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DESIGN AND DEVELOPMENT OF A LOW-COST DRAINAGE CLEANING PROPELLER

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ABSTRACT

In India, 62% of its population is living in slums, where the basic amenities like drinking water, drainage facilities, and electricity supply are not inadequate level. If the interruption happens in the existing amenities, it takes months for rectification, particularly blockage of drainage. The reason stated by the corporation authorities for the undue delay in rectification is the narrowness of the streets and the huge size of the drainage block removal machines. Though the widening of streets can be one of the solutions to this problem, it cannot be implemented immediately and completely. So, the possible and feasible solution is to find some means to remove the drainage blockage with ease. This work, design, and development of a low cost drainage cleaning propeller, not only addresses the above problem but also provides a solution to prevent a person from entering the manholes for cleaning activities. In the present scenario, two types of equipment are used for this purpose: Jet Rodding machine and D'Siltman. This work mainly focuses on cost wise justification to make it feasible and self-dependable, when compared with above-mentioned equipment with the simple technique. Also, it ensures the simple operation to handle the equipment safely and effectively.

KEYWORDS: Slums, Jet Rodding, Technique & Drainage

Original Article

INTRODUCTION

Sewage is the wastewater produced from the everyday activities of the mankind, which includes the wastewater from bathrooms, dishwashers and washing machines (common grey water) and from the toilets that are being flushed along with human wastes and toilet papers (common black water). Due to the excessive use of soaps, detergents and toilet papers from multi-storey buildings in large quantities, the drainage pipes are being blocked frequently and it overflows wherever the manholes are not covered properly. When fresh sewage or wastewater enters a primary settling tank, approximately 50% of the suspended solid matter is settled out. The unsettled solid matter is the reason behind the blockage in the sewage lines. This paper describes the design and development of a low cost, user-friendly, flexible drainage cleaning propeller that helps to remove these blockages with minimal human intervention. It also discusses the advantages of this equipment over the present equipment in the perspectives of cost, design and handling method.

SEWAGE SYSTEM AND MANHOLES

The sewage system in figure1, shows the network of pipes, pumps, and mains which forces the collected wastewater or sewage into a tank. The wastewater from various localities is being collected by these networks of pipes meeting at a common junction, from where the wastewater is further sent to a collection tank for the treatment. Further, this treated water is either discharged into a temporary detention basin or in a stream or river.

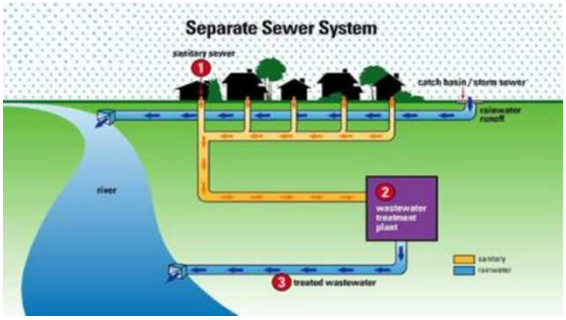

Figure 1: Sewage System

Due to the poor knowledge about the solid waste management, everyday solid wastes like the plastic covers, napkins, and other such things are also being dumped into the same sewers and canals, which gets clogged at a point and lead to the blockage in the sewage pipe. This blockage is too complex to flush out using the Jet rodding machine which is being primarily designed to flush only the sewage and sludge. This leads to a situation where it becomes necessary for the humans to involve themselves directly to remove the blockage.

A manhole (sewer hole) is an opening to the underground sewage system, which provides access for machine insertions, inspections, or maintenance works.

Self Cleansing Velocity

The velocity that prevents the settling down of solids and even washes out the already deposited particles of a given size is called as self-cleansing velocity. This minimum velocity should at least develop once in a day so as not to allow any deposition in the sewers. This velocity is usually attained by means of the inclination of the sewage pipes. This minimum velocity generated in sewers will help for adequate transportation of suspended solids, to keep the sewer size under control and to prevent the sewage from decomposition by moving it faster thereby preventing the evolution of foul gases. This minimum velocity or self-cleansing velocity can be worked out as below:

Formula	Description
$Vs = \sqrt{\frac{8K}{f(S_s - 1)} g * d}$	**K**= constant, for clean inorganic solids = 0.04 and for organic solids = 0.06 **f** = Darcy Weisbach Friction Factor(for sewers = 0.03) $\mathbf{S_s}$ = Specific gravity of sediments **g** = acceleration due to gravity **d** = diameter of grain, m

Equipment Used

Figure 2: Jet Rodding Machine

Figure 3: D'Siltman Machine

At present, there are two machines in practice that are being used to remove these blockages from the sewage pipes.

Jet Rodding Machine: High-velocity jets of water forced through a jet nozzle pipe (shown in figure 2) is used in the Jet rodding machine to dislodge the blocked materials from the pipe walls which are located by the machine using advanced technology and transport them down the sewer. This helps to address the problem quickly and thus costly service is prevented.

D'Siltman: The D'Siltman is a Hydraulic operated, winch driven De-Silting Grab Bucket System that is developed on a 3 or 4 Wheeler, which improves the mobility of the machines even in narrow lanes. Silt or sludge can be easily and effectively collected from a depth of 30 to 50 feet or more with the help of a lever control. Fully equipped machines are provided with a 'Telescopic Extendable Boom' for extended reach and a 'Rear hopper' to collect sludge which can be emptied in big containers. It is economical and available at an optimum price. It is shown in figure 3.

Need for the New Design

The following reasons will show the need for this new design despite the existence of the previously mentioned equipment. The flow of sewage is hindered when the suspended plastic and other solid wastes inside the sewage pipe, gets stranded in spite of the self-cleansing velocity, thus leading to a blockage giving raise to leaks in the nearby manholes. Then the de-sludging is done with the help of the Jet rodding or the D'Siltman machine, with which the blocks are removed. However, in some cases it fails, because the blockages become too complex to be flushed with the help of this equipment and thus there is a need for human intervention.

In order to overcome these drawbacks, a propelling technique is introduced with a pipe or robots which can be immersed in the sewage pipes and remove the blockages. The propeller on reaching the blocked place, will stirr, collapse and ensure the continuous flow of the sewage again throughout the system. Also, it has been found out that, previously maximum work in this field has been done only in the developed countries where the sewer blockage is very rare. Hence all the equipment developed so far is available to inspect the pipes, especially for cracks. No work is found for the detection and removal of blocks inside a sewer line. The main objective of the present work is to detect the blockage, calculate its location and thus remove it.

Conceptual Design

A simple design of the system has been done in Solidworks and shown below in figure 4. In this concept, a propeller attached to a motor is used. It is covered by a casing in a pipe. The pipe direction can be controlled by an operator handled wheel. Once the pipe attached with propeller enters the sewage pipe, it is switched ON. When it reaches the blockage, it will collide and collapse it.

When compared with the existing Jet rodding machine, the jet nozzle has been replaced by a propeller, and water & pressurized air is replaced by an electric motor. Also, the existing design does not have a wheel to control the pipe direction, but in this concept, a direction control wheel is being introduced.

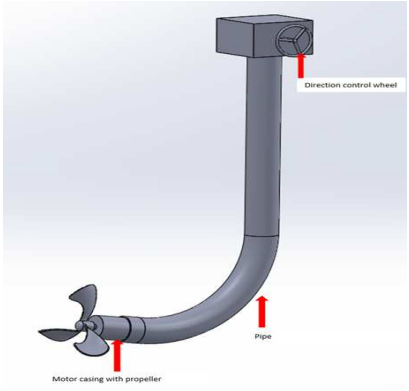

Figure 4: Solid Works Model of the Propeller System with Pipe Adapter

Selection of Parts

- **Motor:** In order to select a motor for this application, a mass of the sludge inside a sewage pipe should be known.

AVolume of Sludge: Since sludge commonly contains only between 1 and 10 per cent solids by mass, their major component is water. This water content accounts for most of the volume of the wet sludge. Furthermore, the sludge solids have the density similar to that of water (around 1400kg/m^3). So, the sludge moisture content is therefore, the single parameter which has the greatest effect on the volume of sludge to be processed at a given plant. If the sludge has a dry solids content less than 20 per cent (that is P_M > 80 per cent), then Density of wet sludge ≅ Density of WATER

Motor Torque Calculation: Assuming the speed of the motor to be 600 rpm and the diameter of the sewage pipe (D) to be 0.5 m,

Torque (T) =(F*D)/2

Frictional force (F) =μ*Sludge weight

Considering, μ = 0.1 and mass of sludge = 30 kg

F = 0.1*30*9.81 = 29.43N

Considering the radius of the pipe,

Torque (T) = (29.43*0.5)/2 = 7.3575Nm

Thus, Torque (T) ≅ 8Nm

Considering the torque to be thrice the actual value, we shall take,

Motor torque = 24 Nm and Motor speed = 600 rpm. The power of the motor will be **2 hp** with its weight not more than **2 kg**

- **Propeller**: The propeller size will be about 250mm in diameter and made up of lightweight composite material such as Al-ZrBr2. The motor shaft is also designed to accommodate specially designed tools to dissolve the sludge. Some of the special tools are shown in figure 5,

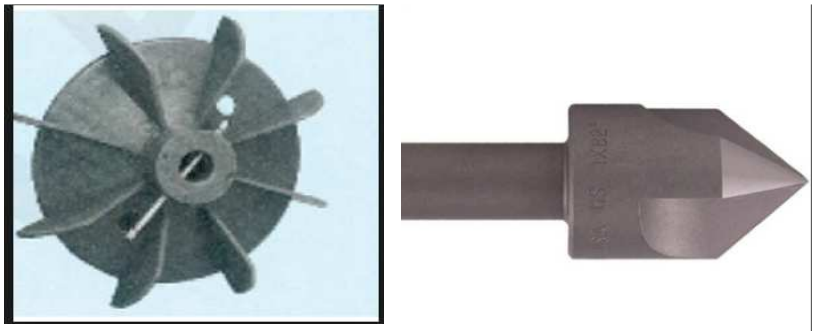

Figure 5: Propeller Types

Fabrication

Based on the design a working model is being fabricated as shown in figure 6.

From the analysis of this fabricated model, the following observations have been arrived

- Wobbling movement of the tube/propeller
- Damage in the propeller and the sewage pipe

Figure6: Fabricated Model

Modification of the Design

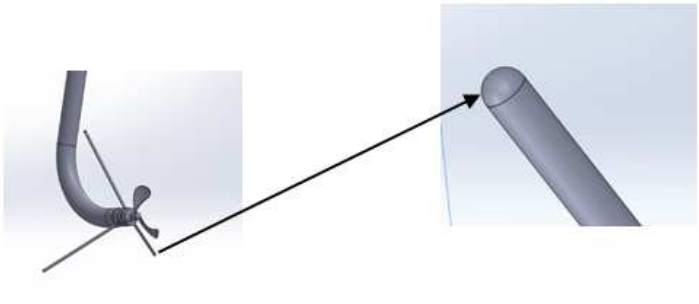

Figure 7: Solid Works Model of the Modified Design

The shortcomings mentioned in preceded part have been corrected by attaching a spring element with smooth edges to the equipment as shown in figure 7. This modified design has the following advantages.

- It has arrested the wobbling of the propeller and the tube
- It has provided a proper guideway to the tube.

Cost Analysis

The following Table 1, shows the cost wise comparison of the existing equipment and the new product,

Table 1: Cost for Procuring and Fabrication for Existing and New Product

EXISTING EQUIPMENT			
S. No	**Parts**	**Spec**	**Cost**
1	Water	6000 litres/month	15000 INR
2	Fuel	200 litres/month	30000 INR
3	Maintenance cost (Twice a year)	NA	10000 INR
		Total cost	**55000 INR**
FABRICATED EQUIPMENT			
S. No	**Parts**	**Spec**	**Cost**
1	Motor**	2-4 HP, DC geared motor	6000 INR
2	Propeller and Special purpose tool	250mm diameter	2000 INR
3	Flexi pipe	10-15 meters	4000 INR
4	Fabrication and Maintenance cost (Twice a year)	NA	10000 INR
		Total cost	**22000 INR**

** Powered by a battery by using the renewable energy source, Solar power panel.

FUTURE SCOPE

The following advancements can be done to the new equipment in mere future for better performance,

- Can have a sensor to sense to locate the block inside the sewage pipe
- Can have a clear visionary system provided with Cams
- Proper automation systems can be installed as an alternative mechanism.
- Robotic arms operated by proper hydraulic circuits can be made

CONCLUSIONS

Cost: When compared with the existing equipment, the cost for procuring the parts and fabricating for real-time scenario will be considerably low. Also with this setup, we can save the water used for this purpose in existing method and can be used wisely.

Efficiency: The human intervention can be minimized / neglected with this new and prescribed equipment. The existing setup is not that efficient where the humans are still getting inside pipe taking risks by putting their life at stake which can be eliminated in the future with the new setup.

Handling: This new equipment also provides the ease and safety while handling. There is no special training to operate this equipment as the design is simple.

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