Automatic Bottle Filling And Capping System

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Abstract: The main aim of the proposed system is to fill the bottles of varying volumes with two different liquids according to user input and automatically cap the filled bottles of different volumes on a single assembly and dispense it. The entire operation of the proposed system is controlled by the means of Arduino. The proposed system makes use of a rotating mechanism to rotate the bottles and the rotating mechanism is driven by a stepper motor. The bottles are filled through a solenoid valve using a water pump. For the capping of bottles of different volumes two DC motors are used and capping is done by linear mechanism. Finally, the bottles are dispensed using a conveyor belt driven by a motor.

1. INTRODUCTION

In the packaging sector, filling machines are crucial pieces of equipment used to put Liquids, gases, pastes, or powders into containers. The material-filled bottles are capped using capping machines. Most companies provide a selection of items. For instance, a beverage manufacturing firm could create bottles of different capacities, such as 200ml, 250ml, and 300ml. To make these bottles, the manufacturers use several assembly lines that are tailored for different quantities (Patil, M. D. (2021). As a result, there are more assembly lines, which means there are more components, which raises the cost of setup. Additionally, each manufacturing line must have its own electrical supply and be monitored independently. The labour cost and operational costs go up as a result. Most manufacturing organisations now employ the just-in-time production principle as a result of the arrival of 21st-century economics (Abashar, A.et al.,2017). This indicates that the businesses only manufacture in small quantities that are determined based on their previous and anticipated sales, rather than producing the goods in large quantities and storing them. In the previously mentioned scenario, if the firm does not experience 300ml bottle sales, producing such bottles would be worthless since the company would suffer losses if they did so. As a result, they would stop producing those bottles (Pannu et al.,2016)

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The assembly line's original setup for 300ml bottles would now be pointless, increasing losses. The proposed system overcomes this problem by filling bottles of varying volumes based on the manufacturer's requirement for their wide range of products (Murali, Y. N. 2012). The system allows them to scale up and scale down based on their business model requirement. The system makes use of solenoid valves and water pumps for the filling of bottles along with a capping system using a motorised arrangement all integrated in a single machine(Zhang, P. 2008).

2. HARDWARE IMPLEMENTATION

The filling and capping systems are integrated into a single mechanism and connected to Arduino to make the whole mechanism automatic. The Proposed system operated based on the user requirements. The user gives the input using a keypad that is connected to Arduino.

2.1 STEPPER MOTOR:

Stepper Motor is used to drive the rotating mechanism which is used to rotate the bottles of different mechanisms. The stepper motor is operated by using a 12-volt DC supply.

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2.2 SERVO MOTORS:

Servo motors are used for pushing mechanisms which push the bottles of different volumes onto the rotating

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mechanisms. Servo Motors are also used for dispensing the filled bottles. These servo motors are operated by 5-volts DC supply.

2.3 SOLENOID VALVE:

Solenoid valves are used to fill the bottles with two different liquids and cut off the water flow automatically when the bottles are filled. It is operated by the 12-volt DC supply.

2.4 INFRARED SENSORS:

IR Sensors are used to sense the starting point on the rotating mechanism and send the signal to Arduino to start rotating. Automatic Bottle Filling And Capping System and to sense the bottles which are to be filled and to sense the bottles which are to be capped.

2.5 PUMPS

Pumps are used to pump the liquids to fill the bottle through a solenoid valve. Two pumps are used for pumping two different Liquids. Pumps are operated using a DC motor driven by a 12-volt DC supply.
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2.6 DC MOTORS

DC motors are used for capping mechanisms which are driven by a 12-volts DC supply. The capping is done by a linear mechanism. DC motor is also used for driving the conveyor belt
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2.7 CONVEYOR BELT

The conveyor belt is used to dispense the filled and capped bottles of varying volumes. The conveyor belt is driven by a DC motor whose speed is controlled
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2.8 MICROCONTROLLER

The microcontroller used in the proposed system is Arduino Mega. It has 54 digital input/output pins and 16 analog input pins, 4 UARTs and a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Here Arduino is used to control the operation of the system and take input from the user and operate all the sensors and automate the whole system.

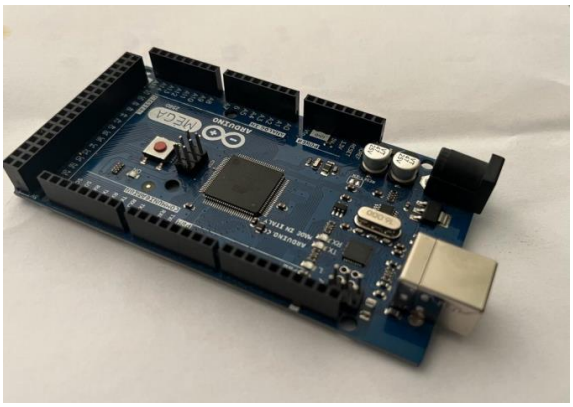

Fig 1. Arduino Mega microcontroller

3.METHODOLOGY

3.1 SYSTEM DESIGN

The proposed system uses Arduino Mega for controlling and automating the system. The input for Arduino for filling the bottles is given by the user through a keypad that is connected to Arduino. **(Berger, H. 2012.).**There is a pushing mechanism that is operated by the servo motor, it pushes the bottle onto the rotating mechanism. The rotating mechanism is used for rating bottles for filling and capping**(Sidik, M., & Ghani, S. C. 2017**). The bottles are filled by using water pumps through the solenoid valve. Then bottles are capped by using two DC motors using a linear mechanism. And the bottles are dispensed using the conveyor belt.

3.2 BOTTLE SELECTION

The user will be prompted at the beginning to indicate how many 250 ml and 500 ml bottles should be filled with water and how many should be filled with juice since the proposed system can only fill these sizes with two different liquids,such as water and juice. The user will also be prompted to indicate how many 250 ml and 500 ml bottles should be filled with water and juice. Users may input data via a keypad linked to an Arduino, and the data is displayed on an LCD screen.

3.3 BOTTLE PLACEMENT

After taking input from the user the system gets started and there are two pushing mechanisms like rack and pinion, one Automatic Bottle Filling And Capping System for 250ml bottles and one for 500ml bottles. The pushing mechanism pushes the bottle

onto the rotating mechanism. These pushing mechanisms are operated by servo motors.

3.4 FILLING PROCESS

After bottles are pushed onto the rotating mechanism the rotating mechanism starts rotating, IR sensor placed near the filling poles senses the bottle and stops the rotating mechanism. The bottles are filled with two different liquids based on the user input. For filling the two different liquids two water pumps are used and two solenoid valves are used.The water is pumped to the bottle by a water pump that is operated by a DC motor, through a solenoid valve. The filling of the bottle is done based on time, after a certain time when the bottle is filled the solenoid valve cuts off the water supply.If the user needs two bottles of all types then the system will fill the 250ml bottle with water first and then the 250ml bottle with juice and then the 500ml bottle with water and at last the 500ml bottle with juice (Chakraborty et al., 2015).

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3.5 CAPPING PROCESS

After the bottles are filled with the respective liquids, the rotating mechanism moves and the bottle takes the cap from the stack, and an IR sensor placed at the capping mechanism senses the bottle and stops the rotating mechanism, then the bottles are capped by using a linear mechanism in which two DC motors are used. One DC motor is used to move another DC motor UP and down, the other DC motor holds the cap of the bottle and tightens it.

3.6 DISPENSING MECHANISM

Once the bottles are capped then the rotating mechanism starts again and moves the bottle, then the bottles are placed on the conveyor belt which is operated using a DC motor. The conveyor belt moves the bottle and dispenses it. The dispensing is done at four 4 different places, 250ml bottle with water at one place and 250ml bottle with juice at another place and so on.

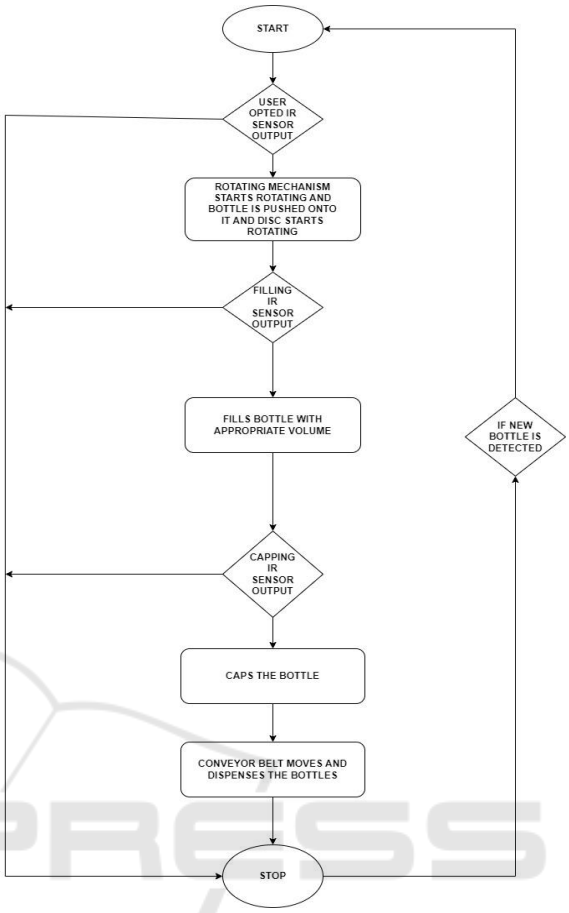

Fig 2. Process Flow of the System

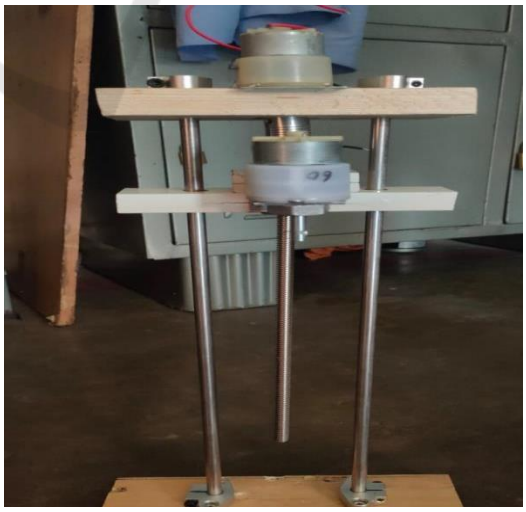

Fig 3. Capping mechanism

Fig 4. Conveyor Belt

4 BLOCK DIAGRAM

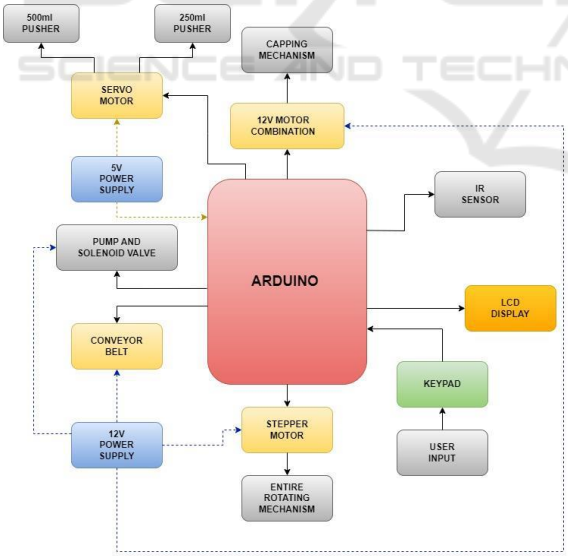

Fig 4. Block Diagram of the proposed system

The block diagram illustrates a proposed system that automates the process of filling, capping, and dispensing bottles. The system operates with a12-Volt DC supply that powers a stepper motor responsible for initiating the rotating mechanism. As the rotating mechanism starts moving, an IR sensor detects a specific point, marking it as a reference. Once this point is sensed, a rack and pinion mechanism is activated, pushing 250ml and 500ml bottles onto the rotating platform. Subsequently, the rotating mechanism begins its rotation, and IR sensors placed near a solenoid valve detect the presence of bottles as they pass by. Upon sensing a bottle, a pump is activated to pump the liquid into the bottle through the solenoid valve. The type of liquid to be filled is determined by the user input and the amount of liquid to be filled is calculated based on time. Once the bottle is filled, the solenoid valve cuts off the liquid flow, preventing overfilling. Continuing the rotation, another IR sensor located near the capping mechanism senses the presence of the bottle, causing the rotating mechanism to stop. At this point, the capping process begins, employing a linear mechanism with two DC motors to secure the caps onto the bottles. Once the capping is complete, the filled and capped bottles are dispensed using a conveyor belt, which is driven by a DC motor. The conveyor belt transports the bottles to four different dispensing points. The system ensures that 250ml bottles of one type of liquid are dispensed at one point, while 500ml bottles of another liquid type are dispensed at another point, and so on. This arrangement facilitates organised and efficient bottle dispensing. The system combines with an Arduino controller to regulate and plan the whole operation. The Arduino serves as the main controlling component, allowing automation based on user needs. This system's integration of multiple parts and use of the Arduino's features results in a simplified and automated method of filling, capping, and distributing bottles in a way that the user specifies (Mashilkar et al,2015).

5 CIRCUIT DIAGRAM

The above figure illustrates the circuit diagram of the proposed system. The proposed system uses Arduino Mega to control and automate the whole system. The Arduino Mega
uses Atmega 2560 microcontroller. A keypad is connected to Arduino to take the user input and LCD

display is used to display the inputs given. The system contains one stepper motor, five 5DC motors, and 5 servo motors. The servo motors are controlled by Arduino mega and all servo motors are connected to the digital pins of Arduino Mega **(Badamasi, Y. A. 2014, September)**. To power the stepper motor and the DC motors 12 volts of power supply. SMPS is used as a 12 volts power supply for high current device that is a stepper motor, a 12-volt 1-amp adapter is used for operating the DC motor used for water pumps, and a 5-volt 1-amp adapter is used to power all servo motors. The servo motors are operated by Pulse Width Modulation (PWM). And to stop the DC motors when needed these DC motors are operated through relays. Eight IR sensors are used one for recognizing the starting point on the rotating mechanism, two IR sensors are used near solenoid valves to sense and stop the bottles for filling, and two sensors are used for capping. And rest of them is used for the dispensing
process.A4988 stepper motor driver is used to operate the stepper motor. The L298N motor driver is used to drive the DC motor used for the capping mechanism in both directions clockwise and anticlockwise. The motor driver helps the DC motor to rotate in both directions clockwise and anticlockwise. The conveyor belt is operated using a DC motor whose speed is controlled by the speed control circuit

6 ANALYSIS AND RESULT

Industries in the real world fill the bottle with different volumes and different liquids in separate assembly lines. This leads to the use of separate control units, separate infrastructures, separate motors, sensors, and separate software programs which results in increased expenses for the company. And industries use PLCs for automation and human-machine interface which are expensive and increase the spending costs of the company. The separate assembly lines consume more power to operate and it makes it difficult for the company to maintain the assembly lines and the quality of products. Using this increases the operational and labour cost of the company. In case of fewer sales of one particular volume of the bottle, the company has to shut down the whole assembly line of that particular volume of the bottle which makes the company face losses.
The proposed system overcomes all these problems and makes the industries spend less money. The proposed system fills the bottles of varying volumes 250ml and 500ml with two different liquids in a single system. And the bottles are capped automatically. This capping and filling mechanism is integrated into a single system. And the proposed system dispenses the filled capped bottle using a conveyor belt at 4 different places and the system operates as per user requirements by taking input from the user. The system uses an Arduino Mega microcontroller for controlling and automation because it is cheaper than PLC. The whole system operates on a single electrical supply. So the proposed system can be more efficient and reliable for the industries as the proposed system can make the industries spend less money on the maintenance of the system, using this system can maintain the quality of products and decrease the operational and labour cost. The figures below show the working model of the project.

Fig.7 Working Model

7 CONCLUSION

The method uses automated technologies to streamline production and eliminate manual work. The system can identify and control bottles of various sizes, ensuring that each bottle receives the right amount of liquid. The system's versatility allows it to be used in a wide range of industries and applications. Additionally, the likelihood of contamination and cross contamination is decreased by the automated filling and capping process. Maintaining a high level of cleanliness and avoiding the blending of liquids, it guarantees

the integrity and quality of the filled bottles. This feature is crucial for industries including pharmaceuticals, food and beverage, and cosmetics. The core of the system is its reliable and sturdy design. The system is equipped with state-of-the-art sensors, actuators, and control mechanisms to ensure precise measurements and smooth operation.

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