DESIGN AND FABRICATION OF AUTOMATI TANK CLEANER

Dr.Kurian John[1], Vasid Ahammed A P[2], Mishab P[3], Labeeb M C[4], Muhammed Sahal M[5]

[1]Assistant Professor, Department of Mechanical Engineering, Mar Athanasius College of Engineering Kothamangalam, Kerala, India.

[2,3,4,5] U G Scholars (Bachelor of Technology), Department of Mechanical Engineering, Mar Athanasius College of Engineering Kothamangalam, Kerala, India

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Abstract - Tanks on rigs, water supply vessels must be cleaned periodically to avoid contamination. Until now, tank cleaning has typically involved laborers equipped with hoses, pressure washers, shovels, and squeegees. The cleaning process undertaken by manual labour at present is very ineffective due to adverse conditions caused by temperature, toxicity of air and also the limited accessibility of labour to every part of the vessel. In order to overcome the above problems we need a alternative method for efficient cleaning. So we are introducing a suitable solution AUTOMATIC TANK CLEANER. The technology employs tank-cleaning machines (TCMs) that are optimally positioned inside the tank. With the help of a powerful water jet and linkage mechanism for jet guidance, irrespective of shape and size of tank the cleaning process can be completed with less water wastage. After the cleaning process waste water along with the dirt are removed using a pump. The main components of ATC are jet guidance mechanism, compressor and pump. There are problems associated with domestic and industrial storage vessel hence this study introduce an innovative water jetting equipment. While this usually eliminates the need for an operative to enter the tank, in those rare cases where a person is required to enter the tank, Unlike other methods of tank cleaning, high-pressure water jets are capable of efficiently and effectively cleaning tanks of all shapes and sizes in next to no time. This method of industrial tank cleaning creates a minimal level of vibration, removing the need for time-consuming and often expensive scaffolding to be erected around the tank when cleaning commences. This time and money-saving feature reduces the downtime experienced and thus enhances business efficiency

*Key Words***:** Water jet, Cleaning, Mechanism, Compressor, Labour, Efficiency, Tank.

1. INTRODUCTION

Storage vessels must be cleaned periodically in order to avoid contamination and safe storage of goods and other products. Importance of storage vessel cleaning in some sectors are mentioned below.

1.1 Industrial Tank Cleaning Process

There are a number of reasons why businesses and industries require a tank cleaning service. Other than the regular care and maintenance of equipment that respected, professional companies carry out as standard business practice, there is often great economic and budget benefit to improving the lifespan of tanks or re-purposing and redeploying an existing tank for another use. Unknown conditions inside the tank can make it difficult to formulate a plan ahead of time. Petroleum storage tanks pose both a flammability and toxicity hazard that must be recognized and managed to ensure there are no actual or potential atmospheric hazards that can affect the entrants. The product isn't draining properly, it should drain towards the sump (a low point usually for water to drain into at the bottom of the tank). Safety risks: you must ensure appropriate personal protective equipment (PPE) is worn and that the tank has been properly ventilated. Activities in adjacent areas could affect confined space conditions. Weather conditions, both extreme heat and lightning storms can present extra danger.

1.2 Domestic Water Tank Cleaning

Water is undoubtedly the most important part of our lives and is something one cannot do without. Not only does it quench our thirst but is also important as far as cooking, personal hygiene and cleaning is concerned. While it is true that water replenishes us, removes toxins from the body and helps us in uncountable ways but at the same time, a lot of diseases are also caused if one consumes water in its impure form. This is why it is important that the water that we drink or cook food in is absolutely clean and pure. This is why it is very important to clean the water tanks installed in our houses and workplaces on a regular basis

2. LITERATURE REVIEW AND OBJECTIVE

2.1 Literature Review

Vishwes vasadi et al This paper explains about a new method used for oil tank cleaning controlled by PLC programming it also explains the advantage of using this method over conventional method. Surveying in lot of companies they found that small scale industries automated tank cleaning process is not used. Still they are using conventional method.

Bhaghat et al this paper describes about the use of water jet in cleaning process. It also explains the jet dynamics. Which means The water may leave the nozzle as a coherent jet but as it travels towards the wall it will tend to break up due to the Rayleigh instability.

Guha et al this paper experimentally, numerically and theoretically investigated the water jet cleaning process. Very high speed water jets (~80-200 m/s) are typically used in such cleaning operations. These jets diffuse in the surrounding atmosphere by the process of air entrainment and this contributes to the spreading of the jet and subsequent decay of pressure. Estimation of this pressure decay and subsequent placement of the cleaning object is of paramount importance in manufacturing and material processing industries

2.2 Objective

To design and manufacture an automatic tank cleaning machine based on slider crank mechanism by using water jet, which would reduce the labor related to storage vessels cleaning process and minimize the hazards involved in cleaning such as chemical hazard, physical hazard, fire and explosion, exposure to toxic gases, oxygen deficiency.

3. METHODOLOGY

3.1 Cad Modeling Of The Mechanism

Computer-aided design (CAD) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. By choosing the optimum mechanism for the cleaning device the CAD model of the device is created with suitable dimensions obtained through engineering drawing.
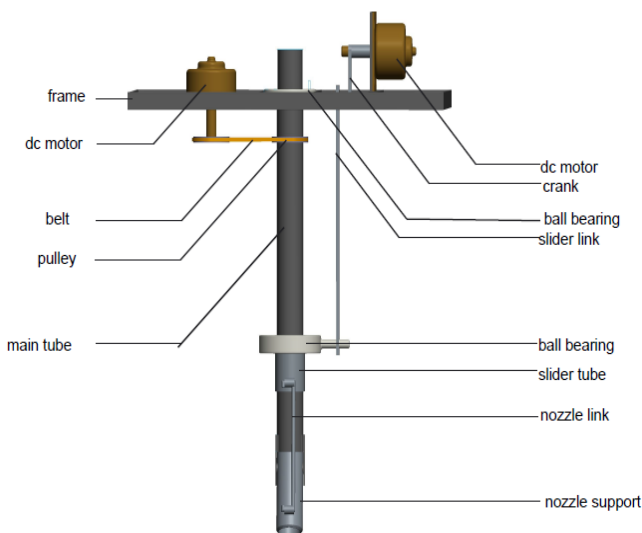
Figure-1: Components of the Tank Cleaner

Figure -2: CAD Model Of The Tank Cleaner

3.2 Calculations

Calculation for nozzle diameter

P1-Inlet pressure at the nozzle=120bar

P2-Outlet pressure of nozzle=1.01325bar (Atmospheric pressure)

V1-Inlet water velocity, (nearly equal to zero)

V2-Outlet jet velocity=?

According to Bernoulli's theorem

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Zg = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Zg$$

Where, ρ -Density of water=1000kg/m3

Z-Datum

g, acceleration due to gravity=9.81m/s2

4.3.2 To find the jet velocity:

1bar= 10^{5}Pascal

$$\frac{120\times10^5}{9.81\times1000} = \frac{1.01325\times10^5}{9.81\times1000} + \frac{V_2^2}{2\times9.81}$$

From this ,

V2=154.26m/s

mass flow rate, m = 0.0971 kg/s

m= ρav2 kg/s

m = 0.0971 kg/s

a=Area of the nozzle orifice

By solving , a=6.291×10-7 m2

Diameter of nozzle orifice=8.957×10-4m

Force calculation

Force acting on the nozzle body , $F=\rho a v2$ N

$F=1000\times6.291\times10\text{-}7\times154.262$N

$F=14.97$N

Torque calculation

Torque of motor required to provide reciprocating motion to the slider , $T=f\times l$ Newton.

Total force on the crank of the motor $f=(m1+FR+RN)$

Where;

m1 = weight of the components connected to the slider

=2kg×9.81m/s2

=19.62 N

FR =Frictional force on slider

=Weight of the components on slider ×coefficient of friction between slider and main tube

= 2×9.81×1.2 N

=23.544 N

Coefficient of friction for metal to metal contact is 1.2*

RN = Reaction force on slider

=14.97×COS(45)

=10.5 N

f=[2×9.81+2×9.81×1.2+14.97cos(45)] N

f=53.664N

l=0.04 m

Hence torque, T=53.664×.04 N

T=2.1465 Nm

Power Calculations For Motor

Power of the motor, P= T×ω Watts.

Where ;

T =Torque of the motor.

ω =Angular velocity of the motor.

T =2.14656Nm

$\omega = (2\times\pi\times N)/60$ rad/sec.

N=Speed of the motor

=60 rpm

ω=6.283 rad/sec

Power, P=2.1465×6.283 W.

Power,=13.48 Watt

3.3 Analysis Of The Designed Components

Analysis Of Slider-The various forces acting on the slider during the working is obtained from calculations and its maximum value is found to be 53.66 N .During analysis this force is applied at one end of the slider after fixing a reference. The direction of force acting on the slider is given to the software. The results of analysis shows the maximum shear stress acting on the slider is 4.1196 MPa . The shear strength of mild steel is 125 MPa . So it is found to be the current design and material selected is safe under shear stress.
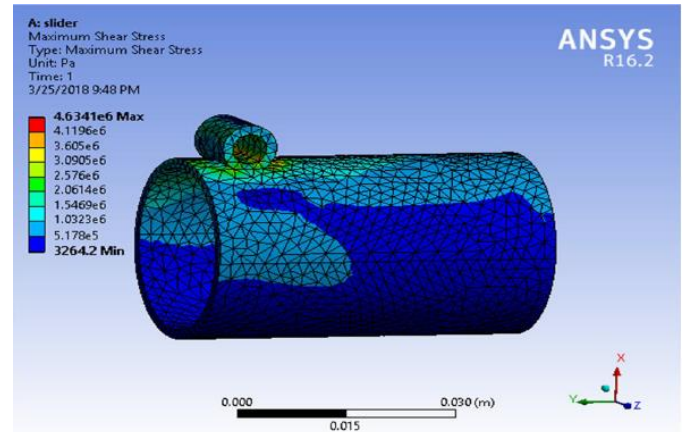

Figure -3: Analysis Result of slider

Analysis Of Nozzle Holder-Reaction forces acting on the nozzle holder is obtained from calculations and its maximum value is found to be 14.97 N and its direction is opposite to jet directions. So the analysis is done for the maximum reaction force. After choosing suitable reference the reaction force is applied to the nozzle body in the opposite direction of water jet .So that the maximum shear stress that will develop on the nozzle holder is found to be 1.6 MPa. The maximum shear stress for galvanized iron is 225 MPa.so the design and hence the material is safe.
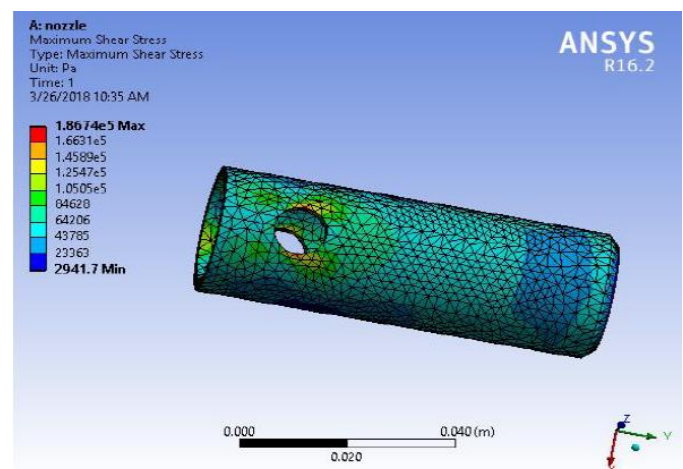

Figure-4 Analysis of nozzle holder

Analysis Of Main Tube-The slider have to slide smoothly over the main tube. So any deformation to the main tube will affect the smooth sliding of the slider tube. It will affect the entire mechanism. So it is important to analyze the deformations of main tube . The forces acting on the main tube is due the weight of components connected to it. After selecting suitable reference the force is applied on the main tube and the results of analysis showed a maximum deformation of 6.23×10^{-5} m. which is very negligible. So the design is safe.
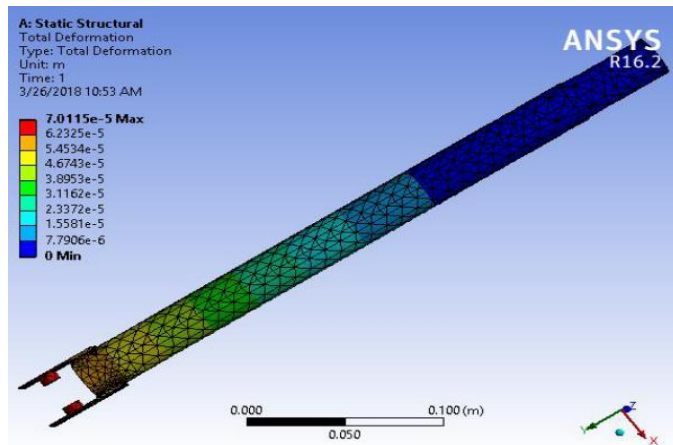

Figure-5 Analysis Result of main tube

3.4 Fabrication

Main Tube:

Main tube is the component which connect the nozzle body with frame and it provides a guidance for slider motion. The main tube rotates 360 degree to cover the entire portion of the tank. material selected for the main tube is galvanized iron pipe, because of its availability and corrosion resistant characteristics. The GI pipe of 3/4 inch turned into 25 mm diameter for a length of 50mm in a lathe from one end to fit the Ball bearing (6205). Then the length of main tube is made to 600mm using a metal cutter tool. The edges of the main tube is ground in order to avoid sharp edges.

Slider:

Bush tube is used as the slider in order to minimize the play while reciprocating over the main tube. Bush tube of inner diameter 27mm and outer diameter 35mm is used. The outer diameter is turned to 30mm to fit the Ball bearing (6206). Length of the bush tube is made to a length of 50mm. The sharp corners and edges are ground for safe handling of the component. A ring of 5mm inner diameter and 8mm outer diameter with 4 mm width is welded to the outer surface slider at a distance 15mm from one end to support the link connecting slider and nozzle body. Ball bearing (6206) is fitted at the other end of the slider and a rod of diameter 10mm and length 40mm welded on outer face of ball bearing.

Nozzle Support:

Galvanized iron pipe of diameter 3/4 inch is used as nozzle support. It's length is made to 75mm using a metal cutter and welded with main tube by a hinge. A ring of 5mm inner diameter and 8mm outer diameter with 4 mm width is welded to the outer surface slider at a distance 15mm from one end to support the link connecting slider and nozzle body. The sharp corners and edges are ground for safe handling of the component.

Frame:

Mild steel angle of 20mmx20mmx3mm is used for construction of frame supporting the main and auxiliary components. It is made to a length of 250mm and 6 of them are welded to form the main frame body. Tracks are welded to fit the DC motor which gives the rotation to the main tube through a belt and pulley drive. A plate of 70mmx50mmx2mm is welded on the frame and the DC / stepper motor which gives the reciprocating motion to the slider is bolted to the plate.

Hinge:

Mild steel flat of 32mmx3mm and a length of 100mm is taken to make the hinge. It is made to 50mm length using a metal cutter and sharp edges are grounded for easy handling. Rectangular piece of 30mmx10mmx3mm is removed from both corners of first flat. Then the remaining portion forged to a round shape. A rectangular piece of 30mmx10mmx3mm is removed from the middle portion from one edge and the remaining portion is forged to form a round shape. Both pieces are locked with a pin to form a hinge joint. One end of the hinge is welded to main body and the other end is welded to nozzle body.

Connecting Links And Crank:

Mild steel flat of 20mmx3mm cut to a length of 270mm and drilled a hole of 8mm at a distance 15mm from both sides. The sharp edges formed during cutting and drilling process are grounded for safe handling. For the link connecting slider and nozzle support a rod of diameter 5mm and length 150mm is used and its end is twisted to form a hook. A crank of length 40mm is bolted to the DC motor shaft to convert reciprocating motion to rotating motion.

Pulley:

The inner diameter of the pulley fitted over the main tube enlarged from 15mm to 26mm using a drilling machine and it is fitted on the main tube at a distance 70mm from top end. The other pulley fitted to second DC motor's shaft.

Assembling Process:

The main tube is fitted over the frame through Ball bearing. Both DC motors are bolted on the frame over respective positions. Belt is positioned in the groove of the

pulley and necessary tension is maintained in the belt by adjusting the position of DC motor over the rail. The links are connected with slider and crank of the DC motor. Then the nozzle body and slider is connected with link of 150mm length. Reinforced flexible rubber pipe of length 1500mm is connected to nozzle and the other end is connected to rotary union. Joints are tightened with hose clamp to ensure no leakage and pressure loss. Nozzle is fitted over the nozzle body and tightened. The other end of the nozzle is connected to compressor inlet by a flexible reinforced rubber pipe. The necessary provision for holding the frame over the tank is provided.

Figure-6 Fabricated Model

4. CONCLUSION

In order to overcome the difficulties of cleaning the storage vessels by manual method we Investigated and studied about an automatic tank cleaning mechanism. It is difficult to clean the water tank by conventional methods which require a lot of human labour. By implementing newly developed method it requires less time and human effort for cleaning any kind of storage vessels. So an automatic system of overhead tank cleaning is designed to provide high safety, high efficiency, less time for cleaning and to avoid environmental pollution problems. Purpose of this project is to clean domestic and industrial storage vessels with the help of powerful water jet as cleaning agent and a guiding mechanism for jet path is provided with suitable mechanism. During the testing periods the equipment performed smoothly and the objectives of the project achieved successfully. For example when we consider cleaning the domestic water tanks it takes more than one hour to clean the tank and it is a labour intense process. By using this device the time required for the whole process can be reduced to less than 15 minute according to the storage capacity of the tank. Since cylindrical storage tanks with difficult access to the interior space are common in domestic purposes so this

project have a significant importance in the current scenario. By using more advanced techniques and resources, the mechanism can be modified and developed according to the required applications.

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