Design of Structure and Control of 3-DOF Manipulator for Medical Medicine Taking

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Abstract: With the advancement of science and technology, robots have been widely used in various industries, especially industrial robots and service robots. In the field of industrial automation, robots, programmable logic controllers (PLCs) and CAD/CAM have become the three technological pillars of automation and play a huge role in modern industry. Collaborative robots, a new type of industrial robot in the industrial sector, can use human intelligence, flexibility, experience and knowledge to combine the robot's own high precision, large loads and speed to solve a number of complex tasks. The three-degree-of-freedom robotic structure takes human muscle movements as the simulation object and combines them with human movement characteristics to apply them in the medical field. Based on this, this paper analyses the structure and control design of the three-degree-of-freedom manipulator with a view to providing applications for the medical field.

1. Introduction

In pharmaceutical production, the logistical transport of pharmaceutical bottles is an important element of automated pharmaceutical packaging lines. The vials need to be inspected, tested, transferred and otherwise operated on the assembly line. The use of three-degree-of-freedom manipulators for the logistical transfer of vials on packaging lines is therefore an important part of the production of such lines. There are various types of manipulators, which can be broadly divided into the following categories: gripper pick-up manipulators, adsorption and recovery manipulators, operation converters and bionic dexterity manipulators. The basic requirements for transfer manipulators are, among others, fast response time of the manipulator, accuracy, high operational safety and a high degree of freedom. To this end, the mechanical structure and electronic control design of three-degree-of-freedom manipulators are reviewed below for design reference.

2. Work Object and Content

As shown in Figure 1, a cylindrical vial with an external diameter of 35 mm and a height of 65 mm needs to be transferred from line L1 to line L2 for the inspection process on the pharmaceutical packaging line, where the flow direction of line L1 is F7 and that of line L2 is F8, with a certain height difference between the flow strips of lines L1 and L2. The vials need to be transferred at the end of the L1 line to the start of the L2 line via the transfer path. The centre of rotation of the required robot arm is mounted asymmetrically between lines L1 and L2.

As shown in Figure 1, the required robot arm is able to perform the following functions: hand grip M1 can do F1-F2 gripping and F3-F4 releasing movements, and after gripping or releasing it can do T1-T2 rotating movements, hand grip M1 can be driven by arm M2 to do F5, F6 back and forth contraction movements. up and down movements, and T3-T4 forward and reverse rotation movements.

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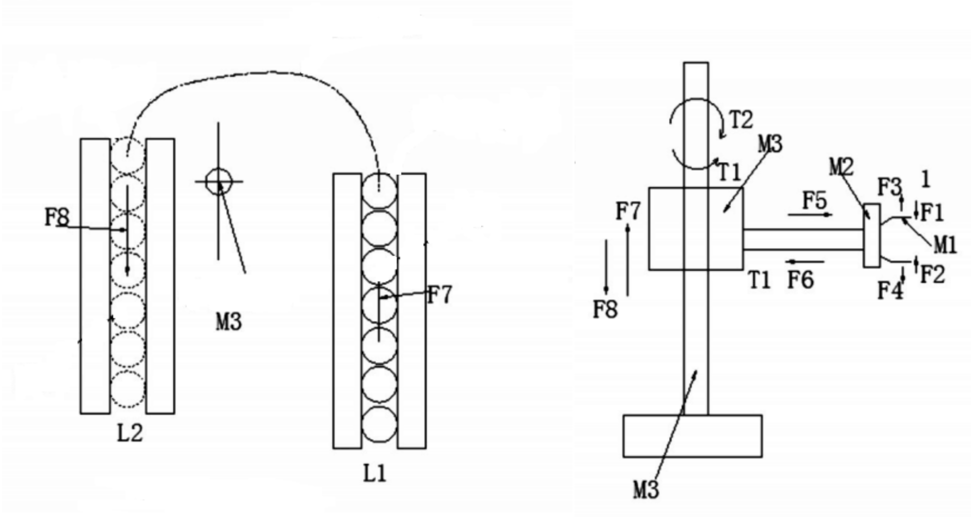

Figure 1 Post function & Action requirements.

3. Manipulator Structure Design

The mechanical structure of the robot arm is designed according to Figure 1. The structure of the arm consists of the following subassemblies: finger assembly, arm telescopic assembly, arm lifting assembly, arm rotating assembly and base. The finger assembly is used to grasp the bottle, the arm telescopic assembly is used to adjust the distance of the arm, the arm lifting assembly is used to lift the finger up and down after grasping, the arm rotating assembly is used to rotate the finger and the telescopic arm, and the base is used to support the whole arm.

In the finger mechanism, the hand grip M1 is a caliper type hand grip, and its components include 1-10. After the two claws are movably fixed on the hand grip plate by pins, they are driven by the finger piston cylinder 4; After the finger piston cylinder 4 is installed on a plate, it is driven by the telescopic arm cylinder 22. The inlet and outlet of the first cylinder 6 are G1 and G2. In the arm telescopic mechanism, the structural components of the finger telescopic arm mechanism include parts 11 to 23. The second cylinder is installed on the support plate 23 through the cylinder support 22, and the core rod 11 is driven to move left and right by the inlet and outlet air of G3 and G4. The support plate 23 is movably installed on the guide rod 24 through two guide sleeves 25 and can slide up and down. The support plate 23 is additionally equipped with a lead screw sleeve 28, which is matched with the lead screw 36 and driven up and down by the lead screw 36.

In the arm lifting mechanism, the components include 24-36, 48 and 49. The upper end of the two guide rods 24 is installed with an upper support plate 26, and the lower end is locked on the support cover 37 through the guide rod 49. The upper end cover 27 is installed on the upper support plate 26, and the upper end cover 27 is used to install the drive motor 32 of the screw 36, and the motor shaft of the drive motor 32 is connected with the upper end of the screw 36 through the coupling assembly. The finger component and the finger expansion component are installed on the support plate 23 to realize the overall drive by the lead screw 36.

The arm rotation mechanism rotates due to the displacement of the finger mechanism. The mechanism components include 37-47. The driving motor 43 is installed on the bottom surface of the base 40 and drives the connecting end cover 46 to rotate through the connecting pin 44. The supporting cover 37 is fastened on the driving connecting end cover 46 by screws. The supporting cover 37 is used for the installation in the vertical direction of the guide rod 24 and the lead screw sleeve 28, and the plane bearing 42 is installed at the lower end of the driving connecting end cover 46, It is used for the vertical axial rotation support of the end cover 46. A load-bearing roller bearing 38 is installed on the inner wall of the lower end of the support cover 37. The lower end of the bearing is clamped by the lower load-bearing end cover 39 and the upper load-bearing end cover

41, and the support cover 37 is supported axially and circumferentially on the base 40.

Base 40 adopts a stepped section shaped disc support structure, which is used to protect the motor 43 from damage and reduce the overall weight of the arm structure. Considering the cleanliness of the working environment of the arm, and the problem of small machinery required by the work, the action drive of the whole arm is driven by pneumatic components and motor.As shown in Figure 2:

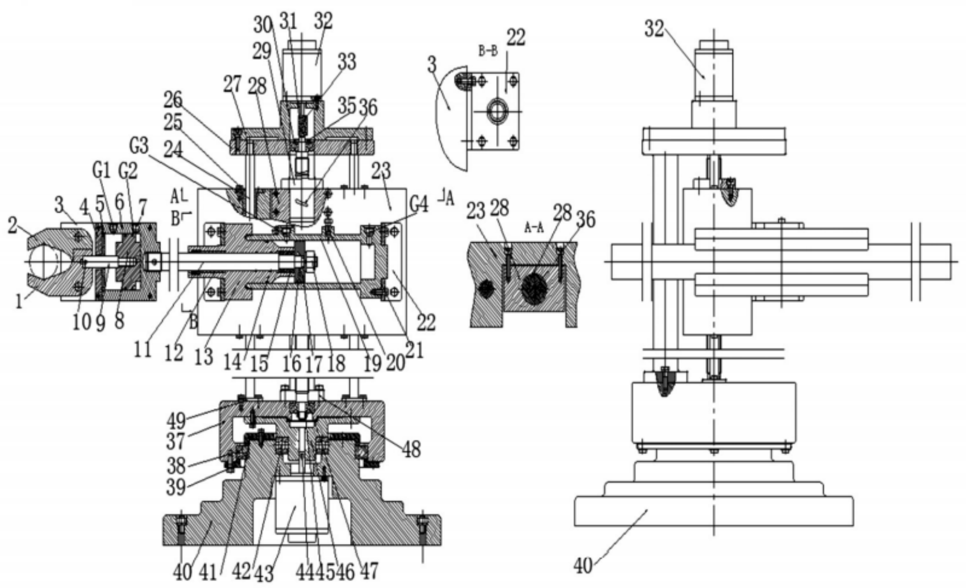

Figure 2 Design on arm structure.

4. Pneumatic Control Design

In the mechanical arm, the driving of the mechanical finger assembly and the telescopic assembly of the mechanical arm is mainly driven and controlled by pneumatic. The air inlet of G3 and G4 of the second cylinder is regulated and controlled by a three-dimensional four-way electromagnetic directional valve 57, and the same three-dimensional four-way electromagnetic directional valve 57 is also used for G1 and G2 of the general first cylinder(Figure 2). The air source 50 is provided by the indoor assembly line air compressor. After the high-pressure gas is stored in the air storage tank 52, it is supplied in two ways through the water distribution filter 53, pressure reducing valve 54 and proportional adjustment. One way is used for the control of the arm telescopic cylinder and the other way is used for the control of the finger clamping cylinder. In order to prevent the sudden action of the arm telescopic cylinder, an adjustable one-way throttle valve 58 is installed at the G3 air port of the arm telescopic cylinder.

5. Electrical Control Design of Manipulator

In the design of manipulator control system, PLC is selected for control. The I/O port distributes the signal to the programmable controller, and then allocates the corresponding input port; Some signals are transmitted to the controlled object by the programmable controller and assigned to the corresponding output port[1]. In addition, the counter and timer shall also be correspondingly allocated with programmable controller to identify the information through number. When designing the control system, in order to make the equipment adapt to more working environment, the control of the manipulator can be adjusted, changed to manual operation, or run automatically. In actual operation, if different situations are encountered, as long as a PLC system is rewritten, it can meet the working conditions of other classes. After commissioning, the manipulator operates without jitter and out of step, and the manipulator system is in good operation state. The three degree of freedom manipulator system only realizes the movement in the three degree of freedom direction, which can be further improved according to the actual needs. Adding a wrist rotation control device to the elbow of the clamping device can make it a four degree of freedom manipulator control system. If conditions permit, you can also use the touch screen instead of MCGS configuration environment to control the manipulator system. MCGS configuration environment has small space, intuitive man-machine interface and more convenient operation[2].

6. Conclusion

Based on the above, combined with the needs of the production station function of the medicine bottle packaging line, a three free station transfer manipulator is designed. The main components of the manipulator include the components of the finger, the telescopic arm and the structure of the manipulator. The grasping and telescopic function of the arm adopts pneumatic control, and two three-dimensional four-way solenoid directional valves are used to drive and control two action cylinders. The lifting and rotation of the arm are driven and controlled by a stepping motor. Combined with the action needs of arm, FX2N-48MR PLC controller is used for electrical control. The advantage of the manipulator is that it can easily operate more workpieces with only a slight change to the manipulator claw, which is suitable for more working environments, improves the cost performance and brings more benefits to the enterprise.

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