.1065
0.05	69438.3163	24.85	31926.994
0.1	69409.5447	24.9	31924.0482
0.15	69361.8238	24.95	31922.2756
0.2	69295.4233	25.0	31922.3614

The force value change curve on the hinge Jiont_4 between the base and the arm over time is shown in figure 4, and the changes force data table is shown in table 2, due to limited space, we intercept the force dates of 0s to 0.2s and 24.7s to 25.0s. As the lifting height increases, the force at the hinge JIONT_4 gradually decrease, the maximum force value is 59796.0435N and the minimum value of 22158.2879N.

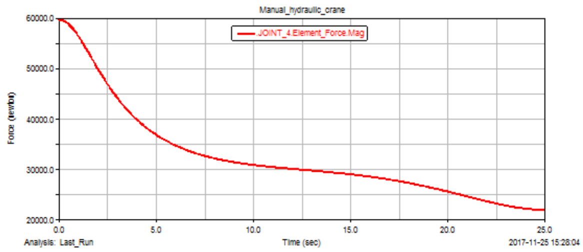

Figure 4 force changes curve of JIONT_4

Table 2 force changes table of JIONT_4

Manual_hydraulic_crane			
Time	.JOINT_4.Element_Force.Mag	24.7	22178.4769
		24.75	22172.1641
0.0	59796.0435	24.8	22166.9837
0.05	59789.0557	24.85	22162.9429
0.1	59760.1459	24.9	22160.0487
0.15	59712.1951	24.95	22158.3072
0.2	59645.4736	25.0	22158.2879

In order to analysis stability in lift process, analysis acceleration and velocity of heavy objects during lifting process. For analysis convenience, take the arm and hook hinged point as MARKER_25, obtain the acceleration curve of MARKER_25 in post-processing module as shown as figure 5, the acceleration change table as shown in table 3, due to the limited space, captures the acceleration change table dates of 0 s to 0.2 s and 24.7 s to 25.0 s, and the velocity curve of MARKER_25 as shown as figure 6.

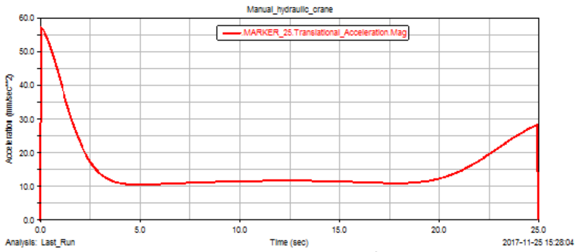

Figure 5 The acceleration curve of MARKER_25

Table 3 table of acceleration changes on MARKER_25

	Manual_hydraulic_crane	24.7	27.683
Time	.MARKER_25.Translational_Acceleration.Mag	24.75	27.8186
0.0	0.0	24.8	27.9503
0.05	57.2635	24.85	28.0782
0.1	56.9228	24.9	28.2021
0.15	56.5103	24.95	28.3221
0.2	56.0285	25.0	3.2613E-017

As shown as figure 5 and table 3, at the beginning and end of the lift process, the acceleration fluctuates greatly and the value is comparatively large, the maximum acceleration is 57.2635mm/s^2, the rest of the acceleration value is smaller, and at most time is a little more than 10mm/s^2. It can be seen from figure 5, acceleration value is small, the value is less than 60mm/s^2 all the time.

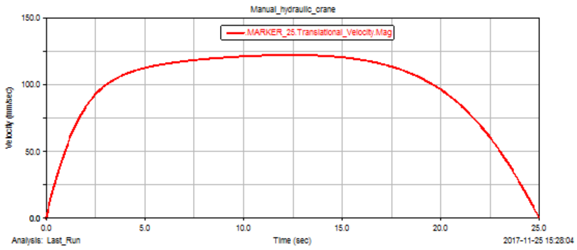

Figure 6 The velocity curve of MARKER_25

As shown as figure 6, at the beginning of lift progress, the velocity of MARKER_25 gradually increase and at the end of lift progress, the velocity of MARKER_25 gradually decline, and the speed curve is smooth. The velocity value of MARKER_25 is less than 125mm/s all the time. Analysis of acceleration result and speed result shows that during lift progress, the acceleration value and the velocity value are relatively small, operate steady, meet the requirements.

5、Conclusion

Use solidworks to establish manual hydraulic crane three-dimensional modeling, use ADAMS to kinematic and dynamics simulation during lift progress, obtain the force curve and the data sheet at main hinge point, and acceleration change and velocity change at the arm and hook hinge point. The simulation study can obtain the movement characteristics of important components during lifting process. According to the obtained simulation characteristic curve, analysis the obtained data and verify the rationality of the model, which provides reference for manual hydraulic crane design and optimization [6].

REFERENCES

[1]Han Guangxin, Hu Yanguang, Tian Xiaoti. Visual analysis of stress and fatigue life of manual hydraulic crane, Water Conservancy & Electric Power Machinery [J], 2007;29(4):40-41

[2]Li Peiqing. Modeling and applications of heavy vehicle cargo transport based on multibody dynamics, Southeast University [D], 2016

[3]Guan Xiqiao, Zhao Qingzhi, Gao Yuewu, etc. Simulation and analysis of Planer guide mechanism based on Solidworks and ADAMS, Coal Mine Machinery [J], 2014;35(10):273-275

[4]Ma Feng, Zhang Hua, Hu Xiaoli. Simulation analysis and modeling of hydraulic excavator based on ADAMS, Machine Tool & Hydraulics [J], 2014;42(9):130-132

[5]Zhang Liyong, Rao Honghui, Luo Shiting, etc. Camellia fruit pick mechanical arm test design and optimization based on ADAMS, Journal of Agricultural Mechanization Research [J], 2017;11:158-163

[6]Wu Jinyi, Huang Jinfeng, Li Wei, etc. Kinematics simulation of loading manipulator based on SolidWorks and ADAMS, Machine Tool & Hydraulics [J], 2016;44(9):52-56