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Design, analysis and data management of open Drain/Sewer solid waste cleaning robot

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Abstract

Sewage Treatment Plants are designed to handle the volume of sewage produced by target areas, however we face issues in streamlining the city's sewage lines to its destination on the grid. It is advisable to treat sewage at source and localize the STP plants. Indian city planning does not have the means and methods to complete elaborate systems at a stretch, this has caused disparity in development even within cities which has left it with numerous open drains and sewers. Though laid to serve as storm drains, open drains and sewers found across taluks are being used as sewage disposal lines. To overcome the difficulty of maintaining such structures, an automated open drain/sewer solid waste desilting machine is proposed. The machine removes all the solid waste that disrupts the steady flow of sewage. As a result, the natural flow velocity with which the pipelines are laid carries over such waste to the required STP. The machine is attached with ultrasonic sensors that detect the amount of waste present and its range. This data is transferred using an IoT software and the resulting data is a coherent graph.

Keywords: Solid Waste Cleaning, Open Drain/Sewer, Sewage Maintenance, Data collection.

1. Introduction

Maintaining a clean and sanitary environment suitable for humans to live and work is an essential duty to municipalities around the world. A wastewater collection system is typically a network of pipes, manholes, clean-outs, traps, siphons, lift stations and other required structures to collect all the wastewater from an area and transport it to a treatment plant or a disposal system. The drain systems of cities in India are relatively older and are not capable to handle the population density of current times. And often we experience blockages or illegal dumping of waste in localities. Though law and order deems this punishable, implementation of these laws haven't been successful in history in spite of numerous campaigns. Only the upper society of current India follow segregation of waste, updated drain pipes, etc. as an attempt to live a better quality of life in polluted cities. As we all know private measures to refurbish sewer lines and scheduled cleaning

requires time, commitment and money which majority of the masses cannot afford. To everyone's dismay the lower middle class and below are the people affected by polluted / blocked sewers, polluted open drainage, etc. These are often the breeding grounds for many communicable diseases. The disease causing organisms have grown resistant to most pesticides demanding the next generation of treatment which will prove to be harmful to both man and environment. They also have major influences in increasing toxicity of water bodies, contaminate drinking water sources, Eutrophication and so on. The Sewage treatment Plant are installed in all major cities, but they are either unable to handle the volume of sewage produced or have problem in streamlining the city's sewage lines to a central point. It is more advisable to treat at source and delocalize the STP plants. An argument about the viability of this scheme is still under consideration in many forums. To support the cause of a cleaner

India and better living conditions, unmanned cleaning robots that periodically clean the drains and sewer lines would prove to be essential. [1-5]

In the vicinity of open drains, ACs have frequent breakdowns and gas leaks. The untreated sewage enters the open drains and produces harmful gases like Sulphur-di-Oxide which corrode the copper cooling pipes in the AC, leading to corrosion and eventual leakage. To tackle these issues of toxic gas production many committees have been formed under the municipal, state and central authorities. Numerous projects are being implemented by different bodies of the government. The foreign particles and solid wastes trapped in the drain and sewer lines have to be eliminated for better treatment of the sewage. This not only reduces the effort in treatment of sewage but also helps in maintenance of sewer lines. The frequency of cleaning the drains can be drastically reduced, information about the sewage ejection in each area can be monitored, the solid wastes can be removed and disposed appropriately, and breeding of mosquitoes and other disease causing agents can be prevented.

Regular waste drop points have to be assigned to dump the waste procured from inside the sewer lines, these wastes can be disposed appropriately. Small system can also be implemented in domestic lines so that they can avoid regular maintenance.

At the city level, the Health and Sanitation Planning Committee; at the ward slum level, a Slum Cluster Health and Water & Sanitation Committee are responsible for ensuring maintenance of sewage systems.

In spite of numerous government projects focused on sanitation and health, in reality, only high income areas benefit from these plans. Localities with open drains and sewers are not maintained regularly due to the constraints of municipal administration. If the residents are financially endowed they can attempt to clean and maintain such structures, however, this is not the case most of the time. In addition, education about waste segregation and recycling is still not widespread in our country. This lack of awareness leads to dumping of solid waste in the open drains which leads to clogging of sewage. This develops numerous secondary problems in the vicinity such as pests, pathogens, pungent smell, etc. Such issues need to be addressed immediately and

remedies must be provided for the wellbeing of the residents.

1.1 City Budget For Drain Workers

AMRUT Atal Mission for Rejuvenation and Urban Transformation launched by the Prime Minister of India in June 2015, focused to establish infrastructure that could ensure proper sewage networks and water supply for urban transformation by implementing urban revival and development projects. A total budget of Rs.1450 Crores has been allocated for this purpose.

Let us consider that there are 100 wards present in a city, each having drain workers in the order of 10 workers per ward. This manpower alone would cost the city around 21 lakhs/year in each ward if the current salary provided by the Govt of India for sanitation workers is to be taken into account. This cost could be cut down if an automated system can be introduced for assisting sanitation workers.

1.2 Literature Review

The following journals, publications and patents were reviewed and studied to understand the kinematic motions of previously successful floating, amphibious and underwater machines.

Bhavani et al., have designed a semi-automatic wireless beach cleaning machine. The primary objective that this machine fulfils is the collection of solid waste from the surface of the beach into a metal tray. The set up is built with a motor and gear mechanism which is used for motion and a RF transmitter is programmed to give it wireless enabling. The contours of the beach might prove to be detrimental for this design.

Boxerbaum et al., have made modifications and improvements to the amphibious Whegs robot, experiments and testing to validate the improvements were made by the team. The front wheels of the previous Whegs model gave the front wheel legs higher reach and prevented high centring by its body joints design. Whegs III and Whegs IV have their individual drawbacks though they were different iterations of improvements. This design has body joints with a series of springs paired with actuators to overcome the kinematic inefficiencies of previous designs.

Daniels designed a river cleaning machine that consists of three main sections- Propellor, Cleaner and Pan. The propellor is the generates power by propelling the water it is placed on, the cleaner extracts the waste and pushes it over to the pan.

This machine only peaked in efficiency during high monsoons and high water level conditions with heavy waste flowing.

Harkins et al., have designed the Whegs model that has the capability to immerse underwater up to 40 ft with a enclosed body frame. This capability provides the system to be easily controlled in all environments. Various designs of Whegs did not survive the field testing but the Whegs IV implements worm gears for movement and to withstand the impact of frequent loads it experiences. Along with its sealed body has space to house any advanced control system components.

Hobson et al., posses a patent in the country of United States of America for the design of an amphibious robot. The design consists of a vehicle body fitted with fins of appropriate proportion for movement and a navigation system to aqueous spaces. The fins are programmed and designed to move relative to the sensor encapsuled body. This system can be attached with external actuators for specific functions of need. The system has high prospects in sectors of surveillance and military.

Jamesetal., provide different efficient methods that can be implemented for better navigation systems specific to oceanographic equipment. The main aim of the navigation system is to locate the current location of the device and to precisely calculate the direction of the device. The time and power utilised can be reduced by installing quantitative science sensors in the system. Further installation of sensors can extract environmental data that could be essential for analysis.

*Leonard*with his mathematical studies validates his assumption that underwater vehicle used for exploration have different design requirements when compared to underwater submarines. The paper provides data to understand the requirements needed for six degree of freedom underwater navigation robots designed with consideration as a rigid body.

1.3Survey

Parameters: The sample set is a randomized mixture of residential and non-residential habitants who either use or are surrounded by open drain/sewers. The following conditions were considered and a questionnaire consisting of relevant questions to deduce the result was prepared.

- Frequency of cleaning by the government

agencies.

- Environmental effects of open drains.
- Growth of pathogens and pests.
- Progression of drain stagnation and overflow of sewage.

Analysis and results: The result of the survey is derived from the responses of 100 participants to obtain optimal conclusions. The correspondents belong to all levels of income and are within the city corporation limits of Coimbatore. From the data, it is seen that the Government services are being carried out fairly well and regularly in most areas of the city. The population largely agrees to the fact that the open drains cause an unpleasant stench in the area. Regular maintenance ensures that the drains do not frequently overflow, however, the numbers are still alarming. Due to rapid urbanization, the drains are not equipped to handle the increased volume of sewage. This requires better or newer lines to be installed. The seasonal changes also affect the sewage in open drains. The data establishes a pattern of the difficulties faced in utilizing open drains, which is highest during the monsoon and decreases in the summer and winter, in that order. The data identified the major cause for stagnation or clogging of open drains in day to day living to be dumping of solid waste in the sewer. The primary result of unmaintained open drains is the breeding of pathogens and insects that affect the health and wellness of resident community. [4-11]

1.4 Objective

- To desilt the solid waste in the open drain/sewer and enable proper flow of sewage to its destinations on the grid.

2. Design and Development

Design: The design is specifically adapted to the conditions observed in the Coimbatore City Planning and their budget constraints. The machine consists of a waterproof, completely sealed compartment to house the battery and motor. The shafts are connected to the desilting fins. The fins are individually designed based on the approximation of sewage capacity of that particular drain/sewer. The fins are radially arranged and connected to the shaft. The motor provides high torque to desilt the solid waste and remove clogging. The fins are provided with teeth to aid in both movement and function of the machine. The sensors are housed on the top of the compartment with transparent and translucent housing. The

housing of the battery and motor with shaft is completely sealed with rubber tapes to make it secure and waterproof to the environment it will be used in. An ultrasonic sensor is attached to a servo motor which rotates 180 degrees. A GPS module is installed and programmed to locate the device, this is also an important parameter that provides useful information regarding the sewage of specific areas. This set up can serve as a radar covering the path ahead of the machine. To transfer the data to an online database an Iot module is installed.

Analysis: A single desilting fin is considered for the design analysis. The static structural analysis applying the appropriate forces and supports is carried out. The analysis for Total deformation, Equivalent stress and equivalent max strain is done. The analysis done validates the design of the machine.

Processing application: the processing application can be created using the Google Firebase, which is a web application platform. The data collected from the ultrasonic sensor is transferred to a database file on the drive. The application gets the input data from the file on the drive and displays the data in the form of a graph (an example is shown below).

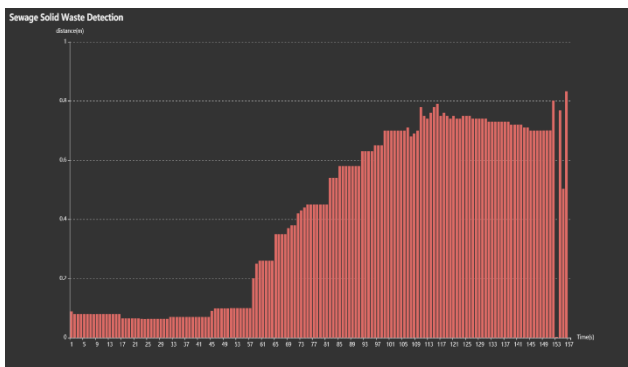


Fig.1.Web Application Output

2.1 Advantages

The machine can be primarily used for solid waste removal and also has the following additional benefits:

- Clean open drain/sewer and UGD of similar dimensions.
- It is cost effective.
- Manual labour in harsh conditions can be prevented.
- It helps to consolidate useful information about the drains.

- The information collected can lead to an effective action plan and resource deployment.

The purpose of the machine being specific carries out its required task efficiently compared to the current system of using manual labor.

2.2 Limitations

- Limited movement.
- No waste collection.
- Retrieval in UGD is problematic.
- Needs human supervision.

Though the proposed machine has its benefits, the testing and development is still at early stages. Subsequent reforms can be made to better the system. Various other robotic technologies such as soft robotics, etc. can be implemented for versatile movement in difficult structures. External actuators maybe implemented as an addition to tackle specific problems in inaccessible areas of sewage.

Conclusions

The robot designed to desilt the solid waste in the open drain/sewer works effectively in aiding the smooth flow and disposal of sewage at required areas of the grid. The machine can be further improved and implemented for various structures of the sanitation system. Future scope includes addition of end effectors to effectively remove and collect the solid wastes contaminating the systems.

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