PLC Based Automatic Sequential Process Control System

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Abstract— Programmable logic controllers are extensively used in industries for controlling sequence of actions of the process. The sequence of process flow is decided for controlling the parameters like level, flow, weight and temperature. The brain of the system is PLC. Appropriate hardware for interfacing the process to the controller is developed for controlling the level ant temperature of the process. For controlling sequence of actions ladder diagram is developed. Programmable Logic Controller (PLC) is designed to operate in real time environment. It has been observed that in many industries distributed control system and PLCs are extensively used. PLC based sequential batch process control (PLCSBC) is a laboratory type setup. This setup will be useful for demonstrating the use of PLC in sequential control operations in industry and development of ladder diagram for particular application. The system under consideration is designed to carry out sequence of events. The process under consideration is Batch process, which is controlled by PLC.

Key words: PLC, valves, Dc Motor, Heater

I. INTRODUCTION

We have four tanks with different liquid samples. We take the mixture of 4 liquids in the measuring Container. Each liquid comes in the measuring Container after a fixed duration of time. And solid sample comes to the Measuring Container through conveyor system. After this we measure the weight of the mixture of samples then the mixture is headed towards the process tank and also checks the level of the process tank, if the level is lower than the set point, inlet valve will turn on or if the level is higher than the set point, the outlet valve will turn on. Now the temperature of the mixture is measured and if the temperature of the sample mixture is lower than the set point, the heater will turn on. After this the stirrer motor is turned on and the sample is properly mixed. Then the output flow rate is measured.

II. DESIGN OF HARDWARE OF THE SYSTEM

The basic components of developed system are as follows:

1) Process Tank
2) PLC
3) Temperature Controller
4) Weight Measurement
5) Level Controller
6) Outlet Valve Controller
7) Pump Controller
8) Stirrer Motor Controller
9) Power Supply Section
10) Conveyor System For Solid

– TANKS:

A. Container:

In order to store four types of liquids four types of different types of container are used and one more container is also used for solid sample.

B. Process Tank:

For experimental setup there are two iron tanks:

1) Process Tank.
2) Sump Tank

Sump tank is used for circulation of water. In the process tank, two level switches are mounted and the distance between the low level switch is 300mm.

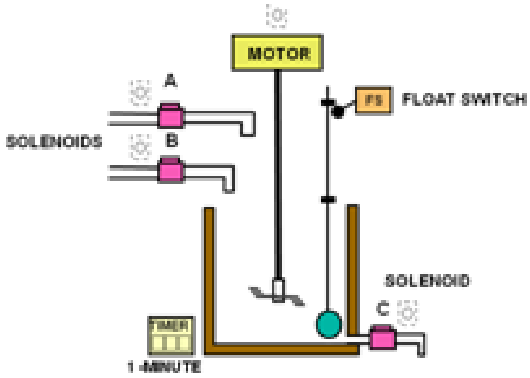

Fig. 1: Schematic Diagram

The state variable is the height “*h*” of water in the tank and the desired output is the output mass flow rate, “q_e”.

By using the mass balance equation of the system results:

$$\frac{d}{dt}m = q - q_e$$

It is well- known that the mass is defined as a product of volume of the tank (V=Ah) and density of the liquid ρ, into a tank with vertical walls resulting as followed:

$$q_e = \rho A_e v_e$$

The output q_e can be written in terms of the output speed, v_e:

$$v_e = 2gh$$

In which the output speed can be written as:

$$v_e = 2gh$$

C. PLC:

PLC is sophisticated controller module used for controlling various operations of the process. PLC accept the input from the process and according to the ladder diagram

It gives output to the process as per the requirement. The ladder diagram is developed according to the determined sequence of operations.

Fig. 2: Experimental Set-Up

D. Level Controller:

The process tank is required to be filled with water to a certain level. Hence it is required to control level in the tank. Tank level control unit consists of the following

1) Sensor
2) Relay driver circuit

Float level sensors are used for sensing the level in the tank. Level floats that are used in the process are of magnetically coupled type. Whenever level of water goes up to the required level then high signal is given to the PLC by the float sensor. In turn, PLC turns OFF the inlet valve. Hence relay-driving circuit is designed for turning OFF the inlet valve. Relay of 24Vdc, 1000 ohm is connected to the output of PLC. According to the level of water in the tank, relay will be turned ON/OFF by the PLC.

E. Inlet Valve Controller:

Solenoid valve is used as inlet valve to fill the water in the process tank. Solenoid valve is operated from the electromagnetic type of relay of 24Vdc, 1000 ohm that is connected to the output module of the PLC.

F. Stirrer Motor Controller:

After filling the tank with water, it is heated using two heaters. Stirrer motor is used for the uniform heating of the water .Following are the specifications of the motor.

Supply voltage- 230V
Phase- single phase
Current- 1 Amp
RPM- 1500

PLC turns ON/OFF the motor depending on the sequence of the program developed for PLC. When stirrer motor is operated then corresponding LED on the front panel of the control box will glow.

G. Temperature Controller:

It is required to control the temperature of water in the process tank. It consists of following units.

1) Sensor
2) Signal conditioning circuit
3) Relay driver circuit

RTD PT-100 is used to sense the temperature of water in the process tank. Resistance is converted into equivalent voltage depending upon the temperature using WSB. The voltage is then amplified and is given to relay driver circuit. Whenever temperature of water in the process tank goes up to the set point, relay gets energized which turns OFF the heaters. The LED, on the front panel of the control box, indicates status of heaters

H. Outlet Valve Controller:

Solenoid valve is used as outlet valve to drain the water from the process tank when temperature of the water reaches to the set point. Solenoid valve is operated from the electromagnetic type of relay of 24Vdc, 1000 ohm that is connected to the output module of the PLC.

I. Pump Controller:

When water is heated to the require temperature, it will be taken out from the process tank. This is carried out with the help of pump. Pump will start only after outlet valve is opened i.e. when the batch process is completed and is started using the relay connected to the output module of PLC.

J. Conveyor System for Solid:

The conveyor belt system is used for carrying the solid sample from the container to process tank

III. RESULTS AND CONCLUSION

PLC checks water level in the tank and if water level is low, it opens the inlet valve. Similarly it has been observed that rest of sequence of events like turning the heaters 1 & 2 ON, timer operation, checking whether set point is reached or not ,opening of the outlet valve etc., work as per the requirement of the process. Different interlocks incorporated in the ladder diagram works satisfactorily. Hence it can be seen the PLCSBC is an ideal application. The PLC SBC is an application of PLC. PLC and its related circuits provide the logic diagnostic and options so as to provide a safe, reliable and versatile system to control various operations of the process. The system is cost competitive and is applicable for industrial applications.

Hence, it can be concluded that the system designed and developed set up works satisfactorily and can be used for demonstrating an application of PLC.

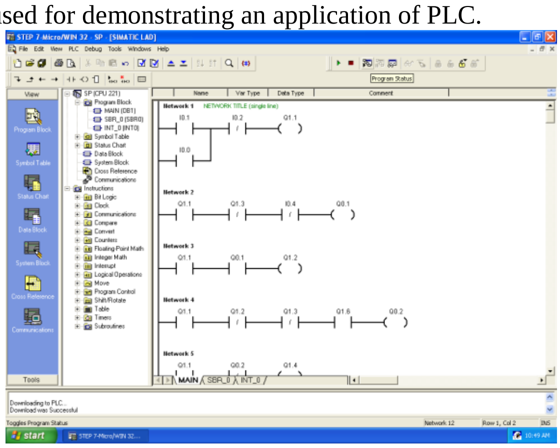

Fig. 3 (A): Ladder Logic for Sequential Batch Process

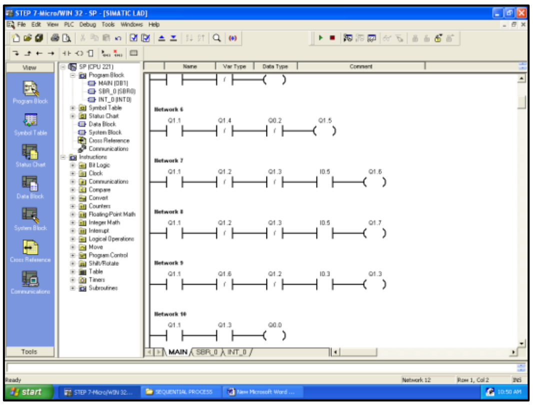

Fig. 3 (B): Ladder Logic of Batch Process

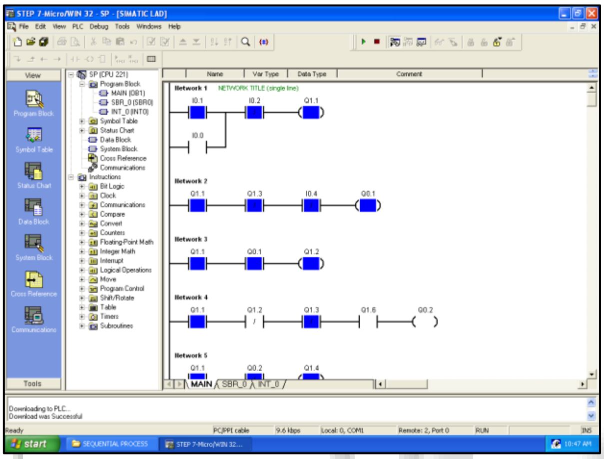

Fig. 3 (C): Simulated Result of Sequential Batch Process

Fig. 4 (A): Output on Simulation Board

Fig. 4 (B): Output on Simulation Board

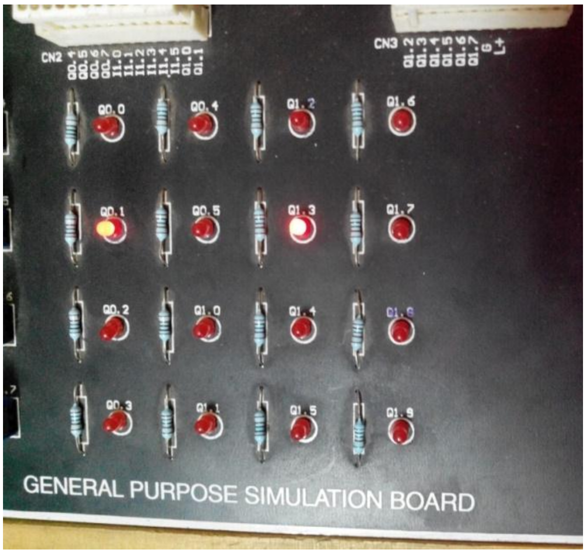

Fig. 4 (C): Output on Simulation Board

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