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Motion Control Technology of PLC Industrial Palletizing Robot

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Abstract: With the advent of the new century, the level of industrial automation has improved significantly, and the application of robots has become more and more in-depth. As a typical representative of robots, palletizing robots are widely used in food, chemical, coal and other industries. This article aims to study the motion control technology of PLC industrial palletizing robots. First, the mechanism design of the palletizing robot is completed, and the type selection of the programmable controller (PLC), and secondly, the PLC program design of the palletizing robot is proposed. Apply the principle of PID parameter optimization. The functions and algorithms of the control software system can be continuously improved and perfected, using the work force of the palletizing robot to perform operations. At the same time, new control functions can be added to adapt to the motion control of other types of corporate robots, especially those that require continuous orbits. Analyzing the PID parameters of the stacking process and optimizing the Trio controller, the experimental results show that compared with the unoptimized palletizing, the palletizing optimization increases the handling rate of 400 packages per hour.

1. Introduction

From the perspective of the national economy, the realization of automation is an important function and development direction of the development of the national economic system in our country at this stage. From the perspective of the development process of the manufacturing industry, the manufacturing process will undoubtedly undergo changes in mechanization, automation, understanding, and information [1-2]. As an indispensable irreplaceable and innovative method in modern manufacturing systems, the application and popularization of industrial robots has become a more perfect choice [3-4]. From the perspective of enterprises, with the rapid growth of the national economy, the level of industrial technology in my country has continued to improve. The emergence of industrial robots, with its important role in automated production lines, has increased the competitiveness of many companies, while also bringing significant benefits to users [5-6].

Industrial palletizing robots are of great significance to all aspects of social production. Sun H studied the mechanism design, dynamic modeling and error analysis of the cable-link series-parallel palletizing robot (CSPR). First of all, CSPR is designed as a series-parallel hybrid mechanism driven by flexible cables, which can effectively reduce inertia and improve dynamic response. As we all know, the kinematics design optimization of compliant mechanisms requires precise and

efficient mathematical models. The kinematics and dynamics models are established through homogeneous coordinate transformation methods and Lagrange equations. Based on the dynamics mathematical model of the robot, a variety of sensors are selected to construct the hardware control system, and the sliding mode variable structure control strategy is designed based on the motion error. Then, the motion performance and bearing capacity of CSPR under different working conditions were analyzed and compared, and the results verified the effectiveness and effectiveness of the mechanism [7]. Kataoka R proposes a smooth motion control method that considers human behavior. The proposed motion control method is based on DWA (Dynamic Window Method), which is a widely used obstacle avoidance scheme that uses multiple objective functions for optimization. Taking into account human behavior, DWA defines an additional objective function to achieve smooth motion control of mobile robots [8]. Industrial palletizing robots are an important branch of industrial robots, so the research and development of industrial palletizing robots has great practical and economic significance.

The PLC-based industrial palletizing robot motion control system designed in this paper is used to improve the work on the assembly line and determine the position movement between the assembly line, grinder and packaging machine. Pre-control requirements for precise control of the control structure of the system. The configuration monitoring system run by the host can monitor operations in real time. In the PLC control design part, analyze the operating requirements of the control system, determine the input and output domains, select the appropriate PLC host, PLC and analog control keys, various sensors, and servo applications. Industrial palletizing robot movement has two operation modes: manual control and automatic control. The PLC control system is constructed according to various control requirements.

2. Research on Motion Control Technology of PLC Industrial Palletizing Robot

2.1 Control System of Palletizing Robot

The manual work is heavy and requires many people to complete the same work, which is inefficient and costly [9]. Powerful palletizing robots are an important foundation for the workshop because they can move the entire box and are compact. In addition, it is characterized by reliability, easy-to-use software management by many users, and can quickly change the palletizing of various boxes; fast delivery speed, significantly increased output, and made a significant contribution to the promotion of automated production lines [10].

The palletizing robot control system includes a main control system and a training box. As the basis of the palletizing robot, the main control system completes the corresponding operations, successfully controls the process trajectory, captures the general intelligent coordinates and transmits them to the motion controller through the communication interface for control, and can give instructions to the process. The training box control is the main purpose of the operator's interaction with technology. Technology directly determines the response speed and stability of the system. The operator can use the buttons and graphics in the learning box to easily input commands and settings [11-12].

2.2 Selection of Programmable Logic Controller (PLC)

Compared with the traditional update control system, PLC has the following advantages: First, it is easy to install and has strong anti-interference ability. Second, the programming is easy to understand and reliable. Finally, it has rich features, completeness and flexibility. It has high performance and can be used in many fields. Judging from the current situation, the world's most famous PLC suppliers include Omron, Mitsubishi, Siemens and Schneider. We used a small PLC

for the object to manage additional costs based on usage requirements. Here, the CP1H PLC of Omron was chosen as a small PLC to meet the design requirements of the object. The PLC selected on the object has the following characteristics:

(1) The processing speed is significantly higher than other small general-purpose PLCs, and the running time in each direction is 0.1 microseconds.

(2) Strong expansion function, PLC input and output points are 24 points and 16 points respectively, and the maximum number of expandable input points and output points is 320 points.

(3) The four arms have powerful high-speed pulse power, which has obvious advantages in normal position and speed control.

(4) High-speed reading function.

(5) The serial port communication ability is strong, can choose RS-232C and RS-422A/485 two kinds of communication panels, it is convenient to connect converters, programmers, scanners, etc.

(6) It can communicate with fieldbus through CJ unit.

(7) It is more convenient to communicate with USB, and online programming, monitoring and adjustment can be carried out through the above-mentioned computer interface.

Since the number of servo motors required in this article reaches 4, the output pulse type is 4 axes, and the number of 3D industry grids is 56. Therefore, it is more appropriate to test the number of micro switches, it's the same. Install two end switches in each position. At the same time, there are 1 origin switch, 2 photoelectric side light sensors, and more than 70 input terminals are required. There is no doubt about the number of input points. Obviously PLC cannot meet the requirements, so the expansion module CPM1A-40EDR is needed here. Finally, the CJCJ1W-PRT21 expansion module is also needed for communication, because it needs to be connected to the field bus.

2.3 PLC Program Design of Palletizing Robot

Before creating a program, you need to configure the PLC. After determining the expansion module and PLC model, you need to establish such a network connection, complete the compilation of the global and local label tables, and set the default search, and select the goods to be stored in the warehouse as an example of system preparation. At the beginning of the plan, all axes need to transmit data information to the memory, and 4 axes such as start frequency, speed, acceleration, etc., are transmitted to the corresponding memory data, and the result is set to "servo on" to avoid system failures this is required to cause system failure. Repeated execution, @MOV direction rising edge can be turned off once per cycle. Since the preparation of the action chain is as described above, and the actual operating procedures of each position of the palletizing robot have strict requirements, this object uses auxiliary registers and the upper part of the guide rail to "prepare the system" in the design to distinguish the behavior of each situation. Assuming that the inbound photoelectric switch is enabled after the "configured" function is completed, the motor will stop rotating at this time and wait for the product to arrive at the outbound end. After you are ready and configured, you can save the entire system. After defining the pulse result, the MOVL process is transferred to the corresponding data memory, and the pulse is extracted from the PLS2 direction. The control system also uses an "emergency stop" function. When an error occurs, the palletizing robot stops running in time through simulation intervention to prevent accidents.

2.4 Principles of PID Parameter Optimization

To obtain the perfect response characteristics of the servo system, various gain parameters of the servo system need to be adjusted. Different devices have different response characteristics. The following gain parameters can be adjusted according to the following steps:

(1) The high-speed motor system can use the minimum gain value (P_GAIN), while increasing

the loop speed gain (OV_GAIN), increase the smoothness of the damping, reduce the following deviation, and keep the entire rotation period low. This detection method allows to increase the further gain of the velocity loop (VFF_GAIN) while using a larger balance gain value to compensate for the next division.

(2) The timing detection at the end of the run can use the average gain and shared gain of the system to meet this requirement, but be aware that overshoot will occur after deceleration.

In the above description, each gain parameter should be adjusted together. At the same time, note that the program must first set the proportional gain separately, the initial default value is 1.0, and then other gain parameters must be specified.

3. Investigation and Research on Motion Control Technology of PLC Industrial Palletizing Robot

3.1 Description of Site Layout

In the experiment, the palletizing robot base, conveying motor, sensor, pallet, etc. are fixed. 1,2,3,4 are the sensor brackets, and the infrared sensor constructs the security area. No. 1 and No. 2 brackets are also equipped with a cargo detection photoelectric switch, the direction is 1 and 2 connection direction. When the cargo approaches the conveyor belt baffle, there is an action signal, and it needs to be adjusted repeatedly to find a valid position.

3.2 Experimental Test Trajectory Conditions

According to the test requirements, using ABB's palletizing test requirements, that is, the effective stroke of the end gripper is: 400mmx2000mmx400mm, and the running trajectory is that the gripper first rises by 400mm, and then is pulled up by 2000mm.At this time, the body rotates about 90 degrees, and the gripper Raise 400mm. After this stage is completed, the end gripper will go down 400mm. During operation, keep the gripper to the specified steering angle and load 75kg.

3.3 Trio205 Controller PID Parameter Optimization

Proportional gain output voltage, Op and follow-up deviation E are proportional, all applicable application settings must use proportional gain, and most systems only use proportional gain as shown in Equation 1:

$$Op = Kp \times E \quad (1)$$

The integral gain generates the production value Oi based on the average value of the deviations produced in the planning process. The partial gain will produce overshoot, which is often used when the system speed is stable and the acceleration value drops, as shown in Equation 2.

$$Oi = Ki \times SE \quad (2)$$

4. Investigation and Analysis of Motion Control Technology of PLC Industrial Palletizing Robot

4.1 Analysis of the Stacking Process of the Palletizing Robot

The stacking process of the palletizing robot is divided into six steps, and the control process after assembly is three steps. The robot returns to the base in three steps for the next loading and packaging process. The two processes are the same, but the return speed is faster than the coding

speed

First, before starting the palletizing operation, the "origin" is the initial position of the robot's gripper. First, let the gripper move to "via point 1 (first point)". Secondly, when the product is picked up, the gripper will move to The "original" position; the third is to go to the "passing point 2", that is, the target position is just above the height of the two goods; fourth, the product is placed on the courtyard; fifth, when the goods are released, the robot grabs The hand will move to "via point 2"; sixth, move to the "origin", after stacking a piece of goods, it is necessary to continue to stack a piece of goods. As can be seen from the above analysis, in the robot stacking process, the movement of the palletizing robot's gripper is in the action state of "take-put-back". When the actual stacking operation is carried out, the gripper will move between four positions. When moving at all two points, it is called a straight transfer.

4.2 Optimizing the PID Parameter Analysis of the Trio Controller

Without any trajectory optimization, a list of representative speed and acceleration values of A-axis, B-axis, C-axis, and D-axis are obtained during operation. In the initial stage of the movement of the palletizing robot, the speed, acceleration and deceleration values of the A-axis, B-axis, C-axis, and D-axis are shown in Table 1; in the middle stage of the palletizing robot's movement, the A-axis and B-axis , C axis, and D axis speed, acceleration and deceleration values are shown in Figure1.

Table 1: Operating data of each axis at the beginning

Joint	A	B	C	D
Speed	60 %s	500mm/s	800mm/s	90 %s
Acceleration	500 %s2	3000mm/s2	3000mm/s2	500 %s2
decrease speed	500 %s2	3000mm/s2	3000mm/s2	500 %s

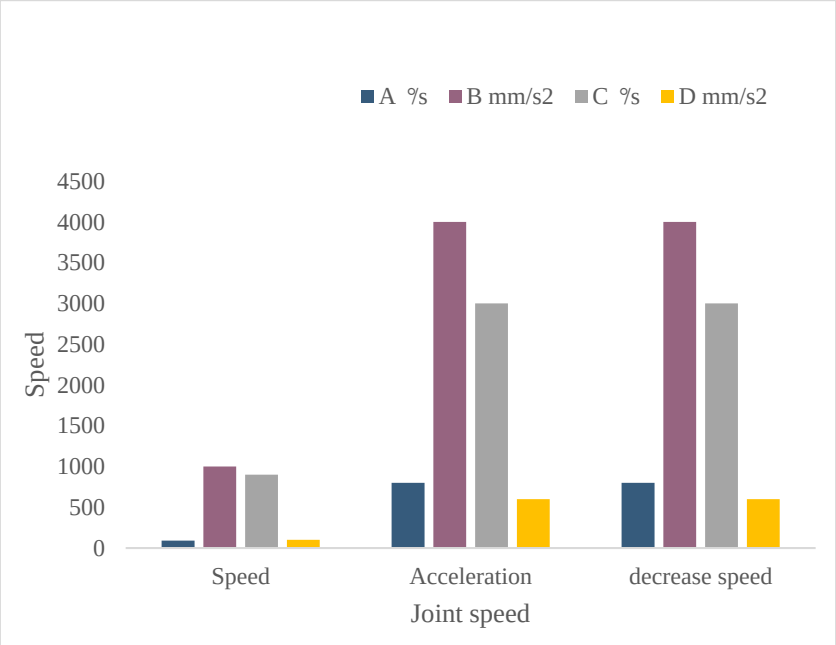

Figure1: The operating data of each axis in the intermediate stage

The palletizing robot finally runs according to the data in the above table. The test results: The actual test is 5 times, and each transfer is 5 cycles. The measured running time is 35.5 seconds, the intermediate pause time is 0.5 seconds, and the total time is 37.5 seconds, that is, each transfer It

takes 7.5 seconds to go back and forth, and the palletizing efficiency is about 500 to 550 packages per hour. After the trajectory is optimized, that is, the speed, acceleration, deceleration, and movement mode of the movement process are optimized and combined, and the actual test is 5 times. Each handling takes 5 cycles, the measured running time is 25.5 seconds, the intermediate pause time is 0.5 seconds, and the total time is 27.5 seconds, that is, it takes 5.5 seconds to move back and forth each time, so that the palletizing efficiency can reach the handling rate of 900 packages per hour.Experimental conclusion: Compared with the unoptimized palletizing motion, the palletizing efficiency is significantly improved after optimization; the reason for the improvement after optimization is mainly because the operating speed, acceleration and deceleration of the A-axis, B-axis, C-axis, and D-axis are obtained. Reasonable improvement, and optimized combination of motion trajectory, smooth and smooth motion process.

5. Conclusions

The industrial robot market is developing rapidly, and new and higher requirements are put forward for quantity and technical requirements. This is a big challenge for my country's robot companies, and it is also a good opportunity for my country's manufacturing industry to palletize robots. In this article, we will conduct field tests on the developed robot palletizing motion controller, connect the robot palletizing control cabinet, design and configure the motion controller's robot zero reset, simulation and point-to-point automation functions, and obtain the results. The code condition is that the motion of the controller can effectively control the robot and perform various motion tasks. The acceleration and deceleration of the process motion are stable, and the motors of each axis of the robot system are repeatedly positioned, which proves the accuracy of the industrial palletizing robot.

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