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Automated Material Handling System Based On the PLC

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Abstract: ***This paper is based upon use of PLCs (Programmable Logic Controllers) for the purpose of automated material handling to pick metallic partsand place it in the box. Currently many researches works have been done on the subject of material handling. However their approach seems to be more complex and cost higher. This is because they always employ complex logic components which are expensive. In this research we proposed an automated material handling which is easy to implement and cost effective.***

Keywords: PLC, metallic parts, Automation, sensors.

1. Introduction

Automation has brought several drastic changes in manufacturing over the past century. These changes include increase in overall productivity and profitability of a manufacturing system. Development of electronics (transistors and microchips) led to a jump in control technology and precision of various instruments. This laid a path for efficient and cost effective manufacturing processes. Automation of manufacturing systems requires integration of various fields such as mechanical, control and electronic systems, and computers .Automation in various forms constitutes the backbone of most major industries. It has become a significant part of defense, medical, aerospace and automotive industries, materials processing and handling, manufacturing, and consumer products to meet the increasing demand for the production volume and product variety.

In the manufacturing industry, automation in material handling has increased the overall profitability of the product with an improvement in the quality and productivity of the system. This is primarily due to two reasons. First, automation reduces the total production cycle time, and second, it helps smooth flow of raw materials and finished products to their desired location with little or no human interference. [1]

2. Case Study

Here we take up the case of automated material system where the objective is to place parts inside boxes through a three axes arm robots.

2.1 Existing System

When a material handling system is to be made autonomous there is a need for additional sensors and appropriate control logic to manage the discrete events. It should be also noted that an autonomous system does not differ much structurally from the existing system. This reduces the overall cost for the automation. Even before the system is built, modelingand simulation of the system gives not only a good perception of the dynamic operations, but also a method to verify the design. An autonomous material handling system can be modeled as discrete event system at a certain level of abstraction. For high speed automation, both gantry and articulated arm robots are widely used throughout industry. Because of the many inherent advantages of the gantry robot, it is rapidly becoming the preferred choice for: [2]

- Palletizing storage and retrieval
- Machine loading parts transfer
- Material handling automated assembly

2.2 Proposed System

The system is used stepper motor, 3ph-motor sensors and PLC to pick the metallic parts and place it inside box. All the manual operations are replaced by sending signals from the PLC to the respective devices. The work of pick & place metallic a part from various places is automatically done by a three axisarm robots setup that is controlled by the PLC.

The EM 253 Position Module is an S7-200 special function module that generates the pulse trains used for open-loop control of the speed and position for either stepper motors or servo motors. It communicates with the S7-200 over the expansion I/O bus and appears in the I/O configuration as an intelligent module with eight digital outputs.

Based upon configuration information that is stored in the V memory of the S7-200, the Position module generates the pulse trains required to control movement.

The Position module provides the functionality and performance that you need for single axis, open-loop position control:

- High speed control with a range from 12 pulses per second up to 200,000 pulses per second.
- Absolute position control.
- Relative position control.

- Manual position control.
- Continuous operation.

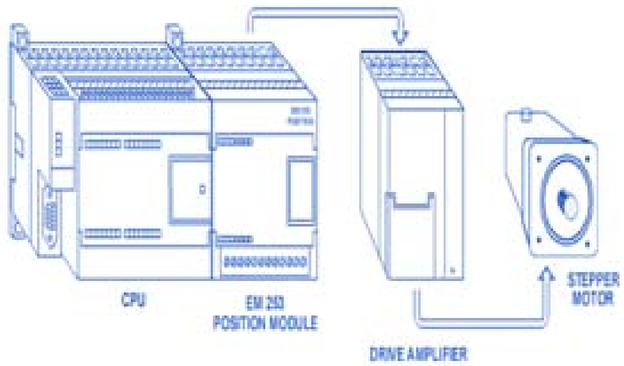

Figure 1: The EM 253 Position Module connected to PLC over the expansion I/O bus

3. PLC Hardware Specifications

A programmable logic controller is a digital computer used for automation of electromechanical processes. Industrial PLC describes the computing unit of any industrial automation system and therefore need to meet several challenging requirements such as high reliability, environmental noise and influence immunity and also enhanced protection classes (e.g. water-resistant and dust sealed).

PLCs also satisfy the needs of continuous 24 hours/7 days operation and availability over a wide environmental temperature range as well as real-time operation capability and security and safety enhancements.

The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC. The communications interface is used to receive and transmit data on communication networks from or to other remote PLCs. It is concerned with such actions as device verification, data acquisition, synchronization between user applications and connection management.

Some of the advantages of using PLC include:

- Programming the PLC is easier than wiring the relay control panel.
- The PLC can be reprogrammed. ConventionalControls must be rewired and are often scrapped instead.
- PLC takes less floor space then relay control panels.
- Maintenance of the PLC is easier, and reliability is greater.
- PLC can be connected to the plant computer systems more easily than relays.

We have chosen **PLC_200** SeriesProgrammable Logic Controllers with the following features.

Table 1:S7-200 CPU Model features [3].

Feature	*CPU 226*
Physical size (mm)	190 x 80 x 62
Program memory: with run mode edit without run mode edit	 16384 bytes 24576 bytes
Data memory	10240 bytes
Memory backup	100 hours typical
Local on-board I/O Digital Analog	 24 In/16 Out --
Expansion modules	7 modules1
High-speed counters Single phase Two phase	 6 at 30 kHz 4 at 20 kHz
Pulse outputs (DC)	2 at 20 kHz
Analog adjustments	2
Real-time clock	Built-in
Communications ports	2 RS--485
Floating-point math	Yes
Digital I/O image size	256 (128 in, 128 out)
Boolean execution speed	0.22 microseconds/instruction
Picture	

4. PLC-Software Specifications

PLC programs are typically written in a special application on a personal computer, and then downloaded by a direct-connection cable or over a network to the PLC. The program is stored in the PLC either in battery-backed-up RAM or some other non-volatile flash memory. Often, a single PLC can be programmed to replace thousands of relays.

The STEP 7--Micro/WIN programming package provides a user-friendly environment to develop, edit, and monitor the logic needed to control your application [4]. STEP 7--Micro/WIN provides three program editors for convenience and efficiency in developing the control program for your application. To help you find the information you need, STEP 7--Micro/WIN provides an extensive online help system and a documentation CD that contains an electronic version of this manual, application tips, and other useful information [5].

5. Basic Design of the System

Major applications of mechatronics include automation, robotics, sensing and control system, microcontrollers / PLCs, computer-machine controls and others. Mechatronics is a design process that includes a combination of mechanical engineering, control engineering and computer engineering. Basically a mechatronic system comprises of a basic mechanical structure (to generate a certain carrying behavior or movement), sensors (to collect information on the system or the environment), processors (to evaluate the information and to generate correcting variables according to certain rules), and actuators (to convert correcting variables into forces, movements, electrical voltages or other quantities which act on the basic system or its environment).

This Automated material handling system is composed of an entry/exit bay of metallic parts, a three axis arm robots, actuators, sensors, drivers and an entry/exit bay of boxes.

Table 2: sensors and the functions

No.	*Type*	*Function*
1	Limit switches	Arm robots detector at zero position (picking area)
2	"	Top limit switch of the arm robots vertical axis
3	"	Bottom limit switch of the arm robots vertical axis
4	Photo electronic	Part detector at the picking area
5	"	Box detector at the placing area
6	Proximity sensor	Arm robots movement detector
7	"	Magnetic gripper detector

Table 3: actuators and functions

No.	*Type*	*Function*
1	3ph-motor	Parts conveyor table
2	"	Boxes conveyor table
3	Stepper motor	Longitudinal axis movement of the arm robots
4	"	Transversal axis movement of the arm robots
5	"	Vertical axis descending movement of the arm robots
6	"	Magnetic gripper

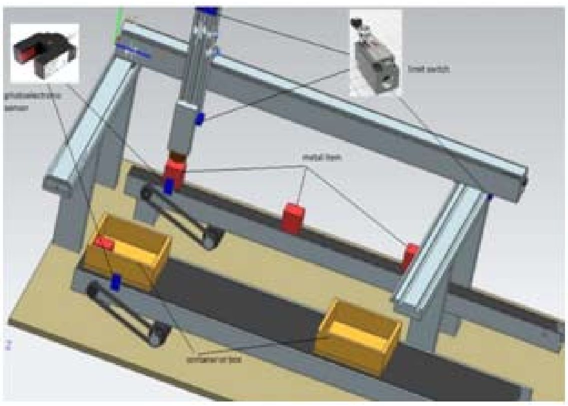

Figure 2: The sensors position into the system

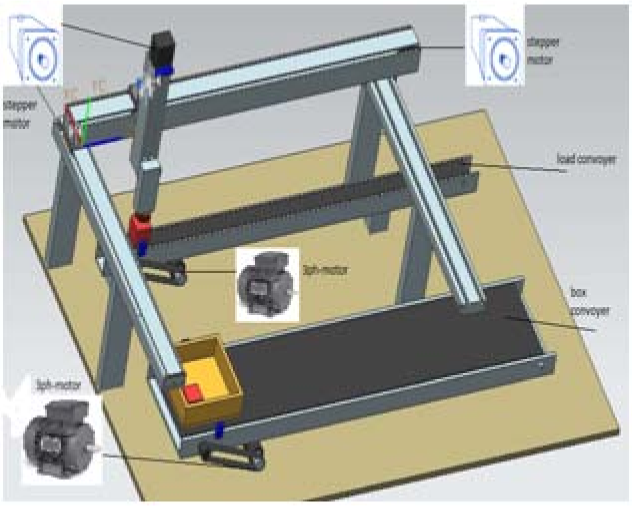

Figure 4: The actuators and their position in the System

Figure 5: Sample for the box

6. Working

When a PLC executes a program, it must know in real-time when external devices controlling a process are changing. During each operating cycle, the processor reads all the inputs, takes these values, and energizes or de-energizes the outputs according to the user program. This process is known as a program scan cycle.

6.1 Generally

Boxes are transported by a conveyor belt from the entry bay to the conveyor belt that positions the boxes in the placing area. The parts conveyor belt transports metallic supplied parts. The three axis arm robot picks the parts using a magnetic gripper and places them in the previously positioned box. The loaded boxes are then transported to the automatic exit conveyor belt for the boxes.

6.2 The boxes

The box is subdivided into 9 cells (part/cell) after the three axis arm robots picks the part then the PLC sends pluses out to control the stepper motor move FW/BW for specific distance according to cells position in the box. The required pluses for stepper motor for this distance it should be calculated and stored into the PLC memory the program it can call it from the memory directly figure (6) shows the box cells and there distances.

The PLC will send pluses for stepper to move 1st time X1 distance, 2nd X2 distance, 3rd X3 distance, 4th X1&Y1 distance, 5th X2&Y1 distance, 6th X3&Y1 distance, 7th X1&Y2, 8th X2&Y2 and the last X3&Y2.

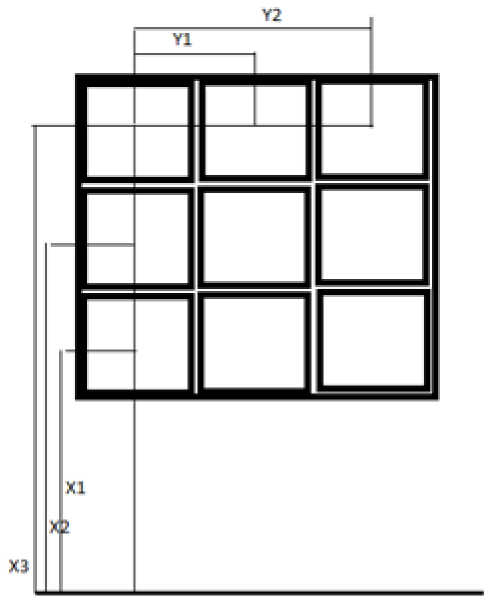

Figure 6: The box cells x1, x2 and x3 are the distance from the part conveyor belt, y1 and y2 the distance from the first Colum to second Colum and third Colum

6.3 Ladder Flowchart

This ladder flowchart shows how the control program looks like

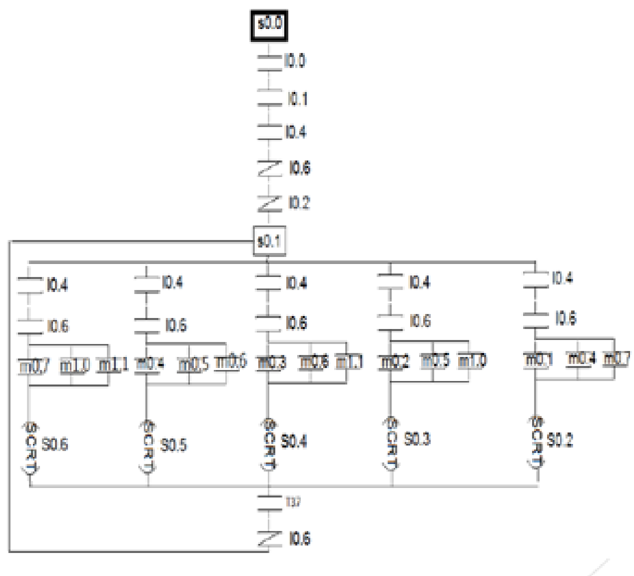

Figure 7: Shows the ladder flowchart.

In this ladder flowchart there are 7th states S0.0, S0.1, S0.2, S0.3, S0.4, S0.5 and S0.7. The S0.0 it will be active when the program start running and then the system will read the Part detector, Box detector, Arm robots movement detector and Magnetic gripper detector to active S0.1 which guide the robots move to zero position (picking area) after pick apart then the program will active S0.2 which allow the robots move to placing area and place the first part into first cell of the box again the program will active S0.1 to pick the 2nd part and then the S0.3 will be active to allow the robots place the 2nd part into 2nd cell The program will repeat same sequence for other parts.

7. Result

After we download the program into the PLC-200 and finish the connection of the sensors, actuator, drivers, inverters, power supply converter, encoders, the EM 253 Position Module and then test the system we did some modification for the ladder after that the system was working stably figure (8), (9) and (10) show some connection of the final model of the system.

8. Conclusions

The whole system has good compatibility and compact structure. It is easy to install, and the line running is stable in the actual production. The labor intensity is greatly reduced for workers, so it has a high degree of automation. On the basis of ensuring the quality, it improves product efficiency, and brings great economic benefits to the production side.

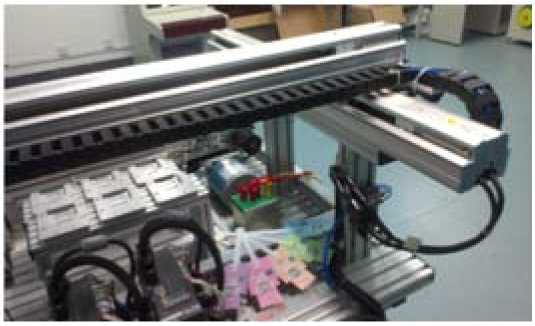

Figure 8: Some connection of the final model of the system

Figure 9: Some connection of the final model of the system

Figure 10: connection of actuator and drivers of the system

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