An Application of the CAN-Bus Based Multi-Axis Servo Control System for Enteric Capsule Production

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***Abstract* — In this paper, a CAN-bus based multi-axis servo control system for enteric capsule production is proposed. It mainly includes Delta® AH-series PLC configured with CAN-bus communication module, 38 servo motors, and Kinco® HMI devices. The system realized data exchange between the controller and Delta® ASDA-A2 series servo drives, the movement control and accurate positioning control with high control precision and fast response speed. All the parameters can be set through a touch screen with friendly user interface. Application practice results show that the system has the advantages of stability, reliability, real-time performance and practicality.**

Keywords - CAN-bus; multi-axis servo control; enteric capsule production

I. INTRODUCTION

Stomach and intestines are the mainly digestive organs of the human body. Stomach is mainly acidic, and intestinal is alkaline. Enteric capsule will be absorbed in the small intestine with the alkaline liquid. Therefore, a layer of anti-acid material surface is covered on the capsules to ensure it won't be melt in the stomach. Automatic production line of enteric capsule is a kind of new advanced capsule production line. Compared to semi-automatic production lines, not only the production has been greatly improved, but also a substantial increase in product quality. This kind of production line including dipping, dehydration, drying, cutting, and other processes to produce the hollow capsule shell.

CAN (Controller Area Network) is developed by BOSCH® in 1986, and it has become the international standard serial communication protocol (ISO11898) [1, 2]. It is one of the most widely used field bus in the world. Now, the high performance and reliability of CAN-bus has been recognized, and it is widely used in industrial automation, shipping, medical equipment, industrial equipment, etc. Field bus is one of the hot topics in the development of automation technology, and it is known as the computer local area network in the field of automation [3-5]. It provides a powerful technical support for the realization of real-time and reliable data communication between nodes in distributed control system [6].

In this paper, we studied on the CAN-bus based multi-axis servo control system application to the enteric capsule production line. The servo motion control system is configured with Delta® PLC AH500-EN, CAN-open communication module AH10COPM-5A and ASDA-A2 series servo drives. The system is designed to control 38 servo motors with the functions of slow start, fast braking, precise positioning and on-line speed regulation. All parameters can be set down through the touch screen with kindly interface.

II. SYSTEM DESCRIPTION

Servo control system is a typical closed-loop control system, which has good performances of high positioning accuracy, fast response time, stable operation, strong overload ability, etc. It is suitable for high precision motion control of the enteric capsule production line. The system structure is shown in Fig. (1).

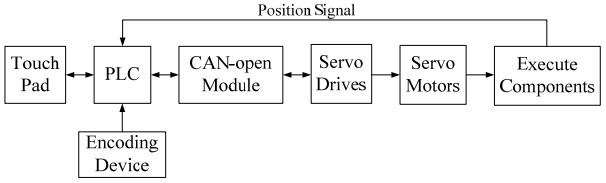

Figure 1. System structure.

Running the system, through the touch pad screen, the speed and displacement values of each segment can be set up, and then PLC will convert these values into the corresponding pulse signals. Servo driver will convert the given the pulse signal into control voltage signal and output it. The servo motor output a certain angular velocity and angular displacement by the given voltage signal to drive the execute components to achieve precise speed and positioning control target. The System hardware configuration is shown in Fig. (2).

There is a strong correlation among the 38 servo motor actions, and if we only rely on position signals of the limit switch and others, it is difficult to achieve a stable, low failure control effect, and even when the motor is in a failure, may cause the associated motors error. Therefore, we used the combined information of the angle value of the encoder and the motion sequence of the motion mechanism to coordinate the start and stop actions of the 38 servo motors.

Some of the main actions sequence diagram is shown in Fig. (3).

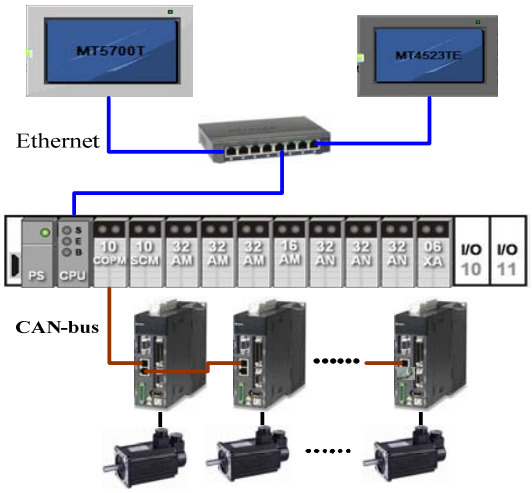

Figure 2. Hardware configuration.

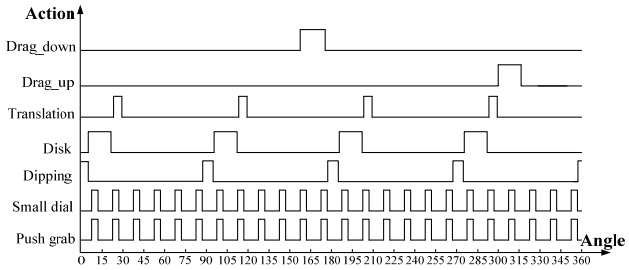

Figure 3. Main actions sequence diagram.

III. COMMUNICATION INSTALLATION

A. CAN-open

CAN-open is a kind of application layer protocol based on CAN network, which has a very good characteristic of Modularization. It is more refined, transparent and easy to understand than the other field buses, which make it widely used in industrial automation field [7-10]. CAN-open protocol has the trigger mode of synchronous trigger, asynchronous trigger, event trigger, and the communication type of master-slave mode and broadcast mode.

CAN-open protocol in our system uses event trigger, master-slave communication mode, it transmits PDO packets using differential method through two signal lines of CAN_H and CAN_L to realize the data transmission between PLC and servo driver. Fig. (4) shows the specific transmission direction of the received PDO (RxPDO) and transmitted PDO (TxPDO). When the RxPDO or TxPDO data is changed, that means an event occurred, the master-slave communication mode is triggered. When the RxPDO data and TxPDO data have no change, the data exchange between the master and slave stations will not be performed.

Fig. (5) shows the CAN-open master-slave network configuration. “001” is the CAN-open master station address, “002”-“039” are the 38 slave stations address of the CAN-open network. Address of the read/write register, the number of the servo drive station, and the communication baud rate should be setup in the master module initialization process. The correspondence between the servo drive parameter variables and PLC register address will be established after the nodes and the PDO mapping configuration. After that, the servo motor can be controlled by the preparation of PLC and touch screen program.

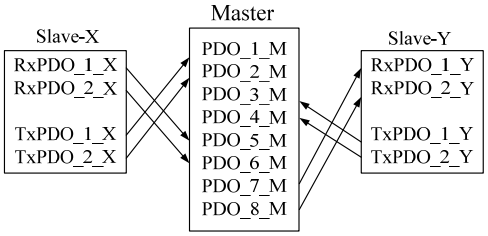

Figure 4. PDO transfer of master-slave communication mode.

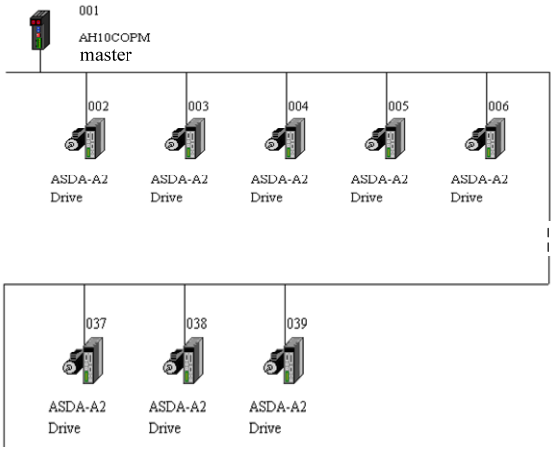

Figure 5. CAN-open master-slave network configuration.

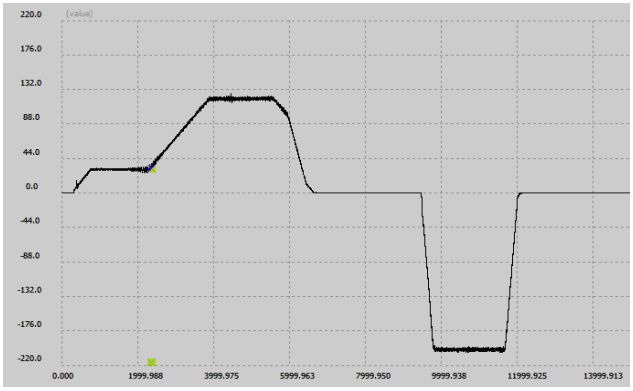

Figure 6. Speed curve of the push grab.

B. Servo control mode selection and setting

Delta® ASDA-A2 series servo drive has three kinds of basic control operation modes of position control, velocity control and torque control, they can use and single or mixed control mode can be used in different application [5, 11]. Requirements of each device's travel accuracy is much

higher than the speed and the torque accuracy in the enteric capsule production process, so we used the PR position control mode in our system. By setting the speed, acceleration and deceleration time and other parameters of the PR position control mode, we can get the speed curve of the execution component. Fig. (6) shows us the speed curve of the push grab, which is one of the main actions of the enteric capsule production process. The horizontal axis represents the displacement, the horizontal axis represents the speed.

TABLE I PARAMETERS AND THE CORRESPONDING REGISTERS.

Register	Parameters	Description
D6000	P3-06	DI source control
D6001	P2-11, 12, 13, P4-07	Special function of the DI bit-strobe
D6002	P5-07	Register for PR selection
D6003	P5-60	Speed of PR1
D6004	P5-61	Speed of PR2
D6005	P5-62	Speed of PR3
D6006	P5-63	Speed of PR4
D6007-D6008	P6-03	Pulse number of PR1
D6009-D6010	P6-05	Pulse number of PR2
D6011-D6012	P6-07	Pulse number of PR3

IV. PLC PROGAM EXAMPLE

After the completion of the enteric capsule production line system, we should write PLC program to control the running state of the servo motor. In practice, we should put the parameters of the servo drives into the registers of the PLC. We take the push grab control program as an example, the parameters and corresponding registers are shown in Table 1, and the implementation procedures are as follows:

LD SM400

MOV 16#E D6000 (* Assignment to P3-06 *)

LD M0 (* M0 is manual condition *)

AND M2 (* M2 is the manual forward button of the push grab *)

OUT D6001.1 (* Set P2-11 of the servo drive to 137 *)

AND M3 (*M3 is the manual reward button of the push grab *)

OUT D6001.2 (* Set P2-12 of the servo drive to 138 *)

AND M4 (* M4 is for faults clearance *)

OUT D6001.3 (* Set P2-13 of the servo drive to 102 *)

LD M1 (*M1 is automatic condition *)

AND M5 (* M5 is the automatic reward condition of the push grab *)

MOV 1 D6002 (* Servo motor execution forward path PR1, PR2, and PR3 *)

AND M6 (*M6 is the automatic reward condition of the push grab *)

MOV 4 D6002 (* Servo motor execution reward path PR4, back to the start point *)

LD M7 (* Parameter confirmation of the push grab *)

MOV D0 D6003 (* D0 is the address of the first speed value of the parameter setting interface *)

MOV D1 D6004 (* D1 is the address of the second speed value of the parameter setting interface *)

MOV D2 D6005 (* D2 is the address of the third speed value of the parameter setting interface *)

MOV D3 D6006 (* D3 is the address of the fourth speed value of the parameter setting interface *)

DMOV D4 D6007 (* D4 is the address of the first displacement value of the parameter setting interface *)

DMOV D6 D6009 (* D6 is the address of the second displacement value of the parameter setting interface *)

DMOV D8 D6011 (* D8 is the address of the third displacement value of the parameter setting interface *)

All the other PLC program for the actions control can be designed in accordance with the above form.

V. CONCLUSION

A CAN-bus based multi-axis servo control system is proposed in this paper. We applied it into enteric capsule production process with construction of the CAN-bus control network, compiling the control program of PLC and HMI to control the servo motors accurately. Practical application shows that the system is stable and reliable, with high control precision, friendly HMI, and high practical value. It improved production efficiency and product quality, and reduced the production cost.

ACKNOWLEDGEMENTS

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