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An Efficient Method of Bottling Plant Application in Industrial Automation

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Abstract— Automation is used for all control systems and the technologies in PLC is use to reduce the human work and helps in increasing the production. Automation also reduces cost of production significantly by efficient usage of energy, man-power and material. Industrial automation also involves significant amount of hardware technologies, related to instrumentation and sensing, Actuation and Drives .PLC plays an important role in world of automation industry. It acts a major function in the automation field which tends to reduce the complexity, increases safety and cost efficient.

The system is designed and developed for automatic mixing and filling of the liquid into bottling plant using PLC.

Key words: Automation,Ladder,PLC

I. INTRODUCTION

The word 'Automation' is derived from ancient Greek words of Auto (means self) Matos (means moving). Thus, a mechanism move by itself or self dictated is called automation.

Automation is used for all control systems and the technologies in industries which is use to reduce the human work and helps in increasing the production. Automation also reduce cost of production significantly by efficient usage of energy, man-power and material. Industrial automation also involves significant amount of hardware technologies, related to instrumentation and sensing, Actuation and Drives PLC plays an important role in world of automation industry. It acts a major function in the automation field which tends to reduce the complexity, increases safety and cost efficient.

Prior to the development of electronic programmable controllers, relay functions were performed by real hardware relays that were physically wired together. A relay is a critical component of many control systems because they offer an indirectly operated electrical switch that can be used for remote control and to control high current devices with a low current control signal .Relays are used to let one power source close a switch for another. It is often the case that the other switch has a high voltage/current. The relay can accomplish this control while keeping the switches isolated. When a programmable controller is used, the only real hardware relays required are those for the actual outputs to the machine.

The limitation of Relay is a hard –wired logic, the control circuit becomes complex due to clustering of components and wires. When a relay panel has been wired to implement ladder diagram. Now if the event sequence is to be changed, it is necessary to rewire the panel to achieve it. This become difficult and time consuming.

Then the purpose of a PLC was to directly replace electromechanical relays as logic elements, substituting instead a solid-state digital computer with a stored program, able to emulate the interconnection of many relays to perform certain logical tasks.

Microcontroller is a microprocessor with internal input and output and memory i.e. RAM, ROM, PORTS.

Microcontroller is not a infinitely expandable input/output logic controller. A microcontroller is also a logic controller but used in dedicated systems which are programmed once and for all, the program for which will not be accessed by the user, and whose program will not need to be altered frequently.

The system is designed and developed for automatic mixing and filling of the liquid into bottle using PLC.The paper has been discussed mainly in four

sections: first section gives the introduction followed by the basic overview of PLC. The Process description and the general block diagram prototype description is discussed in section III and finally conclusions are given in section IV.

II. Programmable Logic Controller

A programmable logic controller is a device which performs discrete or continuous logic in machine control. It was invented to replace the sequential relay circuit for automation.

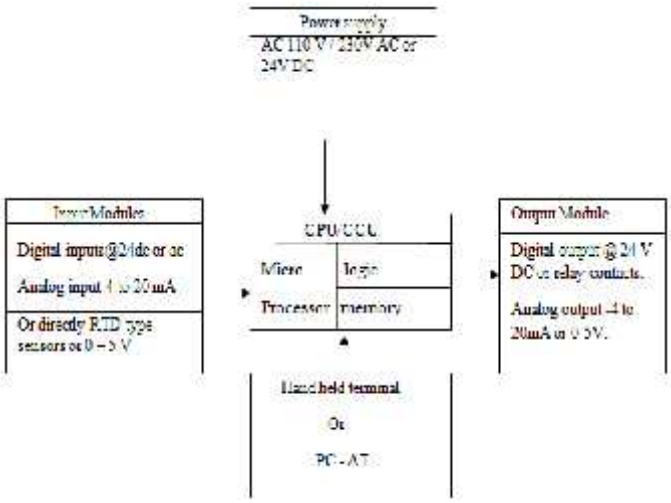

Fig.1. Block diagram of PLC

A. Organization Architecture of PLC

Power supply unit of PLC: Power supply unit of PLC can be built into the PLC or it can be an external unit. Common voltage levels required by the PLC are 24V DC, 110 VAC or 220V AC.

CPU/CCU: Central processing unit also known as the central control unit is the heart of PLC .In this unit ladder logic is stored and processed. The unit does the processing of data as per the requirement of ladder logic.

Input/output modules: A number of input/output terminals are provided so that the PLC can monitor the process. The input modules are used to provide the input status (ON/OFF) from input device to PLC and after processing the PLC processor output the signal to output device via output terminals in output modules according to the ladder logic.

INPUT MODULES: The various inputs to the PLC are given through input modules. The various input device include: Push button, Limit switches, Proximity sensors, photoelectric sensors etc.

OUTPUT MODULES: It is connected to the output terminals of the PLC are devices like, solenoids, Relays, Contactors, Motor Starters etc.

HHT: Now a days the PLCs are easily interfaced with personal computers using suitable software and interface devices. One most important tool which is must for any PLC is a handheld terminal or hand held programmer which can be carried to installation site. It is more useful as a troubleshooting tool.

B. PLC Operation

Once the power is applied to PLC, its central processing unit begins its operation on the scanning basis.

Scan Time: Scan time of PLC is defined as the time required for the controller to read all inputs, execute the program and update all outputs. There are four operations for scan that is self-test, input scan, logic scan and output scan which constitute one scan cycle.

All PLCs have four basic stages of operations that are repeated many times per second . Initially when turned on the first time it will check it's own hardware and software for faults.

If there are no problems it will copy all the input and copy their values into memory, this is called the input scan.

Using only the memory copy of the inputs the ladder logic program will be solved once, this is called the logic scan.

While solving the ladder logic the output values are only changed in temporary memory. While the ladder scan is done the outputs will updated using the temporary values in memory, this is called the output scan.

C. Types of PLC

Base on size and features, there are various typical configuration which is described as Pico , Nano, Micro, Mini, Standard, RTU, Safety, OEM , PAC. It is difficult though identifying the differences of PLCs in the pico and nano class and the micro and mini. A PLC manufacturer may name particular PLC line Pico (for example Allen Bradley), while another competitor will name their line of similarly featured and sized model as nano (for instance GE).

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Among PLC types is the RTU or Remote terminal unit are specialized for communicating remote measurement and process data to a SCADA system usually. Safety PLCs are designed with some form of logic processing and monitoring as well as input and output self checking. OEM PLC are generally without a case of enclosure. PAC or programming automation controllers are essentially the tops of the PLC food chain.

The Unitary model: This type of PLC is the simplest one with all basic operating system that is stored with a box or house. The main Components usually include processor- the one that runs the programs – and also connections to out and input. In Allen bradley's PLC that typical model 1000 micro logix that has on board memory system with 6 input and 4 output ports with a communication port RS-232.This is a DC 24 V Power supply type PLC.

The modular model: In this type of PLC, there are several modules that can be made to work together to make custom controller. The main parts include input and output connection, power regulation, processor, and additional modules.

The rack mount model: A rank is often large (up to 18''by 30''by 10'') and can hold multiple cards. When necessary, multiple racks can be connected together. These tend to be the highest cost, but also the most flexible and easy to maintain. The above arrangement may be reverse for same models of PLC i.e. power supply unit may be right most side.

D. Selection of PLC

There are some main factors to choose a PLC for any application, they are: Input and Output, Memory Size, System speed, easily communicable. Different PLCs have different number of Input ports and in some adding external input cards can increase number of input ports.

E. Communication Network and Programming of PLC

PLCs are programmed using application software on personal computers. The computer is connected to the PLC through industrial communications cable like RS-232,RS-485OR RS-422.The RS-422 cable is used for asynchronous serial communications which is more similar to in many respects to RS-232.It is faster(up to 100kbps) than RS-232.

The programming software allows entry and editing of the industrial control applications. A PLC programming is not actually a wiring diagram but a way to describe the logical relationship between inputs and outputs. The international Electromechanical commission (ICE) recognized five standard programming languages for PLC: Ladder diagram (LD), Function Block Diagram (FBD), Sequential Function Chart (SFC), Instruction List (IL), and Structured Text (ST). Few important key factors for deciding to select the programming language are based on universal language acceptance, simplicity of changing code, application mainly using digital I/O and basic processing.

Ladder logic (LD): Ladder logic is programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware.

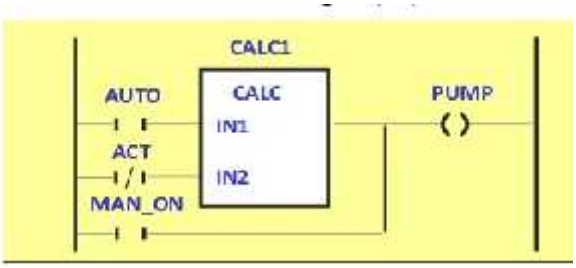

Fig.2. Ladder Diagram.

It is primarily used to develop software for PLCs used in industrial control applications. The name is based on the observation that program in the language resemble ladders, with two vertical rails and a series of horizontal rungs between them.

Function Block Diagram (FBD): The function block diagram is a graphical language for programming logic control design, that can describe the function between input variables and output variables. A function is described the set of elementary blocks. Input and Output variables are connected to blocks by connection lines. Function block programming is probably the second most widely used language. The major advantage is that programs written in function block tend to be easy to follow-just follow the path.

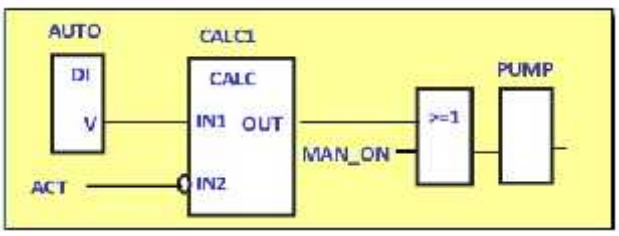

Fig.3. Function Block Diagram.

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However this language is not ideal for large programs using special I/O and functions, also writing a program in Function block requires more preparation upfront to understand the program and how it will flow before any code is written, since it can be more difficult to make corrections later.

Sequential Function Chart (SFC) : Sequential function chart is a graphical programming language used for programmable logic controllers. The SFG standard is defined as, preparation of function chart for control system. SFG programming includes a flow chart on one side and two small program to the right .In an SFG program ,the flow chart boxes and the little horizontal lines with names actually have small program running inside them.

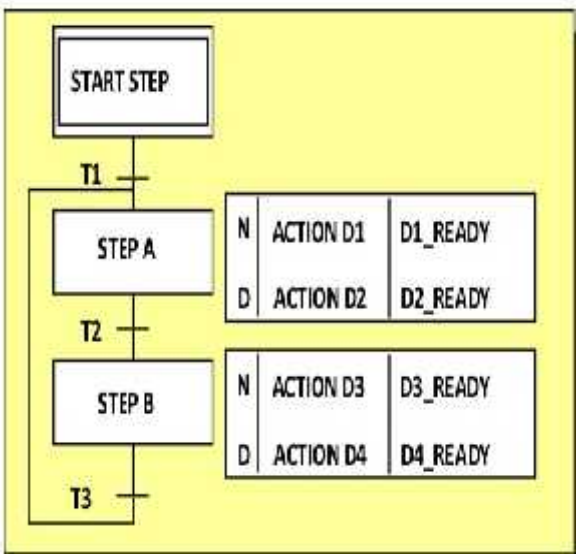

Fig.4. Sequential Flow Chart (SFC).

Instruction List (IL): Anyone who has experience programming microprocessor or experience with assemble language programming will see similarities with instruction list programming. This language is consist of many lines of code, each line representing exactly one operation.

```
A: LD   %IX1 (* PUSH BUTTON *)
   ANDN %MX5 (* NOT INHIBITED *)
   ST   %QX2 (* FAN ON *)
```

Fig.5. Instruction List.

Structured Text(ST) :-Structured Text language closely resembles a high- level computer programming language such as PASCAL or C. This language the growing complexity of PLC programming , such as the process control functions involved in plastics or chemical manufacturing , Trigonometry, Calculus, and data analysis can be implemented for easier in this language than in ladder or instruction list.

```
VAR CONSTANT X : REAL := 53.8 ;
Z : REAL; END_VAR
VAR aFB, bFB :  FB_type; END_VAR

bFB(A:=1, B:='OK');
Z := X - INT_TO_REAL (bFB.OUT1);
IF Z>57.0 THEN aFB(A:=0, B:="ERR");
ELSE  aFB(A:=1, B:="Z is OK");
END_IF
```

Fig.6. Structured Text.

III. APPLICATION OF BOTTLING PLANT

Bottling process generally consists of shifting the empty bottles one at a time to filling point, then filling it and putting a cap on it, then labeling and shifting to a desired location , For developing a ladder diagram program for PLC to control this process, We have to first define the problem using a positional sketch of the whole process. Then input assignment will be done to develop the ladder diagram process. PLC is the main part of the automation plant. The plant is automated by the programmed PLC. In this application Allen bradley's MICROLOGIX 1000 PLC is used. The supply is provided to PLC through 24VDC SMPS. Ladder programming is done using software RS LOGIX Micro ENGLISH. After completed the ladder diagram the program is then downloaded on PLC.

A. Flow chart and process

When the start button is pushed, the motor starts hence the conveyer belt starts moving, there are two inputs to the PLC out of which one is the output of the proximity sensor. The proximity sensor senses the presence of the bottle at the conveyor belt. when the bottle is under the solenoid valve, the bottle is sensed and the motor stops hence the conveyer belt stops. Then the solenoid valve operates and the bottle start filling the water. When the bottle completes filling process, the solenoid valve is

closed and the motor starts, the conveyer belt start moving and carries the bottle away from the solenoid valve, If another bottle is sensed then the above process will be repeated. When stop button is pressed or activated then the entire process will be stopped.

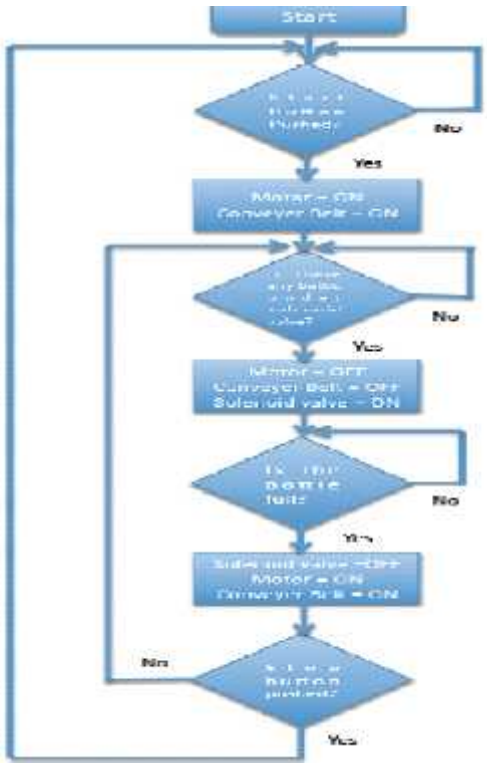

Fig.7. Flow chart of process

B. Product Description

It is based on PLC automation, which consists of various components and are divided into two parts namely-

Hardware Part and software Part

1. HARDWARE PART : Our device consist of PLC ,24v Dc relay , Photo electric sensor , solenoid valve, DC motor , Conveyer belt, ON-OFF Push button and some connectors. The ON-OFF Push button works as the input device. The PLC controls the input and output according to the program given. PLC – A programmable logic controller, PLC is a digital computer used for automation. It is an interface between program and the inputs. PLC works on the basis of input given by the user.

FILLING SYSTEM: Filling is the process in which a machine packs the liquid product such as water, cool drinks etc. This method includes placing bottle onto a conveyer belt and filling bottles one at a time. Hence the system provides large flexibility. The filling system consists of subsystem that includes conveyer system and sensors. Sensor is used to detect the bottles so there is no wastage. The advantage that even if the program is running and there is no bottle on the conveyer the motor 3 will not start and thus valve 3 is also not open so not spill of liquid takes place. The valve 3 will open only when there is a bottle and filling will be done.

OPERATION OF PLC – PLC works by a programmable support with some criteria. The PLC is connected with some components and it is made to run with the help of program.

PLC executes the program by one instruction at a time, where if the first input is ON then it should turn on the first output. Hence it already knows which input is ON/OFF, from the previous process. PLC updates the status of the outputs. First the PLC checks the input by user defined programming. Next the process is executed and finally it checks the output status.

SOLENOID VALVE- Reverse osmosis filter elements for home drinking water are the industries most reliable. Filter technology and automated fabrication allow these elements to deliver consistent performance that equipment supplies, water treatment dealers, and residential customers can relay on healthy elements are shipped dry for convenient handling and long shelf-Life.

This is high quality and widely used reverse osmosis filter, used worldwide in reverse osmosis systems for domestic, commercial, water fed pole, aquarium, misting system to stop the dripping RO's due to its strength of filtering , durability and reliability. Package includes INOS RO solenoid valve 24(DC) RO water purifies Solenoid valve.

PROXIMITY SENSOR M18:- The unshielded M18 inductive sensor has a sensing distance of ~10mm. This sensor has NPN- type style, NO+NC contact type output. The Sensor is Widely applied in measuring counting, Rpm measuring in mechanism, chemical, paper manufacture light industry etc. The typical Specification of M18 sensor rated operational voltage is 24 DC, connection id fly leads and the supply voltage 10 to 30VDC.

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2. SOFTWARE PART:

In software part we are going to discuss about the programs and the logics used. There are some programming languages for control system.

BLOCK DIGRAM : The block diagram of the process is given below.

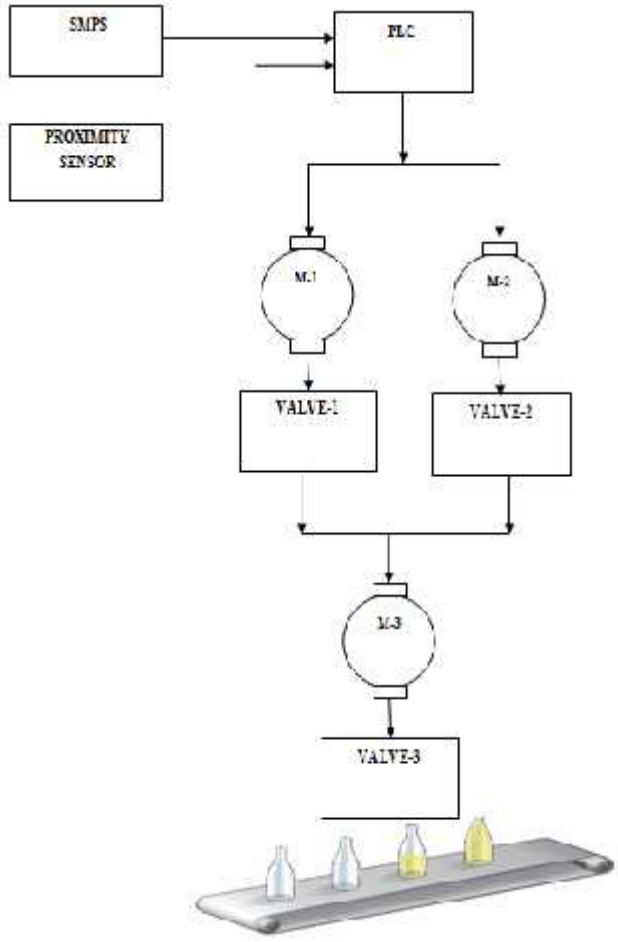

Fig.8. Block diagram of the process.

LADDER DIGRAM

In our proposed device the ladder diagram is used. This is to interface the ON-OFF button, programming logic. There are several programming software's available but in our device ladder logic is used. It is easy to understand and the programming is made more flexible to users.

LADDER LOGIC: - Ladder logic is the main programming method used in ladder logic is based on mimic relay logic . The relay logic diagram are difficult, hence we have selected ladder logic as main programming method.

IV. CONCLUSION

This paper has proposed an application of Industrial automation PLC based liquid filling system. It can only fill approximately one bottle at a time, the process can –be efficiently used in water filling system. The range of fluid types is not so wide. Positioning the solenoid valve is a critical issue and proper care is needed. Another disadvantage is no proper guidance for the bottles to move.

The system process can fill up to 2 or more bottles in 25sec. It can be used commercially in various coffee shops, juce shops and reduce human effort. So the practically result is much satisfactory.

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