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Sonargaon University (SU)

সোনারগাঁও ইউনিভার্সিটি (এসইউ)

Design and Fabrication of a Bottle Cleaning Machine.

A Thesis
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January, 2025

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In partial fulfillment of the requirement for award of the degree
Of
Bachelor of Science in Mechanical Engineering

January, 2025

LETTER OF TRANSMITTAL

January, 2025

To

Nuruzzaman Rakib

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Department of Mechanical Engineering.

Sonargaon University

Subject: Submission of Project Report.

Dear Sir,

We are pleased to submit the project report on " **Design and Fabrication of a Bottle Cleaning Machine”**. It was a great pleasure to work on such an important topic. This project has been done as per instruction of your supervision and according to the requirements of the Sonargaon University.

We expect that the project will be accepted by the concerned authority we will remain happy to further explanation that you may feel necessary in this regard.

Thank You

Sincerely yours,

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DECLARATION

We do hereby solemnly declare that, the work presented here in this project report has been carried out by us and has not been previously submitted to any University/ Organization for award of any degree or certificate

We hereby ensure that the works that has been prevented here does not breach any existing copyright.

We further undertake to indemnify the university against any loss or damage arising from breach of the foregoing obligation.

ACKNOWLEDGEMENT

First, we started in the name of almighty Allah. This thesis is accomplished under the supervision of Nuruzzaman Rakib, Assistant professor, Department of Mechanical, Sonargaon University. It is a great pleasure to acknowledge our profound gratitude and respect to our supervisor for this consistent guidance, encouragement, helpful suggestion, constructive criticism and endless patience through the progress of this work. The successful completion of this thesis would not have been possible without his persistent motivation and continuous guidance.

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ABSTRACT

This thesis presents the design, development, and implementation of a water bottle cleaning machine aimed at improving the efficiency and hygiene of the bottle cleaning process. The primary objective is to design a system capable of cleaning water bottles using various mechanical and electrical components, thereby reducing human intervention and ensuring consistent cleaning quality. The machine integrates multiple cleaning stages, including pre-washing, soap application, scrubbing, rinsing, and drying, to deliver thoroughly clean and sanitized bottles. This report outlines the system design, components used, operation sequence, and testing procedures.

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CHAPTER- 1
Introduction

1.1 Background

The demand for clean, safe, and hygienic water bottles has surged in recent years, especially with the growing emphasis on reusable bottles for environmental sustainability. However, the process of cleaning these bottles remains a manual task in many settings, often leading to inconsistencies in the cleaning process and potential contamination. To address this issue, an automatic water bottle cleaning machine can be developed to streamline the cleaning process and ensure a high level of hygiene. [1]



Figure 1.1: Bottle Cleaning Machine

1.2 Problem Statement

Current manual water bottle cleaning methods are labor-intensive, time-consuming, and prone to human error. Additionally, manual cleaning may not always ensure thorough disinfection and drying, leading to microbial growth and potential health risks. Therefore, there is a need for an efficient, automated, and hygienic solution for cleaning water bottles. The demand for clean, safe, and hygienic water bottles has surged in recent years, especially with the growing emphasis on reusable bottles for environmental sustainability. However, the process of cleaning these bottles remains a manual task in many settings, often leading to inconsistencies in the cleaning process and potential contamination. To address this issue, an automatic water bottle cleaning machine can be developed to streamline the cleaning process and ensure a high level of hygiene. Current manual water bottle cleaning methods are labor-intensive, time-consuming, and prone to human error. Additionally, manual cleaning may not always ensure thorough disinfection and drying, leading to microbial growth and potential health risks.

Therefore, there is a need for an efficient, automated, and hygienic solution for cleaning water bottles.

1.3 Objective

- To design a cleaning system capable of cleaning water bottles.
- To ensure that the cleaning machine eliminates bacteria and impurities from water bottles.
- To reduce human intervention, increasing efficiency and throughput.

1.4 Scope of the Study

This study focuses on the development of a fully automatic water bottle cleaning machine that incorporates washing, scrubbing, rinsing, and drying stages. The system is designed for use in high-volume production environments such as bottling plants, water refill stations, and commercial establishments.

1.5 Significance of the Study

This research presents a step toward automating the cleaning process for water bottles, ensuring hygiene standards are consistently met. The implementation of such machines will help reduce manual labor, increase operational efficiency, and reduce the risk of contamination.

CHAPTER-2

Literature Review

2.1 Introduction

This chapter is arranged on Literature Review. Here's a look at some of last year's literature, like our project. By reading them, we can overcome the mistakes of the previous project and make a more effective project.

2.2 Related Research/ Works

Anna Marie M. Hufemia [1] states the feasibility of recovering caustic soda from bottle washers of a soft drink plant was investigated at pilot-scale using microfiltration (MF) and nanofiltration (NF). This study revealed that the MF/NF system can purify the caustic soda to a certain extent and can be reused back to the bottle washing units. Within the studied pressure ranges, the optimum applied pressure was determined as 101 kPa for MF, and 1,414 kPa for NF with corresponding permeate fluxes of 235 and 15 L/m2-h respectively. Based on these figures, a large-scale installation for the Thai Pure Drinks Ltd., Pathumthani plant was designed and a financial analysis was conducted for the system. The MF/NF system using MEMCOR hollow fiber membranes and MPS-34 (MWCO=300) gave a payback period of seven years and an IRR of13.7%, rendering the system not financially feasible.

An overall water balance was drawn to find alternatives for water purification and reuse in the plant that would lead to reduction of raw water consumption and liquid discharge into the river. It was found that reuse of micro filtered wastewater treatment plant effluent can reduce groundwater input by 40% and liquid discharged to the receiving water by 65.5%. Two proposed options for reclaiming bottle washing rinse water are treatment by reverse osmosis (RO) or purification by ion-exchange (IE). Based on theoretical considerations, an MF/Ro system will recover both pure water and concentrated caustic in the process. On the other hand, IE will recover water fit for reuse in the bottle washers. The two conceptual designs have a payback period of 3.2 and 3.4 years respectively, while the internal rate of return are31.3% and 30.5%.

Ankur G. Gajjar [2] postulates the conventional bottle washer machines are suitable only for

medium scale and large-scale beverage industry due to their high bottle washing capacity and mechanical and control complexity. This paper proposes the design and automation of the economical bottle washer machine for the small-scale beverage industry without compromising its control capabilities. The importance and requirement of the bottle washer machine in the beverage industry has been discussed. The design of the proposed bottle washer machine for RGBs (Returnable Glass Bottles) has been created in the Cero software. The different treatment zones and working of the bottle washer machine has been discussed.

The bottle washer machine has been automatized using the Siemens S7-317-2-PN/DP PLC (Programmable Logic Controller) and programmed using a ladder diagram in the SIMATIC Manager. The level control for different treatment zones is achieved by means of limit switches and temperature control for different treatment zones is achieved by using Pt1000 RTD, SSR (Solid State Relay) and heater. The different control schemes for the temperature control have been discussed, implemented and compared. The results show that the PID temperature control is the most effective control scheme for the temperature control of the different treatment zones. The implementation of the PID temperature control and auto-tuning of the sample process has been shown. The holistic control of the bottle washer machine also has been discussed and assessed.

Ganesh U L [3] showed the usage of mechanical drainage cleaner to replace the manual work required for the drainage cleaning system. Drainage pipes are foul. Sometimes it is harmful to human life while it is needed for cleaning the drainage system. To overcome this problem, they implemented mechanical semi-automatic drainage water cleaner and so the water flow is efficient because of regular filtration of wastages with the help of that project. Different kinds of environmental hazards are reduced with the use of the Drainage system machine.

S D Rahul Bharadwaj [4] Proposed the automatic cleaning of wastewater to prevent global warming and the melting of glaciers. The results emphasize the need for wastewater treatment plants, through which the water is treated before suspending in rivers. Firstly, power is generated, and that power is used for the wastewater cleaning process.

Balachandraetal [5] Reviewed about drainage cleaning to replace manual work to the automated system because the manually cleaning method it is harmful to human life and cleaning time, is more so to overcome this problem, they implemented a design "Automatic drainage water pump

monitoring and control system using PLC and SCADA." PLC and SCADA were designed. In this project, to use an efficient way to control the disposal of wastage regularly, treatment of removal in different way toxic and nontoxic gases. PLC controller from Siemens was used in the treatment system of drainage wastewater control by the stepper motor, compressor, gas exhauster, pressure valve, and the liquid level, flow, and other analog variables to achieve automatic control of wastewater treatment.

Dr.K.Kumaresan [6] explained manual work converted to an automated system. Drainage pipe using for disposal, and it may be a loss for human life while cleaning the blockage in the drainage pipes. To overcome this problem, they implemented the "Automatic Sewage Cleaning System." They designed their project different way clearance of gaseous substances is treated separately, so the flow of water efficiently. This project may be developed with the full utilization of men, machines, and materials, and more They used automation technology related to his application of mechanical, electronics, computer-based systems to operate and control production.

R.Sathiyakala [7] explained E bucket (electronic bucket) use for the drainage cleaning system because E-bucket lifted sewage and used evaporation treatment for this sewage, wet sewage was converted into dry matters, with the of ARM board (ARDUINO), this process was performed. After this process, they added this waste to a government bank without any affection of the bacteria.

Nitin Sall [8] explained the flow of used water from homes, business industries, commercial activities is called wastewater. 200 to 500-liters wastage water are generated by each person every day. So, using wastewater technology that removes, rather than destroys, a pollutant in a drainage system.

NDUBUISI C. Daniels [9], et.al. Showed the Drainage system cleaner machine used to remove garbage and sewage automatically, which helped to protect the environment from different kinds of environmental hazards. The drainage system cleaner has three significant parts, which are the Propeller, the Cleaner, and the Pan, all makeup for its effective functioning.

CHAPTER- 3
Methodology

3.1 methodologies for the project

- Creating an idea for the design and construction of "**Water bottle Cleaning**". And designing a block diagram to know which components we need to construct it.
- Setting up all the components Setup & soldering. Then assembling all the blocks in a board and finally running the system to check if it actually works or not. [4]

3.2 Block Diagram

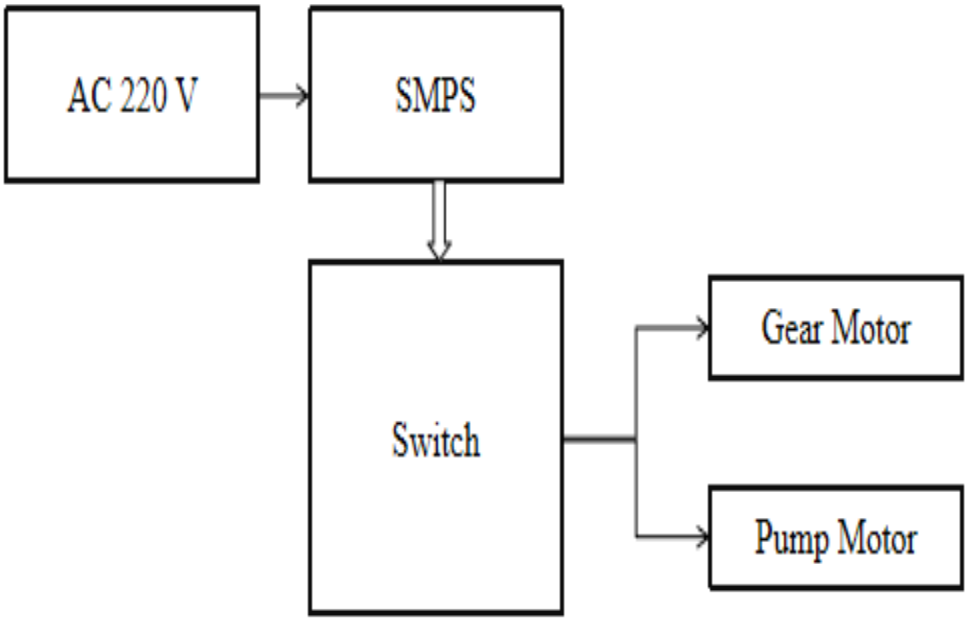


Figure 3.1: Block Diagram

3.3 Schematic Diagram

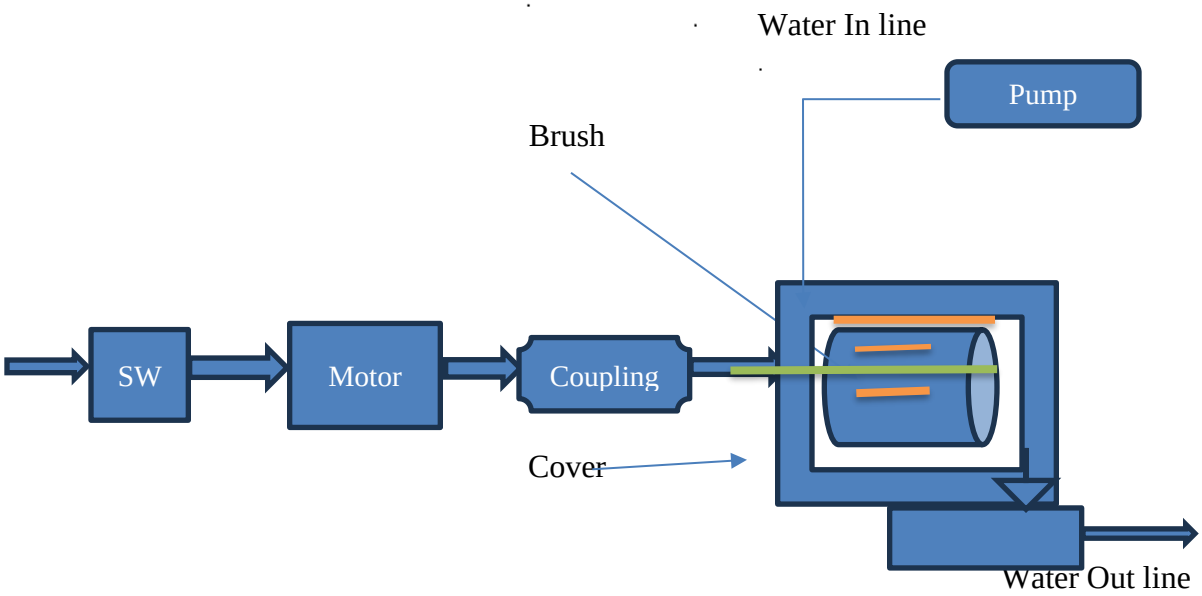


Fig 3.2 Schematic Diagram of bottle cleaning machine

3.4 Circuit Diagram of proposed Model

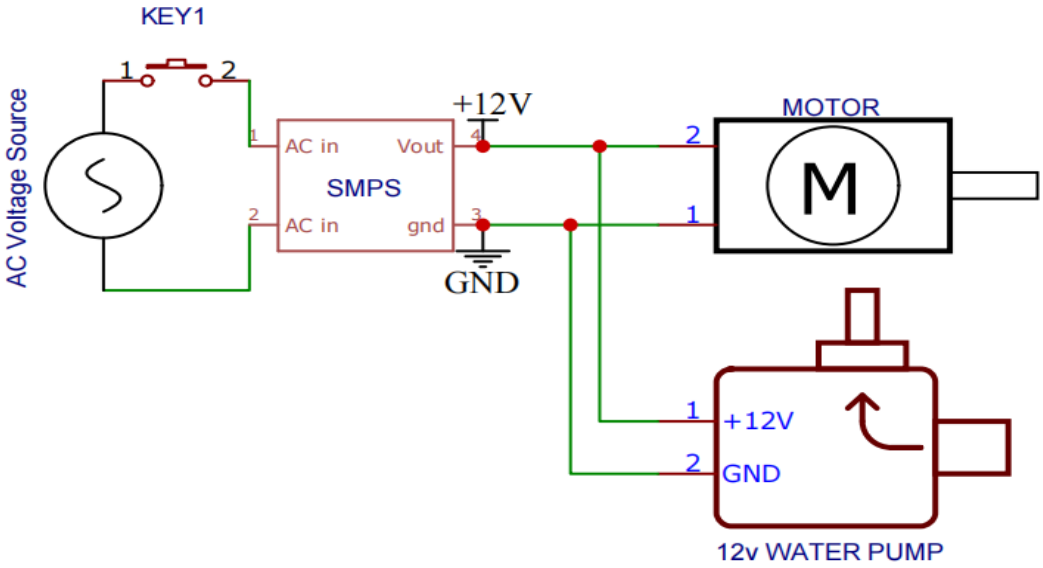


Figure 3.3: Circuit Design

3.5 Working Principle

The working principle of the Water Bottle Cleaning System involves coordinated operation of key components: SMPS, Gear Motor, and Water Pump. The SMPS (Switched Mode Power Supply) provides a stable DC voltage to power the system, ensuring energy efficiency and protection against voltage fluctuations. The Gear Motor drives the rotating brushes, ensuring consistent scrubbing at an optimal speed for effective cleaning. The Water Pump delivers pressurized water through nozzles, aiding in dirt removal and rinsing. Together, these components ensure synchronized and efficient cleaning, with the SMPS powering the system, the gear motor handling mechanical action, and the water pump ensuring thorough rinsing. [4]

3.6 Proposed System

Proposed Water Bottle Cleaning System is designed to offer efficient, eco-friendly, and automated cleaning for reusable bottles. Using advanced components like SMPS, Gear Motor, and Water Pump, the system ensures thorough cleaning through rotating brushes, high-pressure water jets, and detergent mixing. The compact and user-friendly design accommodates bottles of various shapes and sizes, making it ideal for both commercial and domestic use. The system not only saves time by automating the cleaning process but also reduces water and detergent consumption, promoting sustainability. It offers convenience, hygiene, and reliability, making it an ideal solution for maintaining reusable bottles in a safe and eco-conscious manner.



Figure 3.4: Proposed system

3.7 Real View of project



Figure 3.5: Project Hard ware Image

3.8 Project Progress Image

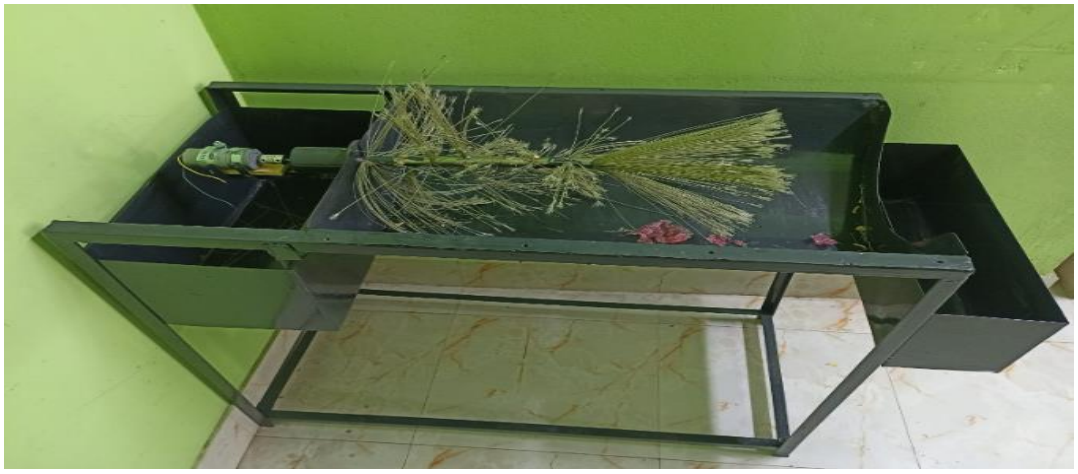


Figure 3.6: Project Progress Image

CHAPTER -4
Hardware Analysis

4.1 Introduction

The water bottle cleaning machine consists of multiple stages, including loading, cleaning, rinsing, drying, and ejection. Each stage is controlled via an integrated system, ensuring consistent and effective cleaning.

Hardware

- SMPS
- Pump Motor
- Gear Motor
- Motor Pulley
- Switch
- Frame
- Brush

4.2 Switch Mode Power Supply (SMPS)

A switched-mode power supply (switching-mode power supply, switch-mode power supply, switched power supply, SMPS, or switcher) is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. A hypothetical ideal switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time (also known as duty cycles). In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply. Switched-mode power supplies may also be substantially smaller and lighter than a linear supply due to the smaller transformer size and weight.



Figure 4.1: SMPS

Switching regulators are used as replacements for linear regulators when higher efficiency, smaller size or lighter weight are required. They are, however, more complicated; their switching currents can cause electrical noise problems if not carefully suppressed, and simple designs may have a poor power factor. Switched-mode power supplies are classified according to the type of input and output voltages. The four major categories are:

- AC to DC
- DC to DC
- DC to AC
- AC to AC

A basic isolated AC to DC switched-mode power supply consists of:

- Input rectifier and filter
- Inverter consisting of switching devices such as MOSFETs
- Transformer
- Output rectifier and filter
- Feedback and control circuit

The input DC supply from a rectifier or battery is fed to the inverter where it is turned on and off at high frequencies of between 20 KHz and 200 KHz by the switching MOSFET or power transistors. The high-frequency voltage pulses from the inverter are fed to the transformer primary winding, and the secondary AC output is rectified and smoothed to produce the required DC

voltages. A feedback circuit monitors the output voltage and instructs the control circuit to adjust the duty cycle to maintain the output at the desired level.[5]

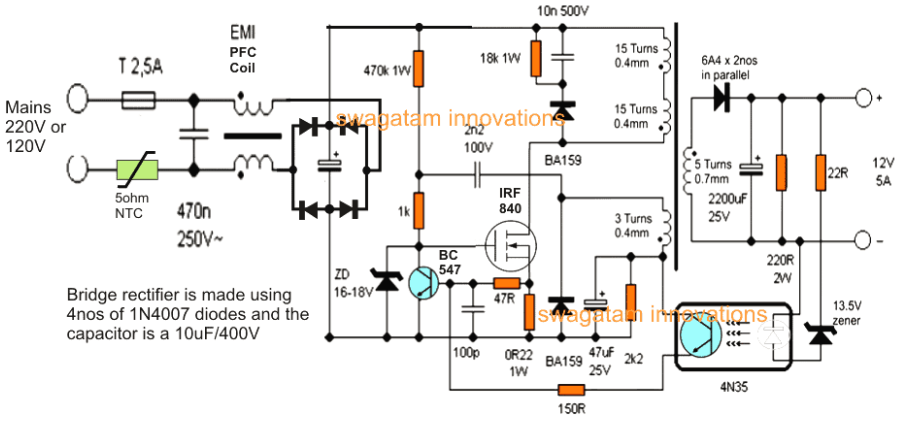


Figure 4.2: SMPS Circuit

Basic working concept of an SMPS

A switching regulator does the regulation in the SMPS. A series switching element turns the current supply to a smoothing capacitor on and off. The voltage on the capacitor controls the time the series element is turned. The continuous switching of the capacitor maintains the voltage at the required level.

Design basics

AC power first passes through fuses and a line filter. Then it is rectified by a full-wave bridge rectifier. The rectified voltage is next applied to the power factor correction (PFC) pre-regulator followed by the downstream DC-DC converter(s). Most computers and small appliances use the International Electrotechnical Commission (IEC) style input connector. As for output connectors and pin outs, except for some industries, such as PC and compact PCI, in general, they are not standardized and are left up to the manufacturer.

There are different circuit configurations known as topologies, each having unique characteristics, advantages and modes of operation, which determines how the input power is transferred to the output. Most of the commonly used topologies such as flyback, push-pull, half bridge and full bridge, consist of a transformer to provide isolation, voltage scaling, and multiple output voltages. The non-isolated configurations do not have a transformer and the power conversion is provided by the inductive energy transfer.

Advantages of switched-mode power supplies:

- Higher efficiency of 68% to 90%
- Regulated and reliable outputs regardless of variations in input supply voltage
- Small size and lighter
- Flexible technology
- High power density
- Disadvantages:
- Generates electromagnetic interference
- Complex circuit design
- Expensive compared to linear supplies

Switched-mode power supplies are used to power a wide variety of equipment such as computers, sensitive electronics, battery-operated devices and other equipment requiring high efficiency. Linear voltage IC regulators have been the basis of power supply designs for many years as they are very good at supplying a continuous fixed voltage output. Linear voltage regulators are generally much more efficient and easier to use than equivalent voltage regulator circuits made from discrete components such a Zener diode and a resistor, or transistors and even op-amps. The most popular linear and fixed output voltage regulator types are by far the 78… positive output voltage series, and the 79… negative output voltage series.

These two types of complementary voltage regulators produce a precise and stable voltage output ranging from about 5 volts up to about 24 volts for use in many electronic circuits. There is a wide range of these three-terminal fixed voltage regulators available each with its own built-in voltage regulation and current limiting circuits. This allows us to create a whole host of different power supply rails and outputs, either single or dual supply, suitable for most electronic circuits and applications. There are even variable voltage linear regulators available as well providing an output voltage which is continually variable from just above zero to a few volts below its maximum voltage output.

Switch Mode Power Supply

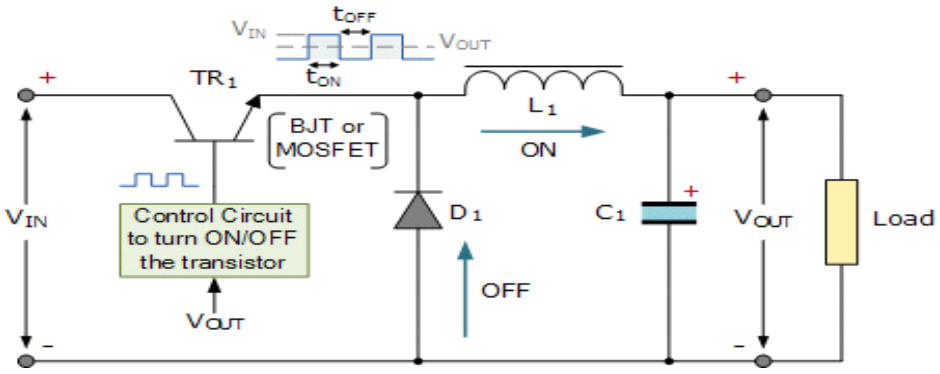


Figure 4.3: SMPS Circuit Connection

Most DC power supplies comprise of a large and heavy step-down mains transformer, diode rectification, either full-wave or half-wave, a filter circuit to remove any ripple content from the rectified DC producing a suitably smooth DC voltage, and some form of voltage regulator or stabilizer circuit, either linear or switching to ensure the correct regulation of the power supplies output voltage under varying load conditions. Then a typical DC power supply would look something like this:

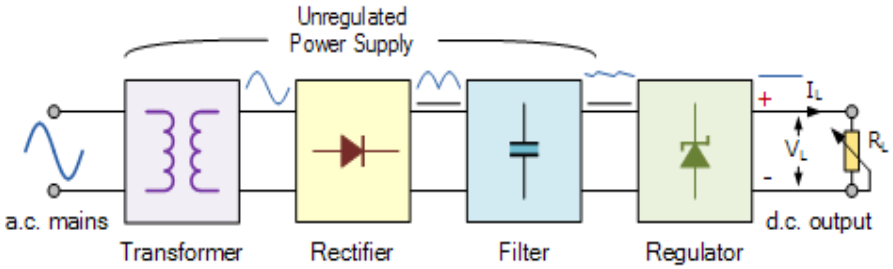


Figure 4.4: DC Power supply way

These typical power supply designs contain a large mains transformer (which also provides isolation between the input and output) and a dissipative series regulator circuit. The regulator circuit could consist of a single Zener diode or a three-terminal linear series regulator to produce the required output voltage. The advantage of a linear regulator is that the power supply circuit only needs an input capacitor, output capacitor and some feedback resistors to set the output voltage. [7]

4.3 Pump Motor

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action, typically converted from electrical energy into hydraulic energy. Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers and other components of heating, ventilation and air conditioning systems. In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.



Fig. 4.5: Centrifugal water Pump.

Specification:

- Material: ABS (Acrylonitrile Butadiene Styrene) + Stainless Steel
- Overall Size: Approx. 80 x 48 x 63mm/3.15 x 1.89 x 2.48"
- Pump Inlet Diameter 16mm (Outer), 12mm (Inner)
- Pump Outlet Diameter: 12mm (Outer), 6.9mm (Inner)
- Inlet/Outlet: 1/2" male thread
- Voltage: 6-12V DC
- Maximum Rated Current: 1.2A
- Power: 16.8W
- Max Flow Rate: 700 L/H

- Max Water Head: 5M
- Max Circulating Water Temperature: 60°C

4.4 DC Gear Motor

A DC gear motor is a compact and efficient device that combines a direct current (DC) motor with a gear system to provide high torque at reduced speed. The motor operates by converting electrical energy into mechanical energy, while the integrated gear mechanism adjusts the speed and torque to meet specific application requirements. DC gear motors are known for their precise control, durability, and versatility. They are widely used in robotics, automotive systems, conveyor belts, and industrial automation. Their ability to operate at variable speeds with high efficiency makes them ideal for applications demanding precision and reliability.

A DC motor is any motor within a class of electrical machines whereby direct current electrical power is converted into mechanical power. A 12v DC motor is small and inexpensive, yet powerful enough to be used for many applications. [8]

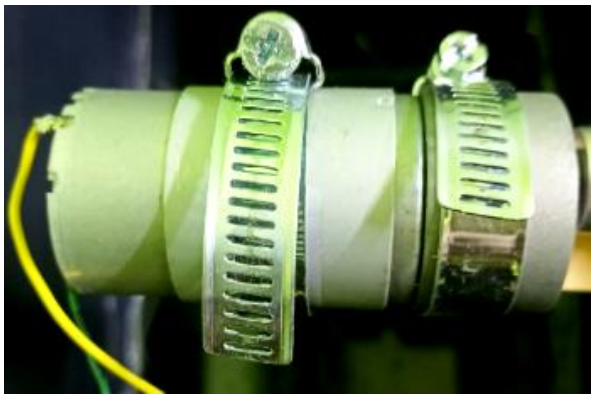


Figure 4.6: DC Gear Motor

Specification:

- Voltage: 12V DC
- Gear ratio: 1/31
- No-load speed: 200 RPM
- Rated Speed: 140 RPM
- Rated torque: 10 kg.cm
- Rated current: 2.5 Amp

- Length of Motor (including spindle): 106 mm/4.17″
- Diameter: 37 mm/1.45″
- Shaft length: 21 mm/0.82″
- Shaft diameter: 6 mm/0.24″

4.5 Switch

A switch that has a single input and two dissimilar outputs is known as SPDT. The term SPDT stands for Single Pole Double Throw Switch which is used to control two dissimilar circuits through a similar single input. The operating of this switch can be done manually or included through the electromagnetic coil.



Figure 4.7: Switch

Switch Applications:

- This switch is used in a three-way circuit for controlling a load from two locations like from the top and bottom of a staircase.
- This switch is used to control two different circuits through a similar single input.
- Control Circuit.
- ABB/Siemens VFDs.
- PLC system output switches.
- Selector switches through a single common arrangement.

4.6 Motor Pulley

A pulley is a wheel on an axle or shaft that is designed to support movement and change of direction of a taut cable or belt, or transfer of power between the shaft and cable or belt. In the case of a pulley supported by a frame or shell that does not transfer power to a shaft, but is used to guide the cable or exert a force, the supporting shell is called a block, and the pulley may be called a sheave. A pulley may have a groove or grooves between flanges around its circumference to locate the cable or belt. The drive element of a pulley system can be a rope, cable, belt, or chain.



Figure 4.8: Pulley

The earliest evidence of pulleys dates back to Ancient Egypt in the Twelfth Dynasty (1991-1802 BCE) and Mesopotamia in the early 2nd millennium BCE. In Roman Egypt, Hero of Alexandria (c. 10-70 CE) identified the pulley as one of six simple machines used to lift weights. Pulleys are assembled to form a block and tackle in order to provide mechanical advantage to apply large forces. Pulleys are also assembled as part of belt and chain drives in order to transmit power from one rotating shaft to another. Plutarch's *Parallel Lives* recounts a scene where Archimedes proved the effectiveness of compound pulleys and the block-and-tackle system by using one to pull a fully laden ship towards him as if it was gliding through water.

4.7 Rotating Brush

The **Rotating Brush Water Bottle Cleaning System** is a practical and efficient solution for thoroughly cleaning the interior and exterior of reusable water bottles. This system employs a motor-driven rotating brush mechanism designed to remove dirt, stains, and residues effectively. The brushes are made of durable, food-grade materials such as nylon or silicone, ensuring gentle yet efficient cleaning without damaging the bottle's surface. The cleaning process involves placing the bottle onto a rotating platform or a secured holder. The motor powers the brush, which rotates

at an optimal speed to scrub the bottle's inner walls, neck, and base. Simultaneously, water jets or nozzles spray water, either plain or mixed with detergent, to assist in loosening tough stains and rinsing away debris. For exterior cleaning, an additional set of brushes may rotate around the inner surface of the bottle. [3]



Figure 4.9: Rotating Brush

The system is designed to accommodate bottles of various shapes and sizes, making it versatile for domestic, commercial, or industrial applications. Its compact design ensures ease of use and maintenance. By automating the cleaning process, this system saves time and reduces water consumption, while ensuring a hygienic and eco-friendly solution for maintaining reusable bottles.

4.8 Frame

The **Body Frame** of a Water Bottle Cleaning System is a robust and ergonomic structure designed to provide stability, durability, and functionality during operation. Typically constructed from corrosion-resistant materials like stainless steel or aluminum, the frame ensures longevity and maintains hygiene standards in wet and humid environments. The frame houses and supports all critical components of the cleaning system, including the rotating brushes, water jets, motor, and control panel. It is designed to minimize vibration during operation, ensuring smooth and efficient cleaning processes. The body frame often features a modular design, allowing for easy assembly, disassembly, and maintenance.



Figure 4.10: Body Frame

To enhance usability, the frame includes provisions such as adjustable bottle holders or clamps to securely accommodate bottles of varying sizes and shapes. Drainage systems are integrated into the base to prevent water accumulation and ensure a clean working environment. Safety is a priority, so the frame is designed with protective covers or shields around moving parts to prevent accidental contact. Compact in design, the body frame optimizes space utilization while maintaining accessibility for operators. This well-engineered structure ensures the cleaning system is stable, user-friendly, and capable of delivering consistent, high-quality performance for residential, commercial, or industrial applications.

CHAPTER-5

Results And Discussion

5.1 Results

After making our project we observe it very careful. It works as we desire. Our project give output perfectly and all equipment are work perfectly. We check how much it works and we get perfect output from this project.

Necessary Information:

- Bottle Size: 20 Liters
- Bottle cleaning time: 30 second
- Interval time: 10 second
- Capacity per hours: 90 pcs
- Gear ratio: 1/31
- No-load speed: 200 RPM
- Rated Speed: 140 RPM
- Rated torque: 10 kg.cm
- Rated current: 2.5 Amp
- Brush length (inside): 470mm, Dia: 380mm
- Brush length (outside): 420mm
- Water required per bottle: 500 ml
- Detergent per bottle: 15 gm

Finally, we have completed our project successfully & check our project its run accurately according to our objective.

At first, we connect the AC 220 to system on.

The automated rotating brushes ensure thorough scrubbing, eliminating contaminants and bacteria, while the corrosion-resistant materials ensure long-term durability.

5.2 Cost Analysis

While the initial cost of the automatic cleaning machine was significant, the savings in labor costs and the increased efficiency of the process provided a strong return on investment. Over a five-year period, the company could expect to recover the initial investment through lower operational costs.

Sl. No.	Components Name	Specification	Quantity	Unit Price	Total Price
1	SMPS	5v 7a	1	800	800
2	Pump Motor	DC 12v	1	900	900
3	Gear Motor	25GA	1	600	600
4	Motor Pulley		1	250	250
5	Frame			4500	5000
6	Others			1500	1500
Total					9050/=

Table 01: Component's Name and Price

5.3 Advantages

There are many advantages of our project because of its accuracy. Some of the advantages are pointed out below:

Efficiency of the Cleaning Process: The automatic water bottle cleaning machine significantly reduced cleaning time per bottle compared to manual processes. With the ability to clean multiple bottles simultaneously, the machine operated at a much higher throughput, leading to improved efficiency. [5]

Water, Detergent, time and Energy Save: The water recycling system helped to reduce water, Detergent, time and Energy usage by 30% compared to conventional systems. Additionally, energy-efficient motors and heating systems contributed to lower energy consumption during operation. [7]

5.4 Application

The application areas for this project in this modern and practical world are huge and some of these are given below:

- Ideal for gyms, cafes, restaurants, and event management.
- To Use in bottling plants, recycling facilities, and pharmaceutical production.
- Schools, colleges, and offices for bulk bottle cleaning.
- Supports reusable bottle campaigns and waste reduction efforts.

CHAPTER-6

Conclusion and Future Work

6.1 Conclusion

The Water Bottle Cleaning Machine is an innovative solution addressing the need for efficient, hygienic, and sustainable bottle cleaning. By automating the cleaning process, it eliminates manual labor while ensuring thorough sanitization, making it suitable for households, commercial spaces, and industrial use. Its eco-friendly design reduces water consumption, promotes reusable bottles, and minimizes waste, aligning with global sustainability goals. This machine offers versatility, being compatible with different bottle materials and sizes, and caters to diverse applications—from personal use to large-scale operations in bottling plants and recycling facilities. Its user-friendly interface, cost-effectiveness, and time-saving capabilities make it a practical choice for individuals and organizations alike.

In conclusion, the Water Bottle Cleaning Machine not only improves hygiene and convenience but also fosters environmental stewardship. Its wide-ranging benefits position it as a valuable tool for promoting health, efficiency, and sustainability across various sectors.

6.2 Future Improvements and Developments

Future work could focus on enhancing the system's versatility, introducing advanced AI for bottle detection, and improving the energy efficiency of the machine. We are thinking about adding many features to our project in the future to get more desirable out comes. Some of the steps that we are thinking about taking are given below:

- In future we will add IoT System to operate in fully automatically.
- In future use of advanced materials and smart sensors for better performance.
- In future include an effective drying feature that removes excess water from bottles, ensuring they are completely dry and ready for reuse.
- In Future implement smart sensors and controls that monitor water and detergent levels, minimizing wastage and optimizing resource consumption.

This research successfully demonstrated the design and functionality of an automatic water bottle cleaning machine that is efficient, hygienic, and cost-effective. [8]

6.3 Challenges and Limitations

Challenge: The upfront investment required to purchase and install an automatic water bottle cleaning machine can be quite high. Mechanical or electrical failures, such as malfunctions in the nozzles or sensor systems, can result in machine downtime and production delays. Bottles come in various sizes, shapes, and materials, which could make it difficult for a standard machine to clean them all effectively.

Limitation: For small businesses or those with low-volume operations, the initial investment may not be cost-effective in the short term. This limits the adoption of such systems among smaller or less financially equipped companies. Frequent maintenance and potential breakdowns can disrupt the cleaning process, leading to additional costs and downtime. This might be problematic for operations that run at high capacities or require consistent cleaning processes. Some machines may require manual adjustments, modifications, or even specific attachments to accommodate non-standard or irregularly shaped bottles.

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