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Design and Fabrication of Overhead Water Tank Cleaning Machine

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Abstract: Overall purpose for designing & manufacturing a machine was for cleaning overhead water tank. Since we have investigated that the general purpose OHWT which is used by (71%)[6] of people approx. needed to be cleaned more frequency than earlier days where sanitation is done manually twice or even thrice per year. According to our research and survey we found that, the quality of water provided by corporation to the public is decreasing day by day. Because of which dirt sediments, fungus and stains are getting integrated on the inside surface of the tank more frequently like every two months. Nowadays 8 out of 10 household have installed water purifier to the OHWT. As the sedimentation & the growth of fungi and bacteria are increased, we need to design & built a machine which can clean the water tank entirely from inside. First of all to remove the stains and algae we need brushes and along with that to provide less friction and better cleaning, integration of continuous flow of soap water via DC pump and nozzle are provided. This system will clean the tank efficiently and in less time as compare to current conventional techniques

I. INTRODUCTION

Regular cleaning of water tank can prevent contamination of water which can indeed improve the quality of water. There are certain appliances in most of houses which are connected to the overhead water tank and if regular cleaning of it is not done correctly then the damage to the appliances is inevitable.

So cleaning the overhead water tank is the most common issue in every single home. There are certain ways to clean the water tank which are implemented by various families like cleaning the water tank manually the person has to get inside the tank and has to clean it by himself which is a very hectic job to do and the efficiency of it is also not that satisfactory plus while cleaning there is a lot of effort required and the inner temperature of tank is not suitable for human beings as the tank is mainly made of plastic and is kept at the terrace where it is in direct contact with sun.

So in order to tackle all these problems an automated overhead water tank cleaning can be developed for the comfort of human .An automated overhead tank cleaning machine can help to improve the water quality which can prevent many water related diseases from happening .

The algae and fungus are the main concern when we speak about cleaning the water tank as the algae and fungus if not cleaned time to time then it will give water a foul odour and can eventually cause bacteria to grow in the water .These two can also be responsible for blockage of pipes, so in order to prevent all these problems an automated water tank cleaning machine can be used. The cleaning machine is designed for the cylindrical water tanks having the capacity of 500 litres.

II. METHODS AND MATERIAL

The following methodology was followed,

1) Study of the structure of water tank along with the sediments & the layer of finger over the surface etc.
2) Design of various components of machine.
3) Calculation of the forces and stress involved.
4) Analysis of the project design.
5) Purchasing of the required items for manufacturing.
6) Manufacturing of project
7) Testing.

A. Design Report

Sr. No.	Part Name	Dimensions/ Specifications	Unit
1.	Length of shaft	100	Cm
2.	Length of links	58	Cm
3.	Length of downside link	37	Cm
4.	Linear bearing	8	Mm
5.	Lead screw (dia)	8	Mm
6.	Hinges	-	-
7.	Battery	12v	-
8.	Dc motor	30	Rpm

B. Construction and Working

The machine consist of 3 main components in which 1st is motor, the motor used is dc geared motor which is having shaft speed 60rpm and torque of 30 kg-cm, the motor rotates the whole setup in both the rotational direction in clockwise and anticlockwise.

The shaft of the motor is directly coupled with the lead screw which is the 2nd main component of the mechanism, the leads screw travel from bottom to top & top to bottom and the brushes are attached to the supporting links which is the 3rd main component of the mechanism.

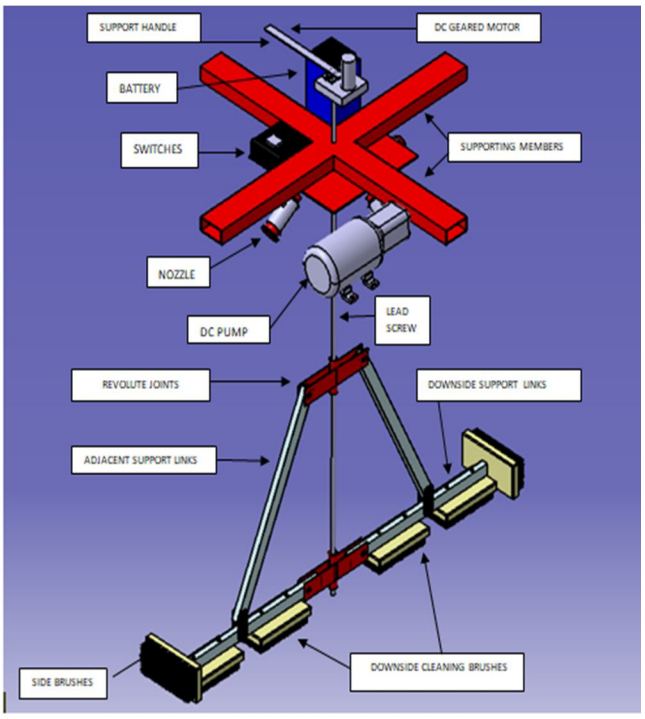

Fig (1) 3D Model on CatiaV5

An integration of four nozzles along with its connection to DC pump to wet the inside surface of tank to provide less friction between brushes and tank surface is done.

The brushes travel along with the supporting members and lead screw. This 3 main components are supported with the supporting members. According to the connection to battery the mechanism rotates, the direction is switched with the help of DPDT switch which is double pole double throw switch. This switch is having 2 inputs and 4 outputs 2 for clockwise and 2 for anti-clockwise. The motor has to be held physically to restrict the motion of motor corresponding to the lead screw.

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The brush are attached such a way that at bottom the brushes cleans the bottom surface of the tank and along with it will clean the inner periphery of the system, the brushes are mounted with graded screw with high strength. The mechanism having good stiffness in loading condition and have good efficiency of cleaning the tank.

The complete action of cleaning the tank i.e. keeping the inside surface of tank wet and action of rotating brushes is done at the same time , the control for rotation of brushes and discharge of water is done with help of two electrical switches .

The same DC pump is used to take out the sediment water which is at the bottom of the tank surface, by putting the suction hose inside the tank.

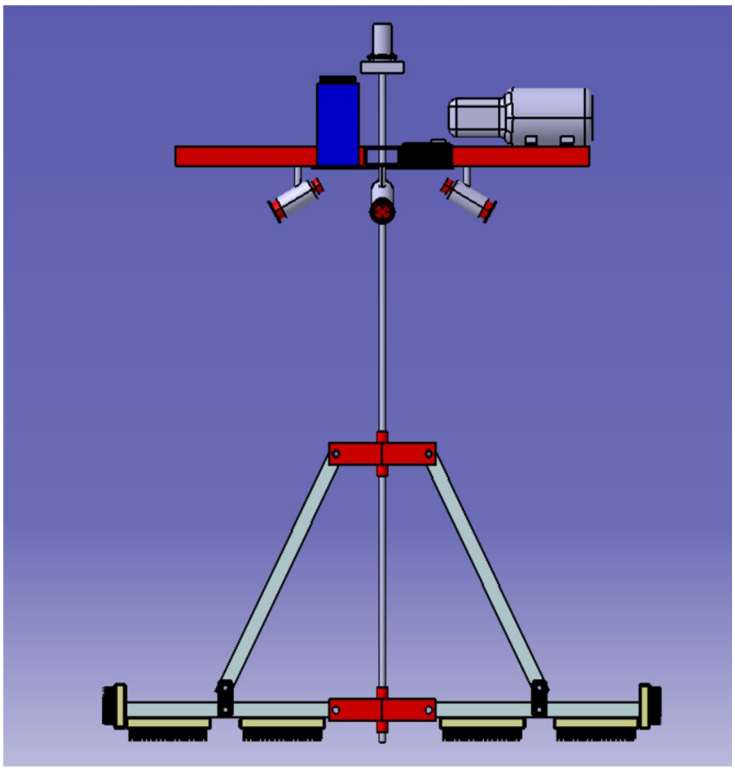

Fig (2) Side view of model.

III. CALCULATIONS

A. Force and Torque Calculations

1) Force Exerted By Four Brushes On Base Of Tank

F = 2 N on each brush.

Hence, on four brushes = 2 × 4 = 8 N.

F_B = 8N.

2) Force Exerted By Two Side Brushes On Cylindrical Wall Of Tank

F = 2 N on each brush.

Hence, on two brushes = 2 × 2 = 4 N.

3) Calculating friction Forces

Considering Static coefficient of friction (μ) = 0.4

Now,

$\mu = F_r / F_n$

Friction force due to base brushes:

$0.4 = F_r / 8$

F_r = 3.2 N

For each brush, $F_r = 3.2/4 = 0.8$ N

F_r = 0.8 N

Friction force due to side brushes:

$0.4 = F_r /4$
$F_r = 1.6$ N
For each brush, $F_r = 1.6/2 = 0.8$ N
$F_r = 0.8$ N

4) Friction Torque at side Brushes

T_{fr} = no. of brushes × (friction force × perpendicular distance from axis of rotation)
$T_{fr} = 2\times(0.8\times0.41)$
$T_{fr} = 0.656$ N-m

5) Friction Torque at base Brushes

T_{fr} = no. of sides × (friction force × perpendicular distance from axis of rotation)
$T_{fr} = 2 \times (0.8\times0.31+0.8\times0.11)$
$T_{fr} = 0.672$ N-m

6) Hence, Total Torque To Overcome Total Friction Torque

$T_t = 0.656 + 0.672$
$T_t = 1.328$ N-m

B. Calculations of Power Screw

1) Specifications of Motor

a) RPM = 50 with gear box.
b) O/p torque range = 16 kg-cm
c) No load current = 800mA (max)
d) Load current = up to 9.5 amp (max)

Data:-
Materials: 1) Screw = steel 2) Nut = bronze
Trapezoidal thread with n=1 i.e. (single start)
$2\theta = 30°$ i.e. $\theta = 15°$.
d = nominal diameter of screw = 15.5 mm
d_c= core diameter of screw = 13.5 mm
Pitch (p) = 2 mm

2) Assumptions

Coefficient of friction between screw and nut $\mu = 0.101$
For collar $\mu = 0.080$
Load = self wt + friction force at side brushes.
Load (W) = 8×9.81+1.6 = 81.6 N.
W = 81.6 N.

a) Mean Diameter

$d_m = d+d_c/2$
$d_m = 15.5+13.5/2 = 14.5$mm

b) Helix Angle

$\alpha = \tan^{-1}(n\times p)/(JI\times d_m)$
$\alpha = \tan^{-1}(1\times2)/(JI\times14.5)$
$\alpha = 2.5139°$

c) Virtual Coefficient of friction (μ_a)

$\mu_a = \mu/\cos\theta$
$\mu_a = 0.101/\cos15 = 0.1045$.
virtual angle of friction
$\phi_a = \tan^{-1}(\mu_a) = 5.965°$

i) step1) Effort to raise the load

$P_r = w\times\tan(\phi_a+\alpha)$
$P_r = 81.6\times\tan(5.965+2.513)$

P_r = 12.16 N.

ii) Step2) Torque required to raise the load:

$T_{tr} = P_r \times d_m/2$

T_{tr} = 12.16×14.5/2

T_{tr} = 0.08816 N-m.

iii) Step3) Torque required to overcome collar friction.

$T_c = \mu_c \times w \times R_m$

$T_c = 0.08 \times 81.6 \times (24 - 15)/4$

T_c = 0.01468 N-m

iv) Step4) Total torque

$T_t = T_{tr} + T_c$

T_t = 0.08816 + 0.01468

T_t = 0.1028 N-m

v) Step5) Power required:

Now,

Total required torque to overcome friction torque, torque to raise the load and to overcome collar friction,

$T_R = T_F + T_t$ = 1.328 + 0.1028

T_R = 1.4308 N-m

T_R = 14.59 Kg-cm

$P_R = 2ЛNT_R/60 = 2Л \times 50 \times 1.4308/60$

P_R = 7.49 watt.

IV. RESULT AND DISCUSSION

Result was taken in the form of working time:-

Method of cleaning	Time required for cleaning the tank.
1) conventional manual cleaning	90-95 (min)
2) water tank cleaning machine	50 (min)

Table no.4.1.1

Since, the working time of our water tank cleaning machine is less than the conventional method it has proved to be more efficient, less time consuming and as per our survey our machine is more cost effective than commercially available machines.

V. CONCLUSION

This water tank cleaning machine is easy to operate as compared to manual cleaning. The weight of this machine is less. This method is more effective and safe than the conventional methods. The brushes used for cleaning are durable and has a long life and if in case they gets damaged they are easy to replace and a person with a nontechnical background can also replace them. The remaining parts of the machines are also easily available and if any case any part of machine dis-functions they can be easily replaced. The design of the machine is such that, it can be easily operated by a quick tutorial of the machine. This method is capable to clean water tanks within less time and less human efforts. 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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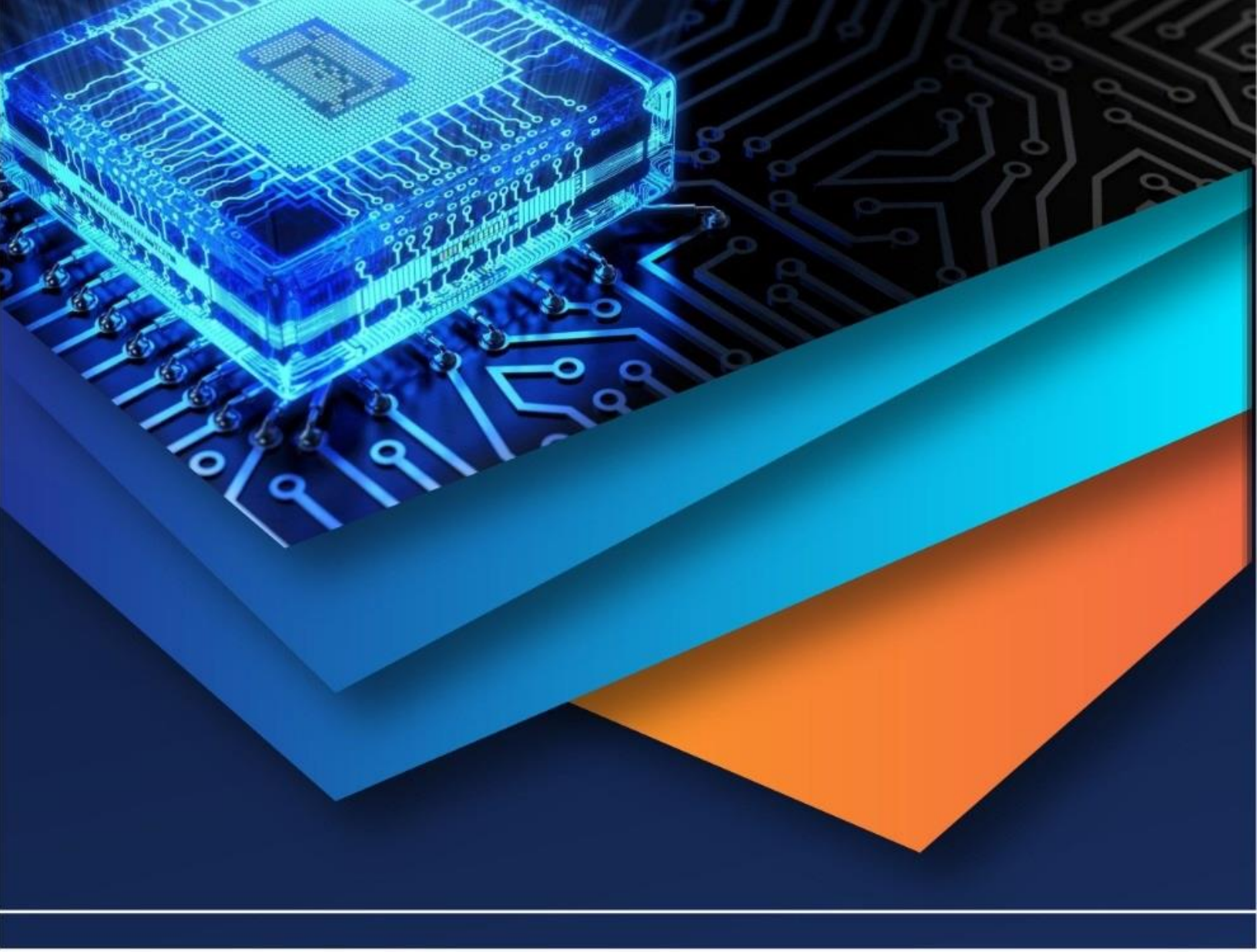

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