

# Design and Development of a Cost-Effective Bottle Washing Machine for Various Small-scale Industries.

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*Abstract— One of the key challenges faced by different industries, including those involved in tissue culture, beverages, medicine, and food, is the effective cleaning of storage or processing containers. These containers, such as bottles, are widely utilized across these sectors for storing a diverse range of products, from food items to seeds, tissues, medicines, and beverages. Ensuring thorough cleaning of these containers before storing any product is crucial. In the tissue culture sector, maintaining clean and contamination-free glass bottles for storing media is essential. Since these bottles are reused multiple times, a meticulous cleaning process is necessary to uphold hygienic standards. To tackle this challenge, we developed a specialized machine to streamline the bottle washing process. This machine significantly reduces the time and effort needed for cleaning. It can accommodate two workers simultaneously, thereby increasing the washing rate and reducing labor compared to manual methods. Equipped with four brushes, each machine can clean four bottles at once. These brushes operate at high RPM, swiftly spinning to thoroughly clean the bottles, removing dirt, stains, and any residues efficiently, resulting in a pristine surface. What makes this machine particularly practical is its simplicity. It operates without complex sensors or programs, making it accessible to ordinary personnel without specialized training. Additionally, it requires minimal maintenance and is easy to install. Its portability is also advantageous, especially for industries located at remote regions. Overall, the machine enhances operational efficiency across various industries, reducing the workload on workers, and improving the quality of cleaning processes.*

*Index Terms- Tissue culture, Cleaning, Storage containers, bottles, jars, Machine, Efficiency.*

## I. INTRODUCTION

The inspiration for the design of bottle washing/cleaning apparatus originates from the field of tissue culture. In tissue culture, plant tissues are nurtured to grow into saplings and then mature plants,

which are supplied to consumers, especially farmers. This process entails carefully preparing a growth medium that includes all the necessary nutrients for the robust growth of saplings. These tissues are cultivated in glass bottles under controlled environmental conditions to promote germ-free growth without any contamination.

During this complex procedure, the cleanliness and hygiene of these jars/bottles is an important factor which significantly influences the characteristics and standards of the final outcome (Sapling, consumables, products, etc.). Swapping out bottles after each use at a large scale incurs significant financial strain, leading to a considerable rise in production costs. Therefore, there is a requirement to efficiently clean and reuse these containers to uphold affordability.

Enter the bottle washing machine—a solution to this challenge. It offers a cost-effective way to clean bottles thoroughly, ensuring they're primed for reuse. Therefore, by assisting cleaning procedure, it eliminates drawbacks of manual washing procedure, such as hygiene concerns, time consumption, and labor costs. This machine is not only economical but also user-friendly, requiring minimal maintenance and offering maximum reliability. Its capacity to wash multiple bottles simultaneously boosts efficiency while maintaining cleaning quality. Its simplicity of operation makes it accessible to unskilled personnel, further reducing operational hurdles.

With its rapid cleaning action and low power consumption, this machine is suitable for various industries beyond tissue culture, including food, beverage, medicinal, agriculture, and chemical sectors. It's a versatile solution catering to the bottle washing needs across diverse applications.

## II. OBJECTIVE

- Developing a cost-effective, low-maintenance machine with minimal capital investment and a small footprint.
- Designing a machine that reduces washing time while enhancing cleaning quality.
- Creating a machine that allows two operators to work simultaneously and independently.
- Engineering a machine with low power consumption.
- Designing a user-friendly machine that is simple to operate and install.
- Solving industrial challenges by providing precise and efficient solutions.

## III. COMPONENTS

### 1. Main Base Frame- Specifications:

- Material- Mild Steel
- Total mass of frame- 20 kilograms
- Pipe section- 30.0 x 30.0mm
- Finishing - Powder coating
- Joining method- Bolting, Welding.

### 2. Motor Mount-

It is positioned at the center on top of frame and secured using bolts. Mount encompasses complete drive system, and serves as core component. This system includes motor (mounted at top), two shaft parallelly mounted, pulley for each shaft, and belt running over all three pulleys. The mount is designed for easy disassembly, allowing for convenient servicing and transportation without needing to dismantle the entire machine. Constructed from 50 \* 50 \* 5 Mild Steel angle, it ensures correct alignment and accessibility of all drive components.

### 3. Motor-

The decision to select an AC 3-phase motor is based on several advantages it offers over a single-phase motor. Primarily, in industrial settings where 3-phase power is readily available, it proves to be more practical. Additionally, considering the project's requirements, a foot-mounted motor was deemed suitable. Opting for a 0.5 horsepower motor strikes a balance between cost-effectiveness and meeting the

necessary torque and speed specifications for efficiently washing glass bottles, ensuring thorough cleaning without risking breakage.

### Specifications:

- Current- 3-phase induction AC motor, drawing
- 1.40 Amperes
- Horsepower/Kilowatt- 0.5/0.37
- Frequency- 50Hz with a tolerance of +3%
- Motor Type- Totally Enclosed Fan Cooled (TEFC)
- Type of Mount- Foot type
- Operating Voltage- 415 volts (AC)
- Speed- 1440rpm
- Efficiency- 70.10%
- Connection type- Star
- Class of insulation- F
- Output (Fixed)- 370 Watts

### 4. Shaft-

Shaft employed is made of cost-effective mild steel with a diameter of Ø28mm. Its length, set at 740mm, is carefully chosen to suit the table length, motor capacity, and bearing requirements while also minimizing costs. The shaft undergoes various processes such as plain turning, threading, facing, step turning, chamfering, and slotting to ensure its suitability for the application. With sufficient strength, it is turned (step) to 25mm diameter at ends, to accommodate Ø25 bearings securely. Threading on both ends facilitates the attachment of chucks, while slots for keys and chamfers ensure a smooth, burr-free finish.

### 5. Bearings-

Bearings play a crucial role in supporting the shaft at equal distances from each end, with a total of four bearings utilized.

### Specifications-

- Type of Bearing - Pillow block insert
- Model- UC 205
- I.D- 25mm (bore)
- Mass- Approximately 0.20 kg

Shaft assembly-



three pulleys have identical diameters.

Specifications-

- - Diameter- 3 inches (~76 mm)
- - Type of Pulley- 3Inch 1(A)
- - I.D (for shaft)- 28 mm
- - I.D(for shaft of motor)- 16 mm

Keys-

Keys serve to transmit power from the pulley to the shaft while preventing any relative motion between mating components. In this machine, square keys measuring 50 x 6 x 6 are employed. The motor shaft's key, which was utilized, came as part of the motor package itself.

Final assembled machine-



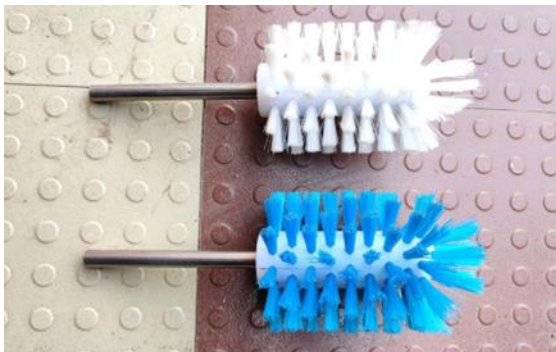
6. Accessories

- Chuck (hand tight able)-

Chuck fastened with help of the threads provided on ends of shafts, serves to securely clamp all brushes. It also facilitates easy replacement of brush whenever needed. Employing a keyless plastic chuck, featuring a 1/2" thread size and capacity of 2~12mm, guarantees practicality and reliability during operation.

- Brush-

The brushes are securely fastened within all four chucks, which are responsible for scrubbing the bottles. This component is pivotal as it carries out the primary cleaning action during the washing process.



7. Pulleys & keys

Pulleys-

To maintain uniform rotation speed with the motor, all

IV. COST DETAILS

Material cost:

Particulars	Material	Weight (kg)	Rate/Kg (Rs)	Amount (Rs)
M.S pipe	M.S	20	75	1500
Angle	M.S	6.7	70	470
Shaft	M.S	7.2	85	612
Base plate	M.S	3.5	70	245
Motor plate	M.S	2.6	70	182
Sheet	S. S	3.5	180	630
Total				₹ 3639

Machining cost:

Operation	Process time	Rate /Hr (Rs)	Amount (Rs)

	(Hr)		
Cutting	2	100	200
Welding	4	250	1,000
Drilling	1	150	150
Grinding	1	150	150
Powder coating	4	200	800
Plain turning	8	250	2,000
Step turning			
Threading			
Facing			
Total			₹ 4,300

Cost of standard parts:

Particulars	Description	Rate/unit	Quantity	Amount (Rs)
Motor	0.5Hp/0.371 W	3500	1	3,500
Nut & bolt	M10/M6	10/6	20/10	260
Pulleys	3”1A	150	3	450
Bearings	UCP205	250	4	1000
Basin	S.S. (18”)	900	2	1800
V-Belt	A823Lp/A31	200	1	200
Tap	Swan neck	150	2	300
Grub screw	M10 x 16	10	3	30
Brushes	Special bottle washing brush	700	4	2800
Chuck	1/2”	250	4	1000
Wire	1.5mm 3Core	80	3m	240
Total				₹ 11,580

TOTAL COST– 3,639 + 4,300 + 11,580 = ₹ 19,519

V. WORKING

To initiate the machine's motor, ensure that the 3-phase power supply is connected, then activate the MCB switch located at one end of the machine. This switch facilitates easy on/off control of the machine and serves as a safety measure to prevent electrical hazards and motor damage. Once the switch is turned on, the belt drive will begin to rotate, transferring power from the motor to the pulleys. Consequently, the two shafts will start rotating. Since all three pulleys share the same diameter, the shafts will rotate at the same speed as the motor.

As a result, the chucks secured to the end of the shaft and thus every brush and chuck, likewise rotates.

Power flow-



Cleansing Procedure-

Insert the jar/bottle onto the brush end. This creates a rotary cleansing action inside bottle, ensuring thorough cleaning of the glass bottle. The high-speed rotation provides strong and continuous brushing action, effectively removing any dirt or debris from inside the bottle. Following this, the operator rinses the bottle with water to flush out any remaining particles.

The machine has a capacity to wash four bottles simultaneously, additionally, the brushes can be customized and easily replaced as needed, thanks to the provided chuck, allowing for adaptations to different bottle sizes and shapes.

ADVANTAGES-

- Simple and compact design.
- Provides effective cleaning.
- Easily customizable to suit specific needs.
- Allows two operators to work simultaneously.
- Requirement of skilled labor is not necessary.
- Belt-driven system eliminates the requirement of lubrication, reducing cost of maintenance.
- Convenient brush replacement facilitated by the hand-tighten able chuck.
- 0.5 horsepower (3 PH) motor which fulfills the requirement for industrial application.
- Minimal consumption of power.
- User-friendly and easy to operate.
- Minimal noise from the drive system.
- Simple assembly and disassembly process.

DISADVANTAGES-

- Possibility of vibrations if shafts are misaligned.
- Moisture may reduce the lifespan of bearings.
- Heavy in weight.

VI. RESULTS

Based on our research, the average cost of an industrial bottle washing machine falls between 95,000 and 245,500 INR. We have managed to design and manufacture a machine with similar functionality and performance at a much lower price point of around 19,519 INR.

Parameter	Manual Washing	Bottle Washing Machine
Washing Time	45 seconds	20 seconds
Washing Rate	80 Bottles/Hr.	180 Bottles/Hr.

An observed 225% increase in washing rate is anticipated to significantly increase the productivity and streamline associated processes, thereby reducing total process time and labor costs.

VII. FUTURE ENHANCEMENTS

- Introducing a single-phase motor for applications in domestic settings and areas without access to 3-phase power.
- Implementing various sensor-based safety mechanisms to enhance operator safety.
- Adding an automated soap dispenser to facilitate the addition of soap during the washing of the bottles.
- Incorporating a speed controller for the motor to enable speed adjustment according to specific applications.

CONCLUSION

The bottle washing machine offers an ideal solution for small-scale industries requiring bottle washing capabilities, presenting a more affordable alternative to larger industrial machines. Its compact design, ease of assembly and disassembly, and straightforward maintenance make it convenient for transportation and installation. Significantly reducing the time needed for

the cleaning process is a major advantage, contributing to increased productivity in the industry. Previously, manual washing was the norm for small to medium-scale industries. However, by adopting this bottle washing machine, substantial time and labor cost savings can be realized. The adoption of this technology promises significant profitability for businesses

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