A PLC CONTROLLED PICK AND PLACE PNEUMATIC ARM BRACE FOR AUTOMATIC MANUFACTURING SYSTEMS

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Abstract: Programmable Logic Controllers (PLCs) are specialized computers used for the control and operation of manufacturing process and machinery, especially in industrial environment. PLC is a user friendly, microprocessor-based specialized computer that carries out control functions of many types and levels complexity that cannot be done by human. This project employees a 9-step problem solving approach to develop a PLC controlled pick and place pneumatic arm brace for automatic manufacturing system in order to solve the problem which appears in a production line. It includes the following steps: define the process operation and list the step-by-step sequence of operation, define and list the input and output devices and sensors required for proper operation, assign corresponding PLC scheme, draw up the PLC scheme, enter the program into the PLC, check the program by using the function mode, wire the PLC system to a simulator and check for hidden safety defects or sequencing problems, check the actual process and make modifications as required. The result shows that the PLC system has been set up and worked properly in the laboratory floor.

Keywords: Automation, PLC, system integration, pick-and-place arm brace

Industrial automation is a process of following the sequence of operations with little or no human labor, by using specialized equipment and devices that perform and control manufacturing processes. An industrial automation also can be defined as the use of control systems (such as numerical control, programmable logic control, and other industrial control systems), in concert with other applications of information technology to control industrial machinery and processes, reducing the need for human intervention. The main advantage of automation is replacing human operators in tedious tasks. Replacing humans should be done in dangerous environments or in making tasks that are beyond the human capabilities such as handling too heavy loads, too large objects, too hot or too cold substances or the requirement to make things too fast or too slow. Moreover, some kinds of automation imply improving in economy of enterprises, society or most of humankind [1].

A programmable Logic Controller (PLC) is one of automation types. PLC automation is also known as Detroit Automation because it was first introduced in automotive factory in1960s. PLC which is a specialized computer used for the control and operation of manufacturing process and machinery is used widely in manufacture and industrial field [2]. Programmable logic controllers are used in almost every aspect of industry to expand and enhance production. Where older

automated systems would use hundreds or thousands of electromechanical relays, a single PLC can be programmed as an efficient replacement [3-4-5]. The functionality of the PLCs has evolved over years to include capabilities beyond typical relay control. Sophisticated motion control, process control, distributive control systems, and complex networking have now been added to the PLC's functions [6]. PLCs provide many advantages over conventional relay type of control, including increased reliability, more flexibility, lower cost, communication capability, faster response time and convenience to troubleshoot [7]. Because of these benefits and in order to achieve high-efficiency, high precision, and improve labor protection, it is a trend now to used PLC to automate manufacturing and assembly process [8]. Moreover, since human labor cannot handle special processes which complex procedures required and for safety reasons, the use of PLC has become extremely crucial.

This project mainly talks about designing an automatic production line process system in manufacturing system by using a PLC control for a pick and place pneumatic arm brace for automatic manufacturing system. This paper demonstrates and explains a 9-step problem solving approach for large scale industrial automation system, such as a pick and place pneumatic arm brace for automatic manufacturing system by using PLC control [9]. The paper is organized as follows: Section 2 illustrates the layout and operation of the system; section 3 shows the design of hardware and wiring; section 4 depicts the software programming; section 5 presents the result and discussion; section 6 concludes this study.

System Layout and Process Operation

The aim of this project is to develop a system to control and deliver production metal parts into container one by one automatically in the production line. In this process, human cannot be taken part consider its safety because the container, where the parts must be put, contains dangerous chemical liquid. The process operation is as follows: When a push button is pressed, one by one of bushing metal parts which have been produced by casting machine must be placed in a conveyor by a pneumatic actuator holder for a period 0.5 second while the system on indicator lamp lights. The conveyor, which is powered by an electrical motor, will bring bushing metal part to near a container and then the conveyor motor stopped. This bushing part then is picked-up by a pneumatic arm brace and placed into the container which contains anti rust fluid. This part cannot be dropped randomly and must be put properly and carefully. At the end after the part has been placed into anti rust fluid in the container, the pneumatic arm brace returns to the original position and the system resets. When a stop button is pressed, regardless the system position, the arm brace will open it claws to release part and then moves back to the original position while the system standby indicator lamps is on. Figure 1 shows the sketch of the pick and place pneumatic arm brace for automatic manufacturing system.

Based on the process operation above, the concept and step-by-step sequence list of process operation are as follows:

1. Turn on the pneumatic air supply
2. Turn the system on. (The button of the power supply system)
3. Push the start button.

4. One of metals parts (position A) is allowed to fall into the conveyor because of the gravity and its weight controlled by a pneumatic actuator, while the system on indicator lamp turns on.
5. Motor conveyor is turned on and moves the metal part to another end of the conveyor (position B).
6. The conveyor motor is stopped.
7. The arm brace of pneumatic cylinder opens.
8. The arm brace cylinder moves down.
9. The arm brace clamps the metal.
10. The arm brace cylinder moves up back.
11. The arm brace moves to the left side (to the container).
12. The arm brace cylinder moves down.
13. The arm brace puts the metal part into the container
14. The arm brace removes the clamp on metal part (position C).
15. The arm brace cylinder moves up
16. The arm brace returns to the original position.
17. The system resets.

Note that pressing STOP button at any time will stop the sequence and resets the arm brace to the original position and the system standby indicator lamps turns on. A detailed flowchart of the program is shown in Figure 2.

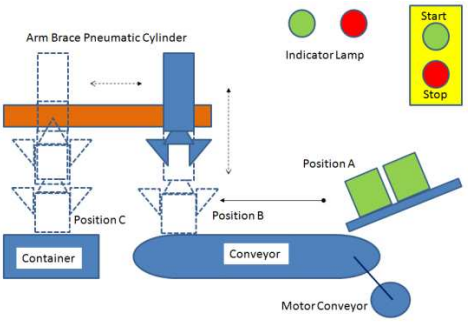

Figure 1 Sketch of the pick and place pneumatic arm brace for automatic manufacturing system

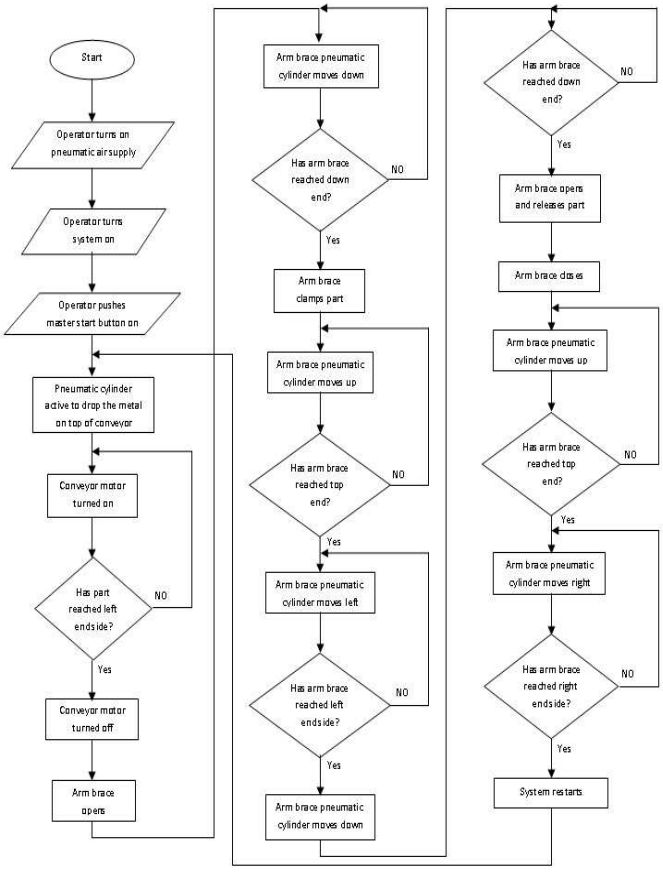

Figure 2 Flowchart of Automated Pick and Place Pneumatic Arm Brace Program

Hardware and wiring

Based on the list of step-by-step sequence of process operation, the required hardware of output and input (I/O) are as follows:

1. System start switch
2. System stop switch-stops everything
3. System pilot lights
4. Metal part holder release and hold
5. Conveyor motor run
6. Conveyor motor stop – position metal part sensor
7. Arm brace releases and clamping – limit sensor down
8. Pneumatic cylinder moves down – limit sensor up
9. Pneumatic cylinder moves up
10. Pneumatic cylinder moves left – limit sensor right

11. Pneumatic cylinder moves right – limit sensor left

The I/O assignment of PLC is given in Table 1 for later use of PLC programming.

Table 1 I/O Assignment for PLC Programming

Inputs		Outputs	
X0	Start switch	Y0	Conveyor Motor
X5	Stop switch	Y2	Pneumatic cylinder moves left
X6	Metal part sensor	Y3	Pneumatic cylinder moves down/up
X7	Limit sensor right	Y4	Arm brace clamping/releasing
X10	Limit sensor left	Y5	Pneumatic cylinder moves right
X11	Limit sensor up	Y6	Pneumatic holder releases/holds
X12	Limit sensor down	Y11	System on pilot lamp
		Y13	System standby pilot lamp

The operation of PLC for inputs and outputs are defined based on the above I/O assignment. Each part has special function that is explained below.

1. Metal part sensor X6: to detect metal part position on the conveyor, to stop conveyor motor and trigger the arm brace opens.
2. Limit sensor down X12: to detect the bottom death point of piston of pneumatic cylinder, to stop it's moving and moves back to up.
3. Limit sensor right X7: to detect the dead point of the right end of pneumatic cylinder, and stop it's moving from the left when it reached the right end point.
4. Limit sensor left X10: to detect the dead point of the left end of pneumatic cylinder, and stop it's moving from the right when it reached the left end point.
5. Start switch X0: to run the program.
6. Stop switch X5: to stop the program, regarding to safety reason.
7. Limit sensor up X11: to detect the top up death point of piston of pneumatic cylinder, to stop it moving when piston reached the top end point.
8. Pneumatic holder Y6: the signal is to control the pneumatic piston cylinder which has two push rod hold and/or release part. Both two push rod work in opposite position. One of the rods is holding one part while another rod is releasing another part on the conveyor.
9. Conveyor motor Y0: to order the conveyor motor to run.
10. Pneumatic cylinder Y3: to control the pneumatic piston cylinder which it has a two-ways moving piston, moving from up to bottom or from bottom to upwards.
11. Pneumatic holder Y4: to order the pneumatic arm brace clamping and releasing part.
12. Pneumatic cylinder Y2: to order the pneumatic piston cylinder moving to the left end side.
13. Pneumatic cylinder Y5: this output is to order the pneumatic piston cylinder moving from the left end side to the right end side.

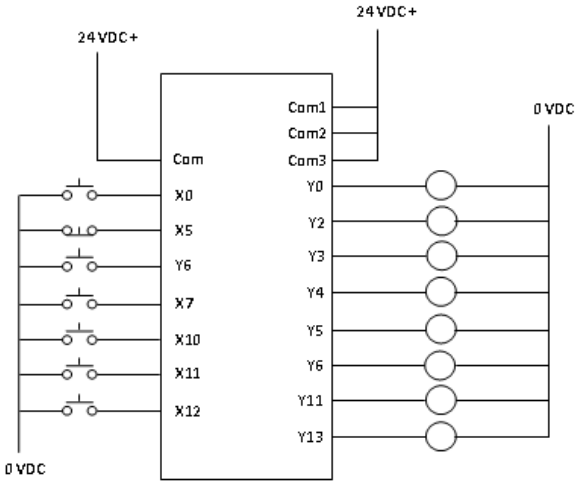

Figure 3 Input and Output Module Wiring for Automatic Pick and Place Pneumatic Arm Brace System

Figure 4 A PLC and Simulator

The next step is wiring the seven input connections and eight output connections, two to pilot lights and 6 to process actuator, to the PLC terminals. The wiring diagram is illustrated in Figure 3. A Mitsubishi PLC and a simulator are used in this project (Figure 4).

Software Programming

A sequential function chart (SFC) to carry out the process is then developed, as shows as Figure 5. The program to run a PLC mechanism with pneumatic arm brace based on steps is designed by using SWOPC-FXGP/WIN-T. A portion of the step logic program (STL) complete ladder diagram is shown in Figure 6.

The procedure for checking the PLC program which has been built for controlled pick and place pneumatic arm brace for automatic manufacturing system is needed. Basically, we have to do an analysis to verify and check program. Many PLCs software have the capability to carry out of a function which is used to verify the program before run it in real machine. Pre-running the process in the office is also useful to see how the program works before hooking up to the actual process. Other purpose doing this step is to avoid equipment damage and operator injury that can appear from any malfunction of the system program.

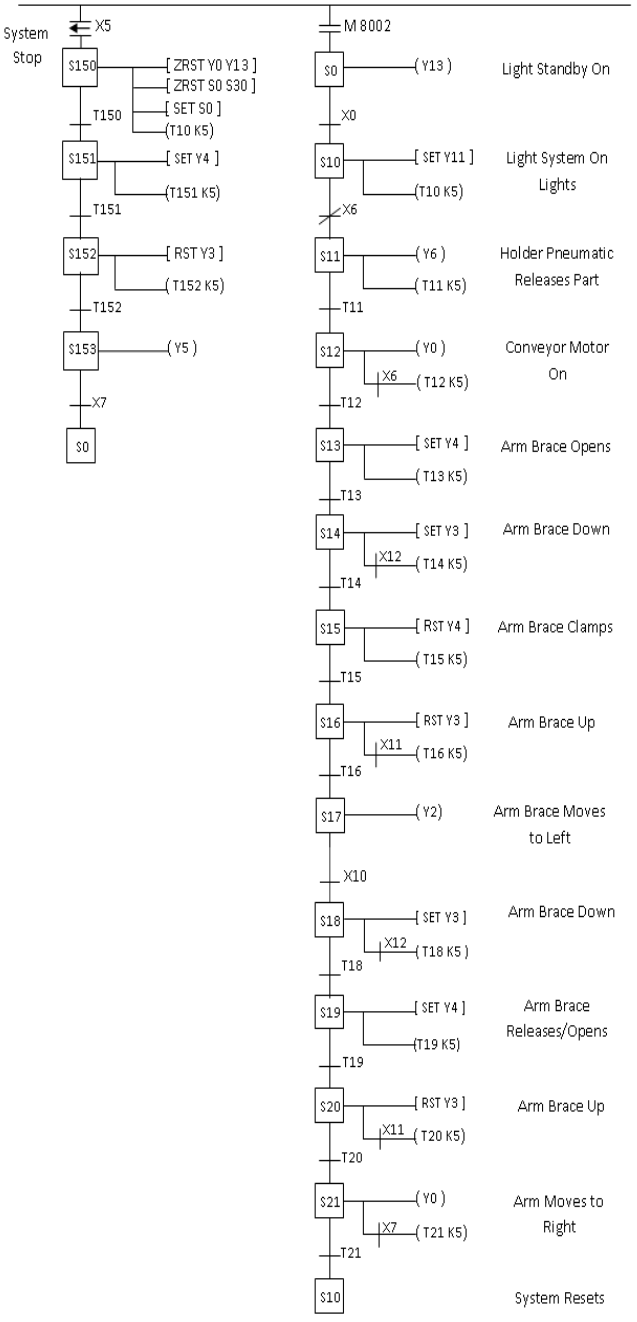

Figure 5 A typical sequential function chart (SFC)

The result of the analysis procedure for this program using monitor function shows that each step-by-step sequences of process operation works properly, and there is no

problem for them work as shown in Figure 6. The next step is to load the program which has been designed and simulated into the PLC's CPU. SWOPC-FXGP/WIN-T program is still used to install program of the automated pick and place pneumatic arm brace system into the CPU of PLC, then run the system.

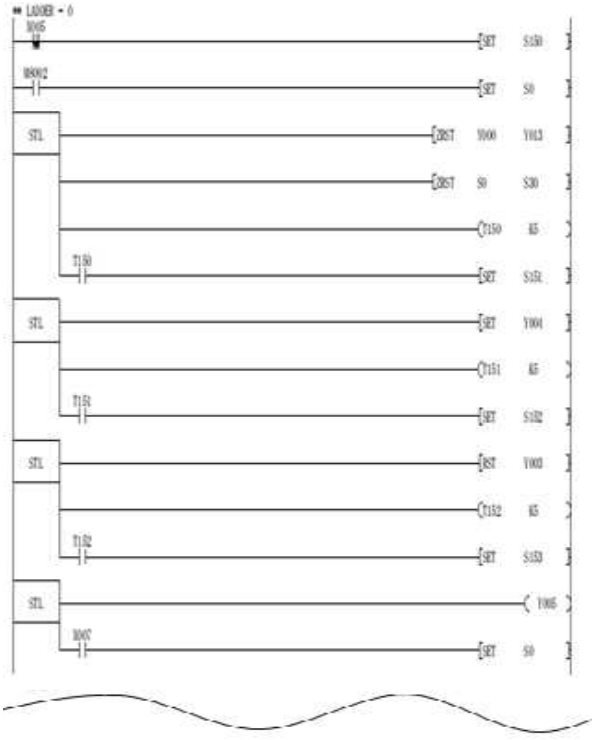

Figure 6 A Typical STL Program

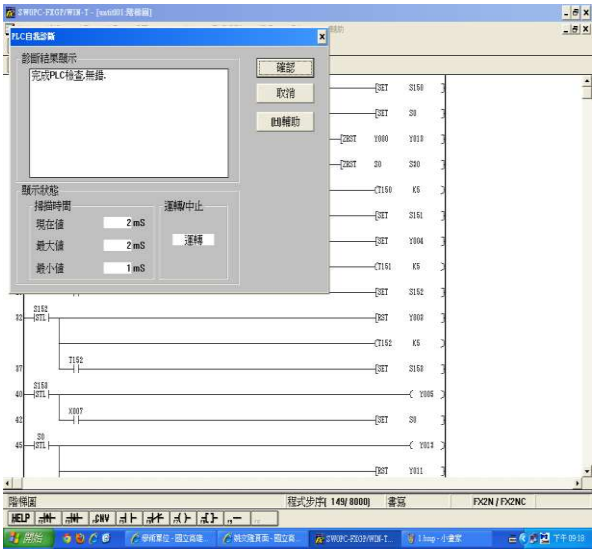

Figure 6 Analysis Procedure Using Monitor Function.

RESULTS AND DISCUSSION

The PLC controlled pick and place pneumatic arm brace for automatic manufacturing system is pictorially shown in Figure 7. For safety reason, it is needed to verify a various out-of-sequence operations to examine for the hidden safety defects or sequencing problem. For roundly and objectively evaluating the performance of soft PLC and mechanical system, we need to fully test the whole running system. Basically, we do the actual test of process operation machine. In this project, the program of PLC controlled pick and place pneumatic arm brace for automatic manufacturing system has been tested and verified in the laboratory system simulator.

Figure 7 The Plc Controlled Pick-And-Place Pneumatic Arm Brace for Automatic Manufacturing System

When the operator pushes the start button, the system starts to run. The part

holder releases the part onto conveyor. The conveyor then runs and stops after the part reached at the end conveyor. The claws of arm brace opens and then moves down to pick up the part. The arm brace moves up then moves to the left while it is clamping the part. The arm brace then places the part into the container after it moves down. It moves back to the original position, the system then restarts. If the operator pushes the stop button during the system works, the arm brace opens its claws, moves back to the original position and then stops. The analysis of the results shows that the system simulator works as steps required. Nonetheless, the program system can be modified and improved based on the requirement needed in the field.

CONCLUSION

A PLC controlled pick-and-place pneumatic arm brace for automatic manufacturing system is successfully developed and tested by a 9-step system integration approach. The process of workpiece production delivery has been well designed by using a PLC controlled pick and place pneumatic arm brace for automatic manufacturing system. Using PLC controlled pick and place pneumatic arm brace system, can be very easy to meet process requirements. PLC joint control with the pneumatic can simplify control the process, reduce the human labor forces, improve the system stability and reliability and reduce the failure rate. The operator is very convenient and easy to achieve a variety of operation in human-machine-interface (HMI). That is, the efficiency of manufacturing is greatly improved. It can be widely applied in any industrial line processing. Our future work is to integrate this system with cloud computing technology for e-commerce application.

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