iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** III **Month of publication:** March 2025

DOI: https://doi.org/10.22214/ijraset.2025.67340

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue III Mar 2025- Available at www.ijraset.com

Design and Development of Semi-Automatic Water Tank Cleaning Machine

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Abstract: The aim of this project is to develop a mechanical system for cleaning water tanks, incorporating two primary mechanisms: a rack and pinion mechanism and a reciprocating four-bar linkage mechanism. The rack and pinion mechanism enables the vertical movement of the entire cleaning system, allowing it to reach different sections of the tank. This movement is controlled via a switch-operated control unit. The four-bar linkage mechanism is connected to a motor shaft and is responsible for scrubbing the tank's inner walls. PVC brushes are attached to the ends of the four-bar linkage, ensuring effective cleaning. The linkage is designed to be adjustable, accommodating various tank diameters. When the motor is activated, the four-bar linkage rotates, and the attached brushes clean the tank walls through a reciprocating motion. This project aims to minimize human effort and eliminate the health risks associated with chemical exposure and manual entry into water tanks for cleaning. By automating the process, the system enhances efficiency, safety, and effectiveness in maintaining hygienic water storage conditions.
Keywords: Rack and Pinion, Four-bar linkage, scrubbing, PVC Brush, Health risk

I. INTRODUCTION

Cleaning is the process of removing unwanted substances, such as dirt, infectious agents, and other impurities, from an object or environment. It is an essential practice across various contexts and industries, employing diverse methods and techniques. Among the many critical cleaning applications, maintaining the cleanliness of water storage systems is particularly important, as water is a fundamental resource for human life, especially for drinking purposes. While the water supplied to households is generally clean, the condition of the storage facility, particularly overhead water tanks, significantly influences water quality. The presence of dirt, sediments, algae, and other contaminants in these tanks can compromise water hygiene and pose health risks. Over time, these impurities accumulate on the walls, ceiling, and floor of the tank, leading to clogged pipes, unhygienic conditions, and potential adverse effects on skin and overall health. Therefore, regular cleaning of overhead water tanks is essential. Traditional methods for cleaning water tanks include the use of chemicals to dissolve dirt and sediments. However, chemical-based cleaning may have negative health implications due to residual contamination. Another common approach is using pressurized water to remove dirt from tank surfaces. While effective, this method is labor-intensive, time-consuming, and requires significant effort. Additionally, cleaning water tanks manually poses serious safety hazards, as workers operate in confined spaces with limited ventilation, increasing the risk of injuries or even fatalities in emergency situations. A confined space is generally defined as an area with restricted entry and inadequate natural ventilation, making rapid escape difficult in emergencies. Cleaning overhead water tanks manually demands specialized tools, equipment, and significant time investment. Given the complexity and risks involved, hiring professional water tank cleaners is often recommended. Professional cleaners are trained and equipped with advanced tools to ensure efficient and effective cleaning, thereby maintaining water hygiene and reducing health hazards. The frequency of overhead water tank cleaning depends on the quality of water supplied in a particular area. Regular maintenance and cleaning are necessary to ensure a safe water supply for daily activities such as drinking, bathing, cleaning, and washing. This study aims to develop an automated mechanical system for cleaning water tanks, reducing human effort and minimizing exposure to hazardous conditions while ensuring thorough cleaning and improved water hygiene.

II. OBJECTIVES

The main objective of this project as follows:
1) To reduce human effort
2) To enhance cleaning efficiency
3) To optimize cleaning time
4) To ensure water hygiene and quality
5) To minimize water and chemical usage

III. METHODOLOGY

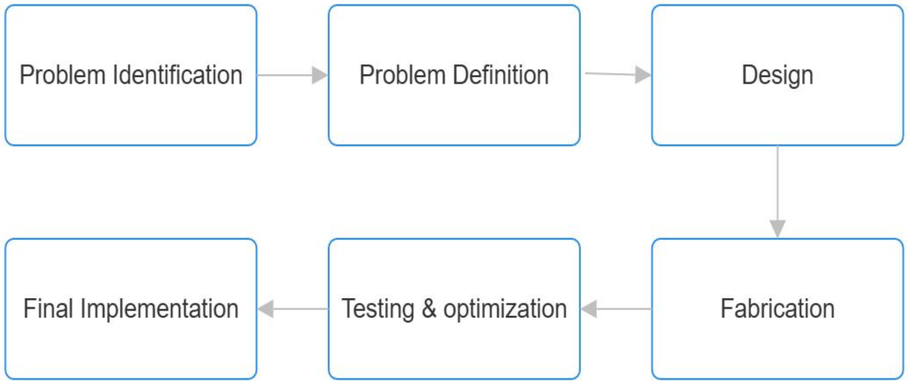

Fig. 1 Methodology

IV. COMPONENTS AND ITS DESCRIPTIONS

A. Gear Motor

Gear motor is used to produce high torque with low speed. The specification of motor as follows: Single Phase, 220 V and 15 A which produce 3.5 HP power, Frequency 50 Hz and Shaft speed is 75 rpm.

Fig 2 Gear Motor

B. Four Bar Linkage

A four-bar linkage is a planar mechanism consisting of four rigid links connected in a closed-loop configuration by rotating kinematic pairs (revolute joints). It is a fundamental mechanism used in various applications to achieve controlled motion. In this case, the four-bar linkage is designed to adjust the inner diameter of a tank. This suggests that the mechanism operates in a way that either expands or contracts a circular or flexible structure within the tank, possibly for diameter regulation, clamping, or sealing purposes.

Fig 3 Four bar linkage

C. Rack and Pinion

A rack and pinion is a type of linear actuator consisting of a circular gear (pinion) that engages with a linear gear bar (rack). This mechanism converts rotational motion into linear motion. When rotational motion is applied to the pinion, it drives the rack to move in a straight line relative to the pinion. In this setup, a motor is attached to the rack, allowing it to move vertically along a guideway. The movement is controlled with the help of a handle attached to the pinion, facilitating manual adjustment.

Fig 4 Rack and Pinion

D. Shaft

A 15 mm diameter mild steel shaft is used to transmit rotary motion from the motor to the four-bar linkage. Adjustable holes are provided on the shaft, allowing the four-bar linkage to be adjusted according to the tank's diameter.

Fig 5 motor Shaft

E. Brush

The brushes are made up of Poly Vinyl Chloride (PVC) polymer. Brushes attached to the ends of four bar linkage

Fig 6 Brush

F. Frame

The frame structure is made of mild steel, and all parts are mounted on it with a suitable arrangement. Boring for bearing housings and open bores is done in a single setting to ensure proper alignment during assembly. Provisions are made to cover the bearings with grease for lubrication and protection.

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G. Battery

The lead-acid cell is commonly used for applications requiring high load currents, such as starting automobile engines, where the starter motor draws 200–400A. It uses a dilute sulfuric acid (H_2SO_4) electrolyte and has a nominal output of 2.1V per cell. Typically, three cells form a 6V battery, and six cells form a 12V battery. As a secondary (rechargeable) cell, it can undergo multiple charge-discharge cycles, lasting about 3–5 years in automobiles. Among secondary cells, the lead-acid type provides the highest output voltage, requiring fewer cells to achieve a desired battery voltage. However, excessive heat, charge, and discharge currents reduce its lifespan.

V. DESIGN OF THE PROJECT

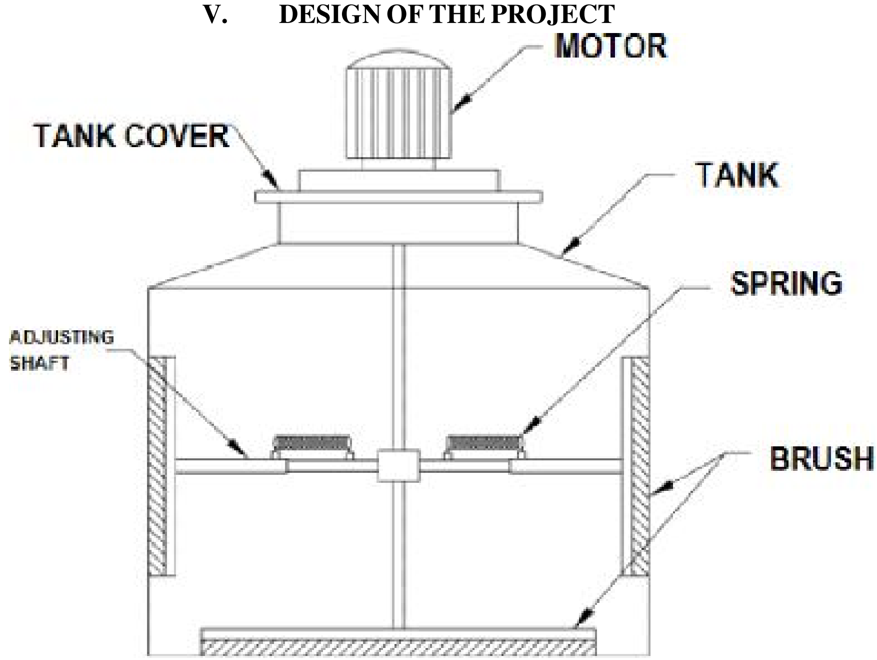

Fig 7 2 D Image of water tank cleaning machine

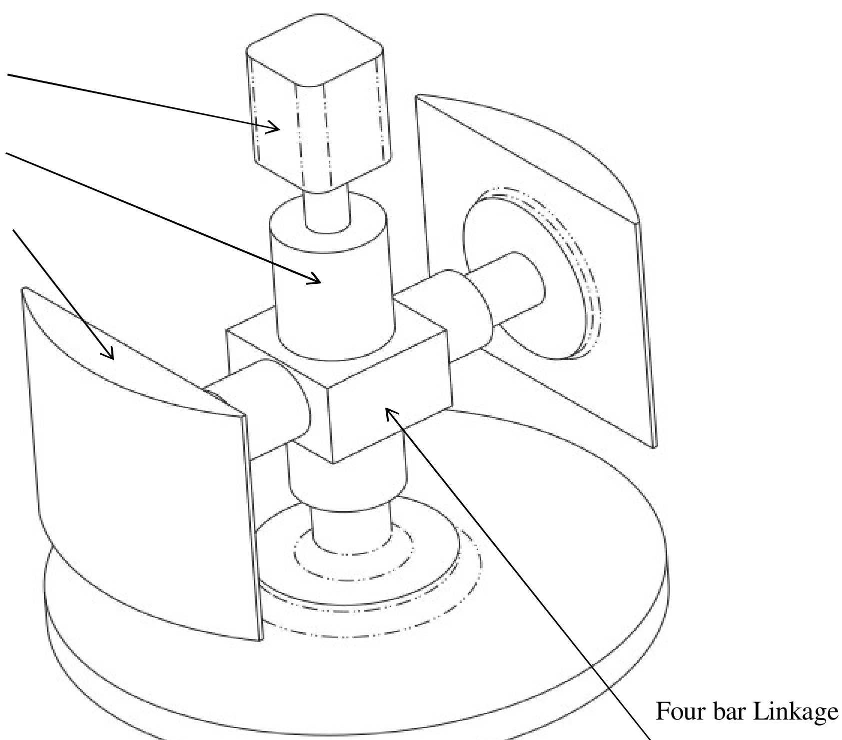

Fig 8 3 D Image of Water tank cleaning machine

VI. WORKING PRINCIPLE

The experimental setup consists of a frame rigidly mounted on the ground using suitable supports. The entire system is initially inserted in its retracted position into the water tank. The four-bar linkage is adjusted to match the tank's diameter **so** that the brush at the end of the shaft makes contact with the inner wall. When the motor is switched ON, the four-bar linkage rotates along with the shaft, causing the brush to scrub the inner walls of the tank. To clean the upper portion of the tank, the entire mechanism is reciprocated along the guideways using a DC motor with a rack-and-pinion mechanism. This ensures efficient cleaning of the water tank in minimal time.

VII. ADVANTAGES AND APPLICATIONS

A. Advantages

1) Simple in construction.
2) Easy to fabricate.
3) The components used are easily available.
4) Efficient method.
5) No need of skilled operators to operate this system.
6) Safe operation can be achieved.
7) Highly reliable.
8) High durability.
9) The replacement and repairing of the components can be done easily.
10) Height of the bore water tank is not a major concern in this type of system.

B. Applications

These types of automatic water tank cleaning machines have a wide range of applications in the fields like,

1) Highly suitable all water tanks.
2) Suitable for construction fields.

VIII. CONCLUSIONS

In this work, an automated water tank cleaner was successfully developed to clean water tanks using rotating brushes. This method is more effective and safer than conventional cleaning techniques, as it reduces cleaning time and human effort. The rotating brushes efficiently clean the tank walls, while water splashes across the surfaces, aiding the cleaning process. The mechanism used for component movement is simple in construction and allows for easy replacement in case of failure. The use of an automated tank cleaning machine also eliminates the health risks faced by workers, such as suffocation from inhaling toxic cleaning agents. The machine has been extensively tested and redesigned to meet modern standards of tank cleaning. Thus, the design effectively saves both human effort and time. We have developed a "Semi-Automatic Water Tank Cleaning Machine", which not only enhances safety and efficiency but also reduces accident rates. Additionally, this concept introduces a new approach to bore water tank rescue operations, making it useful in defense and rescue fields. With further modifications and advancements, this technology can be adapted for various applications, making it even more versatile and effective.

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