Simulations of Automatic Bottle Filling System by using PLC Ladder Programming Method

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ABSTRACT

In this paper, the programmable logic controller (PLC) program is described for automatic bottle filling using timer instruction, conveyor belt, solenoid pump, pilot lamp and proximity sensor. The ladder programming method is used for this research. The ladder program is written by logicpro software. The logicpro software is adopted by Allen Bradley manufacturer.

Keywords *- PLC, Logicpro, Timers, Proximity Sensors.*

I. INTRODUCTION

A programmable logic controller (PLC) is a specialized computer used for the control and operation of manufacturing and machinery. This uses a programmable memory to store instructions and execute functions including on/off control, timing, counting, sequencing, shifting, arithmetic and data handling. PLC 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. Sophisticated motion control, process control, distributive control systems, and complex networking have now been added to the PLC's function[1].

II. DESCRIPTION

A Programmable Logic Controller (PLC) is an industrial computer control systems that continuously monitors the states of input devices and make decisions based upon a custom program to control the states of output devices. It is designed for multiple inputs and outputs arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact.

The term logic is used because programming is primarily concerned with implementing logic and switching operations. Input devices, e.g, sensors such as switches, and output devices in the system being controlled, e.g. motors, valves, etc., are connected to the PLC. The operator then enters a sequence of instructions, i.e. a program, into the memory of the PLC. The controller then monitors the inputs and outputs according to this program. The programmable logic controller consists of computer hardware, which is programmed to simulate the operation of the individual logic and sequence elements that might be contained in a bank of relays, timers, counters and other hard-wired components.

The PLC is basically comprised of a Central Processing Unit (CPU), memory, power supply unit , Input/Output (I/O) interfaces, communication interface and the programming device. The basic arrangement is shown in Figure 1[2].

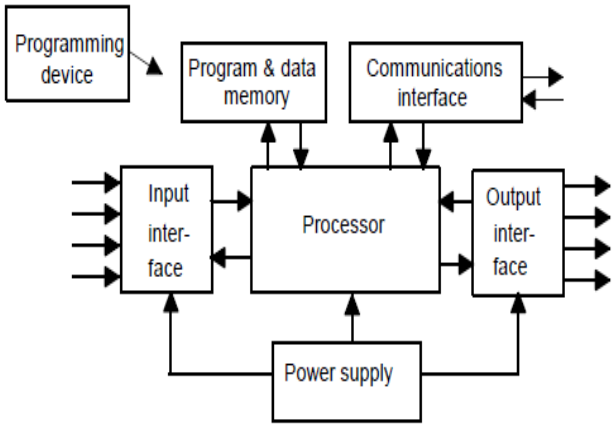

Figure 1 The PLC System

As PLCs have developed and expanded, programming languages have developed with them. Programming language allow the user to enter a control program into a PLC. The International Electrotechnical Commission (IEC 1131-3) standard defines three graphical languages and two text-based languages for use in PLC programming. The graphical languages use symbols to program control instructions, while the text-

based languages use character strings to program instructions.

- Graphical languages
  - ladder diagrams (LD)
  - function block diagram (FBD)
  - Sequential function charts (SFC)
- Text-based languages
  - instruction list (IL)
  - structured text (ST)

Ladder diagram is the most widely used programming language in industrial automation today. Its ease of use, traceability, and visual representation of physical components make it the favored programming method of many engineers. Ladder diagram is a graphical programming language, initially programmed with simple contacts that simulate the opening and closing of relays. Ladder logic programming has been expanded to include functions such as counters, timers, shift registers and math operations[2].

In many control tasks**,** there is a need to control time. PLCs thus have **timers** as built-in devices. Timer counts fractions of seconds or seconds using the internal CPU clock. There are a number of different forms of timers that can be found with PLCs: on-delay, off-delay, and retentive timers.[3]

A conveyor belt can be used to transport goods from a loading machine to a packaging area. When an item is loaded to the conveyor belt a contact switch might be used to indicate that the item is on the belt and start the conveyor motor.

Proximity sensor is used to detect the presence of an item without making contact with it. There are a number of forms of such sensors, some being only suitable for metallic objects. Types of proximity sensors are eddy current type, reed switch and capacitive proximity switch, and inductive proximity switch. [4]

A pilot lamp is a small electric lamp used to indicate that an electric circuit is energized. With one pilot lamp device, it is possible to monitor if a load is on or off, as the LED will be illuminated in either green or red.

A solenoid dosing pump is a form of positive displacement pump which uses a diaphragm and solenoid assembly to displace the fluid into the discharge line. The solenoid 'drive' consists of an electromagnet and spring assembly, which is activated/deactivated with a series of electrical impulses. It is designed to pump a very precise flow rate of a chemical or substance into either a water, steam or gas flow. A dosing pump is generally quite small and is powered by either a small electric motor or air actuator[5].

III. OPERATIONSAND IMPLEMENTATION STEPS

The filling process is a performed by a solenoid pump that fills liquid products such as water, gas or drinks. If a bottle is placed on the running conveyor motor and the proximity sensor detects the presence of bottle which is in position with the solenoid pump, then the motor will stop. If the sensor does not detect any presence of the bottle, the conveyor keeps on moving. After filling the bottle for some delay time (bottle full time), the solenoid pump turns off and the motor starts running. This method include placing bottles on a conveyor belt and filling one bottle at a time. The implementation steps for the research are as follows.

- The ladder logic program is made for automatic bottle filling application using sensors, conveyor belt, motors, solenoid pump and pilot lamp
- The program is simulated and debugged.
- The program is saved on the logicPro software.
- The program is documented.

IV. DESIGN PROGRAMS & SIMULATION RESULTS

The ladder programming method and LogicPro software is used for the designed programs. The LogicPro software is adopted by Allen's Bradley manufacturer. The PLC ladder program for the research is shown in Figure 2.

For the proposed research, when the start input switch I:1/0 is pressed, the 'Run Enable' output pilot green lamp (O2/2) is switched on and the conveyor motor (O2/0) starts moving. The 'ON' states indicating for 'Run Enable' and conveyor belt is shown in Figure 3.

The O2/2 output is used also as the input which is latched with the input switch I:1/0. Therefore , the stop button I:1/1 can only used to stop the 'Run Enable (O2:/2)'. This process is shown in Figure 4.

After the proximity sensor (I:1/3) detects the presence of the bottle on the conveyor belt, the running conveyor motor (O2/0) stops and the solenoid pump output (O2/1) starts filling the water to the bottle. This action is shown in Figure 5. The function of water tank is to store the water which is to be filled in the water bottle via solenoid valve whenever required.

After a given time period (bottle full time -about 30 secs) is over, then the solenoid valve gets de energized completely and water flowing the valve is stopped. Then the bottle full output (O2/4) lamp is 'ON' to indicate the bottle is full and the conveyor motor belt (O2/0) starts moving. This simulation is shown in Figure 6. After that the bottle is away from the proximity sensor, bottle full output (O2/4) is switched off again. Then the program repeats again.

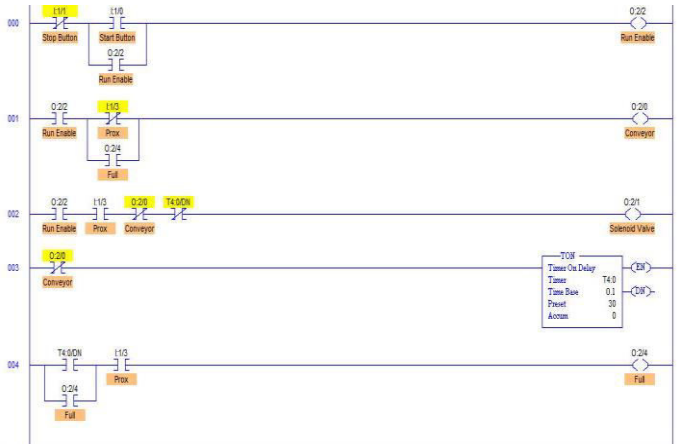

Figure 2. PLC Ladder Program for Automatic Bottle Filling

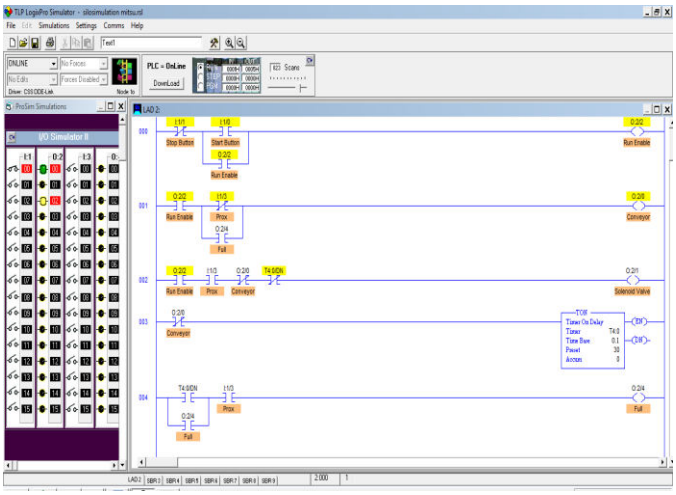

Figure 3. ON States Indication for Run Enable and Conveyor Belt after Pressing Start Button

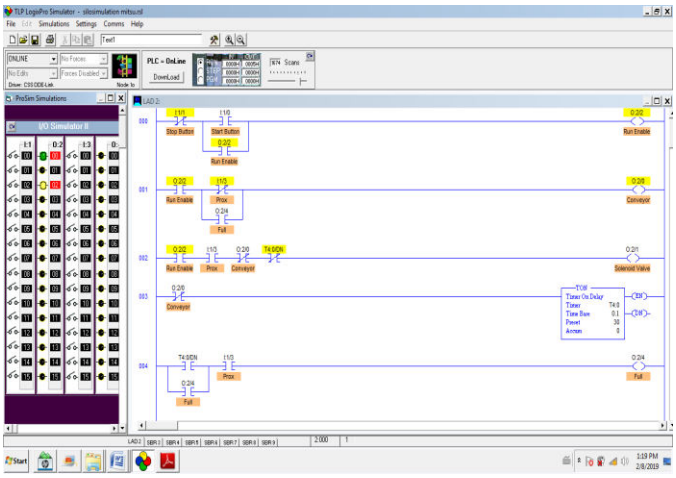

Figure 4. Run Enable and Conveyor Belt remain 'ON' although Start Button is 'Switched Off'

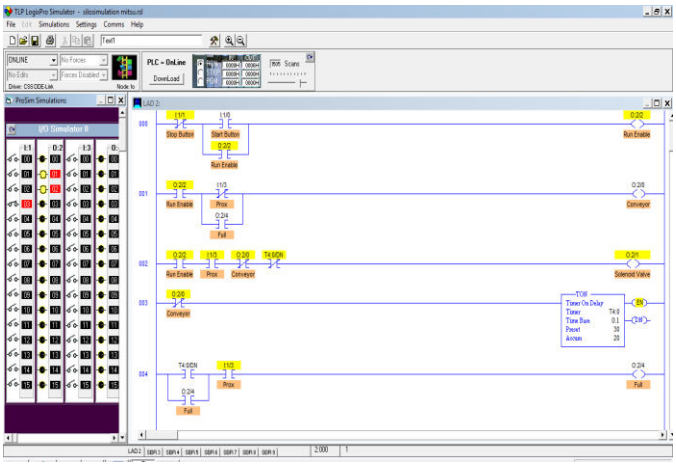

Figure 5. Simulation of ON States Indication of Solenoid Pump and Run Enable

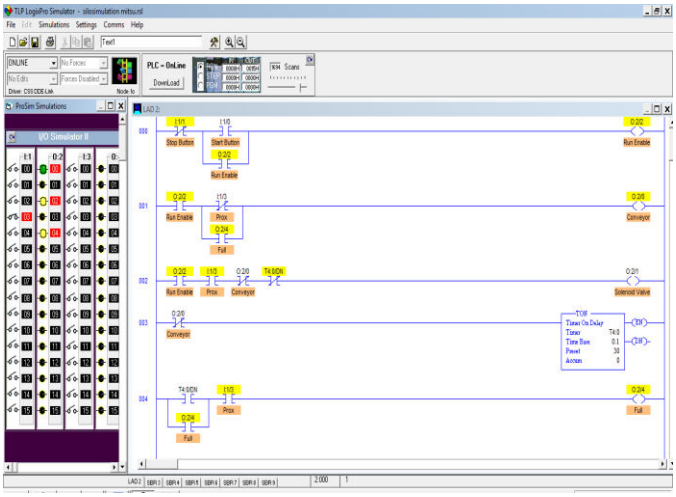

Figure 6. Simulation of ON States Indication of Run Enable, Conveyor Belt and Bottle Full Output

V. CONCLUSION

The main objective of the project is to develop a bottle filling system by using automation process. The automatic filling system is controlled by PLC. The ladder diagram is used as the programming language. The 'logicpro' software is used for simulating, implementing and developing the research program. The system has advantages as simple structure and reliable operations.

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