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Automatic Fluid Filling Unit by Using PLC

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AB S T R A C T

The Automatic Filling Unit by using Programmable Logic Controller (PLC) presented in this project signifies a significant advancement in industrial automation. This system integrates the precision of PLC technology with the efficiency of automated filling processes. The project focuses on designing a reliable and precise filling unit controlled entirely by a PLC, ensuring consistent and accurate filling operations. The PLC serves as the brain of the system, orchestrating the various components such as sensors, motors, and valves to achieve seamless filling processes. The implementation of this system not only enhances the productivity of industrial units but also reduces human intervention, minimizing errors and ensuring a higher level of safety. Through this project, we explore the integration of cutting-edge automation technology to streamline industrial processes, paving the way for a future where efficiency and accuracy in manufacturing are paramount.

Keywords : Accurate Filling Operation, Seamless Filling Operation , Industrial Units, Human Intervention, Cutting-Edge Automation Technology

1. INTRODUCTION

Here introduce the paper, and put a nomenclature if necessary, in a box with the same font size as the rest of the paper. The paragraphs continue from here and are only separated by headings, subheadings, images and formulae. The section headings are arranged by numbers, bold and 9.5 pt. Here follows further instructions for authors.

The growth in Food industry and Healthcare industry has seen a rapid increase in demands of beverages as well as medicines. Precision while filling these beverage containers is required. Non-precision will not only lead the economic loss in the beverage industry but also a danger to consumer health in healthcare industry. A typical manufacturing facility of this kind will require precision as well as velocity in filling operation, to achieve both manually is tedious task. Also to operate manually in hazardous chemical industries is safety concern to workers. To make automated bottle filling machine to achieve both accuracy and speed in filling, is requirement of the time. This can be achieved by help of PLC programming and PID controller. This paper describes the application of PLC programming and PID controller in the field of bottle filling operation. In this paper PLC is used along with various sensors as input to the system and valves are used as output to the system. This paper describes about logic developed to sense the position of bottle on the conveyor and its condition, that is whether it is filled or not. This will give accuracy of the amount to be filled and will drastically reduce the cycle time to fill one bottle ultimately resulting in any goal of any manufacturing facility that is quantity with quality. This paper also describes about the parameters like level and flow of a liquid to be controlled. These parameters are to be controlled with the Programmable Logic Controller (PLC) and the whole process is further controlled by SCADA. PID controller are used to minimize the error. A Human Machine Interface (HMI) can be used so the user can change the set values of different parameters as required

To survive in the competitive world, company should use the latest technologies. The field of automation had a notable impact in a wide range of industries beyond manufacturing. Automation is the use of control system and information technologies to reduce the need for human work in the production of goods and services. High degree of flexibility is basic requirement of manufacturing. Industries face many other challenges like continuously increase in the production volume and reduction in the cost. Also industries need to operate safely. In older systems as there will be continuous increase in production also increases the maintenance cost. So the manufacturer face problem as higher cost, high downtime and unsafe operation. New technologies are required that will reduce water usage, increase energy efficiency and minimize downtime in high-speed beverage production environments. The various process of this system is controlled by PLC. PLC is heart of the system and the system is controlled according to the programmed PLC.

The PLC used for more productivity with less time compactable and is implemented to fill the bottles with water [1]. For detecting the empty bottles designed prototype sensor is used and to fill up the bottle submersible pump were used. [2]. The IR sensor is used to monitor the bottles in the system, the whole process should be completed without inference of human in it. Arduino using C++ language programming, used to control various components. [3]. The work involves control loops using microcontroller like Arduino, Ladder Logic and UNO microcontroller are used to connect ICNADBE 2021 Journal of Physics: Conference Series 1937 (2021) 012004 IOP Publishing doi:10.1088/1742-6596/1937/1/012004 3 heavy components. Arduino using C language programming. [4]. The Sprocket is metal steel with teeth on the outside which is in motor and that is used to rotate the conveyor belt. [5]. The Volumetric filling is the type of filling with the speed of piston and its cost is more expensive than gravitational filling. The piston attach in the volumetric will make entire system fast. [6]. The Water Float Switch is dipped in the water to monitor the water level and to get energize the pumps [7]. To control the process using RASPBERRY PI, which is developed to used for different industries like oil, chemical. [8]. To detects the object which are positioned in particular place on the conveyor belt, Infrared sensor is used here. Brushless DC motor is used to control the electric speed. [9].The PLC & SCADA is used to monitor and control plant equipment. It stores the all the data and it can be viewed anywhere, not just on site [10].

Filling bottles by using SOV and Microcontroller AT89C51 is implemented here to control the project. It is 4KB of Flash programmable and read only memory [11]. The Proximity sensors have been used here to detect the presence of the empty bottle. Ladder logic is used for the programming of the PLC [12]. The Capping system using GRAFCET, GEMMA and WinCC for flexible and good working. GRAFCET is a graphical representation and analysis of an automatism. The GEMMA is used to speed up the system process. [13].The Proximity sensor and load cell is to monitor the empty bottles on the conveyor belt. [14]. The Ladder logic programming using GX work 3 which used to control as well as operate in extreme rush environment conditions. [15]. The design of the proposed bottle washer machine for RGBs has been created in the Creo software. The implementation of the PID temperature control and auto-tuning. [16]. This system using Arduino for controlling the PLC by using Programming and rotary pump is used to fill up the bottles.

- Mallardhya et al (2013) used timer system, this system deals with the present value of the timer. The value is switched ON for that specific period of time and the filling is finished. This system is best use of mechanization exceptionally for large scale manufacturing businesses as different kind of part handled in brief timeframe that build creation. This uses different height of bottle for filling operation.
- Ahuja et al (2014 utilized the Programmable rationale control (PLC) and Supervisory control and data acquisition (SCADA) for process monitored that gives the high level of adaptability to the programmed filling system. This helpful for blending any number of fluid in any extent. This framework give rapid generation utilizing minimum system necessity additionally give high exactness and accuracy in extent of fluid blended. This framework observed by SCADA as procedure can be start and stop by SCADA. That helpful when an issue occur during procedure.
- Lu et Al (2015) researched in the system which utilizes human machine interface straightforwardly with the PLC communicate with one another without programming through the man machine interface can finish the system parameter setting and checking. This programmed filling control system has high level of automation straightforward operation. This give high exactness estimation.
- Ozkana (2012).conducted the experiment with the assistance of PLC that gives elective answer for the as of now available system.
- .Early Development (1960s-1970s):

PLCs originated in the late 1960s as a replacement for complex relay-based control systems in manufacturing plants. The first PLC, known as the "084," was introduced by Modicon (a division of Gould Electronics) in 1969. These early PLCs were primarily used in the automotive industry

- Advancements in the 1980s:

During the 1980s, PLC technology advanced rapidly. The introduction of microprocessors allowed for more complex control tasks. PLCs became smaller, faster, and more versatile, making them suitable for various industries beyond automotive, such as food processing and chemical plants

- .Integration with Computers (1990s):

In the 1990s, PLCs started to integrate with personal computers, leading to improved programming interfaces and communication capabilities. This integration allowed for easier programming, diagnostics, and data analysis

- .Internet Connectivity and Industry 4.0 (2000s-Present)

PLCs continued to evolve with the rise of the internet and Industry 4.0 initiatives. PLCs became more interconnected, allowing for remote monitoring, diagnostics, and control. The integration of PLCs with the internet facilitated the concept of the Industrial Internet of Things (IIoT), enabling smart manufacturing processes and predictive maintenance.

- Technological Advancements and Open Standards:

Recent years have seen advancements in PLC technology, including enhanced processing power, increased memory capacity, and support for advanced programming languages. Additionally, open standards and protocols have become more prevalent, enabling seamless communication between different devices and systems in industrial automation networks.

- Current Trends and Future Outlook:

PLCs continue to evolve, with a focus on cyber security, real-time data analytics, and artificial intelligence integration. Edge computing capabilities are also becoming more prevalent, allowing for data processing closer to the data source, which is crucial for time-sensitive applications.

2. COMPONENT REQUIRED

A. **PLC Fuji NA0PB14R-34C Programmable Controller SPF**

PLC is a programmable device developed to replace mechanical relays, timers and counters. Programmable logic controllers are used in various industries for all controlling operations. The bottle filling machine is controlled by PLC with the help of ladder logic. As ladder logic is a one of the method of programming a PLC. The ladder logic language which was developed to simplify the task of programming PLCs. PLC consist of input/output (I/O) unit, central processing unit (CPU) and memory.

As I/O unit acts as the interface between PLC and real time systems. All logic and control operations, data transfer and manipulation work is done by CPU. PLC have advantages of high reliability in operation, flexibility in control techniques, small space and computing requirements, expandability, high power handling, reduced human efforts and complete programming in a plant. A programmable logic controller (PLC) is a digital computer used for automation of industrial process such as control of machinery on factory assembly lines. The PLC is designed for multiple inputs and outputs arrangement. Program to control machine operation are typically stored in battery backed or non-volatile memory.All figures should be numbered with Arabic numerals ..Every figure should have a caption. All photographs, schemas, graphs and diagrams are to be referred to as figures. Line drawings should be good quality scans or true electronic output. Low-quality scans are not acceptable. Figures must be embedded into the text and not supplied separately. In MS word input the figures must be properly coded. Lettering and symbols should be clearly defined either in the caption or in a legend provided as part of the figure. Figures should be placed at the top or bottom of a page wherever possible, as close as possible to the first reference to them in the paper.

The figure number and caption should be typed below the illustration in 8 pt and left justified [***Note:*** one-line captions of length less than column width (or full typesetting width or oblong) centered]. For more guidelines and information to help you submit high quality artwork please visit:http://www.elsevier.com/wps/find/authorsview.authors/ authorartworkinstructions. Artwork has no text along the side of it in the main body of the text. However, if two images fit next to each other, these may be placed next to each other to save space. For example, see Fig. 1.

Fig. 1 - PLC Fuji NA0PB14R-34C Programmable Controller SPF

B. Proxy Sensor

A proxy sensor, often referred to as a proximity sensor, is a type of sensor used in various industrial and consumer applications to detect the presence or absence of objects without physical contact. These sensors work based on different principles, such as electromagnetic, ultrasonic, capacitive, or infrared, to sense the proximity of an object within their detection range. Here are some key points to note about proxy sensors:

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact.

A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation (infrared, for instance), and looks for changes in the field or return signal. The object being sensed is often referred to as the proximity sensor's target. Different proximity sensor targets demand different sensors.

C. Switched-Mode Power Supply

It seems like you're referring to *SMPS, which stands for **Switched-Mode Power Supply*. SMPS is a type of power supply that uses modern power electronics to efficiently convert electrical power. Unlike traditional linear power supplies, SMPS converts power by rapidly switching the power semiconductor devices on and off, which significantly reduces wasted energy and heat generation. Here are some key points to note about SMPS:

- *Rectifier:* Converts AC (Alternating Current) to DC (Direct Current).
- *Switching Transistors*: Rapidly switch on and off to control the flow of current.
- *Transformer:*Steps the voltage up or down as required.
- *Diodes and Capacitors:*Rectify and filter the output to provide a stable DC voltage.

A switched-mode power supply (SMPS), also called switching-mode power supply, switch-mode power supply, switched power supply, or simply switcher, is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently.

Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power, see AC adapter) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. The switched-mode power supply's higher electrical efficiency is an important advantage.

Switched-mode power supplies can also be substantially smaller and lighter than a linear supply because the transformer can be much smaller. This is because it operates at a high switching frequency which ranges from several hundred kHz to several MHz in contrast to the 50 or 60 Hz mains frequency. Despite the reduced transformer size, the power supply topology and the requirement for electromagnetic interference (EMI) suppression in commercial designs result in a usually much greater component count and corresponding circuit complexity.

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight is required. They are, however, more complicated; switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor.

D. DC Motor

Fig 2 - DC motor

The direction of rotation can be reversed by changing the polarity of the applied voltage or by altering the connection of the rotor windings.

A DC motor is an electrical motor that uses direct current (DC) to produce mechanical force. The most common types rely on magnetic forces produced by currents in the coils. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current in part of the motor.

DC motors were the first form of motors widely used, as they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances.

3. PROPOSED METHOD

A. Input circuit.

i. In input circuit there are sensor used as input for the PlC.

ii. The sensors are proximity sensor, ON push button, OFF push button, and toggle switch.

iii. The proximity sensor senses the location of the cup and gives the command for the presence of the cup to its desired location to the PlC.

iv. The ON push button gives the command to the Plc of the ON operation.

v. The OFF push button gives the command to the plc for the OFF operation and the toggle switch Operate the Conveyor for its Forward and Reverse Operation.

vi. This input circuit sensors provide all. The. Needed sensing and operational commands to the PLC to operate and function accordingly.

B. Output circuit.

i. In output circuit, the PLC provide output to the following equipments for the operation the Circuit.

ii. The equipment are valve and DC motors to operate to function accordingly.

iii. The output are dependent on the program and settings done and code applied to the PLC.

iv. According to which the relay operates.

v. The supply is provided to the motor according to its Forward and reverse function.

C. Power circuit

i. In power circuit,there are three equipments 230 volts supply ,provided to the 24 volts smps and 12 volt smps.

ii. This smps provide supply to the relay and as well as for the operation of DC motors and valve.

iii. The contacts used for the supply are provided through relay.

D. Operation of the circuit.

When 230 volts supply is provided to the MCB and the MCB is turned ON. The supply is provided to 24 volts smps as well asto the 12 volt smps. This smps provide supply to PLC as well as relay for its operation.When the Auto manual switch is Set on auto. The PLC comes in line and it function's. Accordingly when we press the on button. The Conveyour starts and as the Cup come in the proximity of the proximity sensor.It senses the presence of the cup and provide the command to the PLC as the PLC gets the command of the Proximity sensor for the Presence of the cup. It turns on the No contact to NC contact which provided supplies to the relay. Three relays are used. One is for forward Operation. One is for Reverse Operation and one is for manual function.When this contact are through from the plc.

The contact in the Relay are also through.The conveyour move forward moving the Container (Cup).As the proximity sensor senses the location of the cup, the valve is turned on for the specified time (5 second)Particular amount ofWater flows in the cup and the Coveyour moves forward.

As the OFF push button is pressed the PlC turns OFF the circuit. When we switch the. Auto manual switch to the manual position.

In case of an emergency. The conveyor can be Forward and Reversed accordingly as well as Stoped

To calculate the time it takes to fill half of a thermacol tea cup, we need to know the volume of the cup and the flow rate of the liquid being poured into it. The formula to calculate the time taken to fill a container is:

Time = Volume of the container / Flow rate

A. Now the flow of the Pipe (citrate tube) = 35 moll/h

B. Considering the container need to be filled half the volume ideally then =75ml

C. Time = Volume of the container / Flow rate

D. Time =75/35.

4. RESULT AND ANALYSIS

An automatic filling unit controlled by a PLC (Programmable Logic Controller) offers numerous advantages, including: The working model is designed to fill water bottles of various sizes. The amount of water filled in the bottle is related to the time duration set in analog timer. The valve operation duration was determined by trail and error method. The calculated time is fed into analog timer with this adjustment bottles with various sizes were filled. The valve is closed, the filled bottles were counted by counter then conveyor move the bottle to outlet of the machine. This model gives an output of the filled water bottles and the even sized filled bottles are given to the packing unit for future usage. Figure 2 Figure 3 Figure: 2, 3 Working Model of Proposed System. The progress of the machine should be monitored because non-occurrence of bottles is possible in this method. The process is continued for continuous filling of the same size of bottles. The analog timer will be changed for the other types and sizes of bottles and the below tabulation shows the survey of various types of water bottles filled in the trail an

- Precision and Accuracy: PLCs ensure precise measurement and control, leading to accurate filling of containers, minimizing wastage.
- Efficiency: Automation increases the speed of the filling process, improving overall production efficiency.
- Consistency: PLCs maintain consistency in filling levels, ensuring uniform product quality.
- Flexibility: PLC-based systems can be easily reconfigured for different types and sizes of containers, offering flexibility in production.
  Remote Monitoring and Control: PLCs allow remote monitoring and control of the filling unit, enhancing operational supervision and troubleshooting capabilities.
- Data Logging: PLCs can log data related to filling operations, providing valuable insights for process optimization and quality control.
  Safety: Automated filling units reduce the need for manual intervention, minimizing the risk of accidents and ensuring a safer working environment.
- Cost-effectiveness: Although the initial setup cost might be higher, automated filling units powered by PLCs can lead to significant cost savings in the long run due to reduced labour requirements and increased production efficiency.

1. <u>Performance Test:</u>

It's found that accuracy is increased when the bottle size is increased. But all three size of the bottle the filling height is within ± 2% deviation.

Table 1 – Performance Test

Sr.no	**Time**	**mL Filled**
1.	25 Sec	-

2.	20 Sec	-
3.	30 Sec	-

2. Pump control:

Control of pump to start and stop to fill the liquid tank to run complete system. Filling process: As the empty bottle sent in to filling area the position sensor and proximity sensor confirmed the perfect position of bottle for filling. Solenoid valve open for particular time to fill required amount of liquid in bottle. After filling the bottle sent for next operation.

3. Software test:

According to the working process of system the PLC programming, SCADA design and HMI panel design software TIA V12 is used. PLC programming in the form of ladder diagram. The Input and Output communicate with each other to control and monitored the bottle filling system.

A. Performance Test

Performance test of the project was carried out taking samples of different fluid Having different density

In this test a particular measure of fluid is used to get the time required for its filling by the solenoid valve as processed the presence by the proximity sensor according to the speed of the synchronous motor the setting of the PLC is done .top fill the aprox amount in the container

Density can differ at different temperature of different fluid so the test carried out of different fluid are in room temperature (Ambient temperature)

Sample 1 (Water)

Is used to check the flow time of the Fluid

Density=997 KG/L

Table 3– Sample 1 (Water)

Sr.no	**Fluid flowed**	**Time required**	**Speed (ml/sec)**
1	25	4.3	5.814
2	20	3.44	5.814
3	30	5.16	5.814
Avg Speed=5.814			

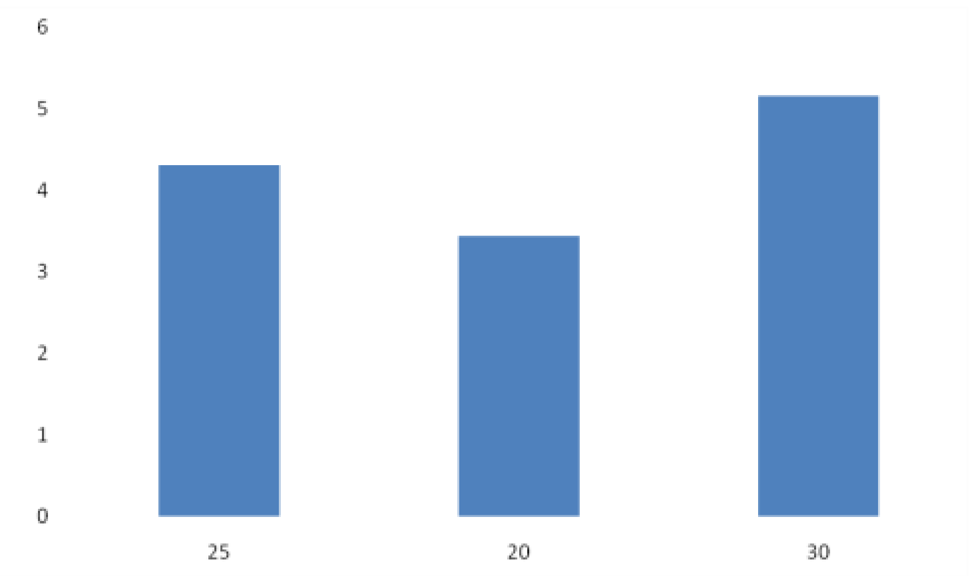


Fig 3 - Sample 1 (Water)

Sample 2 (Milk)

Is used to check the flow time of the Fluid

Density=1.035 Kg/L

Table 4 – Sample 2 (Milk)

Sr.no	Fluid flowed	Time required	Speed (ml/sec)
1	25	4.5	5.5556
2	20	3.6	5.5556
3	30	5.4	5.5556
Avg Speed=5.5556			

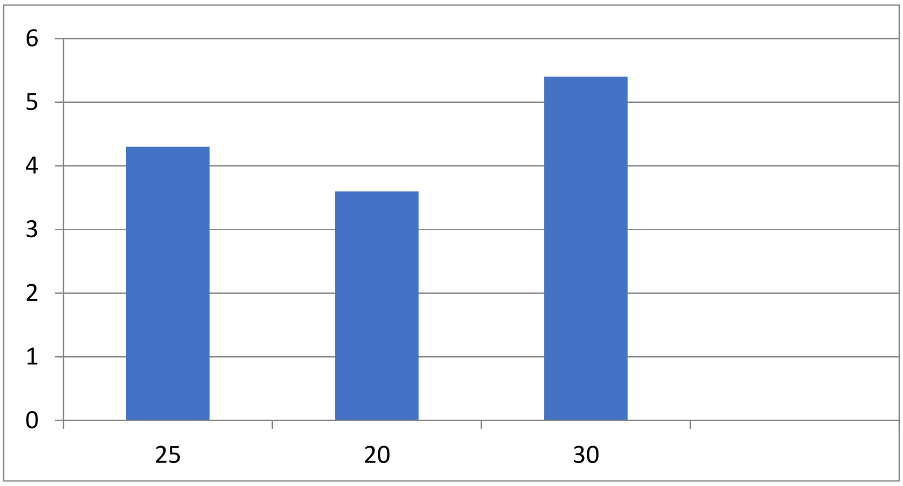


Fig 4 - Sample 2 (Milk)

Sample 3 (Alcohol)

Is used to check the flow time of the Fluid

Density=789 kg/m^3

Table 5 – Sample 3 (Alcohol)

Sr.no	Fluid flowed	Time required	Speed (ml/sec)
1	25	4	6.25
2	20	3.2	6.25
3	30	4.8	6.25
Avg Speed=6.25			

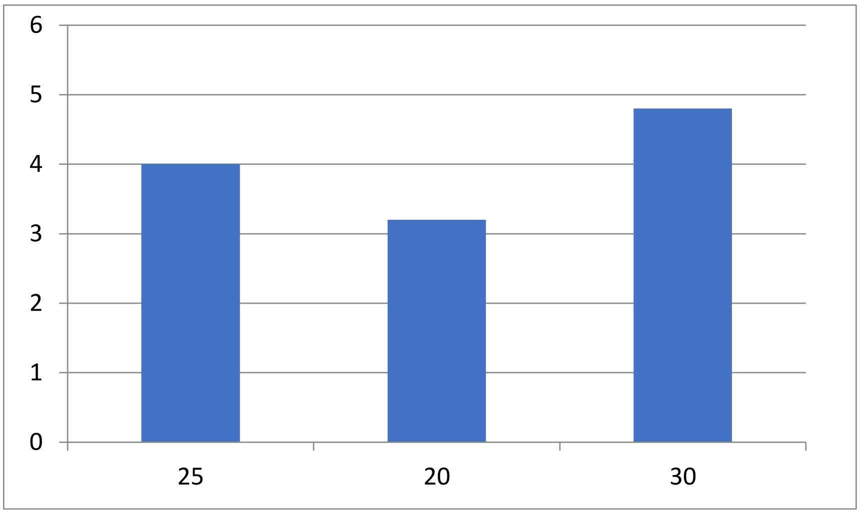


Fig 5 – Sample 3 (Alcohol)

Sample 4 (Phenyl)

Is used to check the flow time of the Fluid

Density=1.03 Kg/m^3

Table 6 – Sample 4 (Phenyl)

Sr.no	Fluid flowed	Time required	Speed (ml/sec)
1	25	4.4	5.6818
2	20	3.52	5.6818
3	30	5.28	5.6818
Avg Speed=5.6818			

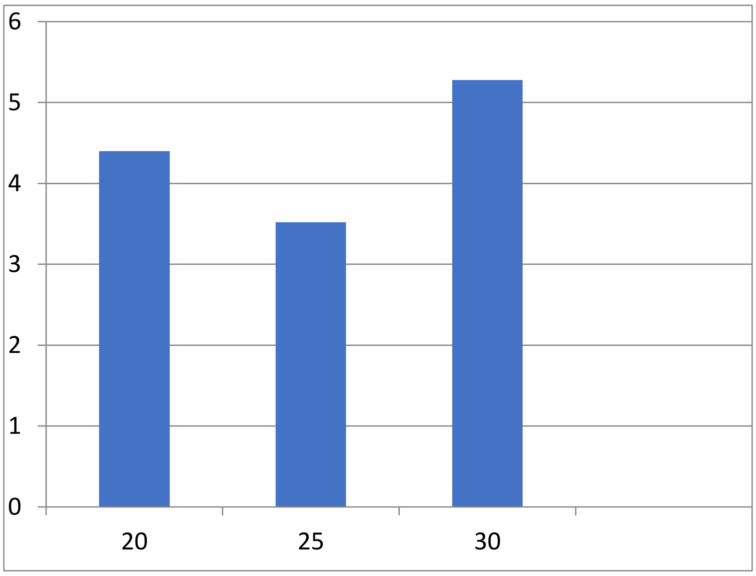


Fig 6 – Sample 4 (Phenyl)

Sample 5 (Cough Syrup)

Is used to check the flow time of the Fluid

Density=1.03Kg/m3

Table 7 – Sample 5 (Cough Syrup)

Sr.no	**Fluid flowed**	**Time required**	**Speed (ml/sec)**
1	25	4.2	5.9524
2	20	3.36	5.9524
3	30	5.04	5.9524
Avg Speed=5.9524			

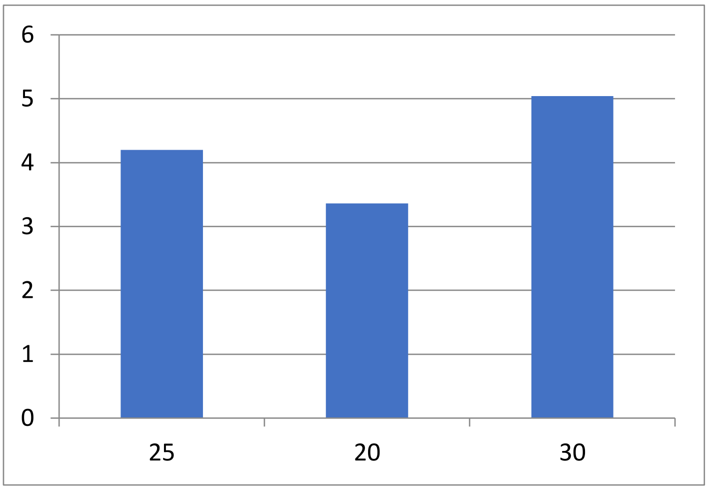


Fig 7 – Sample 5 (Cough Syrup)

5. CONCLUSION

In conclusion, the implementation of an automatic filling unit using PLC technology offers significant advantages in terms of efficiency, accuracy, and reliability. By harnessing the power of PLCs, your project has successfully demonstrated the automation of the filling process, reducing human intervention and minimizing errors. This not only enhances productivity but also ensures consistency in the production line, leading to higher-quality products. Liquid dispensing machine is common device in our day to day life. It is also use in large number of industries for various purposes. As it is use widely In each & every field so it is need of time to design machine having high precision. Following are some important points observe during the design & fabrication of machine

The control system is the main part in the concept of design the automatic liquid filling system. Generally, in the design of electrical systems, the main necessary stepsthat should be determined are the type of design coding and understanding the requirements of the control system to obtain the satisfied response, where using Adriano board In conclusion, the implementation of an automatic filling unit using PLC technology offers significant advantages in terms of efficiency, accuracy, and reliability. By harnessing the power of PLCs, your project has successfully demonstrated the automation of the filling process, reducing human intervention and minimizing errors. This not only enhances productivity but also ensures consistency in the production line, leading to higher-quality products. Liquid dispensing machine is common device in our day to day life. It is also use in large number of industries for various purposes. As it is use widely In each & every field so it is need of time to design machine having high precision. Following are some important points observe during the design & fabrication of machine

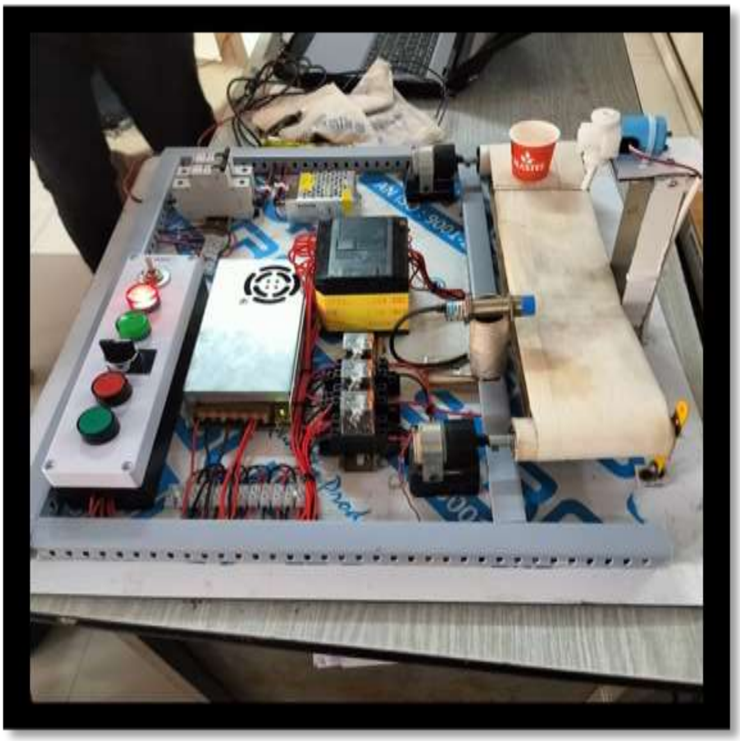
For this purpose it is good to use device of high quality like solenoid valve, programmable syringe etc. In some industries like paint industries, bottle filling plant etc it is important to dispense liquid in some predefine quantity. This is main requirement of any dispenser & hence precise metering device is required in dispensing machine.

1. In some industry, multihead dispensing machine is also use like in bottle filling plant, PCB making laboratory over conventional dispensing machine .In this case it is important to design machine according to requirement so that idle time of each head must be low.

2. Automatic dispensing machine is widely use over manual operating dispensing machine. This automatic machine is operated with the help of well defined programmed microcontroller. Microcontroller AT89C52 is use for this purpose on large scale. Programming of this microcontroller is done with the help VB.net or with the help of metlab language .With the help of microcontroller precision & working efficiency of machine increases.

3. Screen operated dispensing machine is also use in large scale. This machine reduces human error thus increase operator accuracy. Operator familiar with the icon system appreciate touch screens that make automation system user friendly. Touch is considered very useful to reduce the operation complexity of the translate of the machine sequence to ensure the enhancement of the system performance. In this research paper, a new automated filling system with low cost is presented. In the presented process the edge detection and the matching template methods was applied. We succeeded to achieve all tasks of the filling system. Five different methods were examined to detect the level of liquid in the bottle at any time during the filling process based on the edge detection approach. Finally, it was concluded based on the obtained results that the optimal method is the Prewitt method. The main advantages of the developed automated filling system are the high flexibility for filling any liquid with any type of bottle (different shape or/ and volume) without any change in the system setting. In the developed system, other important factors were taken into consideration, such as the conveyor speed and flow rate of liquid into the bottle. In the subsequent researches, the ways to enhance the efficiency and performance of the presented filling system will be investigated.

There is large scope for the improvement of liquid dispensing machine in future. By considering properties of fluid like viscosity, kinematics viscosity ,density, fluid flow in pipe, fluid head, major losses and minor losses in pipe leakage of liquid can be reduce which will help to make machine more efficient. The future work on these issues can improve the application performance of system in critical working environments and complex backgrounds. This will perform a vital role in minimizing human efforts in handling system.



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