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DESIGN AND DEVELOPMENT OF AN AUTOMATED LIQUID BOTTLEFILLING AND CAPPING SYSTEM USING ARDUINO UNO

Pravin S. Wankhade[*1], Shreya D. Upadhye[*2], Prajakta R. Jadhav[*3], Akash K. Uike[*4], Deepak G. Gorlewar[*5]

[*1]Asst. Professor, Department Of Electrical Engg, JCOET, Yavatmal, Maharashtra, India.

[*2,3,4,5]Student, Department Of Electrical Engg, SGBAU, JCOET Yavatmal, Maharashtra, India.

ABSTRACT

This project proposes an automatic liquid filling system using Arduino and capping mechanism. The system is designed to fill a predetermined amount of liquid into containers and cap them with precision and accuracy. The system consists of an Arduino microcontroller, a liquid flow sensor, a solenoid valve, a peristaltic pump, and a capping mechanism. The flow sensor is used to measure the volume of liquid that is dispensed by the peristaltic pump.The solenoid valve controls the flow of liquid, and the capping mechanism is used to cap the filled containers. The system is controlled using an Arduino microcontroller that uses a simple algorithm to determine the volume of liquid that needs to be dispensed. The capping mechanism is activated after the liquid has been dispensed to cap the container. The proposed system can be used for a variety of liquid filling applications in industries such as food, pharmaceuticals, and cosmetics. The system offers high accuracy and precision in filling and capping, reducing the risk of human error and improving productivity.

I. INTRODUCTION

The automation of industrial processes has revolutionized the manufacturing industry, providing significant improvements in productivity, accuracy, and efficiency. One such process that has seen a surge in automation is liquid filling. Automatic liquid filling systems are widely used in industries such as food, pharmaceuticals, and cosmetics, to fill containers with precise amounts of liquid.

The traditional liquid filling process is manual and prone to human error, leading to inconsistent fill levels and product wastage. Furthermore, the manual process is time-consuming and labor-intensive, limiting the production capacity. Hence, there is a growing demand for automation in the liquid filling process, which can reduce errors and increase production capacity. In recent years, the use of microcontrollers such as Arduino has become popular in the automation of industrial processes. Arduino is a low-cost microcontroller that offers a flexible and versatile platform for building automation systems. The use of Arduino in automation has enabled the development of low-cost and efficient systems for various industrial applications.

In this paper, we propose an automatic liquid filling system using Arduino microcontroller. The system is designed to fill containers with a predetermined volume of liquid accurately and efficiently. The system is also capable of capping the filled containers, providing a complete automated solution for the liquid filling process.

The proposed system comprises of a liquid flow sensor, a solenoid valve, a peristaltic pump, and a capping mechanism, all controlled by an Arduino microcontroller. The system is capable of filling containers of varying sizes and shapes, making it suitable for a wide range of liquid filling applications.

II. METHODOLOGY

The methodology for developing an automated liquid filling system using Arduino Uno can be divided into several stages:

a) System Design:

The first step in developing an automated liquid filling system is to design the system's components and determine their specifications. The system components typically include a liquid flow sensor, a solenoid valve, a peristaltic pump, a capping mechanism, and an Arduino Uno microcontroller.

b) Hardware Assembly:

Once the system components are designed, the next step is to assemble the hardware. The liquid flow sensor is connected to the peristaltic pump to measure the volume of liquid dispensed, while the solenoid valve controls the flow of liquid. The capping mechanism is connected to the system and is designed to cap the filled

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containers. The hardware assembly should be performed carefully to ensure proper functionality.

c) Programming the Arduino Uno:

The Arduino Uno microcontroller is programmed to control the system components. A suitable programming language like C++ can be used to program the microcontroller. The program should be designed to read the liquid flow sensor's output and use this information to control the solenoid valve and peristaltic pump. The program should also control the capping mechanism to cap the filled containers.

d) Testing and Calibration:

Once the hardware is assembled and the Arduino Uno is programmed, the system should be tested and calibrated. The liquid flow sensor should be calibrated to ensure accurate measurement of the liquid flow rate. The solenoid valve and peristaltic pump should be tested to ensure proper control of the liquid flow. The capping mechanism should be tested to ensure accurate capping of the filled containers.

e) Integration into Production Line:

Finally, the automated liquid filling system should be integrated into the production line. The system should be designed to fill containers of varying sizes and shapes, and the capping mechanism should be designed to work with different types of caps. The system should be tested and validated to ensure proper functionality in the productionline.

The development of an automated liquid filling system using Arduino Uno involves designing the system components, assembling the hardware, programming the microcontroller, testing and calibration, and integration into the production line. The use of Arduino Uno provides a flexible and versatile platform for building automation systems, making it a suitable choice for liquid filling applications. The final system should be efficient, accurate, and reliable, improving productivity and reducing errors in the liquid filling process.

III. DESIGN ANALYSIS

The proposed automatic liquid filling system using Arduino comprises of hardware and software components. The hardware components include a liquid flow sensor, a solenoid valve, a peristaltic pump, and a capping mechanism.The software component is an algorithm implemented on the Arduino microcontroller.

a) Hardware Design:

The liquid flow sensor is used to measure the volume of liquid that is dispensed by the peristaltic pump. The sensor consists of a paddle wheel that rotates as the liquid flows through it. The rotation of the paddle wheel is detected by a Hall Effect sensor, which generates a signal proportional to the volume of liquid that has flowed throughthe sensor.

The solenoid valve controls the flow of liquid and is connected to the peristaltic pump. The valve is controlled by the Arduino micro controller and is used to turn on and off the flow of liquid as required. The peristaltic pump is used to dispense a predetermined volume of liquid into the container. The pump consists of a tube that is squeezed by rollers, forcing the liquid to flow through the tube.

The capping mechanism is used to cap the filled containers. The mechanism consists of a motor that rotates a cap on top of the container. The motor is controlled by the Arduino micro-controller and is activated after the liquid has been dispensed.

b) Software Design:

The software component of the system is implemented on the Arduino microcontroller. The algorithm is designed to control the solenoid valve, peristaltic pump, and capping mechanism. The algorithm first initializes the liquid flow sensor and the solenoid valve. The flow sensor is calibrated to measure the volume of liquid that is dispensed by the peristaltic pump accurately. The solenoid valve is then opened, and the peristaltic pump is turned on to dispense a predetermined volume of liquid into the container. Once the liquid has been dispensed, the capping mechanism is activated to cap the container. The motor rotates the cap on top of the container until it is tightly secured.

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IV. WORKING METHODOLOGY

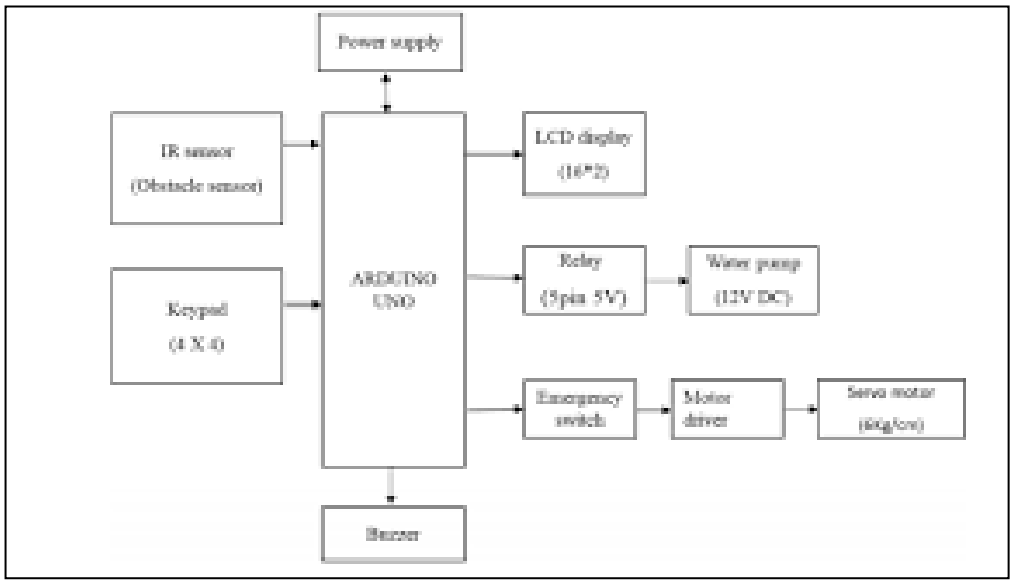

Fig 1: Block Diagram of Workings Methodology

The working mechanism of the automatic liquid filling and capping system using Arduino microcontroller is asfollows:

a) Initialization: The system is powered on and the Arduino microcontroller initializes the liquid flow sensor, solenoid valve, peristaltic pump, and capping mechanism.

b) Container Placement: The containers are placed on the filling conveyor or conveyor belt, which moves the containers to the filling station.

c) Liquid Dispensing: The liquid to be filled is placed in the reservoir, and the volume to be filled is set usingthe control panel. The peristaltic pump is activated, and the liquid flows through the tube into the container. The liquidflow sensor detects the volume of liquid dispensed, and the Arduino microcontroller controls the solenoid valve to turnoff the liquid flow once the desired volume is reached.

d) Capping: Once the liquid filling process is complete, the capping mechanism is activated, and the motor rotates the cap on top of the container until it is tightly secured.

e) Container Removal: The filled and capped containers move away from the filling station on the conveyor belt, and the process is repeated for the next container.

V. DESIGN OF THE SYSTEM

ELECTRICAL DESIGN:

The circuit and PCB design process for the automatic liquid filling and capping system using Arduino Uno involves several steps. The first step is to design the electric circuit using Easy EDA designer software. This software provides an easy-to-use interface for designing and simulating electronic circuits. The circuit design involves selectingthe appropriate components such as Arduino Uno board, liquid flow sensor, solenoid valve, peristaltic pump, and motor. Once the electric circuit design is complete, the next step is to convert the electric circuit file or schematic to a PCB file using the software. The PCB file contains the layout of the components and their connections on the board.

The placement of components is carried out where the components are arranged on a virtual board. It is essential to place the components in the right positions to ensure the smooth operation of the system. After obtaining the placement design, the process of routing is carried out. Routing involves creating paths for the connections between components on the PCB. After completing the routing, a Gerber file is generated, which is used to manufacture the PCB. The Gerber file contains all the necessary information for the PCB manufacturer to produce the PCB. Once the PCB is obtained, all the components are soldered onto the surface of the PCB. This

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process involves placing the components into the right positions, soldering them with the help of a soldering iron, and cutting off the extra terminals from the surface board.

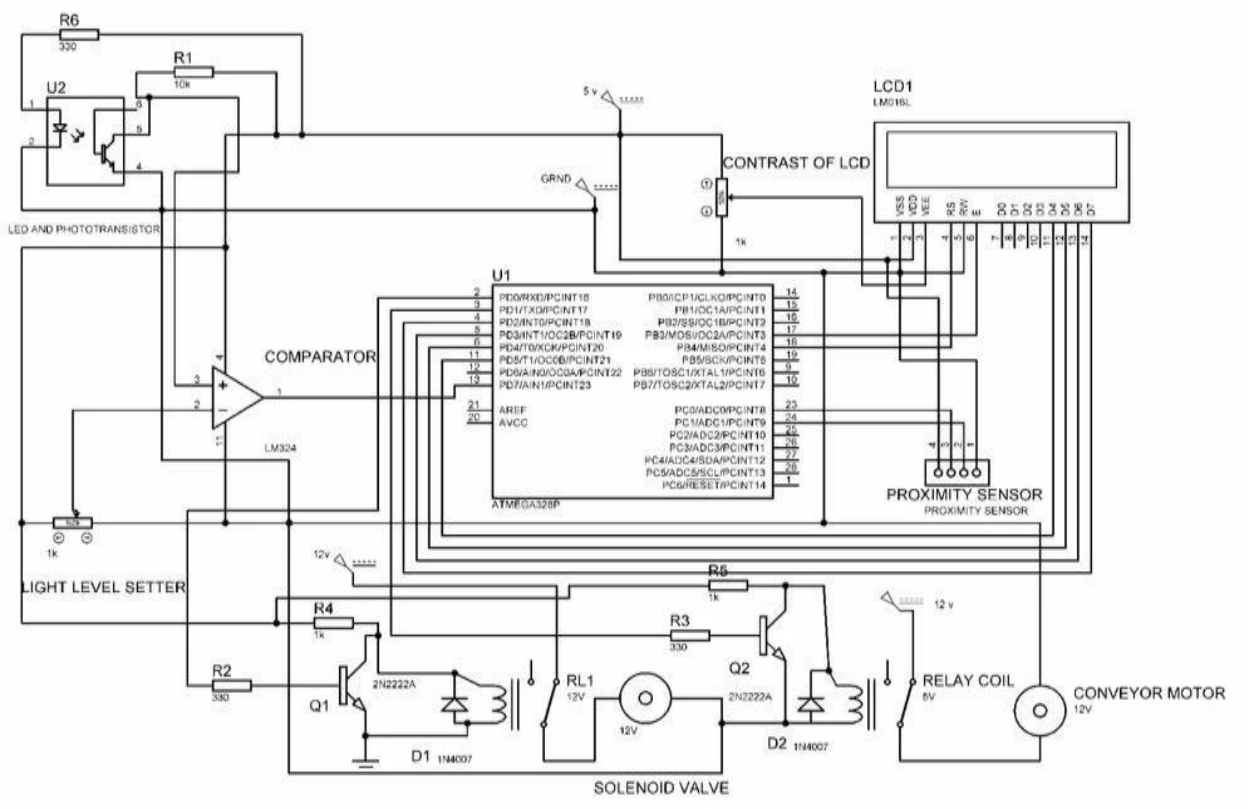

Fig 2: Circuit diagram of automated liquid filling, capping using Arduino Uno

MECHANICAL DESIGN:

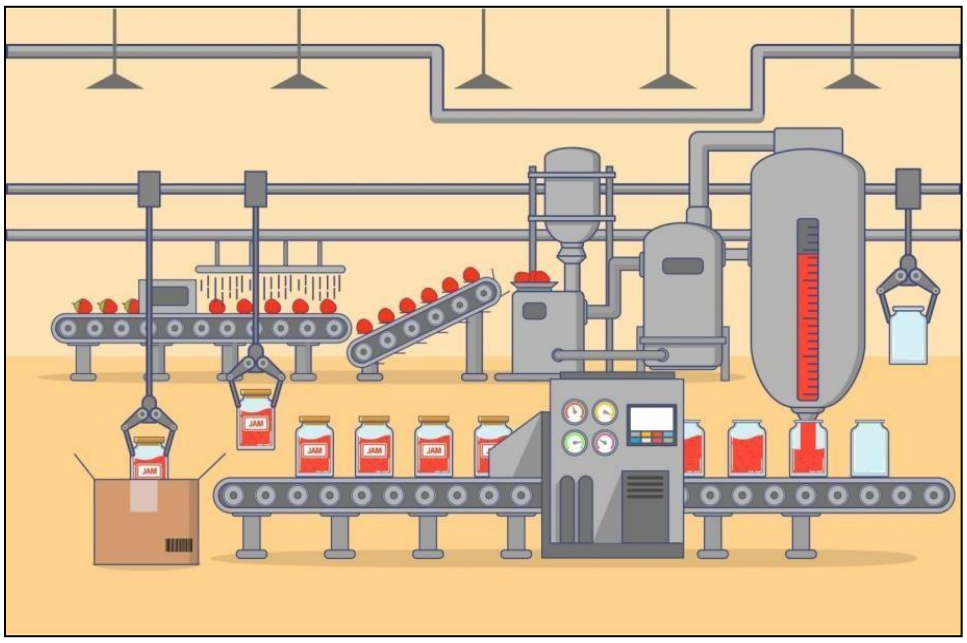

Fig 3: 3D Model for Automated liquid Filling System

The mechanical design of the automated liquid filling system using Arduino Uno involves designing a structure that supports the components and carries out the intended task of filling the liquid and capping the containers. The design is created using AutoCAD software, which is a computer-aided design (CAD) tool used for creating 2D and 3D designs. The first step in the mechanical design process is to create a 3D model of the

structure that supports the components. The model is created using AutoCAD software and includes all the necessary features, such as mounting brackets, support beams, and conveyors. The 3D model is designed to fit the available space and meet the requirements of the system.

Once the 3D model is complete, the next step is to create 2D drawings of the individual components. The 2D drawings provide detailed information about the dimensions and specifications of each component, which is used to manufacture the components.

VI. CONCLUSION

The automated liquid filling system using Arduino Uno along with capping is a modern and efficient way to fill and cap liquid containers in industries. The system offers several advantages, such as accuracy, precision, and speed, over traditional methods of filling and capping. The system utilizes Arduino Uno board as the brain of the system and various sensors such as liquid flow sensors and proximity sensors to control the flow of liquid and monitor the position of the containers. The system also includes solenoid valves and peristaltic pumps to control the flow of liquid and fill the containers. The mechanical design of the system is designed using AutoCAD software, which ensures that the components are supported and carried out the intended task of filling and capping the containers.

The system provides an efficient and reliable way of filling and capping containers in industries, saving time and resources while increasing production efficiency. Additionally, the system offers greater accuracy and precision, reducing the risk of errors and waste.

The automated liquid filling system using Arduino Uno along with capping offers a cost-effective and efficient solution for industries looking to automate their liquid filling and capping processes, improving productivity and reducing production costs.

VII. REFERENCE

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