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Comparative analysis of two types of mechanical grippers for gripping flexible packaging materials

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Abstract: To study the different structure types of flexible packaging material gripping mechanical grippers and their application to the working environment, two types of cylinder-type soft packaging material gripping mechanical grippers are designed in this paper. According to the structural characteristics of the mechanical gripper, mathematical analysis is carried out to determine the coordinate relationship of each joint of the mechanical gripper. The plot function in MATLAB is used to plan and simulate the path curves of the two types of mechanical grippers and to determine the working environment of the two types of mechanical grippers applied respectively; the movement of the mechanical gripper is analyzed by using the fifth-degree polynomial, and MATLAB Robotics toolbox is used for simulation, which results in the displacement, velocity, and speed of the end of the two mechanical grippers. The fifth-degree polynomial is used to analyze the motion of the mechanical gripper, and the MATLAB Robotics toolbox is adopted for simulation, as well as the displacement, velocity, and acceleration curves of the end of the two mechanical grippers. The aim is to understand the motion characteristics of the two kinds of mechanical grippers, master the two kinds of mechanical grippers' working state, and provide a reference for subsequent research on flexible packaging material gripping mechanical grippers.

1. Introduction

In modern light industries, such as food, medicine, and others, plastic bags, and soft paper bag packaging are more common. Due to the soft bag packaging materials [1] with variable characteristics, the contents' fluidity is prone to deformation, the traditional industrial sorting machine gripper sorting object is the shape, texture, and other characteristics of the relatively fixed rules of geometric workpieces, grasping the soft packaging materials will produce leakage of the phenomenon, and therefore the realization of its automatic loading and unloading is very difficult, which is the industry's technical challenges.

This paper aims to realize the mechanical gripper in different working conditions to achieve the function of gripping soft bag materials, designing two different structures of mechanical gripper [2]. MATLAB Robotics toolbox is used to carry out the path curve simulation for the two kinds of mechanical grippers for gripping soft bag materials, and the two kinds of mechanical grippers are compared and analyzed to be suitable for the working condition environment. The fifth-degree polynomial interpolation method is used, combined with MATLAB to analyze the motion of the mechanical gripper, to study the displacement, velocity, acceleration, and other characteristics of the two mechanical grippers during the movement process, to understand the motion characteristics of the two mechanical grippers, to master the working state of the two mechanical grippers, and to provide a reference for the subsequent research on the mechanical grippers of the soft packaging material

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gripping.[3]

2. Structural design of mechanical grippers

In this paper, we designed two types of cylinder-type mechanical grippers that can grasp soft packaging materials. The movement of the two structures is the same, and cylinders are used to push the connecting rod. The gripper part of the opening or narrowing is used to achieve the grasping of the object and the design of this type of mechanical gripper [4], mainly clamping like the bag of milk soft packaging materials, so the height of the part of the object clamping should not be too long, slightly higher than the height of the bag material can be. The length of the opening is slightly longer than the width of the soft bag material and can meet the gripping effect [5], as shown in the figure below:

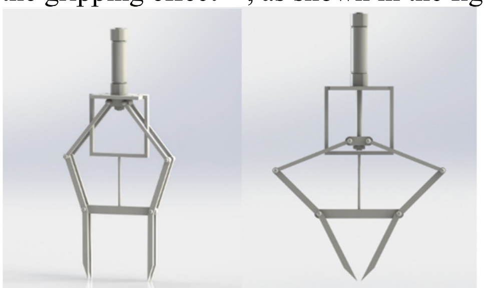

Figure a Figure b

Figure 1. Robot 1 structure.

Figure 1a shows the open state of mechanical gripper 1, and Figure 1b shows the clamping state of mechanical gripper 1.

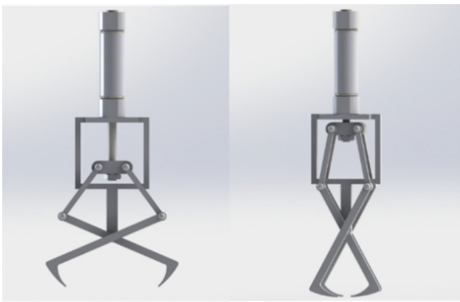

Figure a Figure b

Figure 2. Mechanical gripper 2 structure.

Figure 2a shows the open state of mechanical gripper 2 and Figure 2b shows the clamped state of mechanical gripper 2.

3. Simulation and analysis of path profiles of two mechanical grippers

3.1.Mechanical gripper 1 path profile analysis

Using MATLAB programming to simulate the trajectory curve, the coordinate representation of each joint is known, and a time series t is generated as an input parameter, starting from 0 and increasing upwards in steps of 0.01 to 2. For each time point, the function calculates the state quantity d(i) that the current position should be in, which is linearly weighted to obtain the expected value of the current position [6]. Each time point will be processed next in turn. The function is called to calculate the coordinates of the end and gripper position of the robotic arm, and the EXPlot function is used to plot the construction and position of each part of the robotic arm. The arm skeleton and coordinate system are plotted on the graph, and the plot function shows the position of each key point of the arm. According to the principle of symmetry, the upper and lower symmetrical arm structures are drawn, and the plot function is used to display the coordinates of the corresponding positions [7]. The Curves Plot function

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realizes the function of plotting the path curves of the robotic arm (the change of the coordinates of A, B, and D with time), as shown in Figure 3:

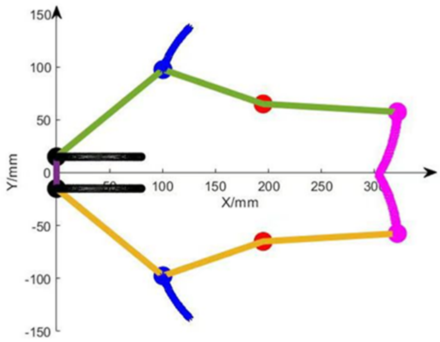

Figure 3. Mechanical gripper path profile.

The Curves Plot function realizes the function of plotting out the robot arm path curves (coordinates of A, B, and D over time), as shown in Figure 4:

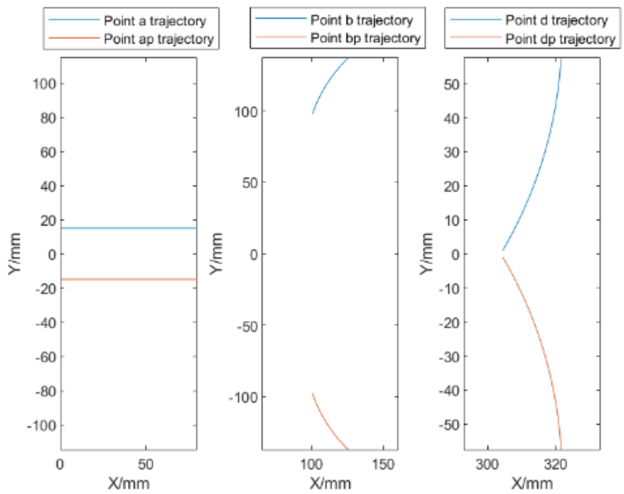

Figure 4. Path profile of each joint of the mechanical gripper.

According to the graphic shown, the mechanical gripper end of the entire movement of the trajectory curve is in an arc-shaped state. Therefore, when the mechanical gripper reaches the designated gripping position (the end of the gripper is infinitely close to the plane), the gripping of single-layer flexible packaging materials on the plane, there will be incomplete clamping of materials, resulting in less than expected gripping effect, so the mechanical gripper is not suitable for gripping a single layer of flexible packaging materials on the plane. When the gripped soft packaging materials for multi-layer materials, according to the mechanical gripper structure design and the end of the position change, by compensating the corresponding displacement to the x-axis direction, the mechanical gripper can meet the demand for gripping multi-layer soft packaging materials [8].

3.2.Robot 2 path profile analysis

From the above, the positional relationship of each coordinate can be obtained through a series of complex mathematical calculations and matrix operations. MATLAB programming is used to simulate the trajectory curve of mechanical gripper 2, and the time sequence t is still from 0 upward according to the step 0.01 increment to 2. According to the input parameter d, we calculate and return to a set of coordinate points of the value. The actual working two-dimensional trajectory curve of the mechanical gripper 2 is obtained through the Plot function and displayed in the right-angle coordinate system, as shown in Figures 5 to 6.

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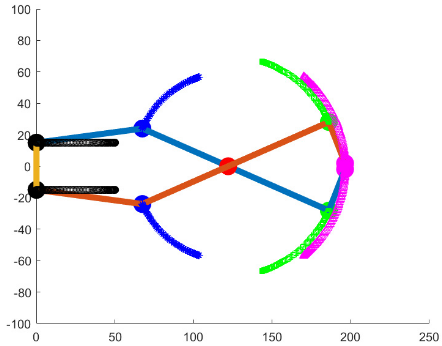

Figure 5. Mechanical gripper 2 path profile.

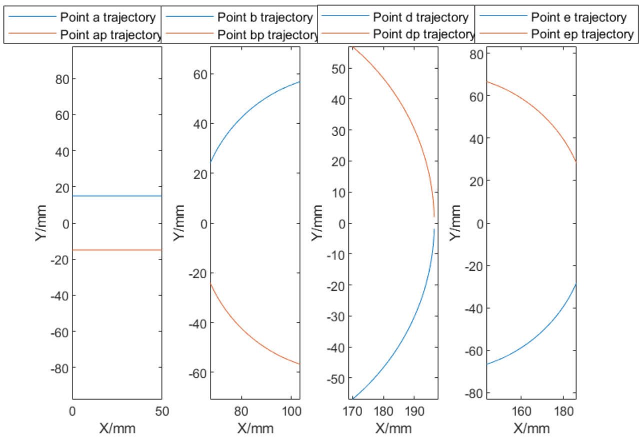

Figure 6. Path profile of each joint of the mechanical gripper 2.

It can be seen at the end of the robot's trajectory, combined with the mechanical gripper path curve diagram, when the mechanical gripper reaches the designated gripping position, the mechanical gripper, and the soft packaging materials for the work of gripping are opened. In the process of gripping the end of the gripper position, there is an extension of the process, making the gripper better wrapped around the soft packaging materials in the gripping process will not appear to leakage phenomenon, so the mechanical gripper can meet the gripping plane on the mechanical gripper, which can meet the work demand of single-layer flexible packaging materials on the grasping plane [9]. When the soft packaging materials are to be grasped for multi-layer materials, according to the mechanical clamp structure design and the end of the position change, the grasping process is easy to clip or touch the lower layer of soft packaging materials, to achieve the desired effect of grasping, so the mechanical clamp is not suitable for grasping multi-layer soft packaging materials.

4. Kinematic analysis of two mechanical grippers

MATLAB simulation software is used to apply the fifth-degree polynomial interpolation method to simulate the kinematics of the two mechanical grippers separately. Since both mechanical gripper structures are symmetrical, the symmetrical structure is also considered. To simulate the end of the two mechanical grippers, the default values of velocity and acceleration at the initial and termination of the transverse and longitudinal movements of the end of the two mechanical grippers are zero, and the running time is 2 s. According to the trajectory diagrams, as well as the corresponding mathematical modeling and simulation contents, the transverse and longitudinal coordinate parameters of the two mechanical grippers can be obtained. According to the known information to call the plot function in the MATLAB robotics toolbox, the trajectory results calculated using the fifth-degree polynomial interpolation method are plotted graphically, and the curves of displacement, velocity, and acceleration of the corresponding joints concerning time are obtained [10], as shown in Figure 7 to Figure 8, respectively.

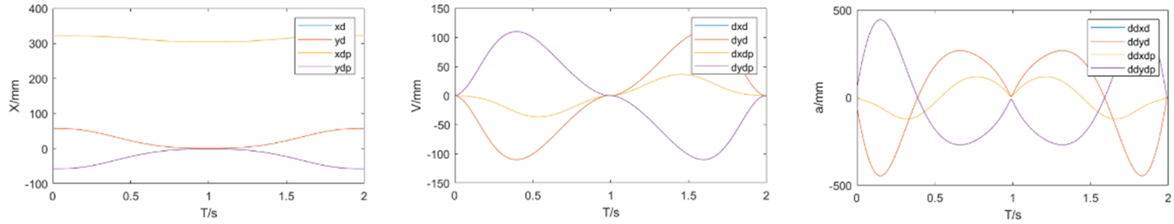

Figure 7. Displacement, velocity, and acceleration profile at the end of mechanical gripper 1.

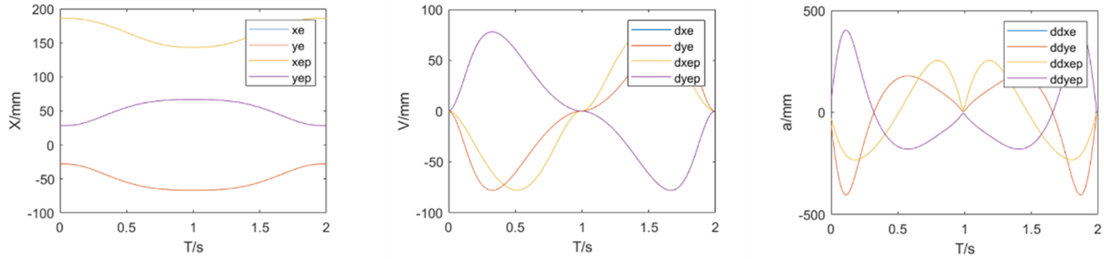

Figure 8. Displacement, velocity, and acceleration profile at the end of the mechanical gripper 2.

From the above figure, the two kinds of mechanical grippers complete a motion cycle within 0 to 2 seconds, and the displacement, velocity, and acceleration graphs of each mechanical gripper are smooth and continuous with no bumps and correspond to each other. According to the symmetry of the curves, only the characteristics of the curves in 0 to 1 second are analyzed. As can be seen from Figures 10 and 11, the speed of both mechanical grippers along the y-axis direction reaches the extreme point in the interval of 0.2s to 0.5s, and the speed along the x-axis direction reaches the extreme point in about 0.5s, in which the y-axis speed extreme points of mechanical gripper 1 is larger than that of mechanical gripper 2, and the size of the x-axis speed extreme point of both is opposite to each other. In terms of acceleration, the acceleration curves of the two mechanical grippers along the y-axis are roughly the same, and the difference in acceleration along the x-axis is obvious, the acceleration extreme point of the end of mechanical gripper 2 is larger than that of mechanical gripper 1, and the acceleration curve of gripper 1 is smoother. Simulation results show that the displacement, velocity, and acceleration of the two mechanical gripper ends have no sudden change phenomenon, the mechanical gripper works smoothly, and the operation is safe and reliable.

5. Conclusion

Through the two mechanical gripper path curve planning and simulation analysis, in different working conditions, the two types of mechanical gripper have their advantages and disadvantages: in the clamping plane of the soft packaging materials, mechanical gripper 2 more advantageous, mechanical gripper 1 will appear leakage; in the clamping multi-layer materials, mechanical gripper 1 more advantageous, mechanical gripper 2 will be clamped or encountered the lower layer of materials. Therefore, in the flexible packaging material gripping, different types of mechanical gripper are chosen according to different working conditions. Secondly, using the fifth-degree polynomials on the two mechanical grippers for motion analysis, using the MATLAB Robotics toolbox for true, resulting in two mechanical gripper ends of the displacement, velocity, and acceleration curves, the results show that the mechanism is stable, simple structure, to meet the basic requirements of loading and unloading materials.

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