Original Article

Design and Development of Tank Cleaning and Inspection Robot

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Abstract

The vessels or ship tanks or water drums or oil tanks have to be inspected regularly to avoid the wastage of the minerals or components stored inside it, which might sometimes be hazardous to the outside environment. Also, the majority of vessels worldwide will have to switch to carrying new fuels as per the company's requirement. To accomplish these tasks, proper cleaning of ship tanks is essential. Here our device comes into play. It is designed in such a way that it can clean as well as inspect the vessels thereby reducing the complexity that was involved in the conventional methods. The main aim of the device is to terminate the human risks and inflate the efficiency. Our device is capable of meeting the ever-growing demands of the companies by keeping the vessel clean and convincing.

Keywords: Tank Cleaning, Tank Inspection, Pipeline Cleaning and Inspections, Thermal Camera.

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INTRODUCTION

Increased consumption of money in labour is one of the major issues that every company or industry is facing. When computers have arrived, people thought that this issue will be solved, but the growth of science and technology is going on parallel with the rise in the needs of the customer or people in general. We made rockets that can fly out of the earth but still we opt for humans to get into large pipelines, chemical storage tanks, etc., for cleaning and inspections. Some products and robots are made to work under these types of circumstances, but still when it comes to cost, they are quite high. Cost is a major issue that compels the organization to send humans inside these tanks and pipelines. The Health and Safety Authority says, in the year 2010 alone nearly 45 crew members were met with an accident while entering the tanks for inspection. Also, we know that "To err is human", and the observations made verifies it. The amount of oil on total released due to leakage in 2018 alone was approximately 116,000 tonnes.

We here use the mode of work to besemi-automatic. The problem with the manual process is more time-consuming and problems on employee's health. And the problem with a fully automatic process is its cost. The cost of the computer boards and controllers are not that cheap enough for all the companies to afford, and if there is a problem or error on working then again lots of money are spent on it. So, we chose a semi-automatic working process. We use a simple mechanism to save the lives and happiness of many labours and their families. A shaft is made to rotate with the help of the motor, vertically. This shaft must be rotated such that, the axis of rotation of the shaft must coincide with the central axis of the drum or tank to be cleaned. A retracting mechanism is used to retract the rotation of the shaft after a certain angle, this is to avoid the tangling of hose pipes provided for the cleaning purpose. These flexible hoses are attached to the central shaft. We use a total of two hoses from two different pump setups. One hose will be attached such that its tip pointing slightly downwards to cover the bottom area of the tank/drum, and another will be such that it covers the top portion of it. The motor used to rotate the shaft that is mounted on a support, such that there is no weight imposed on the central shaft, also the shaft is supported at two positions with the help of ball bearings between itself and the rigid support. This is to provide a smooth and easy rotation and retraction of the shaft. One of those support for the shaft is provided with the motor's support and another at the bottom. The bottom of this shaft is mounted in a rigid base with ball bearings between them. This base is then placed on the base of the drum. When the setting up of the component is over, the motor is switched on and the water started to clean the interior of the tank. We especially use hot water for cleaning because in the inspection setup we use thermal cameras. So, when the hot water is sprayed along the surface of the tank, the thermal images captured by the camera will be red indicating high temperature. If there is a crack or a hole, then the air surrounding will be getting in. The image captured along the

cracked area or the area with a hole will indicate blue colour, showing there is an anomaly. These data will be sent to the server outside and will be analysed by technicians. This is mainly designed to meet the needs of the following applications.

APPLICATIONS

a) Ship tank manufacture Applications

Ship tank manufacture applications include the inspection and cleaning of the ship tank while manufacturing them. Many hull manufacturers can use this product before selling the tanks.

b) Tanks and pipes inspector

After a long run, all the products will need a repair, in that case, our product can be used efficiently. And usage of thermal cameras for inspection reduces the cost of importing machine vision systems.

LITERATURE REVIEW

Chris J. Hebert, Ralph T. Hollister, developed a "Cleaning apparatus for ship holds" in which he used gear cuts for bringing down the component. When the tooth cut on the shaft equals that of the setup it gets fitted to it and is pushed down. And for providing a rotational force for setting up they are using a separate gear mechanism. And that makes a bit complicated design. Here there is no need for such a complicated design as we simply use rotation along with retraction motion to reduce the input power, with the same output.

Bill D. Tyree, developed a "Ultrasonic Inspection Apparatus" in which he uses a magnetic vehicle to inspect the interior of the tank surface. As the vehicle consist of magnetic wheels, only tanks of ferromagnetic materials can be used. We know the age of metals is dying and we can't conclude that Ship hulls and tanks would always be manufactured from metals. Many scientists and researchers are diverting their field towards ceramics and its properties. Sooner or later the metals will be replaced by Ceramics. Corrosion resistance is another reason for the change in manufacturing material. In such cases, the usage of magnetic wheels is not eternal. Also, in case of using magnetic wheels, one needs to provide more amount of energy in the form of electricity to create a strong magnetic field around the wheels and the tank surface. And another problem is the coverage area per some amount of time is very low as they are very much nearer to them. Our design is placed at the center to cover the maximum area in the viewpoint of the camera.

Gary Strait, Paul Murphy, developed a "Portable Inspection Equipment for Ocean-Going Vessels" in which the inventors used normal television cameras with heavy lightings to provide a clear image or proper video to the outside handler so that he could carefully see the video running to search for a hole or any cracks. We used that idea and slightly modified it. We splashed hot water of certain temperature to the tank surface while cleaning which is then followed by inspection where the thermal cameras, we use will broadcast the red colored surface indicating the hotness of the surface, and if there is a crack or hole the air gets in resulting in the blue area. So, one can easily find the defects of the tank rather than slamming their eyes completely on the computer screens.

DESIGN DIAGRAM

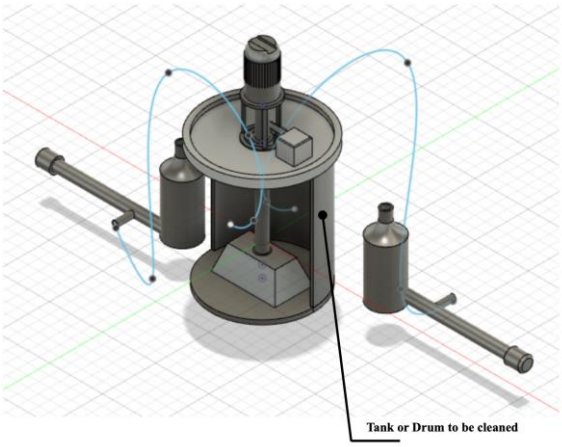
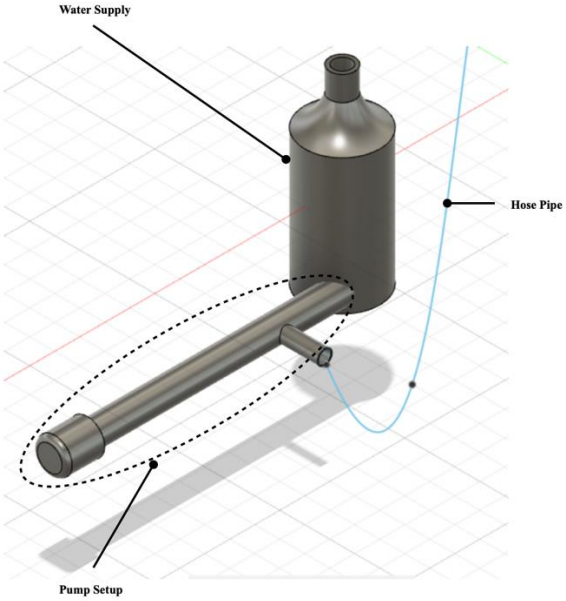


Figure 1- The complete setup of Tank/Drum cleaner

The above figure shows the complete setup of the mechanism, after placing accordingly inside the drum or tank to be cleaned. The figure just shows the whole setup in a single frame, for further understanding, in the following pages we will discuss every part in detail. There are two ways, through which the hot water is supplied inside the tank. Why the hot water, as discussed before if there is a hole or crack inside the tank or drum, then with the help of thermal cameras provided we can detect the areas with the hole or crack, as the display shows blue region when the camera covered the defected part. In the central shaft along the side of the retracting mechanism, a small wing or adjunct is attached, such that when the shaft rotates a 360°, this wing will push the motor switch to 'off', so with the help of retraction force the shaft is retraced back to its initial position. And at 0°, again the wing throws the switch 'on', and the motor rotates the shaft for another 360° and again the switch is turned off and the shaft retraces its path to attain its initial position. This process continues until the power supply is completely turned off. With the help of this mechanism, we were able to overcome the problem faced due to the tangling of hoses around the shaft, also the power supply reduced to half the consumption.

The two long pipes consist of a small motor inside them. The shaft of the motor is extended throughout the length of the pipe, and the very end of this shaft from the motor is fitted with blades. Such that, the one end which is outside

the water supply is attached with the motor, and the other end fitted inside the water supply contains the blade. When the motor is turned on, the blade rotates. The blade angle is such that, it pushes in the water from the supply to the small extension provided. And from that extension, the water is pumped to the interior of the tank. The placement of the pump setup depends on the power of the motor to be used to pump. We in our project placed the pump set up in the bottom, as we used the high power motor.



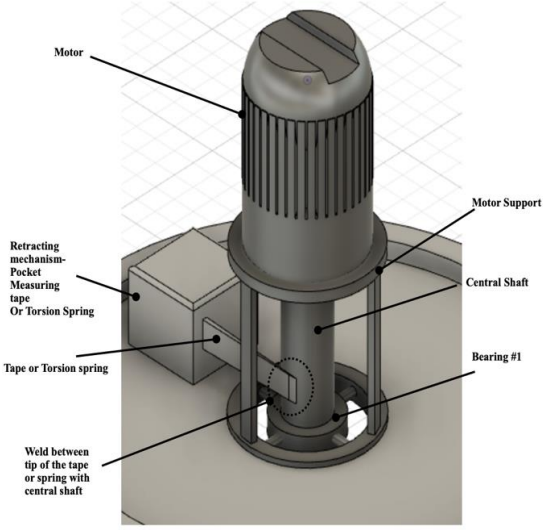


Figure 2- Pump setup Figure 3- Motor setup and Retracting mechanism

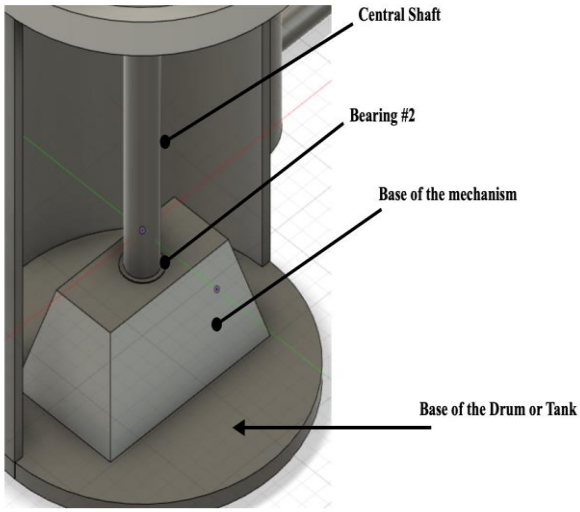


Figure 4- Base of the component and its placement inside the drum/tank

Figure 2 shows the detailed design picture of the pump setup. The motor and vanes are fixed inside the pipe marked as the pump setup. When the motor is turned on, the blade pushes the water to the tank/drum through the hose marked. In figure 3, a closer look atthe motor setup and retraction mechanism is shown. The figure also shows the welded part between the tip of the tape or spring with the shaft. The motor to rotate the shaft is shown and the bearing is attached with the rigid support. And finally in figure 4, the detailed look of the remnants of the mechanism placed inside the drum- the rigid base bolstering the shaft with the help of bearing.

CIRCUIT DESIGN

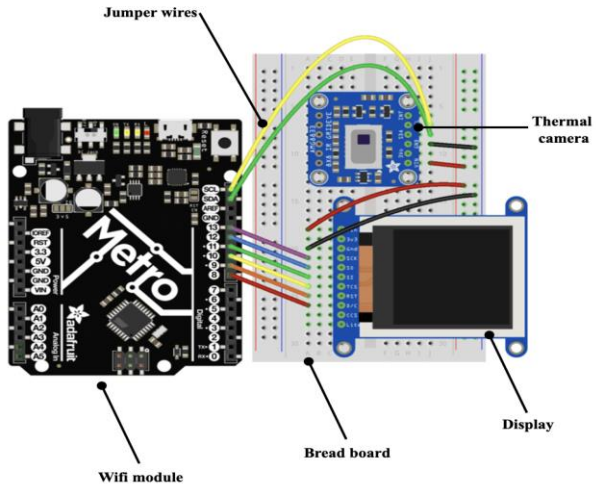


Figure 5- The circuit connection for the inspection process

Figure 5 shows the circuit design done using Tinker CAD software. With the help of the Wi-Fi module, the data collected will be sent to the display screen, where the

images captured by the thermal cameras can be viewed. By just looking at the display, the workers can identify the defects in the tank/drum. With the help of this way of inspection, the workers are not needed to get down physically. The work is done directly with the help of thermal cameras and microprocessors. When the hot water is slashed to the interior surface of the tank, the display shows the images captured. If the tank/drum has any hole in it then the display shows a blue region, with the help of which the inspector can identify the faults in the manufacture of the drums/tanks, easily.

Also, the circuits and thermal cameras are guarded against the water.

WORKING PROTOTYPE

Figure 6- Prototype of the design model

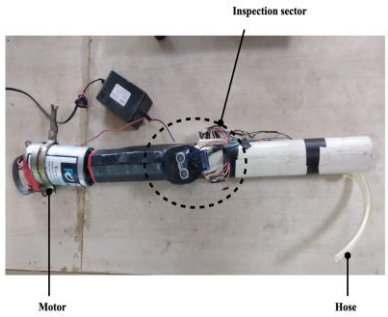


Figure 7- The prototype along with the labeling

The figure 7 shows the basic prototype of the designed model. We have made this prototype to test the retraction mechanism. At first, we ran the motor without the inclusion of the retraction mechanism. As predicted, the result is not that good, the hose got tangled with the central pipe (which we used instead of the shaft). Then we included the retraction mechanism in the design. We also used ultrasonic sensors here along with the thermal camera module, but the result is not efficient and we observed that without the sensor also the inspection is happening. So we removed the sensor from the final circuit design.

CONCLUSION

Ship vessels or tanks or drums cleaning and inspection have remarkable benefits as a tool to optimize efficiency and curb leakages of the tank. However, some uncertainties are persisting in human safety. Although the objective of the most recent technologies includes the maximization of vessel efficiency, they still have not reached the touchstone. We hope that our product would serve as an exemplar for the products to come shortly.

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