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Design and Fabrication of Automatic Water Bottle Filling Machine

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ABSTRACT: The automation sector play an increasingly important rolein the world economy in wide range of industry beyond industrial automation. Control system and infomartion technology are often used minimize human effort in the development of products and service automation. The process manual filling as many flaws such as spilling of water while filling not filling equal amount of water time delay due to human error. This problem is faced by micro scale industry compels this system to be designed. The key part of the control system is that a microcontroller is programmed to control different components within arduino system. Micro controller is very simple to programme and user friendly, cost effective, space efficient and reduce complexity. The study of bottle filling system act as an interdisciplinary practice in engineering design. This covers, computer, electronics and mechanical engineering elements. This study mainly includes design,fabrication and control system for automatic bottle filling system.

KEYWORDS: Automation, Manual filling, Micro controller, Conveyor system, Micro and small scale industries.

I. INTRODUTION

The present industry scenario includes the application of emerging technology to simplify. Automation can increase the production efficiency and availability to satisfy consumer requirements. In bottle filling plants the same view is practiced to satisfy consumer expectance and pace the filling bottle virtually automatic in all operations. The automatic bottle filling requires the installation of a cylinder, pneumatic system and PLC to operate which is expensive. While all this is available in the market local businesses often use a manual process to fill the bottle. The cost of the system is the limitation that they cannot use this convenient technology. Electricity was used in filling plants in recent development and the power was made based on relays. These relays only allow powers to be switched ON and OFF without mechanical switch. Relays are widely used to render simple logical control decisions. The introduction of a microcontroller was the most frequent choice for production management. Microcontroller has achieved prominence on the floor of the factory and would undoubtedly dominate over time. The control system is an important part of contemporary society. The intended output or response of data is generated by a control system. The reason for installing the control system is because of the power enhancement, remote control, convenience of input-form, and noise compensation nowadays, the system has a wide range in use for guidance, navigation, control missile and flying aircraft. The research focuses on cost reduction using an Arduino microcontroller. Container filling operation is carried out manually in small factories [micro industry], these are drawback pouring of water when filling it in a container, equivalent water cannot be filled, delay due to normal human activity. This an automatic operating system can make the operation seamless and the refilling cycle will reduce the expenses of manpower and time.

II. PROBLEM DIFENITION

In recent years automation has influenced wide variety of sections beyond manufacturing by reducing process time increasing system output and process control. Although all these are in market local firm prefer use the manual methods to filling bottles. The use of manual filling methods results in poor efficiency production and losses through spillage. The research outlines design and development of an automated low cost bottle filling system.

III. DESIGN CALCULATIONS

i. Velocity

$$V = \frac{\pi DN}{60}$$

$$= \frac{\pi \times 0.04 \times 30}{60}$$

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= 0.062 m/s

ii. Length of conveyor belt (1)

$$L = 2C + \pi\left(\frac{D+d}{2}\right) + \left(\frac{D-d}{4C}\right)^2$$

$$= (2 \times 900) + \pi\left(\frac{40+40}{2}\right) + \left(\frac{40-40}{4 \times 900}\right)^2$$

= 1925.69 mm
= 1.925 m

iii. Length of conveyor belt (2)

$$L = 2C + \pi\left(\frac{D+d}{2}\right) + \left(\frac{D-d}{4C}\right)^2$$

$$= (2 \times 300) + \pi\left(\frac{40+40}{2}\right) + \left(\frac{40-40}{4 \times 300}\right)^2$$

= 725.68mm
= 0.725 m

iv. Belt pulley of conveyor (1)

$$T_e = \frac{[F_r + (W_2 + 2W_B + R_2C_2 + R_2 + C_2 + R_iC_i) + (W_2)h]}{F_2}$$

$$= \frac{\{0.0751 \times 1.925[0.4 + (2 \times 0.5) + (0.1 \times 2) + 0 + 0 + 0 + (0.4 \times 0)]\}}{0.85}$$

= 3.76 N/m

v. Torque of conveyor (1)

Torque at drive roller to move belt
T = T_e×drive roller diameter
= 3037 × 0.04
= 0.150 N-m

vi. Belt pully of conveyor (2)

$$T_e = \frac{[F_r + (W_2 + 2W_B + R_2C_2 + R_2 + C_2 + R_iC_i) + (W_2)h]}{F_2}$$

$$= \frac{\{0.075 \times 0.725[0.4 + (2 \times 0.5) + (0.1 \times 2) + 0 + 0 + 0 + (0.4 \times 0)]\}}{0.85}$$

= 0.102 N/m

vii. Torque of conveyor (2)

T = T_e×drive roller diameter
= 0.102 × 0.04
= 0.0040 N-m

viii. Rack and Pinion

Motor : 10 RPM
Pinion : 14 teeth (30mm)
Rack : 44 teeth
1 rotation of pinion = 70mm
Circumference of pinion : r = 15mm

= 2πr

= 2π × 15

= 94.26 mm

Assumption

Total weight load (m) = 0.5 kg
speed (v) = 10 RPM
= r × RPM×0.10472
= 0.015 × 10 × 0.10472
= 0.0157 m/s

- Gravity = 9.8 m/s^2
- Pitch circle pinion d= 2mm
- Friction co-efficient = 0.1
- Safety factor = 1.5

ix. Max speed of pinion (N_v) $= \frac{(V \times 19100)}{D}$

$= \frac{0.0157 \times 19100}{30}$

= 9.99
≈ 10 RPM

x. Torque (T_N)$= \frac{Fn \times d}{2000}$

$= \frac{0.1 \times 30}{2000}$

= 0.0015 N-mm

xi. Design torque (T_{NV}) $= T_N \times S_B$

= 0.0015 × 1.5
= 0.00225 N-mm

xii. Tangential force (F_N) = M × g×(μ + M)
= 0.5 × 9.8 × (0.1 × 0.5)
= 0.245 N

xiii. Flow Rate

Velocity of water at inlet of pipe V = $\sqrt{2gh}$
and
Q = AV
where
A = cross section of inlet of valve
V = velocity of water
H = Height of tank

$V = \sqrt{2gh}$
$= \sqrt{2 \times 9.81 \times 0.42}$
= 2.87 m/s

Q = AV
$= \frac{\pi}{4} \times 5 \times 10^{-3} \times 2.87$
= 0.01127 m^3/s

Flow rate is in m^3/s and for proposed project bottle is of 500ml

Net time required to fill bottle $= \frac{0.5}{0.01127}$

= 44.36 sec

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IV. CAD DESIGN OF AUTOMATIC BOTTLE FILLING MACHINE

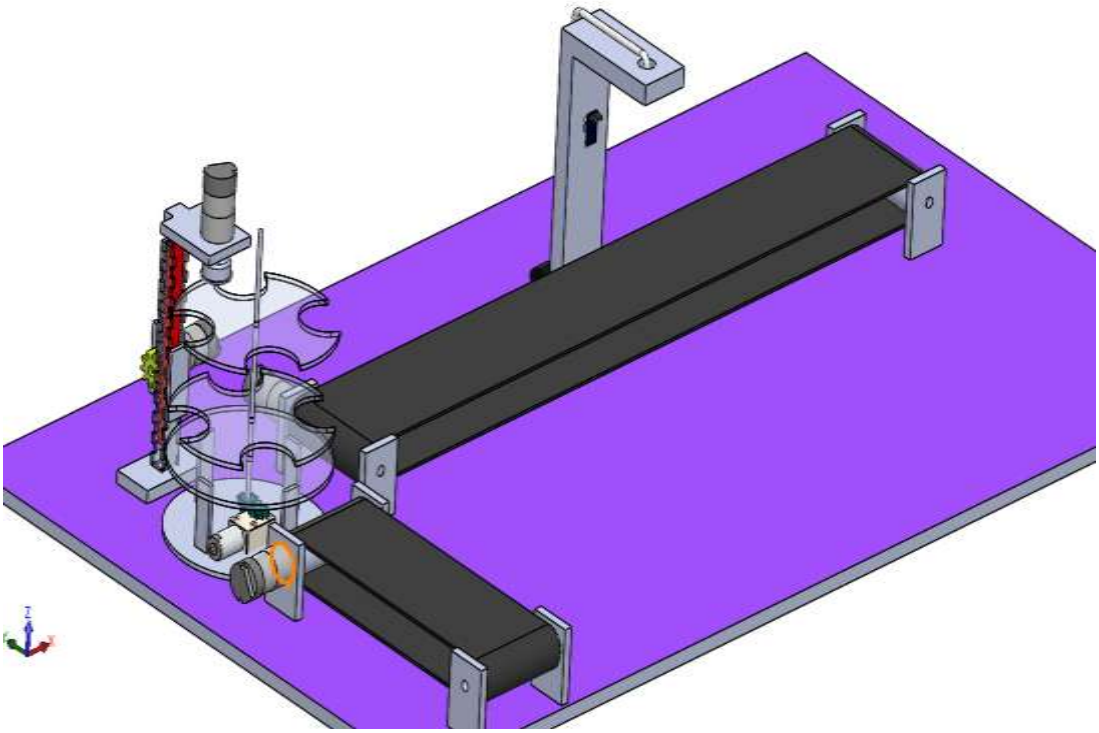
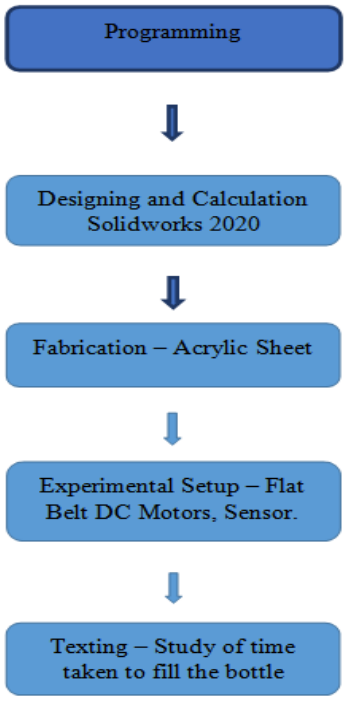


Fig 1: 3D model of Automatic bottle filling machine

V. METHODOLOGY

A conveyor belt is placed between the two rollers, over roller which drives it and another roller which pulls the belt has belt travels. On the table frame the conveyor belt and roller are mounted. In order to detect the container, the IR sensor is mounted on the dark screen in certain location. The bottle are placed on the conveyor belt, using support of a tank or sink is mounted the control the rotary pump is done by arduino. Which delivers frame which are driven by 12V DC supply and 30 RPM. The electric circuitry, panel and keyboard are installed along with battery on top of table frame.

First switch is made ON the motor and conveyor belt start moving. The used DC gear type motor is a DC motor the shaft of which coupled directly to the roller. At the same time the bottle is put on conveyor belt the sensor detects the bottle and conveyor stops working while bottle approaches IR sensor. As the conveyor stops the water starts filling the bottle. After given period over the water flowing stops and conveyor belt starts moving. Then the bottle is moved towards the disc, IR sensor senses the bottle cap holder is lowered and capping bottle is completed. The cap holder moves upward and disc rotates the bottle with help of limit switch bottle is placed on another belt.



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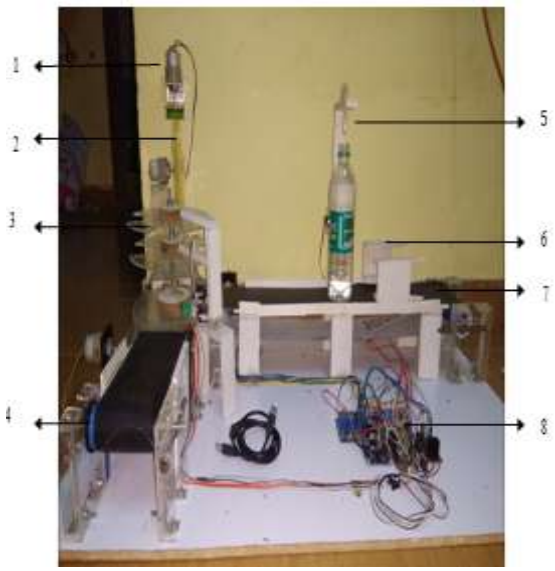

Fig 2: Experimental Setup

TABLE I LIST OF COMPONENTS

1	DC Motor
2	Rack
3	Bottle rotator
4	Roller
5	Dispensing of water
6	Guide ways
7	Conveyor belt
8	Control panel

ALGORITHM

STEP 1 : Start
STEP 2: Conveyor belt starts moving
STEP 3: Bottle passes through aligner
STEP 4: If bottle is detected by the sensor 1, go to step 5, else repeat step 4.
STEP 5: Conveyor 1 stops and water pump starts.
STEP 6: After the bottle is filled with water, conveyor 1 starts.
STEP 7: If the bottle is detected by sensor 2, go to setp 8, else repeat step 7.
STEP 8: Conveyor stops, rotator 90 ° rotates anticlockwise.
STEP 9: If bottle detected by sensor 3, go to step 10, else go to step8.
STEP 10: Caping system turn ON. Capping done.
STEP 11: After capping, rotator rotates 90° clockwise.
STEP 12: If bottle is detected by sensor 4, go to step 3,else repeat step 12.
STEP 13: Rotator stops. Bottle pusher pushes the bottle at conveyor 2.
STEP 14: Conveyor 2 takes the bottle to box.
STEP 15: Stop.

VI. RESULTS AND DISCUSSION

As mentioned all the system of the desired project was implemented and the results of the system are illustrated. As the empty bottle sent into filling area the IR sensor confirmed the perfect position of the bottle for filling. To fill require amount of liquid in bottle it took 80.04sec. After filling the bottle sent for next operation.

Motor speed = 30 RPM

Conveyor (1) = 0.9m
Conveyor (2) = 0.3m
Roller radius = 0.02m

1. Linear velocity (V) = r × RPM×0.10472
   = 0.02 × 30 × 0.10472
   = 0.063 m/s
2. Time taken to pass conveyor (1)

$T_1 = \frac{0.9}{0.063} = 14.28$ sec

3. Time taken to fill bottle

$T_2 = 55$ sec

4. Time taken to capping

$T_3 = 6$ sec

5. Time taken to pass conveyor (2)

$T_4 = \frac{0.3}{0.063} = 4.76$ sec

Total time taken $= T_1 + T_2 + T_3 + T_4$
= 14.28 + 55+ 6 + 4.76
= 80.04 sec

Advantages And Disadvantages

Advantages

- Higher production speed
- Reliability and consistency
- Simple controls
- Upgradable machinery

Disadvantages

- Unemployment
- Only suitable for small-scale industries
- Not robust as demanded by the large scale industries

VII. CONCLUSION

The modern era of automation demand for accuracy is increasing day by day. Another big problem for any micro and small industrialist is how to introduce automation in industries. A successful implementation and study of automation bottle filling system using arduino was done . The

system capable of performing the table of autonomous quality control system used in industrial manufacturing and is ideally suited to the micro and small industry. From the study the time required to fill the liquid is 55 seconds. The automatic bottle filling machine helped to minimize labour, time and filling cots. Our study is combination of electronics and mechanical work. It gives knowledge and makes us mindful of all factors to be taken into consideration when planning automation based product

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VIII. FUTURE SCOPE

Improvisation cannot be constrained, new approaches will illustrate the developments in how application and interdisciplinary integration with technology will increase the efficiency of the product. More features such as RFID reduces and tags can be introduced and the frame work can be built to setup sensor synchronize system that can moniter multiple dispensers. Based on types, shapes and weight of the container additional functionality such as user defined volume specification can be applied to device.

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