International Journal on Recent and Innovation Trends in Computing and Communication ISSN: 2321-8169
Volume: 4 Issue: 4 581 - 585

Fabrication and Automation of Solvent less Packaging Machine

Masood Nazir*, Prof Rashmi Ranjan Das#

* M.tech Student at School of Electrical Engineering, VIT University Vellore, Tamilnadu-632014 India

Professor at School of Electrical Engineering, VIT University Vellore, Tamilnadu-632014 India

masoodnazir111@gmail.com, rashmiranjandas@vit.ac.in

Abstract: With the rapid technological advances in the automation technology, a need has been felt to incorporate these technological advancements in the packaging industry so that the accuracy of packaging is of the highest order, thereby reducing losses and improving efficiency. This research paper focuses on the technological advances in the automation technology which address the various problems plaguing the packaging machine. It involves the use of pneumatic, hydraulic, mechanical and electrical devices along with the existing machinery to reduce the wastage of time due to the various faults that cause frequent stoppages of the machine. The purpose of the study is to reduce the manpower and time spent in identifying and clearing these faults. A Siemens S7-200 PLC along with Temperature and Analog modules is used to automate the system. After the successful programming of the PLC, it is found out that a considerable amount of time is saved during auto refilling and fault stoppages. The paper recommends automating the packaging machine using a PLC along with an HMI to save time and increase production.

Keywords: *Siemens S7-200 PLC, Siemens HMI KTP700, Static Mixer, Variable Frequency Drive, MPCB*

*****

I. Introduction

With automation becoming the global trend in manufacturing, an effort has been made to incorporate these ideas in this system. This system is a meter, mix and dispense system, i.e., it meters out specific amount of solvents, mixes them and dispenses the solution on a conveyor belt with a predetermined ratio and shot size. The system also controls parameters like ratio, shot size, drive frequency and flow rate of the pumps. The system comprises of two tanks each fitted with a 12cc gear pump at the bottom, which in turn are driven by two induction motors. When the system is operated, the solvents from the two tanks are metered out in a predetermined ratio, mixed by means of a Static mixer and dispensed on the conveyor belt.

The Control Unit comprises of a 12cc External Gear Pump, a 1*1 (Single Input, Single Output) Solenoid Valve and an Encoder. The Gear Pump is coupled to an Induction motor and has a gear box ratio of '14'. This ratio assumes significance as it has an important hand in determining parameters like flow rate and ratio of the dispensed material. The Solenoid Valve comes into picture at the time of auto refilling of the tank. It acts as the PLC output and opens as the tank level goes low. The Encoder disc rotates as the pump rotates and sends pulses to the PLC during each cycle. Hence it helps to calculate the amount of material dispensed on the conveyor belt during each cycle. The Electrical circuitry consists of an Isolation transformer, Induction motor, Switchgear equipments like Motor Protection Circuit Breaker (MPCB), Variable Frequency Drive and a Contactor.

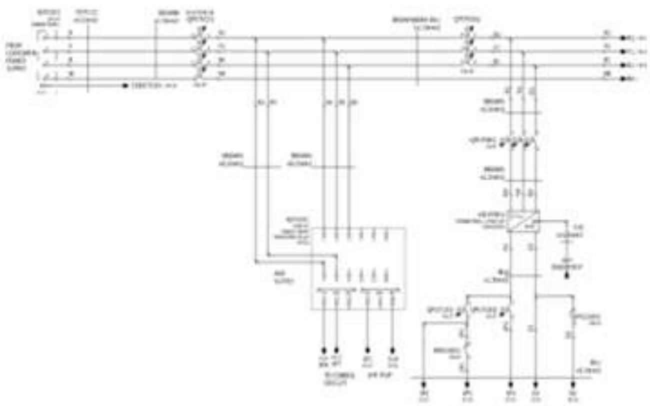

Fig: 1 line diagram of the Electrical Control Circuit.

The Automation Unit comprises of a Simatic S7-200 (Step 7) PLC along with two Temperature modules and an Analog module. The Temperature modules keep track of different temperatures like hose heater temperature, tank temperature and plate heater temperature while as the Analog module keeps track of the varying analog signals like pressure of the solvent, level in the tank etc. Electromechanical and pneumatic control is employed in the machine while as the execution of the machine is carried out by the PLC. Ultrasonic level sensors and pressure sensors are used to sense the level and pressure of dispensed fluid. These

signals act as inputs to the PLC which executes the process according to a pre programmed logic.
The PLC communication is 'duplex' type and the type of cable used is RS 485 Profibus cable. The software used to write the ladder logic is Step 7 Micro Win Smart V2.0.

II. System Description

The system employs a host of electrical, pneumatic and mechanical components. The electrical components are employed in the electrical circuitry of the machine while as the pneumatic and mechanical components form a part of the Process and Instrumentation circuit. A Siemens S7-200 PLC along with a Mitsubishi HMI is used to automate the packaging process. In addition to this, two Temperature modules and an Analog module are used in conjunction with the CPU. The S7-200 PLC has 24 inputs and 16 outputs. The inputs are taken from the various sensors fitted in the machine like level sensor and pressure sensors while as the outputs are used to control the machine process. The Input, Output configuration of the PLC is shown below.

The given figures show the various input and output variables associated with the PLC. The input variables such as the sensors and switches reflect the conditions and status of the machine process and execute the process according to the flow diagram. The PLC interfaces and executes the flow diagram in the form of ladder logic.

In this system, the PLC takes the inputs from:

- Level Sensor: A 0-10V ultrasonic level sensor is employed which is placed on the lid of each tank. It emits high frequency ultrasonic waves that are reflected back from the fluid and are detected by the emitting transducer. The sensor measures the time taken by the signal to return back and translates this into the liquid level present in the system.
- Pressure Sensor: A 4-20mA pressure sensor is placed at the bottom of each tank. It acts as an input to the PLC and constantly keeps relaying information regarding the pressure of the solvent emanating from the tank.
- Encoder: Another input to the PLC is from the Encoder. This input is meant to calculate the amount of material dispensed in each cycle so as to keep a track of the total consumption.
- SPP: The PLC receives an input signal from the Single Phasing Preventer (SPP) to prevent single phasing of the circuit as all other components involved in the system work on a 3 phase supply.

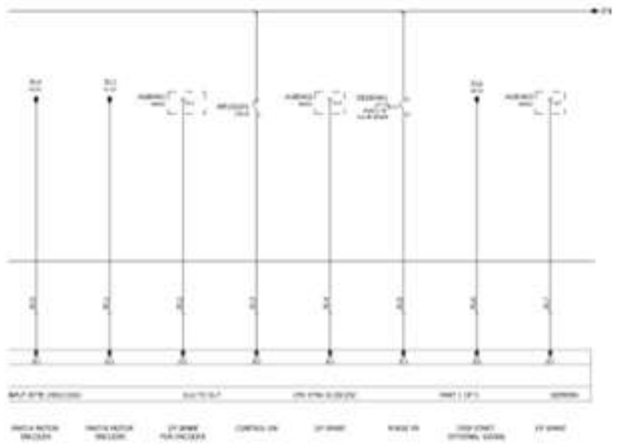

Fig 2: Input Variables of the PLC.

The Output variables involved are as follows:

- Solid State Relay: An SSR is employed in place of an ordinary relay because the temperature of the tanks ke Fig: Input Variables of the PLC. uctuating temperature can damage the moving parts of an ordinary relay. The SSR controls the tank heater and hose heater temperatures as guided by the PLC.
- Buzzer: This output variable is employed to go high in case of a fault generated in the system.
- Purge Lamp: It indicates cycle start and normal execution of the process.
- Solenoid Valve: A single Input, single Output Solenoid Valve is activated by the PLC at the time of tank refill.
- Variable Frequency Drive: This is employed to account for overvoltage/ over current or overload of the motors involved.

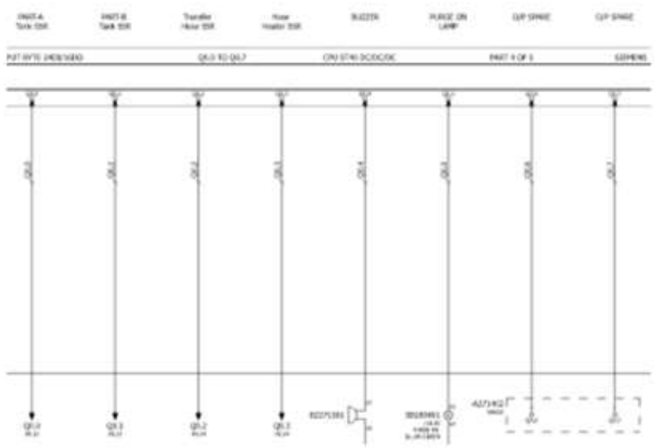

Fig: 3 Output Variables of the PLC.

The two expansion modules used are the Analog module and the Temperature module. An Analog module keeps track of the changes in analog quantities such as the fluid level remaining in the tank after each cycle. The Temperature modules keep track of the changing plate heater temperature and the hose heater temperatures. Two temperature modules cater to the two tanks present in the system. These modules are used in addition to the CPU. The rest of the inputs and outputs are kept spare.

III. Literature Review

The below figure illustrates the process of metering, mixing and dispensing involved in this process. This is a stepwise process corresponding to the various input and output variables that are included in the ladder logic. The PLC ladder logic executes as follows:

- As the process starts, the PLC checks if the PB is pressed. In that case, the PLC checks for various faults that may lead to the stoppage of the machine. These faults include:
    - a) Low pressure/ high pressure fault.
    - b) Ratio error fault.
    - c) Encoder open fault.
    - d) Drive trip fault.
    - e) Pressure sensor open fault.
    - f) Temperature not reached fault.
    - g) Low level/High level fault.

- In case the PB is not pressed, the system checks for the fluid level in the tanks. Incase of low level, autofilling of the tanks starts by opening the Solenoid Valve.
- Next, the PLC temperature module checks for the hose heater and tank heater temperatures. The process executes if these temperatures remain within the permissible range, i.e greater than the low level and lesser than the high level. These limits are set by means of an HMI.
- The program is designed so that when the dispensing hose temperature reaches 40ºC, then only the execution cycle starts. This is verified by another PLC output namely 'Green Lamp ON'.
- Next the calculation part of the program comes into play to calculate the various parameters like flow rate and pump rpm. The pump rpm at a given ratio= (Pump rpm at 100:100 ratio)* (desired ratio). The total flow rate is the sum of the flow rates at the two ratios.
- The cycle stops if the ratio readings do not match with the values input in the program.

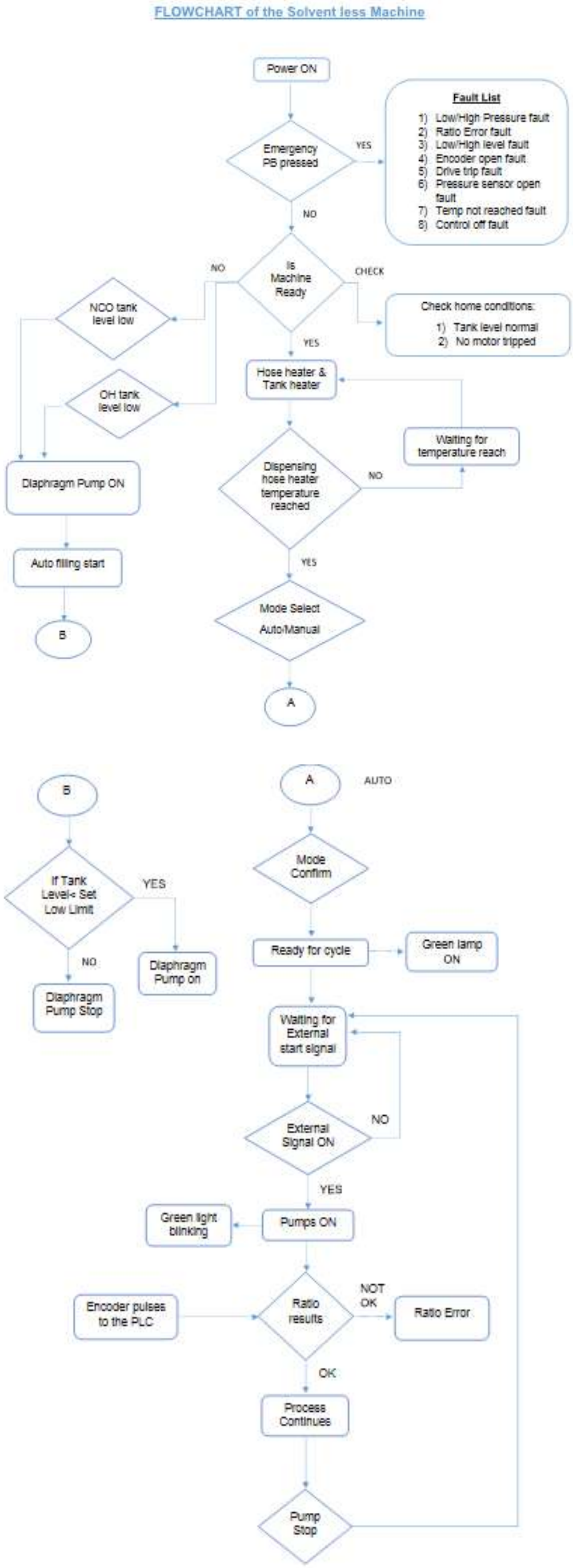

Fig 4: Flow chart of the Packaging Machine System.

IV. Programming of the PLC

The technical specifications of the Programmable Logic Controller are as:

- Power Supply: 24V DC
- Number of Inputs and Outputs: 40 (24 Inputs, 16 Outputs)
- Output Type: Transistor
- Power Consumption: 18W

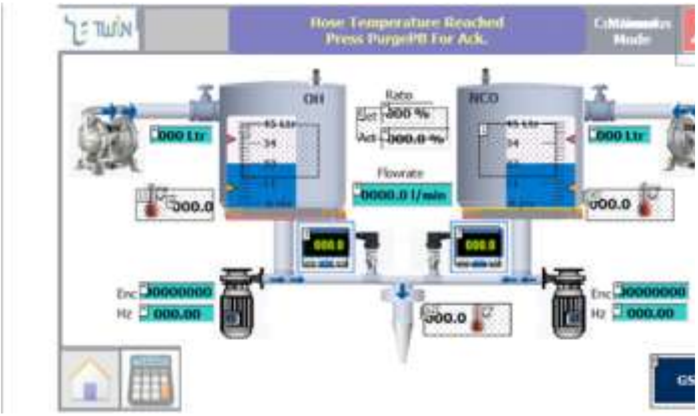

Fig: 5 A Screenshot of the HMI screen showing parameters like Fluid level, Pressure, Flow rate and Ratio.

The Siemens S7-200 PLC is used to address the various faults plaguing this system to save time. After a thorough inspection, we find that these faults have a particular pattern, i.e. these faults are generated when the different electromechanical components of the machine work outside their prescribed range. A brief understanding of the fault generation is explained below:

- Level Sensor: A 0-10V level sensor is used in this system. It emits ultrasonic waves that hit the fluid and get reflected back. The level of the fluid is computed by measuring the time of flight. The level sensor 'counts' are measured at the time of fitting the level sensor. It is found that these 'counts' vary from 0 to 485. This very fact is used in the ladder logic so that when the level sensor reads outside this range, the PLC gets to know the status of the fluid level in the tank.
- Pressure sensor: In this case, the count varies from -2 to 61. As is the case with level sensor, the PLC is activated when the pressure sensor 'counts' go out of the prescribed range and the pressure sensor alarm is activated.
- Encoder Fault: An Encoder is fitted with a disc that is divided into transparent and opaque segments. When the encoder stops, either of the segments faces the light detecting sensor. This very fact is used in the ladder logic program. Accordingly when either of these inputs is activated, the PLC sends an output signal of 'encoder stop fault' and the machine stops.
- Ratio Error: Here a range is decided by the user himself by making use of the HMI screen. A 'tolerant' limit option is provided to the user. The PLC is programmed so that it adds and subtracts the 'tolerance limit' and the 'HMI entered value'. The added and subtracted values correspond to the 'higher limit' and 'lower limit', respectively. The PLC is activated and the ratio alarm is set off when the ratio value goes out of this range.
- Air Pressure Error: The lower limit is set at 0.5 bar while as the higher limit is set at 5 bar. The air pressure alarm is sounded when the air pressure goes out of this range.
- Dispensing Hose Temperature Error: This logic works in the same way as the ratio error logic. The higher and lower limits are set by entering the tolerance values and the HMI entered value.
- Drive Hz error: This logic works if the frequency of the drive goes below 12 or above 50.1 Hz. The reasons for drive Hz error may be overvoltage, over current or overloading of the motor.

Fig 6: A complete view of the PLC along with the Analog and Temperature modules.

V. Experimental and Programming Results

The ladder logic ensures that not much time is wasted during auto filling of the tanks (a frequent operation) as the PLC immediately starts the diaphragm pump once the tank level goes low. Also, the user can identify and rectify the faults immediately as the PLC is programmed to take corrective action.

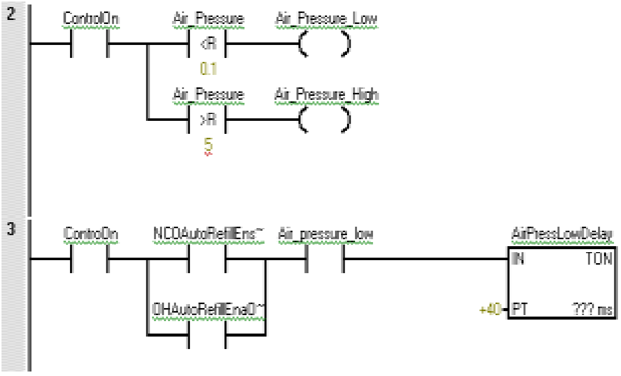

Fig:7 A screen shot of the ladder logic program.

After comparing the performance of the system with and without the Automation Circuitry, some startling revelations come to the fore. The most important among them is the amount of time that is saved in different processes, which results in increased productivity. As shown in the table, we see that the reaction time during auto filling of the tanks reduces from 75 sec to 45 seconds, which is a saving of 30 seconds. Similarly, the time saved in fault clearance is 15 seconds. The fast PLC process also ensures that the PLC is able to calculate the process variables like flow rate, ratio with increased speed and accuracy. The overall time saving in one machine is close to 60 seconds for one cycle! This results in increased production.

Trial 1	Process	Manual	Proposed Method
1	Auto filling	70 Sec	42 Sec
2	Fault Clearance	50 Sec	45 Sec
3	Process Calculations	55 Sec	33 Sec

Trial 2	Process	Manual	Proposed Method
1	Auto filling	73 Sec	45 Sec
2	Fault Clearance	48 Sec	45 Sec
3	Process Calculations	47 Sec	30 Sec

Serial No	Process	Manual	Proposed Method
1	Auto filling	2	0
2	Fault Clearance	1	1
3	Process Calculations	2	0

Fig: Comparison of manpower requirement between an Automated and a Manual process.

VI. Conclusion

This research paper presents the up gradation and automation of material processing in a packaging industry which is often done manually. This is accomplished by means of a Siemens S7-200 Programmable Logic Controller. By virtue of the ladder logic programming, the PLC is able to identify and rectify the various faults associated with the machine and hence saves time and results in increased production. The ladder logic is divided into two stages. The 1st stage takes care of the calculations involving the different machine parameters like flow rate and ratio while as the 2nd stage takes care of the various faults that may hinder the smooth running of the machine. All in all, the comparison of the two methods suggests that automating the process has innumerable advantages and results in increased productivity.

VII. References

[1] Rajesh G Khatod, Chandrashekhar N, Fabrication of Liquid Dispensing Machine using automatic control for engineering industry, IJITEE, ISSN:2278-3075, Volume1, Issue 5, October 2012.
[2] Alhadi Algitta, Mustafa S, Ebrahim F, Abdalruof N, Automated Packaging Machine using PLC, IJISET, Volume 2, Issue 5, May 2015.
[3] “Dr. R. K. Bansal” A Textbook of Fluid Mechanics Laxmi Publication Ltd 1st edition, 2008.