

## Simulation for Automation of Manufacturing, Filling And Capping The Bottles

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**ABSTRACT:** The industries require large amount of labour to increase the production rate. The low cost industrial automation process is best suitable for small scale industries to increase the production rate of bottle manufacturing, filling with liquid and capping the bottles. In the present work the electric circuits for the above process have been designed and simulated. The sequence of operations are such as automatic clamping, unclamping, injecting the molten material, filling and capping process of the bottles, which is achieved through the use of simple devices like limit switches, relays, electrical controls, pneumatic actuators and sensors. The sequence of operation is tested and simulated by using Fluidsim Pneumatic simulation software.

**Keywords:** Fluidsim Pneumatic simulation software, pneumatic actuators, relays, sensors.

### I. INTRODUCTION

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 [1] is best suitable for small scale industries [2]. This is achieved through electric circuits, relays, pneumatic actuators, limit switches, sensors, solenoid valves and Electropneumatics which are controlled by electrical impulses [3]. The sequence of operations are such as automatic clamping, unclamping, injecting the molten material, filling [4] and capping process of the bottles [5] which is tested and simulated by using Fluidsim Pneumatic simulation software. The Fluidsim Pneumatic Simulation software supports learning, educating, and visualizing pneumatic knowledge. The Pneumatic components which are explained with textual descriptions, figures, animations and its working principles. The user will quickly learn to draw and simulate electro-pneumatic circuit diagram.

### II. FLUIDSIM PNEUMATIC SIMULATION SOFTWARE

Fluidsim Pneumatics is a teaching tool for simulating pneumatics basics and runs using Microsoft Windows. It can be used in the combination with the Festo Didactic training hardware or independently. Fluidsim was developed as a joint venture between the University of Paderborn, Festo Didactic Company and Art Systems software in Paderborn. A major feature of Fluidsim is its close connection with CAD functionality and simulation. Fluidsim allows DIN-compliant drawing of electro pneumatic circuit diagrams and can perform realistic simulations. Simply stated, this eliminates the gap between drawing of a circuit diagram and the simulation of the related pneumatic system. The CAD functionality of Fluidsim has been specially tailored for fluidics.

#### 2.1. Fluidsim Toolbar Menu

Start Fluidsim via the Start Menu under Program Files/FestoDidactic After a few seconds the main window from Fluidsim should appear on the screen as shown in below Fig 1.

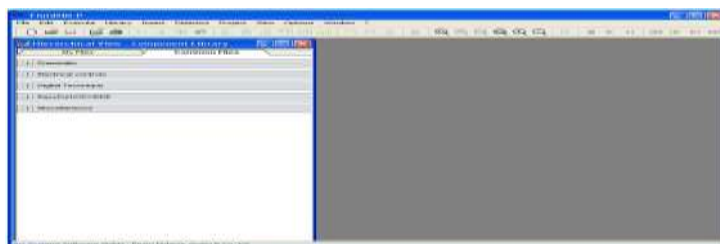
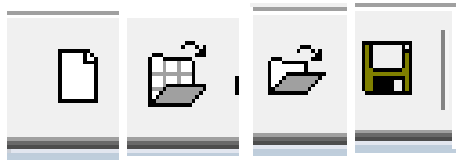


Fig 1: Fluidsim window.

The left-hand side shows the component library of Fluidsim in its hierarchical view, it contains pneumatic, electrical and digital components for the designing new circuit diagrams. Using the menu bar at the top of the window, you may access all functions provided for designing and simulating circuit diagrams. The toolbar below allows convenient access to frequently used menu functions. The toolbar contains the following nine group of functions.

### 2.1.1 Creating New Circuit



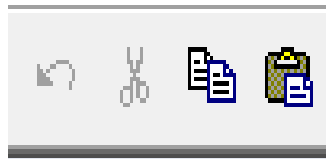
Creating new circuit diagrams, previewing a circuit diagram, opening and saving circuit diagrams

### 2.1.2 Print



Printing the contents of the window, for example circuit diagrams and component photos.

### 2.1.3 Editing Circuit



Editing circuit diagrams they are undo, cut, copy and paste respectively.

### 2.1.4 Alignment of Components



Alignment of components.in align left, align horizontally centered, align right, align top, align vertically centered, align bottom respectively.

### 2.1.5 Rotate and Mirror



The first icon is used for Rotate and next two icons are used to mirror. Horizontally and vertically respectively.

### 2.1.6 Grid



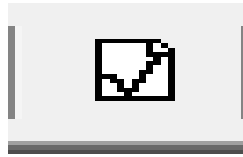
By this option the grid lines appear on the screen.

### 2.1.7 Zoom



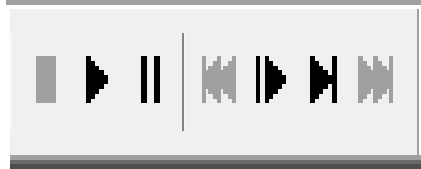
Zooming in and zooming out of circuit diagrams, component pictures, and other windows the icons shown are used for standard size, previous view, fit to window, zoom by rubber band, zoom in and zoom out respectively.

### 2.1.8 Superficial Circuit Checking



It Superficial checks whether the there are any openings of the. Ports in the pneumatic circuit and detection of short circuit in the electrical circuit.

### 2.1.9 Simulation



Simulation of circuit diagrams is done by this option. The icons shown represent the buttons of stop, start, pause, reset, single step, simulate until state change and next topic respectively.

## 2.2 Creating Circuits

Create an empty drawing area by clicking on new icon or under File menu click New to open a new window. The following window appears as in Fig 2.

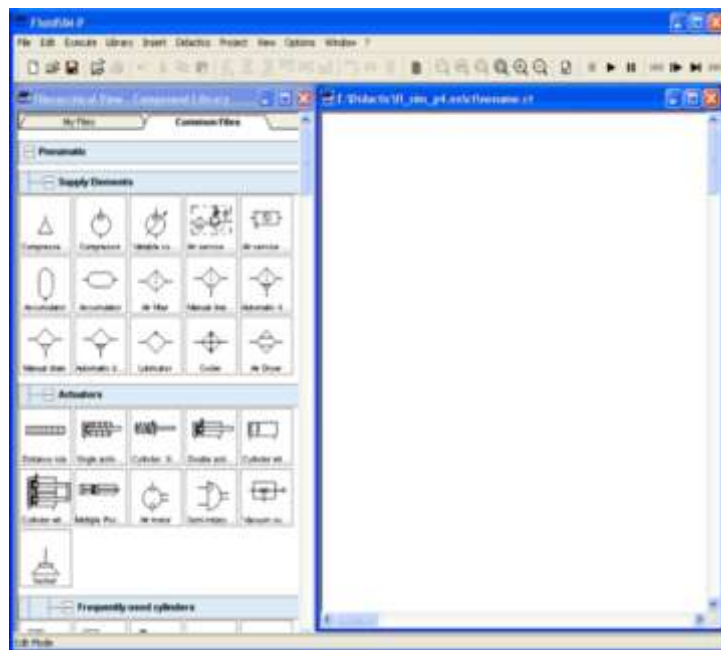


Fig 2: New file window

While in basic mode, you will see the available component groups in the hierarchical view of the component library. To list the components of a group, you may list off the group by clicking it. For a better overview you may also hide non-required elements and subgroups by once more clicking and hence closing the hierarchy. Component groups may often contain further subgroups that may also be listed off or closed.

To list off a group including all of its subgroups, you may hold the Shift-Key while clicking. This will reduce your efforts to list off each subgroup. You may similarly use the Shift-Key to close all subgroups of a superordinate group.

Press the Shift-Key, hold it and click "Pneumatic" The entire group of pneumatic components will be listed off. Using the scrollbars, you may browse through the component library to the left and right or up and down as shown in Fig 3.



Fig 3: Components library

Using the mouse and “drag-and-drop” you may drag components from the component library to the drawing area. Move the mouse cursor to a component in the library, more specifically to the cylinder. Press the left mouse button. While continuing to hold down the button, move the cursor. The cylinder is then highlighted (selected) and the mouse cursor changes to a four way directional cross the components outline moves with the mouse cursor. Move the cursor to the drawing area and release the button on the mouse. This action places the cylinder in the drawing area as shown in Fig 4.



Fig 4: Dragging selected components.

In this way it is possible to “drag” each component from the component library and place it in the desired position in the drawing area. In the same way it is possible to rearrange components already in the drawing area. Arrange all the cylinders and components required for the circuit and connect the ports from air supply to the cylinders, and remaining components like direction control valves, flow control valves etc. Double click the valve to assign an operation mode to it. A dialog box appears as shown in Fig 5.

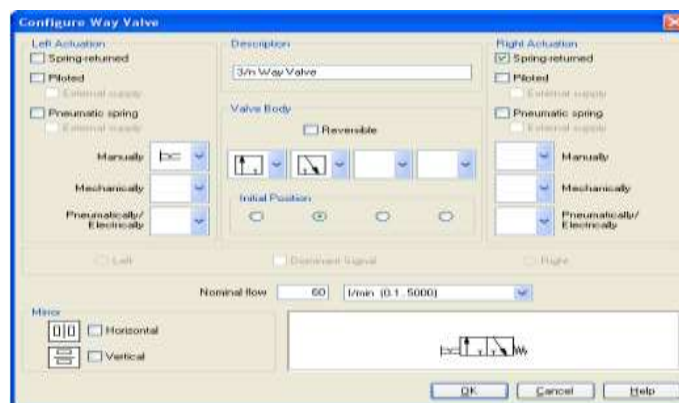


Fig 5: Configure a way valve.

## 2.3 Description of the Dialog Box for Configure Way Valve

### 2.3.1 Left/Right Actuation

For both sides the actuation modes of the valve can be defined individually; it can be one or more of the categories “Manually”, “Mechanically”, or “Pneumatically or Electrically”. An operation mode is set by clicking on the down-arrow at the right-hand side of the list and selecting a symbol. If for a category no operation mode is desired, simply choose the blank symbol from the list. Moreover, for each side of the valve the attributes “Spring-returned” and “Piloted” can be set.

### 2.3.2 Description

Enter here a name for the valve. This name is used in the state diagram and in the parts list state diagram and in the parts list.

### 2.3.3 Valve Body

A configurable valve has at most four positions. For each of the positions a valve body element can be chosen individually. Such an element is set by clicking on the down arrow at the right-hand side of the list and selecting a symbol. If for a position no element is desired, simply choose the blank symbol from the list. The valve may be marked “Reversible” to indicate that there is no particular direction of flow.

### 2.3.4 Initial Position

This button defines the valve’s initial position (normal position or neutral position), which is the position without having any operation applied to the valve. Note that this setting is only exploited if it physically does not contradict a spring returned setting.

### 2.3.5 Standard Nominal Flow Rate

This is where you define the standard nominal flow rate of the valve.

## 2.4 Configurable Symbols

Fluidsim is capable of simulating a vast number of different cylinders and valves. The combination of all part designs and functional types would lead to displaying many thousands of symbols. Therefore there are some common part designs in the component library, configurable and representative components. In order to adapt a cylinder or a way valve, drag one of these representatives in the circuit and open the status dialog. Here the settings helps in defining layout and function of the component.

## 2.5 Configure Cylinders

Double-click the cylinder to define part design, parameter and external influence of a cylinder. The status dialog of the cylinder will open. The dialog consists of several registers, providing a convenient overview despite the vast number of settings.

### 2.5.1 Register “Configuration”

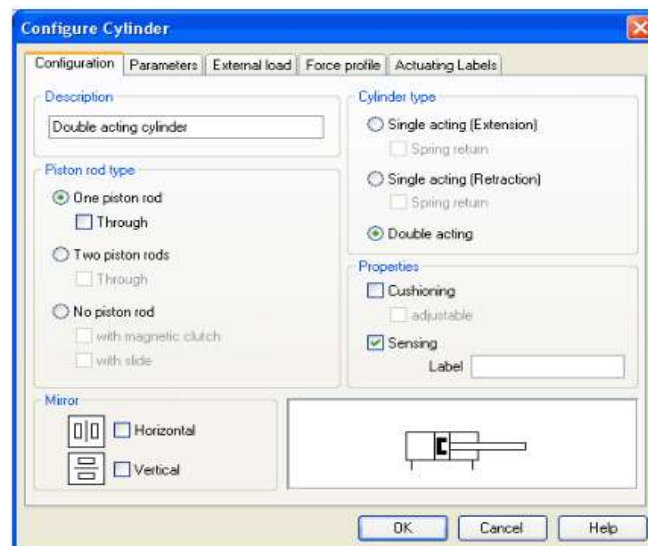


Fig 6: Configure cylinder

**2.5.2 Description of the Configure Cylinder Dialog Box**

**2.5.2.1 Component Description**

The user can enter a description for the cylinder into the text field, it will show in the state diagram and in the parts list.

**2.5.2.2 Cylinder type**

Cylinder type (single-acting, double-acting, spring return)

**2.5.2.3 Piston rod type**

Piston rod type (quantity, part design, magnet coupling, slide unit)

**2.5.2.4 Properties**

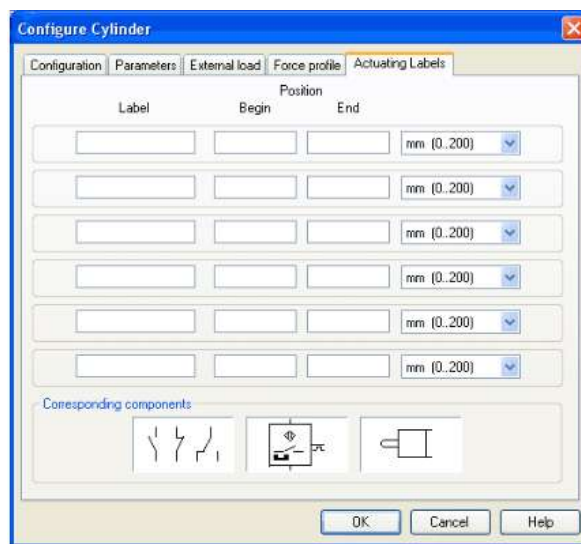
More properties of the cylinder (end position cushioning, sensing). The label you may define at “sensing” serves as an interconnection with the displacement encoder.

**2.5.2.5 Mirror**

This is where you may define whether the cylinder will be mirrored horizontally or vertically.

**2.5.2.6 Register “Actuating Labels”**

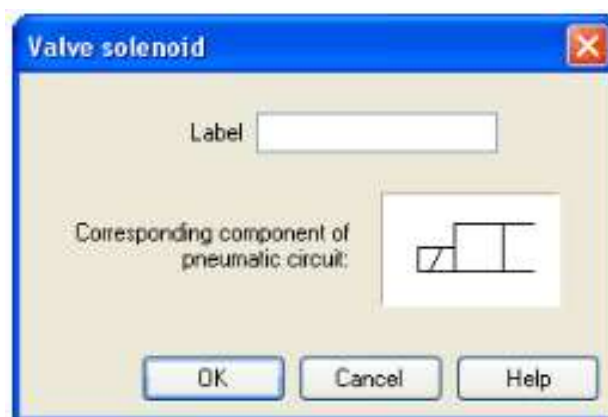
In this dialog box define new actuating labels or change existing ones as shown in below Fig 7.



**Fig 7:** Actuating labels for cylinders

In the same way Fluidsim allows to create pneumatic circuit diagrams, the software also allows to design electrical circuits. The components for the electrical circuits can be found in the component library and dragged from there to be inserted on the drawing area. Electrical components are connected in the same way thus the fluidic components done.

**2.6 CONFIGURE SOLENOID VALVES** Each solenoid valve should be labelled without labelling the simulation does not take place. The following dialog box appears as in Fig 8.



**Fig 8:** Configure Valve solenoid

### 2.6.1 Description of Configure Valve Solenoid Dialog Box

#### 2.6.1.2 Label

This text field gives the label its name. A label can be up to 32 characters in length consisting of letters, numbers, and symbols. Enter a name for this label, for example "Y1". Double click on the outside of the valve solenoid to open the dialog box for the label name input the same label name as for the solenoid, for example "Y1". The solenoid is now linked to the valve.

## III. SIMULATION FOR AUTOMATION OF MANUFACTURING, FILLING AND CAPPING THE BOTTLES

For automation of bottle manufacturing filling and capping process the sequence consists of Clamping the die block, moving the ram of injection moulding machine downwards, wait for a while and unclamp the die block, clamp the bottle, move the filler into the bottle, open the nozzle valve, after filling, close the nozzle, unclamp the bottle, clamp the bottle, move the capping motor downwards, after capping, move the capping motor upwards and unclamp the bottle. Thus consists of mainly three sections bottle manufacturing, filling and capping of the bottles.

That's the required sequence for overall process is A+B+B-A-C+D+V+V-D-C-E+F+F-E-

The interlocks occurs between B+ and B-, similarly in V+ and V-, F+ and F- to remove these interlocks relays are used. The total sequence is divided in to three operations. They are mentioned below.

- Automation for manufacturing of the bottles by Injection Moulding machine.
- Automation of filling the bottles.
- Automation of capping the bottles.

### 3.1 Sequence for Automation of Bottle Manufacturing Process

For automation of the bottle manufacturing process the sequence consists clamping of the die block, move the ram downwards and inject the molten material in to die block, move the ram upwards, wait for a while and unclamp the die the bottle is ejected on to the conveyor.

For automation of this process the sequence is A+B+B-A-.

#### 3.1.1 Design of Electric Circuit for Automation of Bottle Manufacturing Process

- Connect the start button and solenoid valves A+, B+ to the NC of the relay K.
- Connect the solenoid valves B-, to the NO of relay K.
- Connect TB- NO with timer T as shown in circuit.
- Connect the timer switch to the solenoid valve A-.
- Connect the TB+ to relay K.
- Hold the relay K with K and TA- NC.
- The circuit is designed as per the shown fig below.

#### 3.1.2 Simulation of Electric Circuit for Automation of Bottle Manufacturing Process

The design of electropneumatic circuit is drawn in the Fluidsim software the pneumatic circuit is drawn from the components under the pneumatic library and the electric circuit is drawn from the components under the electrical controls library. After completing the circuit. Then press the simulation button and press the start button in the circuit and the simulation starts as shown in Fig 9.

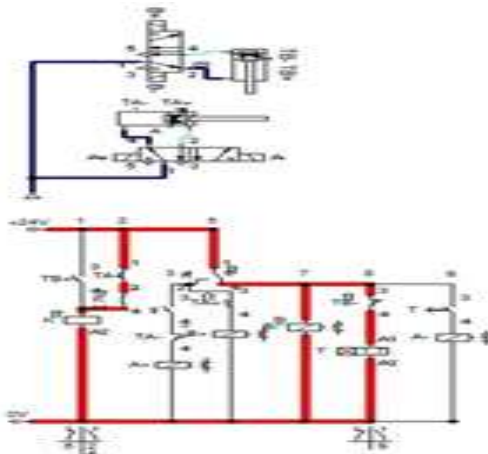


Fig 9: Simulation of electric circuit for automation of bottle manufacturing process.

### 3.2 Sequence for Automation of Filling the Bottles with Liquid

For automation of the filling process the sequence consists of clamp the bottle, inject the filler in to the bottle, open the valve, fill the bottle up to required quantity, close the nozzle valve, eject the filler from the bottle, and unclamp the bottle

The sequence for this process is C+D+V+V-D-C-

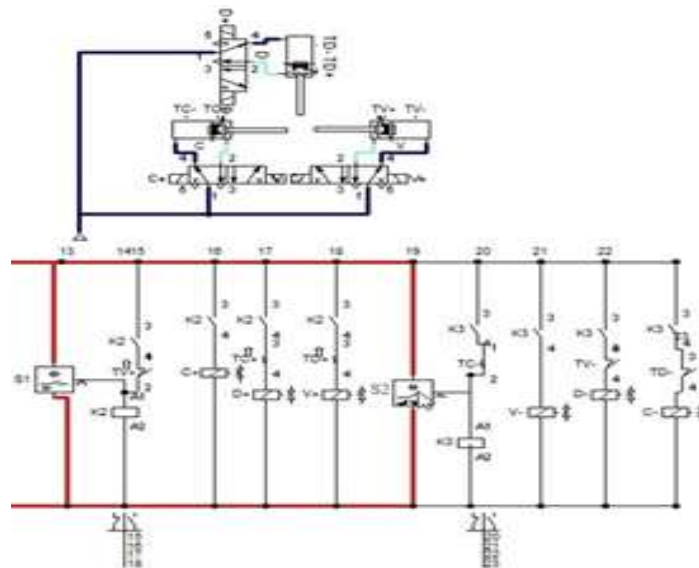
Cylinders C, D, V are used for clamping of the bottle, movement of the filler, and nozzle valve open or close respectively.

#### 3.2.1 Design of Electric Circuit for Automation Process of Filling the Bottles

- a) The sensors have three terminals one is connected to +ve, -ve and the other is output.
- b) The output of sensor 1 is connected to the relay K2 and the output of the sensor s2 is connected to relay K3.
- c) The relay K2 is hold with K2 NO (Normally Open) and TV+ NC (Normally Close).
- d) The relay K3 is hold with K3 NO and TC- NC
- e) The solenoid C+ is connected to K2
- f) TC+ NO and the solenoid D+ are connected to K2
- g) TD+ NO and solenoid V+ are connected to K2.
- h) The solenoid V- is connected to K3.
- i) TV- NO and the solenoid D- are connected to K3.
- j) TD- and the solenoid C- are connected to K3.

#### 3.2.2 Simulation of Electric Circuit for Automation Process of Filling the Bottles.

The design of electropneumatic circuit for filling process is drawn in Fluidsim software and start the simulation by pressing the simulation button and the simulation starts when the sensors are activated as shown in Fig 10.



**Fig 10:** Simulation of electric circuit for automation process of filling the bottles

### 3.3 Sequence for Automation of Capping the Bottles

For automation of capping process the designed sequence is clamp the bottle, movement of the capping motor, unclamp the bottle. For automation of this process the designed sequence is E+F+F-E- Two double acting pneumatic cylinders E and F are used for clamp the bottle and to the capping motor respectively.

#### 3.3.1 Design of Electric Circuit for Automation Process of Capping the Bottles

- a) The +ve and -ve terminals of the sensor3 and sensor 4 are connected to power supply and ground.
- b) The output terminals of the sensor 3 is connected to relay K4 and the output of the sensor 4 isconnected to relay k5.
- c) The relay K4 is hold with k4 and TF+ NC.
- d) The relay K5 is hold with K5snd TE- NC.
- e) The solenoid E+ is connected to K4.



- f) TE+ and solenoid F+ is connected to K4
- g) The solenoid F- is connected to F
- h) The solenoid E- and TF- are connected to K5

### 3.3.2 Simulation of Electric Circuit for Automation Process of Capping the Bottles.

The design of electropneumatic circuit for capping process is drawn in Fluidsim software and start the simulation by pressing the simulation button and the simulation starts when the sensors are activated as shown in Fig 11.

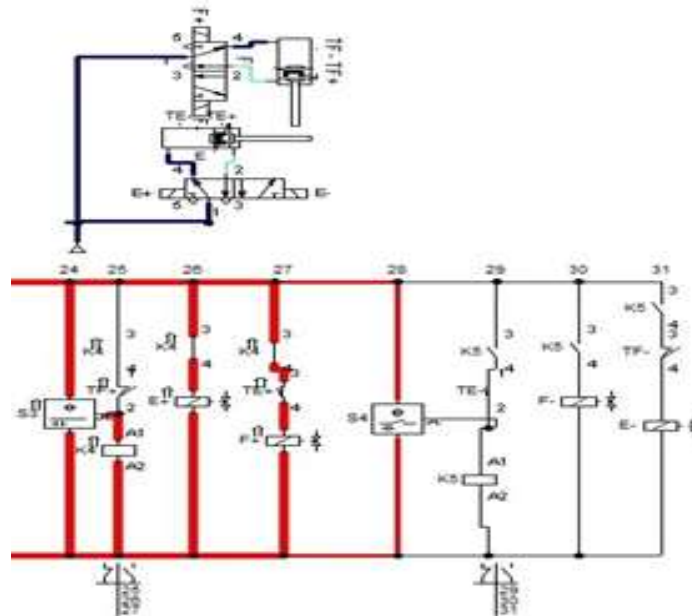


Fig 11: simulation of electric circuit for automation process of capping the bottles

## IV. CONCLUSION

The electric circuits are designed and the sequences of operations are tested by using Fluidsim Pneumatic simulation software. The sequence of operations are such as automatic clamping, de-clamping, injecting the molten material, filling and capping process of the bottles are essential in industries to increase its production rate. This is achieved through the use of simple devices like limit switches, relays, sensors, pneumatic actuators and electrical controls. The automation process has preciseness and accuracy in their operations, which is controlled through its controllers. The automation process helps in reducing the time taken for the process to be completed and helps at low cost to yield higher productivity. The bottles with defect are to be eliminated from the conveyor by using Machine Vision.

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