Design and Fabrication of Water Tank Cleaning Machine

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Abstract: ***This paper proposes to design and develop a machinery for cleaning domestic rectangular water tanks. It is known fact that cleaning of water tank is a meticulous and labor intensive task. It is very important to regularly clean and maintain the water tank to keep the water borne diseases from spreading. The water in storage units are used for both domestic and industrial purposes. The presence of toxic substances in water can also cause skin diseases. This can be avoided with the use of an efficient tank cleaning system. The system consists of a machine designed with a movable body and an extendable shaft mechanism supporting a rotating brush. The movement of shaft and brush scrubs the walls of the tank. A sprinkler mechanism rinses the sediment deposits from walls of the tank and additionally a vacuum device ingests the sludge from the floor of the tank. The object of this machine is to reduce the overall time and effort invested in the cleaning of water tanks.***

Index Terms: Extendable Shaft, Rotating Brush, Rectangular Water tank, Shaft mechanism, Sprinkler, Vacuum Device, Water Tank.

I. INTRODUCTION

Every day the water stored in the tank is used for Domestic and industrial purpose. The vessel used to store water for various purposes can be made of plastic fiber glass, Concrete and stone, Steel and can be oblong or cylindrical inch.
Over the period of time residues sludge and scale deposition gets formed on the inner walls and floor of the tank. The sediments contaminate the water make it unfit to use. Bacterial growth in water can cause infection and can spread diseases.Hence, Cleaning and maintenance of water tank t regular is absolutely necessary. The traditional methods of manual scrubbing has become redundant and are labor intensive.Therefore in this pare alternative efficient method has been attempted with the aim of reducing human effort involved in cleaning the water tank.

II. DESIGN AND EXPERIMENTAL WORK

A. Calculations

The parameters and specification for various moving components and parts of the machine were first calculated for preparing an optimal design of the product. Calculations for wiper motor and dc servo motor drive has been performed to predict driving force of the motor, shafts and brush. Similarly, the water jet force and pressure has been calculated to predict the intensity of water stream produced by the water motor. Also, the vacuum pressure of the suction device has been calculated, using which the machine would ingest sludge and sediments from the floor of the tank for complete and efficient cleaning.

1. Force of Wiper Motor

Voltage = 12V, Current = 5 amp,

N = 60rpm, Pulley diameter = 2.5 inch,

r = 0.03m

Power = 12*5

Power = 60W

Power = 2πNT/60

60 = 2π (60) T/60

Torque = 9.54 Nm

T = F*r

9.54 = F*0.03

Force = 318N

2. Force of DC Servo Motor

Voltage = 12V, Current = 1 amp

Power = 12V, N = 100 rpm

Power = 2πNT/60

12 = 2π (100) T/60

T = 720/628.31

Torque = 1.14 Nm

Length of the Brush = 20 cm

T = F*r

1.14 = F*0.1

Force = 11.8 N

3. Output power, Pressure, Jet force of Water Motor

Voltage = 12V, I = 0.35 Amp

Qmax = 280 L/H, Size = 4.5cm x 2.5cm

Head = 2.2 m, D1 = 0.007 m

D2 = 0.0085 m

Input power = 12 x 0.35

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I/p = 4.2W

Theoretical velocity = √2gh

Qth = π/4 (0.007)2 x √2 x 9.81 x 2.2

Qth = 0.000252 m3 / s

For nozzle, coefficient of discharge (Cd = 0.9)

Qact / Qth = Cd

Qact = 0.9 x Qth

Qact = 0.002268 m3 /s

Qact = π/4 (0.007)2 x V

0.002268 = π/4 (0.007)2 x V

Vact = 5.89 m/s

P1 / 1000*9.81 = (1.0132*105 / 1000*9.81) + ((5.89)2 / 2*9.81)

P1 / 9810 = 10.3282 + 1.7682

P1 = 118504.8 pa

P1 = 1.185 bar

Jet force F = ρav2

a = π/4*(0.007)2

F = 1000 * (π/4*(0.007)2) * (5.89)2

F = 1.33N

Maximum power = ρ x g x Qth x H / 1000

1000*9.81*0.00252*2.2 / 1000

54.38664 / 1000

Max power = 5.43 x 10-3 Kw

4. Suction Pressure

Power = 100w, Speed, N = 3000 rpm = 4.71 m/s,

24 Voltage = 12V,

radius of nozzle = 0.015m

Dimension of tank assumed = 1.2 x 1.2 m

Sludge thickness assumed = 0.02 m

Volume = 1.2 x 1.2 x 0.02

Volume = 0.0288 m3

Mass of sludge = 1.5 kg

ρ (density of the sludge) = 52.08 kg / m3

Atmospheric Pressure = 101.3 kpa

Absolute Pressure = 96.3 kpa

Patm = Pabs + Pvaccum

Patm - Pabs = Pvaccum

Pvaccum =101.3 – 96.3

Pvaccum = 5 kpa

Bernoulli's Equation

P1 = 101.3 kpa

P2 = 96.3 kpa

101.3 / 52.08 = 96.3/52.08 + v2 2 /2

5/52.08 = v2 2 /2

10/52.08 = v2

v2 = √0.1920

v2 = 0.438 m/s

B. Design

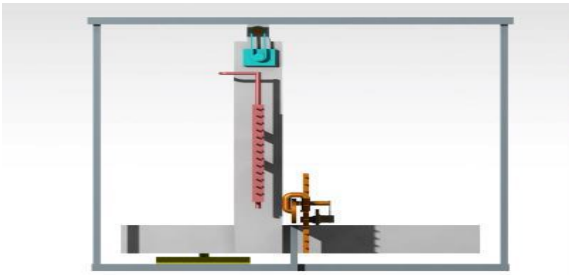

Fig.1. (Machine Design)

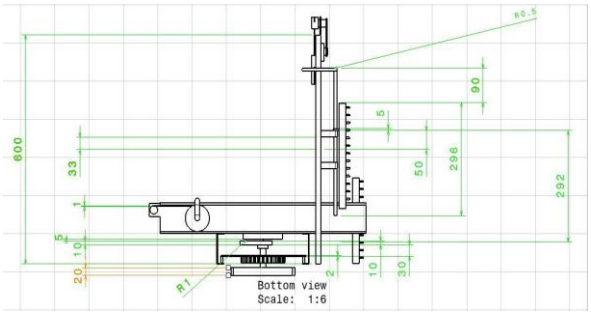

Fig.2. (2D View)

The design was developed using CatiaV-5 software. It depicts machine Developed for cleaning rectangular water tanks. The entire mechanism is controlled using wiper motor drives. The wiper motor pulley drive enables the slider to extend in both horizontal and vertical directions, providing motion in all 3-axis. The extending shaft consist of a rotating brush mounted to it. The combined reciprocating motion of the shaft and rotating motion of the brush scrubs the walls of the tank. The frame is fitted sprocket wheel bae. It enables machine to move in the tank floor. A sprinkler mechanism is fitted to rinse the walls of the tank during scrubbing process and after scrubbing the vacuum device ingests the sludge from the floor of the tank. Hence completely cleaning thee tank through this process.

III. WORKING PRINCIPLE

The water from the tank is first pumped out. Once the tank has been emptied, the cleaning machine is gradually placed inside the tank through the tank opening passage. The machine consists of a scrubbing mechanism positioned towards the face of the tank, which is to be cleaned first. The scrubbing mechanism has an extendable shaft system supporting a rotating brush.

The brush mounted on the shaft is rotated at a speed of 100 rpm

The shaft holding the brush is driven by a 12volt wiper motor-pulley mechanism, which provides the brush with a reciprocating motion in both vertical and horizontal direction. The combined rotary and reciprocating, motion of brushes makes the scrubbing of the walls possible. The machine is controlled by a 3 way DPDT switch box. After scrubbing one wall (edge to edge), the machine can be positioned to clean the other faces of the tank respectively.

A sprinkler system has been installed in the machine, which sprays pressurized water with a pressure of 120 bar simultaneously during the scrubbing of the walls. Thus, the scales and sludge after scrubbing and rinsing with water gets collected at the bottom of the tank.

There is a suction mechanism provided at the lower end of the machine, which absorbs all the waste from the floor of the tank to a storage placed outside of the tank. The suction mechanism installed absorbs the sediments from the tank floor at a designated pressure. This procedure can be repeated for two to three cycles for complete cleaning of the tank, with reduced time and effort. The entire tank can be cleaned efficiently with minimum human interference.

IV. SELECTION OF PARTS

Table.1. (List of Parts)

S.NO	COMPONENTS	QUANTITY
1.	DPDT SWITCH BOX	1
2.	WIPER MOTOR 12V	4
3.	CHAIN SPROCKET	1
4.	SQUARE PIPEGRADE12 (MS)	2
5.	SMPS(230V TO 12V)	1
6.	DC SERVO MOTOR 12V	1
7.	BALL BEARING	2
8.	BRAKE CABLE	2
9.	ACRYLIC WIRE BRUSH	1
10.	PULLEYS	4
11.	VACCUM CLEANER	1
12.	WATER MOTOR	1

The table depicts all the moving parts and materials is used in the construction of the machine. The parts allow the machine to be fully functional and to move and clean the tank with minimum human interference.

V. FABRICATION

At the initial stage of fabrication process the frame structure of the machine has been made using square pipe Grade – 12 of mild steel material. Mild steel has been used considering its ductility and hardness. The long mild steel pipes were cut into desired dimensions after which the pipes were welded together using welding process after the completion of welding, a frame of 600mm and height 900mm is obtained.

- The base of the frame is fitted with an axle to which a pair of wheel is mounted on either side of the machine. Gear sprocket has been assembled centrally to this axis which provides linear and rotating motion to the wheel of the machine.
- Two pair of mild steel rods has been welded on the base and front of the machine. Slider pulley mechanism is mounted over the rods. This allows the scrubbing system to move in all 3 axes, such that the shaft can be extended from rear end of the machine and can be further extended in both vertical and horizontal direction. The pulleys are driven using 12 V wiper motor and brake cables passes over the pulley this allow the shaft to provide reciprocating motion to the brush.
- An acrylic brush is mounted to the moving shaft of the scrubbing system. The brush is rotated with a 12V Dc servo motor which rotates the brush at a speed of 100 rpm.
- The top end of the frame is attached with 9 V water motor which enables the sprinkler to spray water at 2 bar from the water stored in external container.
- The vacuum cleaning machine of 60 W power has been attached to the machine. After scrubbing and rinsing the walls of the tank. The sludge gets collected to the floor of the tank. The vacuum attached to the machine ingests all the sediments and sludge from the floor up-to 20 mm thickness. After all the working components of the machine have been added the machine covered with sheet metal of 1 mm thickness. The base of the machine is covered using foam sheet. The entire machine has been wired to DPDT switch and SMPS has been used to convert voltage from 230V-12V power input for control mechanism.

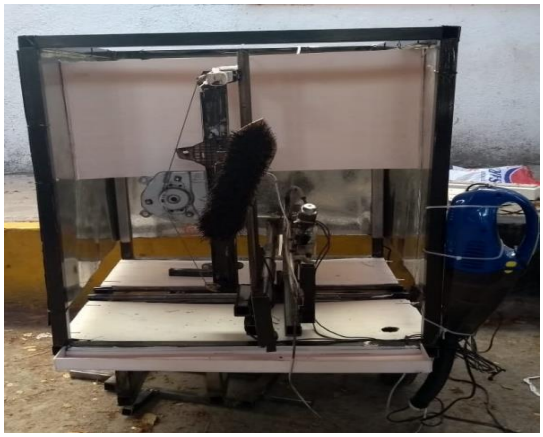

Fig.3. (Front View)

Fig.4. (Side View)

VI. RESULTS AND DISCUSSION

A. Testing results

The testing of the project has been carried out in different stages. At first the system was designed for circular tanks but according to the need and considering economic factors the systems has been modified for the cleaning of rectangular and square shaped tanks. The system has been tested and cleaning operation has been improved to have a linear motion due to which larger sludge covering area of the walls can be cleaned. Once the cleaning operation starts it involves one wall at a time completely, a sprocket mechanism is involved for turning of the machine for cleaning the next face of the tank. Through the repeated cleaning of the wall we came to know that the sludge cannot be removed completely thus a suction mechanism is involved at the bottom for complete removal of the sludge from the tank. After cleaning the sides and bottom of the tank the drain water supply is used for final washing of the tank.

The cleaning mechanism of the machine has been tested and it is predicted that

→The time taken by machine to clean the entire 4 surfaces of the wall through scrubbing mechanism is estimated=22 mins.

→The suction mechanism which is implemented can absorb the sludge at a time = 76 mins.

→Hence the total time taken for the machine to clean the entire tank is = 1hr 36mins.

VII. CONCLUSION

The tank cleaner developed uses rotating brush to clean the walls of the tank. This new method is more effective and safer than conventional process. The mechanism utilized for the motion of components, which serves the cleaning purpose, are simple in construction and easy to replace in case of failure. The utilization of automated tank cleaning machine avoids the health problem of labourers due to suffocation while inhaling the toxic cleaners during the process. The machine has been extensively tested and redesigned for the purpose of meeting modern standards of tank cleaning process. Thus, the design of our project is highly capable of conserving both human effort and time invested in the cleaning tank

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