
Dynamic Simulation Analysis of Palletizing Manipulator Based on ADAMS

Xiaogang Ren^a, Ru Yu^b and Cheng Guo^c

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

^a1241896425@qq.com, ^b961253385@qq.com, ^c812716490@qq.com

Abstract

Taking the four-degree-of-freedom palletizing manipulator as the research object, the Solidworks software is used to build the 3D model, and the simplified 3D model is saved into the Parasolid format and imported into the ADAMS software. Create a virtual prototype by adding material properties, constraints, driving functions, and external forces to the imported model, and perform dynamic analysis on the virtual prototype to obtain the motion characteristic curve of the key components. The peak torque characteristics of key components are analyzed, and the rationality of the model is verified, which lays a solid foundation for subsequent research.

Keywords

Palletizing robotic arm, ADAMS, Dynamics analysis.

1. Introduction

The study of robot dynamics is of great significance for fast-moving robots and their control. The purpose of the research is to control and ensure that the robot maintains good dynamic and static characteristics. As an industrial robot, the palletizing robot has multiple degrees of freedom, and there are complex coupling relationships between the joints. Due to the complexity of structure and motion, high cost and the vigorous development of computers, the simulation analysis of virtual prototypes using ADAMS software is the most commonly used analysis method for today's research and analysis. ADAMS is used for auxiliary analysis, and various performance tests are performed on the product, which can shorten the development cycle and reduce the development cost. This paper analyzes the dynamics of the palletizing manipulator based on ADAMS[2,5].

2. Palletizing Manipulator Body Structure

The structure of the palletizing manipulator shown in Fig. 1 and Fig. 2. It mainly includes four rotary joints such as a rotary joint of the lumbar region, a revolute joint of a big arm and a small arm, and a revolute joint of a wrist. In order to ensure that the robotic arm operates smoothly, three parallelogram linkage mechanisms are used in the structure. The working principle: the base is fixed on the ground as the mounting support of the mechanical arm, the servo motor for controlling the waist rotation is installed in the base, and the servo motors for controlling the big arm and the arm driving of small arm are respectively mounted on both sides of the waist to drive the rotation of the big arm and swing of the arm driving of small arm. Under the mechanical constraints of the parallelogram linkage mechanism I and II, the rotation of the big arm causes the telescopic movement of the small arm. Therefore can control the position of working space of the small arm. And the swing of the arm driving of small arm causes the pitching motion of the small arm. Due to the mechanical constraint of the parallelogram linkage mechanism III, the relative posture of the wrist and the triangle linkage remains unchanged, so

that the posture of the wrist is always maintained during the movement to ensure its stability. Since the servo motor that drives the small arm moves down to the waist, the center of gravity of the arm is lowered, which increases the smoothness of the operation[1,3].

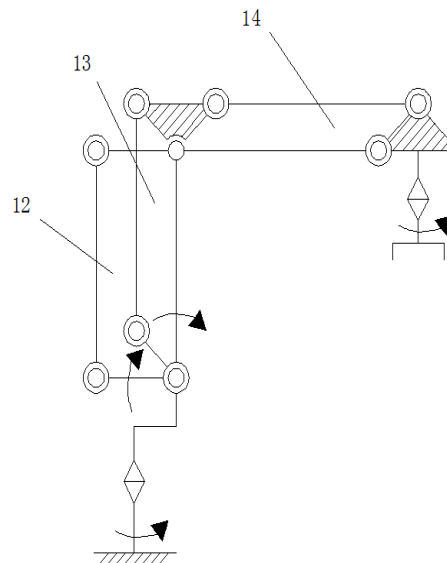
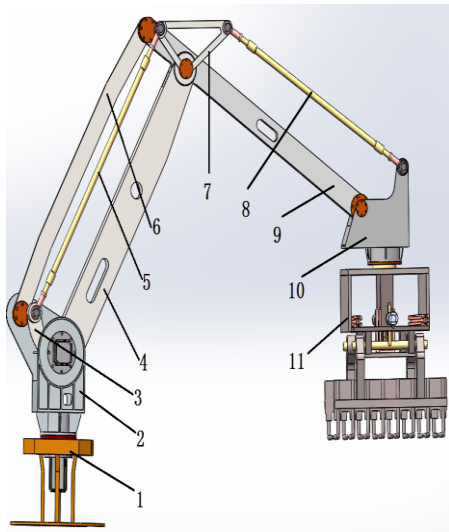


Fig. 1 Manipulator structure model Fig. 2 Structure of the mechanical arm

1. Base 2. Waist 3. Arm driving of small arm 4. Big arm 5. Balance bar I 6. Balance bar II 7. Triangle linkage 8. Balance bar III 9. Small arm 10. Wrist 11. Hand grasp 12. Parallelogram linkage mechanism I 13. Parallelogram linkage mechanism II 14. Parallelogram linkage mechanism III

3. Virtual Prototype Modeling of Palletizing Manipulator

3.1 Import Models and Add Material Attributes and Constraints

The rationality of the 3D model plays a crucial role in the subsequent dynamic simulation. To ensure the accuracy of the simulation, the 3D model is simplified as much as possible before imported into the ADAMS software, and the parts without related motion are reduced, such as screws, nuts, washers, etc. Save the simplified 3D assembly model into Parasolid format and import into ADAMS/View module. In order to make the virtual prototype closer to the real prototype model and improve the degree of simulation, it is necessary to add materials and quality attributes to each part of the imported model. The material of the main parts of this paper is consistently set to steel. Add motion constraints to each joint, add rotation pairs to parts with relative motion, and add fixed pairs to parts without relative motion. The virtual prototype model is shown in Fig.3, The motion constraints between the main parts are shown in Table 1.

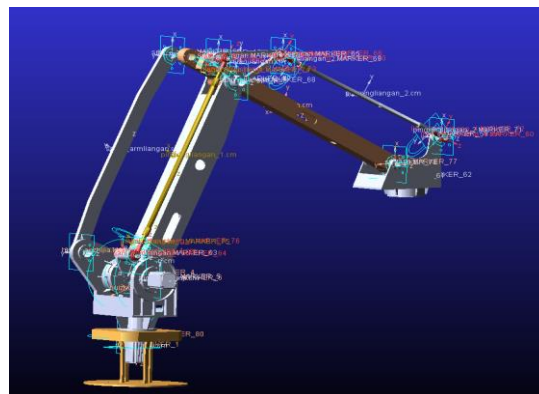


Fig. 3 Virtual prototype model

Table 1 The motion constraints between the main parts

Names	Types	Part1	Part2
Base JOINT1	Fixed pair	Base	Ground
Waist JOINT2	Rotation pair	Waist	Base
Big arm JOINT3	Rotation pair	Big arm	Waist
Small arm JOINT4	Rotation pair	Small arm	Big arm
Wrist JOINT5	Rotation pair	Wrist	Small arm
JOINT6	Rotation pair	Big arm	Triangle linkage
JOINT7	Rotation pair	Arm driving of small arm	Waist

3.2 Adding a Driver Function

The motion path of the Palletizing Manipulator is proposed as follows: (1) The wrist grabs the material vertically and lifts the height in the vertical direction; (2)The waist rotates to shift the material according to the horizontal position; (3)The wrist declines vertically to lift the material and then lifts to a certain height in the vertical direction; (4) The waist rotates to the initial position, and the actions of (1), (2), and (3) are repeated[2].Based on the proposed path, drivers are added to these motion pairs to move the parts according to the proposed path.It is driven by the STEP function. The driver functions are as follows:

Base joint:STEP(time,0,0,2,SIN(30d*time))+STEP(time,10,SIN(30d*time),14,0);

Big arm joint:

STEP(time,0,0d,2,-25d)+STEP(time,2,-25d,4,0d)+STEP(time,4,0d,8,25d)+STEP(time,8,25d,10,0d)+STEP(time,10,0d,14,0d);

Small arm joint:

STEP(time,0,0d,2,-25d)+STEP(time,2,-25d,4,0d)+STEP(time,4,0d,8,15d)+STEP(time,8,15d,10,0d)+STEP(time,10,0d,14,0d).

4. Dynamics Simulation and Analysis

After setting the material and mass properties of the model, motion constraints, and driver functions, open the simulation controller, set the simulation termination time to 14 seconds, set the simulation steps to 1000 steps, and click the simulation button to simulate it.

4.1 The Motion Curve of the Big Arm and Small Arm

Fig.4 and fig.5 are the motion curve of the big arm and small arm, and each of them includes angular displacement, angular velocity, and angular acceleration.It is not difficult to see from the figures that the angular displacement of the waist, the big arm and the small arm is gently changed with time, without mutation.Which angular velocity accelerates or decelerates with the change of displacement, and there is no discontinuity.Which angular acceleration increases or decreases with the change of the angular velocity, the change is continuous and the trend trends to zero[4].

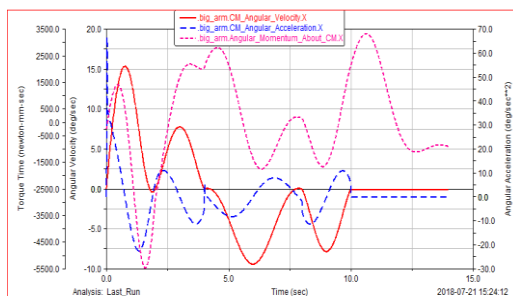


Fig.4 Motion curve of the big arm

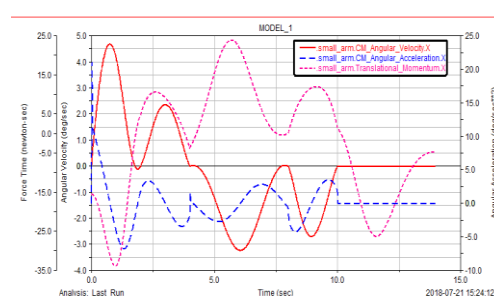


Fig.5 Motion curve of the small arm

4.2 Joint Torque Curve of the Big Arm and Small Arm

Fig. 6 and fig. 7 are the joint torque curves of the big arm and small arm. From the overall point of view, the operation is stable and there is no drastic change. The torque peak of each joint can also be seen from the figure, which lays the foundation for subsequent structural optimization and motor selection.

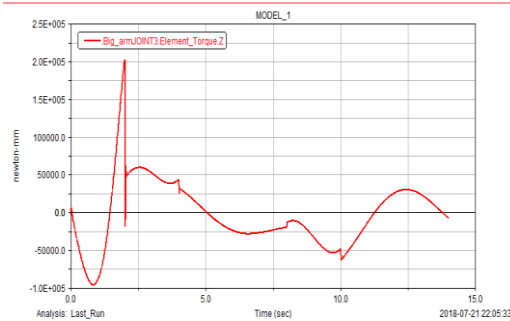


Fig.6 Joint torque curve of the big arm

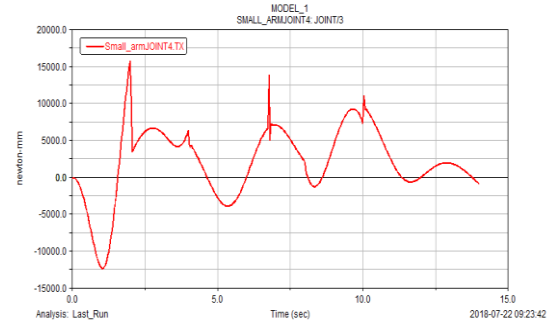


Fig.7 Joint torque curve of the small arm

5. Conclusion

In this paper, the four-degree-of-freedom palletizing manipulator is used as the research object. The three-dimensional model is built by Solidworks software. The virtual prototype is built by ADAMS/View module and the dynamic of the mechanical arm is simulated. The motion curve of the main part and torque variation of the main joint are obtained according to the PostProcessor module. It verifies the rationality of the model and lays a foundation for subsequent research.

References

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