International Journal of Engineering and Management Research e-ISSN: 2250-0758 | p-ISSN: 2394-6962
Volume-13, Issue-2 (April 2023)
https://ijemr.vandanapublications.com https://doi.org/10.31033/ijemr.13.2.16

Design and Fabrication of Manhole Cleaning Machine Using Glass Fiber Gripper

S. Nitish Kumar[1], SK. John Gopi[2], U. Pavan Kumar[3], N. Naga Manikanta[4] and E. Madhu Sruthi[5]
[1]Student, Andhra Loyola Institution of Engineering and Technology, INDIA
[2]Student, Andhra Loyola Institution of Engineering and Technology, INDIA
[3]Student, Andhra Loyola Institution of Engineering and Technology, INDIA
[4]Student, Andhra Loyola Institution of Engineering and Technology, INDIA
[5]Assistant Professor, Andhra Loyola Institution of Engineering and Technology, INDIA

[1]Corresponding Author: nitishmech149@gmail.com

Received: 15-03-2023 **Revised:** 30-03-2023 **Accepted:** 18-04-2023

ABSTARCT

Manual scavenging is one of the major problems facing by the whole world. Particularly manhole cleaning is getting more dangerous and harmful to workers involving in the cleaning process. According to research 50% of the sewer workers die before the age of 50 due to health issues. In order to reduce and stop this problem the design and fabrication of manhole cleaning machine is presented in this project as a solution. The new manhole cleaning machine is used to clean the manhole without involving the worker to go inside the manhole. The machine uses mechanical gripper made up of glass fiber. It uses screw mechanism to collect and dispense the sludge. The gripper is carried by a vehicle which will travel on the track. The track and vehicle make the system to be continuous and automatic. The track can accommodate multiple grippers for continuous removal of sludge. Dc motors are used as the major power transferring devices.

***Keywords*--** Manual Scavenging, Manhole, Mechanical Gripper, Screw Mechanism, Track, Vehicle, Arduino Boards

I. INTRODUCTION

The main idea of this paper is to replace manual scavenging of manholes by the manhole cleaning machine. Manhole cleaning is process of cleaning holes and other underground structures such as storm, drains and debris from the area needs to be cleaned and disinfecting the area. Any grease, solid residues, soapy water or liquid can stop the flow of any manhole. In the traditional cleaning process, the workers are losing their lives due to the expose of harmful gases like hydrogen sulphide, ammonia, methane, carbon dioxide, Sulphur dioxide and nitrous oxide. The major health issues being faced by the workers are cardiovascular problems, respiratory system problems and pulmonary function diseases. Even manual scavenging is banned in our country under the Prohibition of Employment as Manual Scavengers and their Rehabilitation act, 2013 (PEMSR). Even though the act has been passed, its implementation was not that much effective due to lack proper mechanization of the cleaning process and cost of the mechanical cleaning. So, it is very important and needful to develop the design and fabrication of manhole cleaning machine which can eliminate the manual cleaning process done by the worker.

II. LITERATURE REVIEW

Mithun [1] multi-operated manhole cleaning machine using twist mechanism to open and close the buckets of the gripper is been used to get rid of manual scavenging of the manholes. The machine is somewhat cheaper than the existing machines. But the main disadvantage of this system it require human effort in transferring the equipment from the manhole to disposal area and it even takes more cleaning time. It can remove the sludge usually from 1.8 depths.

Padmavathi *et al.* [2] made the review on mechanization of sewer cleaning to replace manual scavenging. The various mechanisms include sewer cleaning rods for the removal of sewer obstructions in smaller diameter sewers. grab bucket equipment is used to remove the silt from the manholes. De-silting machine has been used in clearing the sludge from the manhole.

Abhijeet *et al.* [3] developed semi-automatic manhole cleaner to clean the water in the drainage system. It uses a motor driven conveyer system to collect the obstructions which are floating on the water surface. The water has been flowing below the unit and the conveyer arrangement obstructs the flowing waste and collecting it into a storage. This system can be used only in an open water body.

A start-up named Genrobotics developed Bandicoot Manhole Scavenging Robot [4]. It combines electric and pneumatic actuators; it is so designed that to make possible the safe and good way for cleaning manholes in a short time. Infrared cameras helping in live internal inspection. It is so expensive about 17 lakhs also it uses complicated mechanism. It uses a Gripper mechanism to collect sludge. The main disadvantage of this kind of system is it requires manpower to move the

This work is licensed under Creative Commons Attribution 4.0 International License.

unit from collecting point to disposal point and also it takes more time to clean.

Anshul *et al.* [5] developed sewage cleaning machine system which uses a slurry suction pump and motor cutters for the breakdown of the solid waste. The slurry pump works on tornado principle. The waste is collected by the slurry pump and stores in the storage tank which is having filtration nets for the separation of water and sludge.

Ramanathan *et al.* [6] sewage cleaning machine using gripper for three collection and disposal of the sludge from the sewage. The gripper is a kinematic linkage based one. Pneumatic piston is used for the opening and closing of gripper. The process is automated using Arduino Uno, fire blade motor driver and Bluetooth module.

Daniels [7] drainage system cleaner a solution to environmental menace. It is a machine which is used to clean the drainage system by removing the solid waste floating over the surface of the water. It contains a propeller to generate the power required by the machine. The power has been generated due to the flow of water. A cleaner is used to remove the solid waste and transfers it to the pan where the waste is stored.

Anand *et al.* [8] developed automatic sewage cleaning machine to eradicate manual scavenging in drainage system. The machine consists of motor, shaft, chain, sprocket, lifter, collecting bin. The chain has been rotated by the motor through shaft and sprocket. The lifters are connected to the chain at its both ends. The chain turns the lifters. When the one lifter moves from top to bottom it collects all the garbage and drops it in the bin. As there are 2 lifters the collecting time is less.

Aditya *et al.* [9] had made a design, analysis and fabrication of manhole cleaning system. The system is typically a vertical conveyor with collecting bins arranged on it. When the belt along with bins driven into the manhole, the belt gets rotated. And the sludge being collected by the bins and dispensed at another end.

Kunal *et al.* [10] developed a manhole cleaning machine based on Archimedes screw. The principle of this Archimedes screw is the screw under a cylinder rotates about its axis. When the solid particles which are settled in the manhole goes upward and then it will be collected in the chamber. The Archimedes screw can only work effectively at 20°.

III. METHODOLOGY

The main component of the machine, gripper has been carried by the vehicle and the vehicle is moved on the track which is the form of closed loop. This closed loop shape makes possible for the continuous operation. The track may contain nυ number of gripper units according to the size of the track. The driving mechanism of the vehicle moves the vehicle along with the gripper from manhole toυ disposal point. When the gripper is at the manhole, the driving mechanism stops for the period of time taken byυ the gripper to reach the sludge in the manhole, to collect it and then to come out of the manhole. when the vehicle stops to move, gripper is been sent into the manhole by the motor placed on theυ vehicle. Once the gripper reaches the sludge, the working jaw of the gripper will close collecting the sludge and then gripper is pulled back from the manhole. After the gripper is reaching its initial position again the driving mechanism of the vehicle isυ activated, moving the vehicle to the disposal point. At this point the gripper jaw will open releasing the sludge. The vehicle keeps ideal till the previous gripper finish its work that is 1.20 min. After this againυ the vehicle moves to the next point. The initial working gripper will be replaced by the gripper which is behind It. And the cycle continues till the full sludge is removed.

Figure 1

IV. CALCULATIONS

Volume of the Gripper:

Volume of rectangle 1= l×w×h

= 22×24.5×8.5

= 4581.5 cm^3

Volume of rectangle 2 = l×w×h

=7×2.8×24.5

= 480.2 cm^3

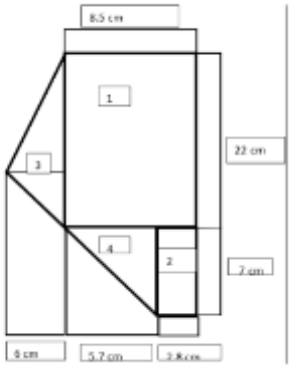

Figure 2

This work is licensed under Creative Commons Attribution 4.0 International License.

Volume of triangle 3 = $\frac{1}{2}$×b×h×l

= $\frac{1}{2}$×22×8×24.5

=2156 cm^3

Volume of triangle 4 = $\frac{1}{2}$×b×h×l

= $\frac{1}{2}$×7×5.7×24.5

= 488.775 cm^3

Total volume = 1+2+3+4

= 4581.5+480.2+2156+488.775

= 7706.475 cm^3

= 0.0077 m^3

The volume of the sludge that can be accommodate in the gripper = 0.0077 m^3

Mass of the Sludge:

Density = $\frac{mass}{volume}$

The density of the sludge = 1400

1400 = $\frac{mass}{0.0077}$

Mass = 10.32 kg

Total mass = mass of the gripper + mass of the sludge

Mass of the gripper = 2.07 kg

Mass of the sludge = 10.32 kg

Total mass = 2.07 + 10.32

= 12.39 kg

Total weight to be lifted = 12.39 × 9.81

= 121.54 N

V. LIFTING MOTOR POWER

Power = $\frac{work}{time}$

Time is considered as 60 seconds for the depth of 3 meters.

Work = mgh

Total mass to be lifted by the motor = 12.39 kg

Acceleration due to gravity = 9.81 $\frac{m}{sec^2}$

Height to be lifted = 3 meters

Work = 12.39×9.81×3

= 364.63 J85

Power = $\frac{364.63}{60}$

= 6.077 W

Torque Needed to Lift 121.54 N of Weight

Torque = load × perpendicular distance

= 121.54 × 0.006

= 0.729 N – m

Power = $\frac{2 \times \pi \times n \times t}{60}$

6.077 = $\frac{2 \times \pi \times n \times 0.729}{60}$

n = 79.6 rpm

Stresses Induced in the Gripper Joints

Diameter of the connecting rod (D) = 5 mm

= 0.005m

Area of the connecting rod = $\frac{\pi}{4} \times d^2$

= 1.96 × 10^{-5} m^2

Load = gripper weight + sludge weight

= 2.07 + 10.32

= 12.39 × 9.81

= 121.54 N

Tensile Stress of Connecting Rod:

Stress = $\frac{load}{area}$

= $\frac{121.54}{1.96 \times 10^{-5}}$

= 5.35 $\frac{N}{mm^2}$

Shear Stress of the Bolt:

Area of the bolt = $\frac{1}{2} \times d^2$

Diameter of the bolt = 0.008 m

A = $\frac{1}{2} \times 0.008^2$

= 5.0265 × 10^{-5} m^2

Load = 121.54 N

Shear stress = $\frac{121.54}{5.0265 \times 10^{-5}}$

= 2.41 $\frac{N}{mm^2}$

Bending Stress of Supporting Link

Bending moment = $\frac{wl}{4}$

M = $\frac{(0.420 \times 9.81) \times 0.265}{4}$

= 0.27296 N – m

I = $\frac{\pi}{64} d^4$

Diameter of rod = 5mm

= 0.005m

I = $\frac{\pi}{64}(0.005)^4$

= 3.0679 × 10^{-11} m^4

Bending stress = $\frac{M}{I} y$

Y = $\frac{d}{2}$

= $\frac{0.005}{2}$

= 0.0025

Bending stress = $\frac{0.27296}{3.067 \times 10^{-11}} \times 0.0025$

= 22.24 $\frac{N}{mm^2}$

Power Required to Lift the Gripper Jaw by the Motor

θ = 40°

T = force × perpendicular distance

= w × $\frac{1}{2}\sin\theta$

This work is licensed under Creative Commons Attribution 4.0 International License.

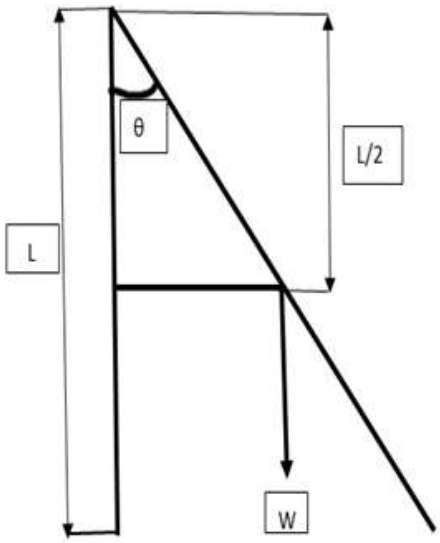

Figure 3

$$\text{Power} = \frac{2 \times \pi \times n \times T}{60}$$
$$= \frac{2 \times 6\,0 \times w \times \frac{1}{2} sin\theta}{60}$$
$$= 2.495\ w$$

VI CONCLUSION

The manhole cleaning machine can clean the manhole without the aid of a worker to go inside it. The cleaning process will be continuous cycle. The glass fiber gripper can withstand the manhole environment as it is having high corrosion resistance than metals. The screw mechanism used for the actuation of gripper will be a good substitute for hydraulic actuation gripper in terms of cost, maintenance, controlling, and screw mechanism will not have any leakage problems as that of hydraulic actuators.

REFERENCES

[1] Mithun, S. & M. Pramukh. (2021). Design and fabrication of a compact multi operated manhole cleaning machine. *International Journal of Engineering Applied Sciences and Technology(IJEAST), 6*(6), 224-231.

[2] Padmavathi,.k. R., R.Ramakrishnan & P.T.V. SureshKumar. (2022). A review on mechanisation of sewer cleaning to replace manual scavenging. *International Journal of Novel Research and Development(IJNRD), 7*(5), 501-507.

[3] Abhijeet, N., Inzalkar, O. Gaurkar, M. Swapnil, Mundhe, S. Kamble & S.Sabale. (2018). Semi-automatic manhole cleaner. *International Research Journal of Engineering and Technology (IRJET), 5*(11), 79-82.

[4] https://www.genrobotics.org/bandicoot2.

[5] Anshul Mahur, Hitesh Soni, Rohan Pareek, Vivek Singh Rawta & Anil Vaishnav. (2021). Sewage cleaning machine system. *International Journal of Current Research, 13*(5).

[6] Ramanathan, S., R. Sudharshan, B. Karthik, A. Mohammed Suhail & S. Chiranjeev. (2019). Sewage cleaning machine. *International Journal of Research and Analytical Reviews, 6*(3), 124-129.

[7] Daniels, Ndubuisi C. (2014). Drainage system cleaner a solution to environmental hazards. *International Refereed Journal of Engineering and Science (IRJES), 3*(3), 54-60.

[8] Babu, B., P. Raja & A. Anand Jayakumar. (2021). Design and development of automatic sewage cleaning machine. *Scientific Hub of Applied Research in Engineering & Information Technology, 1*(1), 18-23. https://shareit.joinjet.org/ojs/index.php/shareit/article/view/3.

[9] Sakharpe, Aditya, Shubham Patil & Shivam Sadafale. (2019). *Design, analysis and fabrication of manhole cleaning system*.

This work is licensed under Creative Commons Attribution 4.0 International License.