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PNEUMATICALLY OPERATED PUSH ON CAPPING SYSTEM

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Candidate's Declaration

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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Abstract

Automation is constantly making significant impact on many industries other than manufacturing. Automation has been taking over the manual operations that have been carried out in the industries for centuries. By reducing the human effort automation completes the tasks in the minimum possible time. Bottle capping is a vital task for many industries. When this process is automated, industries require minimum human effort to complete the job in the least possible times. Push on capping system is an important part of many consumers goods manufacturing process in industries. However, the available automated machines are out of reach for many small and medium industries due to their higher capital cost. This simple machine can be designed and manufactured using low-cost readily available apparatus. In this work, a simple and economic push on capping system has been designed which can cap bottle automatically with acceptable performance. This machine will cost only one tenth the cost of the commercially available units in the market which will help small and medium enterprises to utilize their precious capital.

Keywords: Automation, Pneumatic system, Push on capping

Chapter 1 Introduction

Automatic filling and capping are the methodology, in which fluid is packed into a bottle, can or any container [1]. Filling and capping of bottles are very common in industries when the product is in liquid forms such as beverage and medicine industries. Automatic filling and capping usually related to costly PLC, which is the fundamental component of automation in industries, and this device is profoundly suited to largescale production [2]. At present all the manufacturing industries use automatic machine. To automate the process pneumatic system is reliable and cost effective. In this project we have introduced the push on capping system that operates pneumatically. Push on capping is required in fabric Brightener, Shampoo, Oil manufacture industry.

With this system that operates automatically, every process can be smooth and the process of refilling can reduce the man power cost and operation time. Automation promotes cost oriented reference architectures and development approaches that properly integrate human skill [3,4]. The proposed bottle capping system, accompanying low-cost rapid bottling, could be augmentation in automation to the existing small-scale industries such as juice shops, coffeehouses and other beverage manufacturing.

Industrial Automation is the use of Control Systems to control Industrial Machinery and Processes, reducing the need for human intervention. If compared, a job being done by human and by Automation, the physical part of the job is replaced by use of a Machine, whereas the mental capabilities of the human are replaced with the Automation.

Automation plays very important role in today's world economy. One of the most important applications of automation process is in beverages and soft drinks industries, where continuous filling and capping process is carried out. If human effort or mechanical effort is used in this field then it is very much tough to perform this long and continuous process and so it is being substituted by automation process which completes the task with very much ease.

Chapter 2 Literature Review

The small scale industries require large amount of labour to perform the operations such as manufacturing of bottles, filling with liquid and capping the bottles. To increase the production rate the low cost industrial automation process [5] is best suitable for small scale industries [6].

Pongallu and Suralkar [7] developed & tested the automatic multivariate liquid filling system & conveyor control using PLC & SCADA. The system provides a real-time implementation of SCADA with user-defined liquid filling & conveyor diversion using tank selection for filling a variety of liquid in bottles. They designed for small firms which have limited resources & spaces with a variety of products.

Kumar et al. [8] worked with automatic bottle filling, capping & embossing using PLC. They focus on the application of Low-Cost Automation (LCA), particularly in small scale industries with simple usage of devices like pneumatic, hydraulic actuators with electrical control to the existing conventional methods. This tends to make the automation at low cost to yield higher productivity.

V.K. Mehta said It is achieved through the use of variety devices, sensors, actuators, techniques and equipment that are capable of observing the manufacturing process, making decisions concerning the changes that need to be made in the operation, controlling all aspect of it. Now a day Microcontroller is using widely in the

Industries to make their process fully automated. It also gives the facilities to monitor the process and find out the problems if necessary [9].

In W Bolton's word Automation has had a notable impact in a wide range of highly visible industries beyond manufacturing. Once-ubiquitous telephone operators have been replaced largely by automated telephone switchboards and answering machines [10].

For low-priced derivative, a popular controller in automation is Arduino, which is mostly used in small-form solutions that one can build oneself at home [11]. Lakshmeesha [12] worked with automated bottle filling and capping machine using Arduino. They focused on small industries and low costs. The design has Arduino Uno instead of PLC, and a single conveyor belt which seems to be bulky from the prototype.

Weights, certainly, favour more to the PLC than Arduino and Raspberry PI devices in cases like Equipment durability. Additionally, most PLCs are the element of part families, extending scalability and breadth of native capabilities, rendering it much easier to enlarge. Further, with add-ons such as I/O modules and other accessory equipment, PLC is far softer to operate and more time-efficient than other platforms such as Arduino and Raspberry PI [13].

Medical processes such as primary screening electrocardiography or radiography and laboratory analysis of human genes, sera, cells and tissues are carried out at much greater speed and accuracy by automated systems. In general automation has been responsible for the shift in the world economy from agrarian to industrial in the 19th century and from industrial to services in the 20th century. [14]

For inputs and outputs, PLC has a definite number of connections. The advantages of using PLC are smooth operation, low cost and high filling speed. To improve filling accuracy, it is necessary to apply PLC in automatic filling system. The process is controlled by ladder logic. Filling is controlled by using various methods using motor, level sensor, proximity sensor, conveyor belt, PLC, solenoid valve. This system can be made with arduino but flexibility will be less. The arduino programming language is more complex than PLC ladder logic. The PLC ladder logic is symbol based that's why it can be changed easily. Lu, Y.-D., et al developed an automatic beverage filling machine by using PLC [15].

They used PLC to make the system flexible and to improve production rate. The ladder logic can be changed easily so they use PLC instead of arduino. Baladhandabany, D., et al. have studied on the principle of programmable logic controller and its importance on automation [16]. This process involves placing bottle on the conveyor and filling the bottle at a time. The purpose of this paper is to explain the process of filling more bottles at a time. For this purpose, stepper motor is used effectively to run the conveyor. It requires less number of sensor and it was cost effective. They have used ladder logic to control the whole system. M.H. Muhammad Sidik and S.A. CheGhani have made their paper on automatic liquid filling machine by using arduino to measure volume [17].

They studied on automatic filling machine used in food industry. This type of filling machine is available in the market which is hypocritical and expensive to clean up the cylinder piston that requires pneumatic system. They used ultrasonic sensor instead of cylinder piston to make it easy

and simple. They used arduino to control the whole system. They also used two solenoid valve to control the flow of liquid. Qijun Gong et al. developed an automatic liquid filling system by using image technology [18].

Simulink is used to make a simulation model which was used to control the filling system. This computer based technology reduced the accidents and labor costs. Kunal Chakraborty et. al. developed an automatic bottle plant [19]. This paper describes the fundamental stage of filling and capping method. The objective of this paper is to maintain the filling and capping operation at a time. To perform filling operation, bottles are placed on the conveyor. After completing the filling operation, they used a new set of empty bottles under the solenoid valve. They used PLC to control the system. Kulkarni, S.L. et. al. developed a PLC microcontroller for bottle filling system [20]. They studied on beverage as well as medicine in food industry and health care industry. As the demand of beverage and medicine are increasing day by day, filling is required to fill up this requirement. In health care industry, manual filling operation is dangerous. Manual filling in beverage industry is economical loss. It consumes more time than automatic filling system. To remove these disadvantages, they built up automatic bottle filling machine by using PLC. Kiran, A.R et. al. investigated the principle of PLC and its importance in automation [21].

In these age of computers, automation in process of sensing, monitoring of changes and storing the changes per millisecond which is involved in experiment with high accuracy. Moreover, the tasks which are to be repeated many times with same sensitivity and accuracy can be successfully completed using automated instruments. Industrial automation helps to meet the demands such as more productivity, better accuracy, better quality and optimum

utilization of available resources and manpower. Industrial automation improves the rate of production through superior control of production. Therefore, a given labor input it produces a large number of results. [22]

However, many of the small industries, for instance restaurants, are still doing their jobs manually. An affordable bottle filling and capping scheme, made of Arduino and locally found materials, could raise their production levels and increase qualities with hygiene. Therefore, by this research, an economical automatic bottling and capping system tends to serve those small industries to some extent. [23]

Chapter 3 Methodology

Introduction

In this complete automated system that is used to apply the capping system in term of hardware and development. The hardware development and implementation. We have designed a pneumatic push on capping system where the successive capping period is variable and The capping length can be adjusted. The manual capping process has many shortcomings. This automated capping system works on to eradicate the flaws of manual capping.

Capping System

A Capping Machine is used to securely apply plastic or metal threaded caps, lids, snap caps, plugs and other similar closures to bottles or containers at low and extremely high speeds. It's an electro-pneumatic system which performs the capping operation. It consists of pneumatic cylinder, Directional control valve (solenoid valve),Relay, push pad

Pneumatic Cylinder

Pneumatic cylinders are mechanical devices which use the power of compressed gas to produce a force in a reciprocating linear motion.

Like hydraulic cylinders, something forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force it develops to the object to be moved.[1] :85 Engineers sometimes prefer to use pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage.

Because the operating fluid is a gas, leakage from a pneumatic cylinder will not drip out and contaminate the surroundings, making pneumatics more desirable where cleanliness is a requirement.

In our project we used a compact type pneumatic cylinder. Push pad is bolted with the cylinder's actuating rod.

Fig: 3.1: Pneumatic Cylinder

Compressor

An air compressor is a specific type of gas compressor. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible; while some can be compressed, the main action of a pump is to pressurize and transport liquids.

An air compressor is used in this process. An air compressor is a pneumatic device that converts power into potential energy stored in pressurized air by one of several methods, an air compressor forces more and more air into a storage tank, increasing the pressure. When the tank's pressure reaches its engineered upper limit, the air compressor shuts off. The compressed air, then, is held in the tank until called into use. The energy contained in the compressed air can be used for a variety of applications, utilizing the kinetic energy of the air as it is released and the tank depressurizes. When tank pressure reaches its lower limit, the air compressor turns on again and re-pressurizes the tank. An air Compressor must be differentiated from a pump because it works for any gas/air, while pumps work on a liquid. We used an air compressor to give air supply to pneumatic capping system.Air is supplied through a FRL unit and pneumatic distributor to the directional control valves which moves the pneumatic cylinder.

Fig: 3.2: Compressor

Selector Switch

A selector switch can control on or off of different currents circuit by rotating the handle. Common used for control consisting of a mechanical or electrical or electronic device for making or breaking or changing the connections in a circuit.

In this project we used a 2 position (ON & OFF) selector switch. The purpose of using the selector switch to skip the gathering of too many devices and making a easy maintenance and low cost machine

Fig: 3.3: Selector Switch

Relay

A relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. The switch may have any number of contacts in multiple contact forms, such as make contacts, break contacts, or combinations thereof.

Relays are used where it is necessary to control a circuit by an independent low-power signal, or where several circuits must be controlled by one signal. Relays were first used in

long-distance telegraph circuits as signal repeaters: they refresh the signal coming in from one circuit by transmitting it on another circuit. Relays were used extensively in telephone exchanges and early computers to perform logical operations.

It is used to hold the power constantly. Normally open (NO) of the relay is used to turn on the timer. Instead of relay we could use magnetic contactor. But to develop a machine for small size entrepreneur we used low cost but reliable and hassle free devices.

Fig: 3.4: Relay

Timer

A timer is a specialized type of clock used for measuring specific time intervals. Timers can be categorized into two main types. A timer which counts upwards from zero for measuring elapsed time is often called a stopwatch, while a device which counts down from a specified time interval is more usually called a timer. Timer is used to set the pushing time interval as per requirement. Normally open (NO) of the Timer base is used to turn on the solenoid valve. Because of using timer it is easy to determine the hourly capping production.

Fig: 3.5: Timer

Solenoid valve

A solenoid valve is an electromechanically-operated valve. Solenoid valves differ in the characteristics of the electric current they use, the strength of the magnetic field they generate, the mechanism they use to regulate the fluid, and the type and characteristics of fluid they control. The mechanism varies from linear action, plunger-type actuators to pivoted-armature actuators and rocker actuators. The valve can use a two-port design to regulate a flow or use a three or more port design to switch flows between ports. Multiple solenoid valves can be placed together on a manifold. Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. They are found in many application areas. Solenoids offer fast and safe switching, high-reliability, long service life, good medium compatibility of the materials used, low control power and compact design. Here 2 position 5 way valve is used. Spool of the directional control valve actuates left and right to push down and lift the push pad

Fig:3.6: Solenoid Valve

FRL Unit

An FRL unit is comprised of a filter (F), regulator (R), and a lubricator (L). They are often used as one unit to ensure clean air in a pneumatic system but can also be used individually. Filters remove water, dirt and other harmful debris from an air system. The air supplied by compressors is often times contaminated, over pressurized, and non-lubricated meaning that an FRL unit is required to prevent damage to equipment. Filters, regulators, and lubricators can be bought individually or as a package (as seen in Figure 1) depending on what is needed to ensure the proper air specifications are being met for downstream equipment. It is recommended to install these devices if you:

- Use pneumatic tools and equipment;
- Are installing an HVAC system;
- Require clean air to be delivered to your facility or workplace;
- Require compliance to ISO, OSHA, ASHRA or other air quality standards;
- Want to improve the service life, safety and reliability of your air system.

Fig: 3.7: FRL Unit

Pneumatic Pipe

The basic function of pneumatic pipe is to convey pressurized air to actuators, valves, tools and other devices. In broad terms, hose is more rugged than tubing but costs more. The air supply and application set a baseline for the necessary product performance. It is used as the air distributor from the compressor to the pneumatic cylinder through solenoid valve actuation.

Fig: 3.8: Pneumatic Pipe

Power Supply

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as electric power converters. Some power supplies are separate standalone pieces of equipment, while others are built into the load appliances that they power. Examples of the latter include power supplies found in desktop computers and consumer electronics devices. Other functions that power supplies may perform include limiting the current drawn by the load to safe levels, shutting off the current in the event of an electrical fault, power conditioning to prevent electronic noise or voltage surges on the input from reaching the load, power-factor correction, and storing energy so it can continue to power the load in the event of a temporary interruption in the source power (uninterruptible power supply). In this case the power supply unit consist of 220 VAC.

Items Required

To make this machine we needed many instruments such as pneumatic cylinder, relay, timer, solenoid valve, power supply, pneumatic pipe, FRL unit, compressor, push pad , selector switch . All the items and their price are listed in the table below.

Serial No	Item Name	Quantity	Price in BDT
1	Pneumatic Cylinder	1	650
2	Relay	1	150
3	Timer	1	450
4	Solenoid Valve	1	350
5	Power supply	1	
6	Compressor	1	
7	FRL Unit	1	
8	Pneumatic Pipe	1	300
9	Push pad	1	
10	Selector Switch	1	100
11	Machine structure	1	1000

Table 3.1: Items required

Process Description

In this process at first we have to fill the bottle with desired liquid using liquid filling machine. It shouldn't be overflowing, otherwise some amount of liquid might spill out of it. It should be filled properly in the exact amount. Then we have to hold the bottle steadily and place it carefully in the desired location under the pneumatic cylinder push pad. Before that we have make it sure that the height of the bottle isn't too much so that it doesn't fit below the push pad. After that we have to turn the machine on. We will also have to set the time interval of pushing. It varies from bottle to bottle. But there should be enough time so that we can replace one bottle with another one in between. According to your set time the push pad will push down and lift. Once it pushes down and the capping is done on one bottle, the cap becomes firmly fixed. We have to move it from that location and carefully place the next one there. We have to continuously repeat the process until we switch off the machine. Only one operator required constantly to run the machine properly. But if it was done manually, then we might need several people at the same time working together and still the

rate being very slow. Here in a controlled atmosphere and regular interval we can do the capping of a huge amount of bottle perfectly. Below is a flow chart of the whole process.

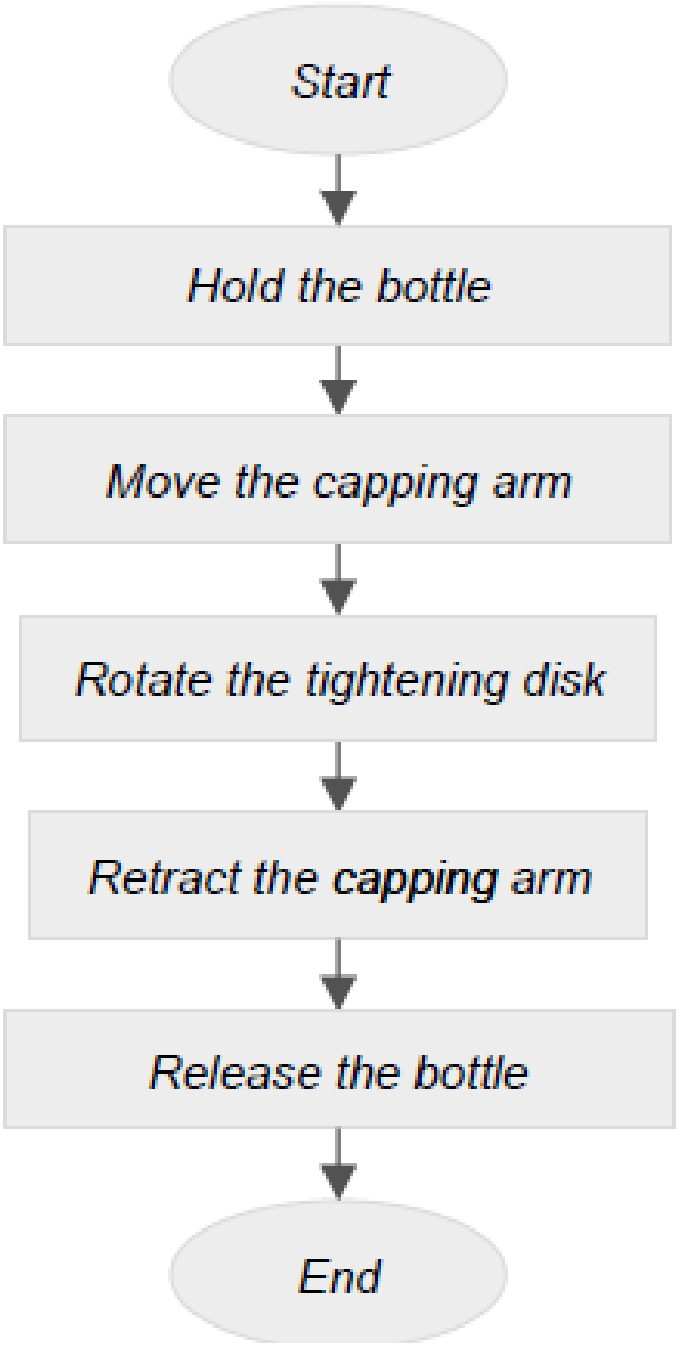

Fig:3.9: Process flow chart

Cost Comparison

In market the available machine cost will be around twenty five(25000 BDT) to thirty thousand(30000 BDT) taka whereas for constructing this machine we only needed three thousand (3000 BDT) taka. There is a huge gap in case of the total cost of the machine. This difference in investment inspires the small and medium size entrepreneurs to initiate a project and continue.

- Market Price : 30,000 BDT
- Project Cost : 3000 BDT

  Difference in initial cost = (30,000-3000) BDT

  = 27,000 BDT

Connection Diagram

Power comes to the selector switch first. When selector switch is closed electricity passes tothe relay coil. Output of relay is drawn from the NO and connected to the coil of timer through NC of the timer. Power given to the coil of solenoid valve from the No of timer (output side).As timer get reset after the set time so push pad goes down and lifts successively. We can see the whole connetion diagram in the figure below.

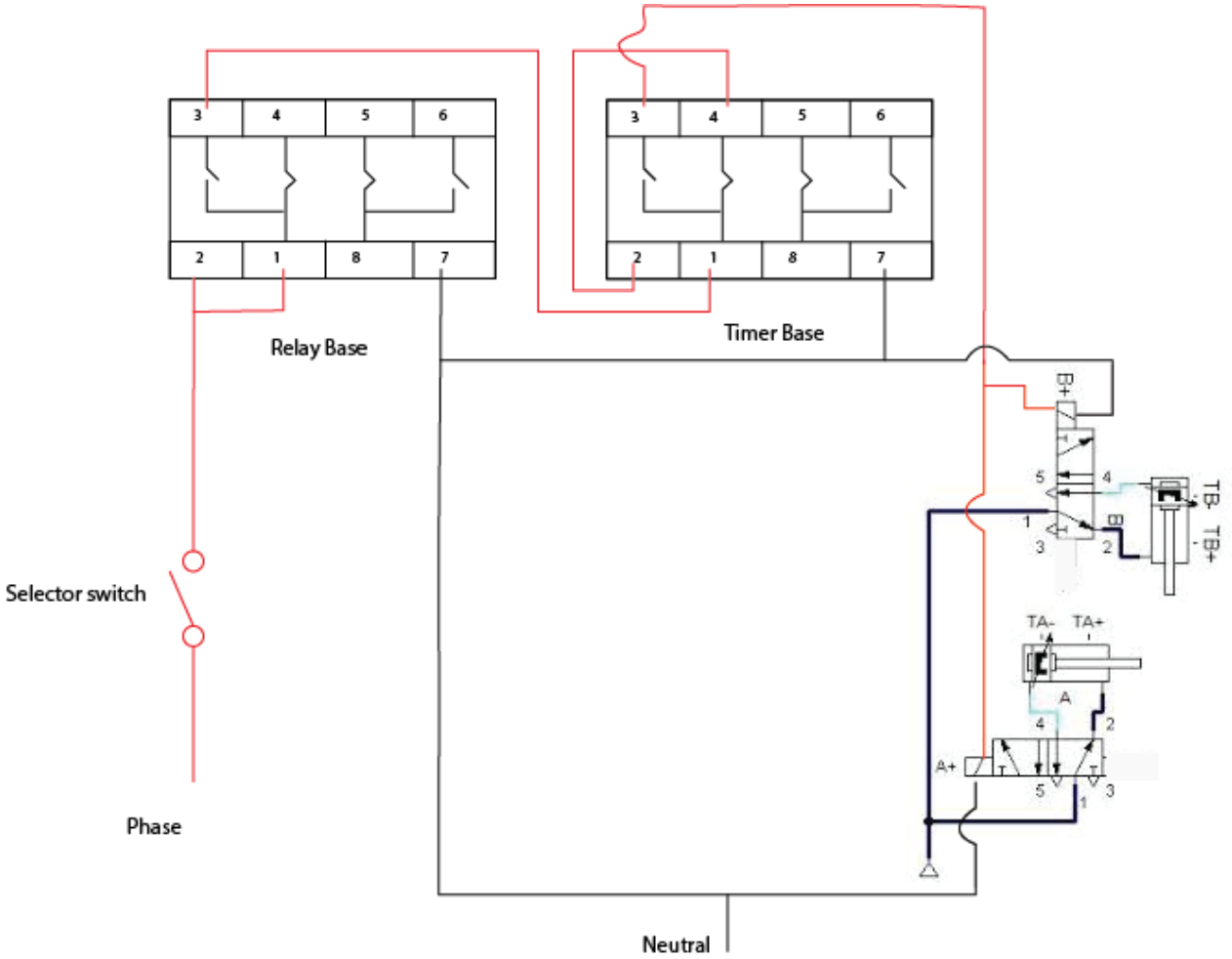

Fig:3.10: Connection Diagram

Chapter 4 Results & Discussions

In this project, an automatic bottle filling machine is designed and constructed. It has some advantages over traditional filling process. It can cap upto 120 bottles per hour. This filling machine is cost effective. It saves human effort and time. In this research, an economical automatic capping system is designed and fabricated. The main goal, which has been achieved, was to develop a low-cost bottle filling and capping system which uses 100% locally available materials. The economical design, along with portability, smaller volume, and reducing human effort, tends to increase the automation in small beverage and other fluid bottling or canning industries. All the components are performing well. It can fill 200 ml bottle in 3 second. It is a time based control system and it can fill 67 ml per second. The design could be upgraded to specific uses and requirements. Friction, vibration, mechanical alignment, current ratings were the main problems to run the project properly. IC, transistor, voltage regulator had to be changed for several times.

Chapter 5 Conclusion

Automation increases productivity and economy of a country. Our project can be implemented in industry where Push on capping is required. I have gained sufficient knowledge about pneumatics, electric devices through this project. It can be used in small scale bottle filling systems such as coffee shops, juice shops and other beverage industries. Future works might consider quality inspection, sealing, and packaging in an integrated system.

Future Work

This system is flexible in nature and there is huge scope for further development. We have plan to add PLC to make the process more smooth. Rack and pinion gear can be used for adjusting height for different bottles. Specially, in beverage industries this type of prototype is suitable. But for industrial purpose we need high production rate. A large production rate can be obtained by modifying the prototype. Although this prototype worked for mineral water filling but there are some substances which cannot be filled by gravity pressure such as toothpaste, honey, edible oil etc. We need moderate pressure for those types of filling. We can use a pump and a nozzle instead of solenoid valve for those types of filling.

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