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Automatic Overhead Water Tank Cleaning System: A Review and an Approach

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Abstract— *Aim of this paper is to develop a mechanical system for cleaning domestic cylindrical water tank. The mechanical system includes two main mechanisms which are rack and pinion gear mechanism and reciprocating four bar linkage mechanism. The rack and pinion arrangement is used to move whole mechanical system up and down for cleaning the cylindrical tank. The rack is fixed on the motor and the four-bar mechanism is attached to the motor shaft. PVC brushes are attached to the ends of the four-bar linkage. Four bar linkage is made in such a way that it can be adjusted according to inside diameter of the tank. When the motor is started the linkage rotates and with the help of brushes, cleaning of wall and base of tank takes place. The purpose of this project is to reduce the human efforts and to avoid the chemical influence on health of person entering the tank for cleaning.*

In this modern world, cleaning of overhead tanks manually is a tedious job. To overcome this we have aimed at tackling the disadvantages of cleaning overhead tanks, so an automatic system overhead tank cleaning is designed to provide high safety, high efficiency, less time for cleaning and to avoid environmental pollution problems. Purpose of this paper is to clean domestic cylindrical water tank with the help of mechatronics system. The mechatronics system consists of a grooved gear rod attached to two arms with brushes at ends. The two arms are connected to the gear rod by nut. By rotating the gear rod, the up and down motion of the two arms is achieved. The gear rod is rotated with the help of a D.C gear motor. The main grooved shaft is powered by an A.C motor. The motor and the shaft are connected by a rubber belt. The clockwise rotation of the main shaft will make the arms move and vice versa. The whole operation is controlled by a circuit consisting of relay switches, buttons, and PIC microcontroller. The number of times for the operation to repeat can be fed into the circuit. The achievement of this project is reduction of cost and manual labour because there will be harmful diseases for the person who will go inside and it will affect the health as well as the other human being who consumes water from the tank.

Keywords—Water Tank Cleaning, Cylindrical water tank, four bar linkage, motor shaft, rack and pinion, PVC brush.

I. INTRODUCTION

In recent studies it has been found that no automation based machine used in cleaning of overhead tank. This is because of the irregular shape and various heights of the tank locations. With previous survey made an attempt to make a machine by automation process for cleaning tank. An alternate solution has made a plan to solve this problem. In India, the usage of sintex tanks by the people is approximately 71% After studies made the information that have faced a lot of difficulties like continuous work in the dirty places, irregular payment and other various reasons. Continuous work and irregular payment may also be the major reason for this attempt. So came to a conclusion that cleaning the overhead tank using automation process can be useful to solve all these problems. In this case, machine has the capability to clean the tank easily and quickly. Designing of our machine is based on the survey report conducted.

1.1 Necessity of Cleaning Water Tank

Every day we use the tank water for brushing and bathing, for cleaning and moping, for washing clothes and in other household chores. With the passage of time, sediments scale and algae get deposited on the walls, ceiling and floor of the water tank. This deposition contaminates the water and makes is unfit for use. With time algae and bacteria grow and breed in this water infect it and could make us fall sick eventually. Hence water tank cleaning is very important.

1.2 Methods of water tank cleaning.

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Manual scrubbing in which wall and floor of tank are scrubbed to remove dirt, sediments, fungus and stains, but this method is more tedious and time consuming. The water tank can also be cleaned by using chemicals to remove the dirt and sediments. The chemicals used may affect the human health. Pressurized water can be sprayed on the walls of the tank which will remove the dirt from the tank surface. These methods are time consuming and require more efforts for cleaning. To find such an approach, there is need of studying the existing approaches and algorithms that had already been used for automatic overhead water tank cleaning system. This motivates us for the literature review.

The organization of this paper is as follows. In Section 2, systematic presentation of the literature review is done; which involves the list of the related approaches along with the summary of the related work that is more relevant to developed approach. Section 2 concludes with our findings from the literature review and motivation behind identified problems. Section 3 focuses on the formulation of the identified problems. Section 4 is dedicated to the proposed approach. Section 5 emphasizes on the experimental results. Section 6 addresses the conclusions along with the future work.

II. LITERARURE REVIEW

This section presents the critical analysis of existing literature which is relevant to overhead water tank cleaning system and its mechanisms. Though, the literature consists of a lot many research contributions, but, here, we have analyzed around eight research and review papers. The existing approaches are categorized based on the basic concepts involved in the mechanisms. The emphasis is on the concepts used by the concerned authors, the database used for experimentations and the performance evaluation parameters. Their claims are also highlighted. Finally, the findings are summarized related to the studied and analyzed research papers. Section concludes with the motivation behind identified problem.

Table.1: Literature Review

Sr. No.	Ref. no. Concerned Author(s) and years	Concept used	Claimed by concern authors (s)	Our findings
1	Thonge Suraj , Shelke Prasad, Wakte Vaibhav , Thonge Sharad , Prof. Shinde ,(2017)	A mechanical system which clean the tank mechanically using brush, rack and pinion , bar linkage and motor.	The authors observed that the Cleaning is done more effective than the conventional methods.	Adjustment of the system inside the tank is difficult.
2	S. Abhishek, D. Kiran, P. Praveen and Dr. K. L. Senthilkumar (2017)	A mechanical system which clean the tank mechanically using brush, rack and pinion , bar linkage and motor.	The authors observed that the Cleaning is done more effective than the conventional methods.	Cleaning of the tank using this system is not effective.
3	Prayosha innovative (2017)	Sedimclean water tank cleaning machine which clean sediments in the tank. It is a vacuum cleaner type system which clean the tank without removing the water from the tank.	Sedimclean water tank cleaning machine which clean sediments in the tank. It is a vacuum cleaner type system which clean the tank without removing the water from the tank.	Only clean the sediments in the tank not the scale and algae inside the tank.
4	Brown J. A (1989)	vacuum tanker for cleaning storage tanks which is an vaccine cleaning system for cleaning the water tank and also acts as a water pump to force water.	Powerful technology to clean Big water tank more efficient and in very less time.	Very expensive
5	M.S.Triantafillou and G. S. Triantafyllou, (2003)	An efficient swimming vehicle is a mechanical system to clean the swimming pool using	Fish-like underwater micro robot which clean the swimming pool effectively.	Good working

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		motor, mechanical arrangements, brush and floss.		
6	W. S. N. Trimmer and K. J. Gabriel (1987)	Design considerations for a practical electrostatic micro-motor	A high torque less speed motor of very small in size.	Good perform-ance
7	Dr.R.K.Bansal (2011)	Kinematics of machine.	None	Good study
8	Shubham Shrivastav, Hari Om Kumar (2016)	Design and Development of Cylindrical Water tank cleaner.	Easy to use and effective cleaning of the water tank is done	It is large in size and heavy in weight.

III. PROBLEM FORMULATION

This section presents the formulation of the identified problem, which based representation of an overhead water tank cleaning system. All the reviews on theoretic approaches involve the same common terminologies.

The problem of cleaning the water tank by the conventional can be formulated as:

All methods of cleaning water tank as discussed above are time consuming and require more human efforts. So the alternate method is required for cleaning purpose which will overcome the drawbacks of all other methods. Therefore, we are developing water tank cleaning equipment which requires less time and human efforts for cleaning.

There are many ways to generate electricity such as nuclear, thermal, diesel, solar, hydropower based generation system. In nuclear based generation there is always risk of nuclear radiation accident also it requires high initial cost and impacts on human life. In thermal based generation there is a huge production of CO2 in atmosphere and it depends on availability of coal as fuel. In diesel based generation running charges are more due to high cost of diesel and also cost of lubrication. These are the problems that occurs in generation of electricity

In flying electric generator there is no need non-renewable fuel. Also it does not have any impact on environment or human life. There are various problems that are overcome by flying electric generator

IV. PROPOSED APPROACH

This section is subdivided into 5 sub-sections wherein the report presents the detailed working of automatic overhead water tank cleaning system that is incorporated in our work along with our approach. Sub-section A includes the information about the main components used in the project. The material and methods is mentioned in Sub-Section B. Working of system is explained in Sub-Section C with the aid of flowchart. Our proposed approach is introduced in Sub-Section D. Sub-section E provides detailed working of the proposed approach.

A) Main Components

Gear Motor

Fig. 1 Gear Motor

Gear motor is used to produce high torque with low speed. Motor used has specifications as single phase 220V, 15A which produces power of 0.35 HP and frequency of 50 Hz and the shaft speed is 75 rpm.

Four Bar Linkage

Fig. 2 Four bar linkages

A plane linkage consisting of four links pinned tail to head in a closed loop with lower or closed joints. It is a plane mechanism consisting of four links that form rotating kinematic pairs. The four bar linkage is arranged in such a way that it adjusts the inner diameter of the tank.

Rack and Pinion

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Fig. 3 Rack and pinion arrangements

A rack and pinion is a type of linear actuator that comprises a pair of gears which converts rotational motion into linear motion. A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack". Rotational motion applied to the pinion causes the rack to move relative to pinion. Thus the motor attached to the rack is moved in vertical direction along the guide way with the help of handle attached to the pinion.

Shaft

Fig. 4 Motor shaft

Shaft made up of mild steel of diameter 15mm is used to transmit rotary motion from motor to the four bar linkage. Holes provided on the shaft, adjust the four bar linkage according to the diameter of the tank.

Brush

Fig. 5 Brushes

The brushes are made up of Poly Vinyl Chloride (PVC) polymer. Brushes attached to the ends of four bar linkage revolve due to rotation of motor shaft to clean the inner surface of the tank.

B) Materials and methods

Selection of Materials

The machine setup is considered. The rows and columns of the machine are of mild steel material. The DC Motor are used to move the shaft from starting to end position of the brushes and the brushes rotates continuously based on the input power which it receives from the AC Motor to clean the overhead tank. The two types of rotary brushes are used to clean the overhead tank in horizontal and vertical positions. A shaft is used to hold the brushes in side view and bottom positions in which the adjustable springs with tension are used in between the brushes to adjust the size of the side view brushes as per the tank's space requirement. The 0.25 horse power electrical type single phase Ac motor is used to run the machine. The up and down motion of the shaft can be controlled with help of the microcontroller. The Microcontroller is used to set the total number of rotary motion of the shaft which is used rotate the brushes at the two ends of the machine. It is operated in a supply voltage range of (0-12) V ac. The vertical shaft is about length of 3.5 feet and the horizontal shaft is about length of 3 feet which is eight in number. The setup stand is made up of mild steel such that all the components are easily made to fix upon it. A series of brushes are placed in shaft of the rotor in which the pulley gives the required speed, such that the distance between each brush from center is exactly 40cm.

Selection of Motor

Two motors are used in the machine. The 0.25 horse power electrical type single phase Ac motor is used to run the rotatory brushes. Another 12V horse power DC motor is connected to the shaft to run the brushes and it is connected to the connecting rod to transfer the rotary motion into linear motion by means of reciprocating motion is achieved. This is used for up and down motion of the shaft which is the last step carried in the machine. The mechanism used is spring compression mechanism.

Selection of springs

A spring is an elastic object used to store mechanical energy. Springs are usually made out of spring steel. There are a large number of spring designs; in everyday usage the term often refers to coil springs. Small springs can be wound from pre-hardened stock, while larger ones are made from annealed steel and hardened after fabrication. Some non-ferrous metals are also used including phosphor bronze and titanium for parts

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requiring corrosion resistance and beryllium copper for springs carrying electrical current (because of its low electrical resistance).When a coil spring is compressed or stretched slightly from rest, the force it exerts is approximately proportional to its change in length (this approximation breaks down for larger deflections). The rate or spring constant of a spring is the change in the force it exerts, divided by the change in deflection of the spring. That is, it is the gradient of the force versus deflection curve. An extension or compression spring has units of force divided by distance, for example lbf/in or N/m. Torsion springs have units of torque divided by angle, such as N•m/rad or ft•lbf/degree.The inverse of spring rate is compliance, that is: if a spring has a rate of 10 N/mm, it has a compliance of 0.1 mm/N. The stiffness (or rate) of springs in parallel is additive, as is the compliance of springs in series.

Selection of Screw

A screw is a mechanism that converts rotational motion to linear motion, and a torque (rotational force) to a linear force. It is one of the six classical simple machines. The most common form consists of cylindrical shaft with helical grooves or ridges called threads around the outside. The screw passes through a hole in another object or medium, with threads on the inside of the hole that mesh with the screw's threads. When the shaft of the screw is rotated relative to the stationary threads the screw moves along its axis relative to the medium surrounding it for example rotating a wood screw forces it into wood. In screw mechanisms, either the screw shaft can rotate through a threaded hole in a stationary object, or a threaded collar such as a nut can rotate stationary screw shaft. Geometrically, a screw can be viewed as a narrow inclined plane wrapped around a cylinder.

Selection of Nut

A nut is a type of fastener with a threaded hole. Nuts are almost always used in conjunction with a mating bolt to fasten two or more parts together. The two partners are kept together by a combination of their threads' friction, a slight stretching of the bolt, and compression of the parts to be held together. The most common shape is hexagonal, for similar reasons as the bolt head - 6 sides give a good granularity of angles for a tool to approach from (good in tight spots), but more (and smaller) corners would be vulnerable to being rounded off. It takes only 1/6th of a rotation to obtain the next side of the hexagon and grip is optimal. However polygons with more than 6 sides do not give the requisite grip and polygons with fewer than 6 sides take more time to be given a complete rotation. Other specialized shapes exist for certain needs, such as wingnuts for finger adjustment and captive nuts (e.g. cage nuts) for inaccessible area. A wide variety of nuts exists, from household hardware versions to specialized industry-specific designs that are engineered to meet various technical standards. Fasteners used in automotive, engineering, and industrial applications usually need to be tightened to a specific torque setting, using a torque wrench. Nuts are graded with strength ratings compatible with their respective bolts.

C) Working

Firstly, whole water is removed from the tank. Detergent is then sprayed on the inner wall of the tank for easy removal of dirt. The whole system is inserted in retracted position into the tank. The four bar linkage is then adjusted according to the tank diameter in such a way that brush at end of the shaft touches the bottom of tank. Now the motor is switched ON. The four bar linkage starts rotating along with the shaft. This causes scrubbing of inner wall of tank by the brush attached to the ends of linkage. For cleaning upper portion of the tank the whole mechanism is reciprocated along the guide ways with the help of handle connected to the rack and pinion arrangement. In this way the tank gets cleaned within minimum time.

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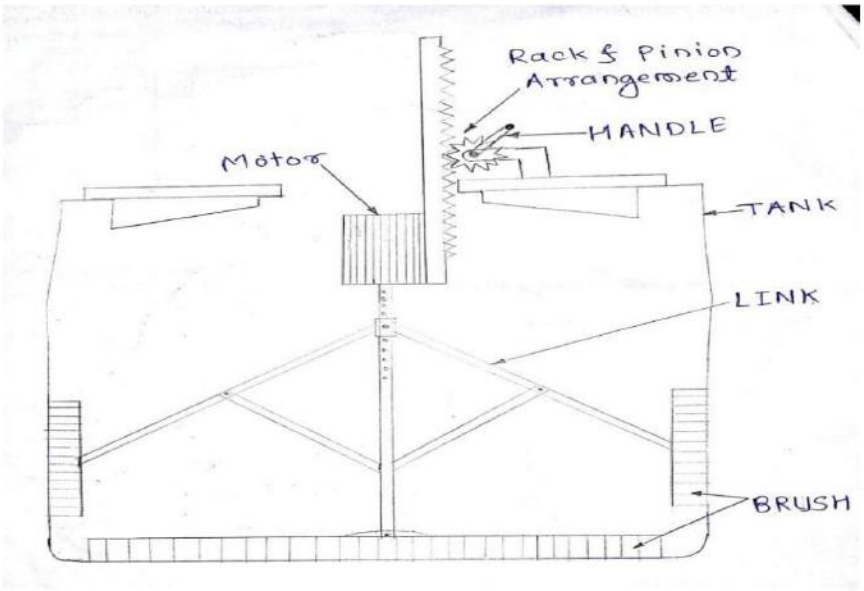

Fig. 6: Automatic overhead water tank cleaning system

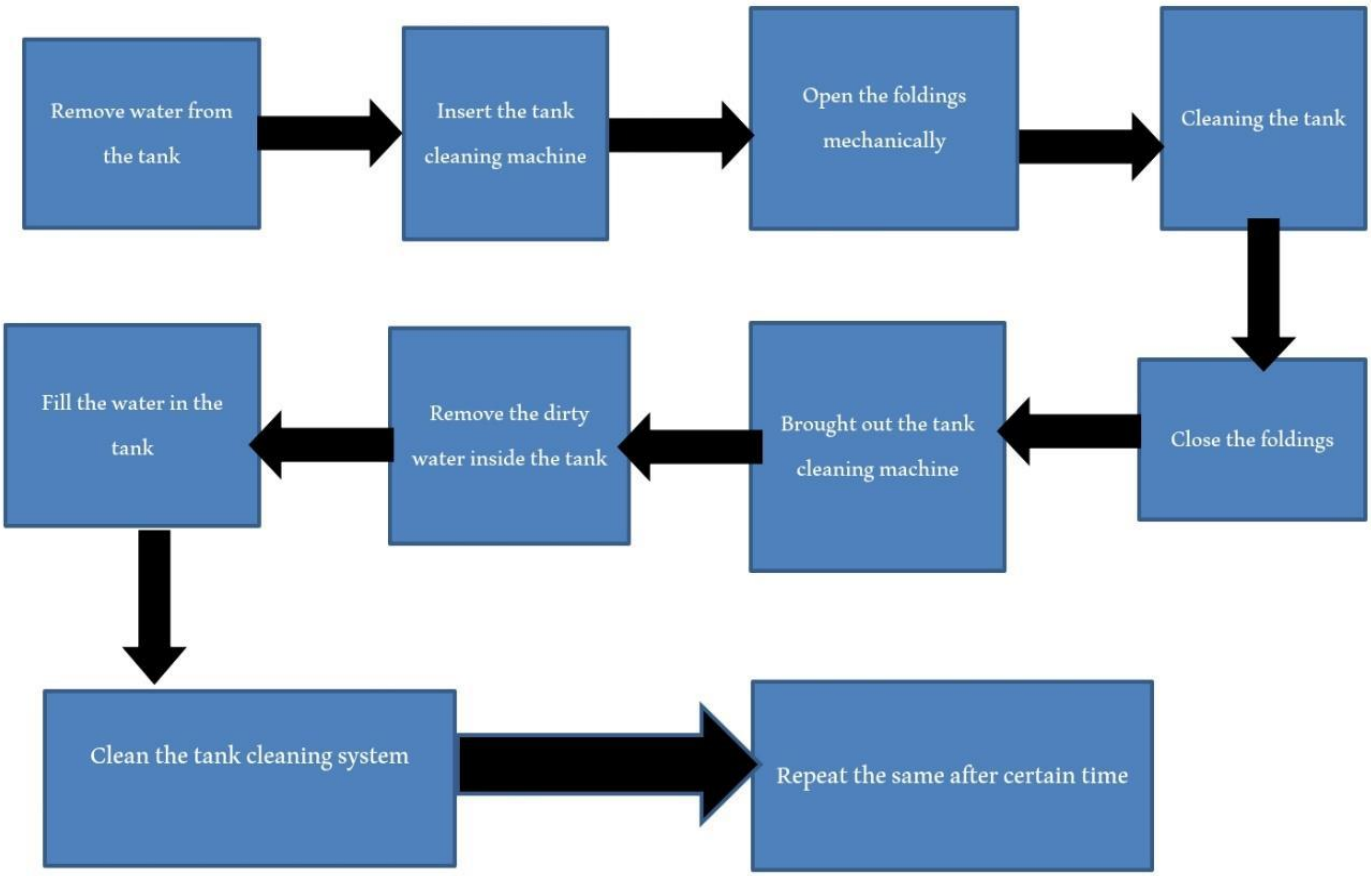

Fig. 7: Working flowchart

D) Proposed Approach

Software View

An animated design of the prototype has been made with the Solid works and Creo 2.1.0 version software's. An automated tank cleaning machine is a machine used to clean the overhead tanks such those found to store the water. Tanks must be cleaned from time to time for various reasons. The main reason is to clean the tank is allow to gets fungus. Thus the tank is to be inspected or maintenance to be performed regularly

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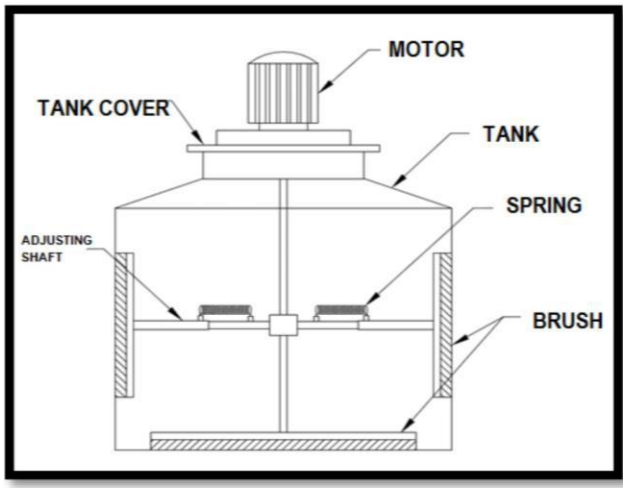

Fig. 8: Design of prototypes

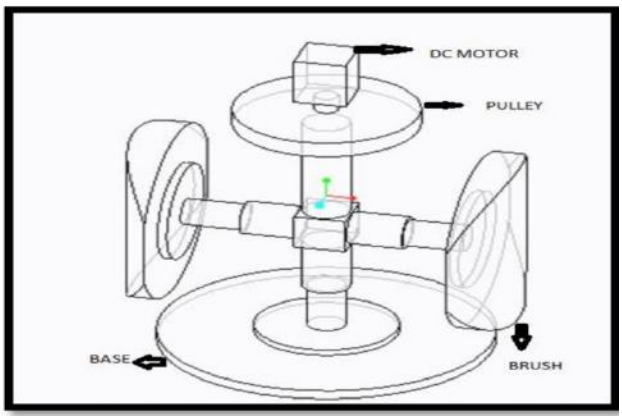

Fig. 9: The prototype

E) Details

Fabrication and Testing

Automated tank cleaning machines work in a manner similar to a wall cleaner. A D.C motor of about 12V which runs at 60rpm is used in this project to move the side shafts up and down continuously. An AC motor of about 0.25HP which runs at 1440rpm is used for rotating the shaft at the fixed speed. The shaft is mounted on the motor in the T- shape rod. The machine is attached at the top of the tank. Then the brushes are mounted at the three end of the shaft through a surface of the tank. A PIC Microcontroller and LCD display Timer is used to set the number of rotation times of brushes and movement of shaft.

After the complete setup, the motor rotates and the brushes rotate at the surface of the tank. A spring compression is mechanism is attached between the brush and shaft. Finally the water gets drain by the outlet of the tank. Portable water washing systems are widely used, but tanks that are cleaned frequently may have a fixed system installed.

V. EXPERIMENTAL RESULTS

An automated tank cleaning machine is a machine used to clean the overhead tanks such those found to store the water. Tanks must be cleaned from time to time for various reasons. The main reason is to clean the tank is allow to gets fungus. Thus the tank is to be inspected or maintenance to be performed regularly.

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VI. CONCLUSION AND FUTURE SCOPE

This section presents the conclusions drawn from the evaluation and comparison of experimental results. The section concludes with future scope.

Conclusion:

The water tank cleaner was used to clean the water tanks by using rotating brushes. This method was more effective and safe than the conventional methods. This method is capable to clean water tanks within less time and human efforts

Advanced model for tank cleaning system is cleaning the tanks thus making the operation user friendly. The working prototype is promising both in terms of imparting cleanliness and avoiding excess manpower. The future scope of the project is to extend it with auto feeding mechanism by which the manpower involved in feeding gets removed. Through the help of the auto feed mechanism it is easy to clean the tanks without excess man power. The project can be even extended to increase the cleanliness of the tank by insulating the frame and other components using stainless steel.

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Future Scope:

- This system is user friendly and time saving also the cost is less hence it can be used in the future water tank cleaning purpose.
- In future the advance system may also be invited like the vacuum cleaner type system that can clean the tank without removing the water from the tank.
- The system could be more compact and light weighted and more user-friendly and efficient by improvement in the design and using some other advance equipment.

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