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THE ROBOTIC MASS MEASUREMENT SYSTEM DESIGN

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Abstract: The paper described the design of the robotic mass measurement system. The dedicated device was the upgrade of the existing balance, which the measuring range is (1~ 220) g. Measurement process and auxiliary devices for the control were introduced. The electric slider make one-dimensional motions, and the robot arm was constructed by some series electric cylinder module combined in sequence, so robot arm can make a three-dimensional moving. The Programmable Logic Controller (PLC) was programmed to control the Robot Arm and Electric hands to pick, move, and place the weight, one weight at a time. The device programmed can measure the weight or make ABBA type compare automatically without human participation.

Keywords: mass, balance, weight, robot arm.

1. INTRODUCTION

The procedures of the mass measurement and calibration are repetitive artificial task: First, the weight was clamp, then shifts from the container to the pan; until the indicated value was stable, the value recorded automatically; last, the weight was captured again and shifts from the pan to the container. Mass Laboratory of Chongqing Academy of Metrology and Quality Inspection have dedicated to improve efficiency of measurement and calibration.

The industrial automation technology had been widely used; the rapid development and popularization of the database could real- time processing data. The procedures of weighing weight could automate by robotic system, and the system can work automatically and come to easy operation, height efficiency and low cost.

2. SYSTEM FUNCTION INTRODUCTION

Based on the industrial applications and the available high precision electronic balance, the system function defined as follows: the worker put the weights on the warehouse and set procedures, the system can automatically complete the following work:

1) The robotic hand could clamp, release, moves one weight, each time.

2) The movement of the robotic hand had been coordinated with the balance such as open side door etc. smoothly and continuously.

3) The database record the indicator of the balance.

The robotic mass measurement system was coupled by the robotic arm, electric hand, closed loop control, electric cylinder module, database etc.

3. CONSTRUCTION OF THE DEVICE

3.1 Basis of the design

The robotic system has three parts: mechanism, control segment and PC. Besides the PC, all of the parts were installed in electric control cabinet.The mechanism is the fundamental part of the system, including mechanical parts of the robotic arm, electric hand and electric control cabinet etc. Fig. 1 shows a schematic of the mechanism. The control segments of the system, such as the PLC, were fixed on the electric control cabinet. The PC was programmed to communicate with the balance and control segments.

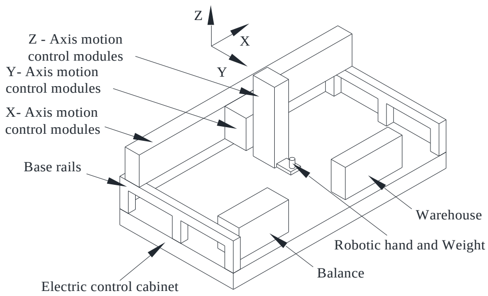

Fig. 1 A schematic plan view of the System

The coordinate System is shown in Fig. 1, the X-Y plane is horizontal and Z-axis is upward. The motion module compose the robotic arm and robotic hand. The electric control cabinet is placed on the floor, the ground floor contain the control equipment such as the bus etc. The mechanical layouts of Layer 2 is the robotic arm, balance, warehouse etc. the robotic arm is mounted on the electric control cabinet, and the robotic hand is fixed on the arm. The warehouse is used to layout the weight.

3.2 Mechanical Construction.

The movement of the weight from the warehouse to the span or the reverse turn complete by the robotic arm and robotic hand together. The finger hold or release the weight, and the weight move with the arm. The actual trajectory of the weight is complicated and reduced to three individual one-dimensional motions. Correspondingly, the motion module of the weight is set up of three sets of linear motion modules, including base rail, XYZ motion module respectively. The motion relation defined as following:

- The base rails fixed on the control cabinet.
- The Y motion module moves along the base rail in the X-axis.
- The X motion module moves along the X-axis on the Y motion module.
- The Z motion module moves long the Z-axis on the Y motion module.

The robotic hand fixed on the Z motion module, it consists of electric gripper and non-metallic finger assemble. The electric gripper has two gripper, which make open-close motion (one-dimensional motions along the X-axis). The finger fixed on the gripper.

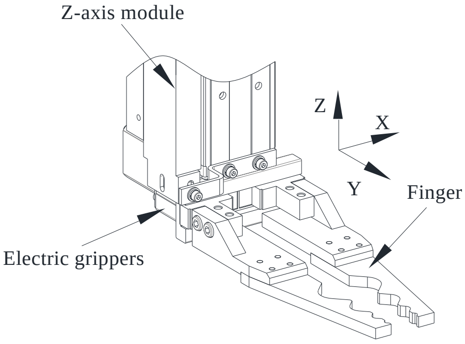

Fig.2 Robotic hand

To minimize the airflow, the motion modules are carry out one by one, each motion module had independent control systems. To avoid the magnetization, the warehouse, working table and the finger are non-metallic. The warehouse has three-layer, the ground floor is the standard weight, and the others are checked weight. The weights are arranged by manual.

3.3 Control System Construction.

The system is composed of the software and hardware module. The hardware includes the PC, balance, PLC, electric cylinder module and linear scale etc. The framework diagram is as Fig.3, the arrows mean the direction of data transmission. The electric cylinder module, which is driven by servomotor, is composed of the ball screw, the precise guide rail etc. The electric cylinder module can use for linear motion.

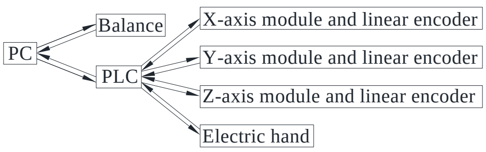

Fig. 3 the Control diagram

Technical grade PLC applied, which get pulse signal of linear scale and transfers to position signal. The control system deploys closed-loop control on each motion module independently, and every closed-loop control has its individual linear scale. The system compares the data of closed-loop control and the encoder. There are two sets of PLC are applied, because the amount of the control parameter is huge and logical sequence is complicated: PLC1 control the XYZ motion module and PLC2 in charge of data acquisition of linear scale and the control robotic hand

3.4 Software System

The software system includes the HMI (Human Machine Interface) module, OPC sever and PLC programme, Fig.4 is the diagram.

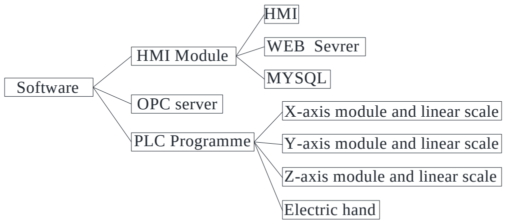

Fig.4 diagram of software system

The HMI Module is the Web Application, and consists of several modules: HMI, WEB server and MySQL. When the HMI launch, the software start the following procedures: the system check, input the information of the checked weights, read the indicator of the balance, define the router etc. MyEclipse is the Java compilation environment, Fig.5 is the main page. The HMI access the database through Jboss server. MySQL store the following data:

- Username and Password
- History data for future calls, review and other work
- System parameters, such as the velocity of the motion module

Fig.5 screenshot of main page

MySQL is a relational database, HMI define some relational tables such as userInfor class, record class and so on. Record class Form included the ID, customer information, verified data etc. ID is the primary key (Non - empty auto increment an integer variable).

The data interface of the most balance is RS232 serial port or USB. The system experiment use Sartorius ME215s, the HMI connect balance via RS232 serial port, which the pin 2 is data output and the pin 3 is data input. The output of balance is hexadecimal and the format is 22 characters in length. The control commands had some formats; such as the open of left door, the control commands can have up to 26 characters:

ESC W1_ CR LF

The HMI module connect the PLC Programme via OPC server, the HMI module and OPC server are installed and run on PC, PLC module run on the PLC. The PLC connects the PC via standard network port. Profinet use to connect between the PLCs, between the PLC with robotic arm and robotic hand, and the communication protocol is S7.

There are two kinds of communication method between PC and the motion module: the first, Using C language or other advanced language program design, calling the API Function to manipulate the data interface, which require higher levels of software development and once the HMI is not responding, the whole system would be out of control or breakdown. The alternative method is the industrial control configuration software. The PLC Programme configured by Portal that had shortened development period and improved design efficiency.

4. MEASUREMENTS.

After online debugging and experimenting, the robotic mass measurement system has been accomplished (Fig.6) and the function of the system are:

1) The system do not confine to the particular balance, the experiment use Sartorius ME215s, PC connect the balance by RS232 interface, which can open/close shield door, check the status of the door etc.

2) The weight layout on warehouse by manual, and during the experiment, the weight is automatic by program.

3) The data in database are easy to query and print.

4) The weight can be catch/release/translate by the robotic arm.

5) The HMI is the Web application; tester can query the system status or the historical data by internet.

Fig.6 The robotic mass measurement system

A 200g weight and a 20g weight were selected for test. The procedure defined as following: the weight was put in the warehouse by manual. Then, the weight was checked automatically. The 200g weight is the first, the Fig. 7 is the data of 200g weight repeated 10 times; the 20g weight was second, the fig 8 is the data of 20g weight repeated 10 times.

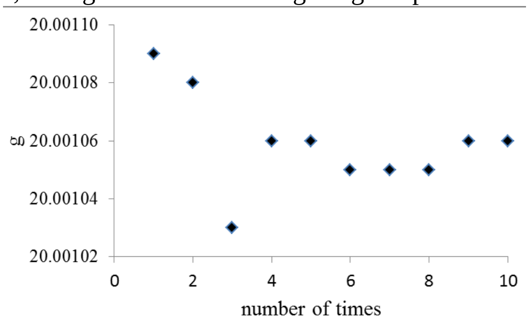

Fig.7 Result of 200g

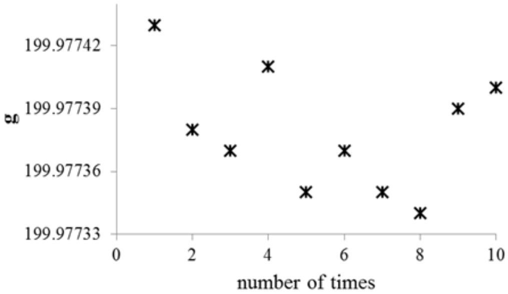

Fig.8 Result of 200g

5. CONCLUSION.

The installation of a robotic mass measurement system brings many benefits to the quantity-transfer system of weight. In addition, the system did not replace or add new balance, it is an upgrade of the balance in-use in automation. Robotic systems can reduce labor intensity and improve efficiency in mass calibration.

The system has finish installation and debugging by the end of 2016, and it is in its trial running repeatedly and continuously in order to improve and optimize the system to ensure an accurate and reliable traceability system of quantity.

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