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Evaluate the Optimum Size of Railway Retention Tank by Simulation

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The Retention tank for railway coaches includes a wastewater tank, toilet bowl and output pipe. Waste water tank is connected with toilet bowl. This type of tank emptied at intervals. This complicates and increases the cost of maintenance. Moreover it should be that the systems designed for railways it is always preferable to avoid high volumes and weights, such as those involved in tank of this type. Irrespective of coach designs the biological toilet system is required to meet the following objectives:

- Hygienic, Clean and aesthetically pleasing toilet.
- No discharge of unprocessed waste.
- Minimum life cycle cost to IR.
- No Discharge and spillage of wastes on the bogie parts, under gear or track.

By considering the above points, a strategy for making the platform hygienic will be designed. The size of the retention tank will be determined by using simulation. In this paper research of existing system is done and based on the above objectives the size of retention tank is calculated by using the simulation . By running of the program module the capacity of tank and frequency (number of times a capacity occurs) are obtained.

Keywords: IR, Simulation, Embedded System, BG.

1. Simulation

Simulation is an imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviors of a selected physical or abstract system.

However, the connection between simulation and dissembling later faded out and is now only of linguistic interest. Simulation is used in many contexts, including the modeling of natural systems or human systems in order to gain insight into their functioning. Other contexts include simulation of technology for performance optimization, safety engineering, testing, training and education. Simulation can be used to show the eventual real effects of alternative conditions and courses of action. Key issues in simulation include acquisition of valid source information about the referent, selection of key characteristics and behaviors, the use of simplifying approximations and assumptions within the simulation, and fidelity and validity of the simulation outcomes.

a) Role of Simulation in Embedded System Design.

Simulation is used to observe the dynamic behavior of model of a real or imaginary system. Indeed, by simulating the complex system we are able to understand its behavior at low cost. Otherwise we would have to carry out complicated theoretical research or to build a device and observe how it crashes to get hints for improvements in the design. Software simulates a hardware unit like emulator, peripherals, network and input-output devices on a PC. A simulator remains independent of a particular target system. It is usable during the development phase for application software for the system that is expected to employ a particular processor or processing device. The simulator is essentially software to simulate all functions of an embedded system circuit. In embedded systems, Simulation has potential use in following: exploring various designs alternatives, functional simulations, high-level performance and power estimations, and cycle-accurate performance and power simulations. Functional simulators are used to verify the correctness of the modeled system (without regard to the resources used) and its algorithms. Estimators are used to quickly estimate performance, energy and power characteristics of the modeled system. Results provided by power estimating simulations of subsystems are used in calculating the system-level performance and power estimates.

2. Introduction

The vacuum disposal system with wastewater temporary retention tank for railway carriages, of the type that includes a wastewater tank to which is connected at least one toilet bowl and which has an outlet pipe with a discharge valve. Vacuum disposal systems for railways involve the fitting of toilets whose outlets have traditionally been connected to a wastewater collector tank of high capacity. This tank must be emptied at intervals, for example when the train reaches one of the ends of its route, and this naturally complicates

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and increases the cost of maintenance of the installation. Moreover, it should be taken into account that in systems designed for railways it is always preferable to avoid high volumes and weights, such as those involved in a tank of this type.

Another disadvantage of this system with general tank is that the stations need to have suitable equipment for emptying such tank.

Some recent systems include an intermediate tank, having a volume of four or five liters, connected to each toilet bowl, so that one dose of wastewater passes rapidly and with low energy consumption from the bowl to the intermediate tank, and this intermediate tank later discharges into a larger tank, which is emptied at intervals.

This design improves the efficiency of the system, due to the fact that it requires lower consumption for emptying the contents of the toilet bowl into the intermediate tank, but it does not eliminate the above-mentioned disadvantages associated with the maintenance, volume and weight of the system.

The object of the present invention is to solve the aforesaid disadvantages by developing a vacuum-disposal system that does not require maintenance and occupies a small space. In accordance with this object, the vacuum-disposal system of the present invention is characterized in that said tank is placed under the floor of the railway carriage and in that said outlet pipe is open at its bottom part facing down on to the track, the discharge valve being connected to a control module.

Thanks to these structural characteristics, after a predetermined number of operating cycles of the toilet the wastewater tank can be emptied automatically when the train is running through an uninhabited zone, thereby eliminating the need for maintenance operations related with emptying of the tank. Furthermore, the tank can be small in size and of low weight.

Preferably, the tank is substantially cylindrical and is placed vertically underneath the floor of the carriage, the outlet pipe being connected at its bottom part.

A tank of these characteristics can be emptied by gravity or under pressure. In accordance with a preferred embodiment of the invention, the tank has associated therewith a level detector; the emptying process can thus be activated either after a certain number of operating cycles or when a certain level of wastewater is reached, thereby preventing excessive filling of the tank from occurring.

The system essentially comprises a toilet bowl , a wastewater tank to which is connected the outlet from the bowl through a cut-off valve and a pipe , a pneumatic unit which includes electrically-operated valves for controlling the various organs of the system and an ejector for causing vacuum into the tank , and a control module .

In accordance with one particular feature of the invention, the tank is mounted underneath the floor P of the carriage and has at its lower part an outlet pipe with a discharge valve, governed by the control module. The outlet pipe is open at its lower part, so that the wastewater discharged from the tank drops onto the track.

Associated with the tank, provision is also made for a level detector, whose signal is supplied to the control module.

The pneumatic assembly and the control module have connections to the various pneumatic and electrical components of the system.

On the other hand, the discharge valve from the tank is controlled by one of the electrically-operated valves of the pneumatic assembly, which is in turn governed by the control module.

In accordance with the invention, the contents of the tank are emptied onto the track when the conditions are appropriate, that is, away from inhabited centers. For this purpose, the control module governs the discharge from the tank by opening the discharge valve when, following completion of a predetermined number of toilet bowl discharge cycles, or once a certain level in the tank (indicated by the level detector) has been reached, the train is travelling at a speed higher than a predetermined threshold, for example 40 km/h. This ensures that the train is in an uninhabited zone; furthermore, thanks to the speed of the train, the discharge takes place over a relatively long section of the track, thereby minimizing its impact.

Thanks to this characteristic, the tank of the system of the invention can be of relatively low volume and occupy little space, and at the same time it does not require intervention at intervals in order to empty it. When the discharge valve is opened, the emptying of the tank can occur simply by gravity or by simultaneously inducing a partial pressure in the tank itself through a suitable connection with an element of the pneumatic assembly.

3. DESIGN OF RETENTION TANK

Retention tank toilet system with chemical treatment treats human waste so that solids are treated and entrapped in the filter. The liquids are made free from pathogen before being discharged. It is applicable to western and Indian style toilets of mainline broad' gauge (BG) coaches of Indian Railways[1]. This Schedule of Technical Requirements specifies the waste processing, discharge and interfacing of Western and Indian style toilets to be fitted on different types of main line broad gauge (BG) coaches on Indian Railways. Generally, IR mainline passenger coach has 4 toilets, of either Western commode or Indian squat-pan types. Some

coaches may have only 2 or 3 toilets. The number of toilets and their type (Indian or western) depends upon the coach type. Irrespective of coach designs the biological toilet system is required to meet the following objectives:

- Clean, odour-less, hygienic and aesthetically pleasing toilet.
- No discharge of unprocessed waste.
- No spillage of wastes on the bogie parts, under gear or track.
- Minimum life cycle cost to IR.

The toilet system should be simple to operate and safe for users. It should not contain any components, which are prone to pilferage. It should be robust, reliable and low-maintenance, and should require minimum ground facilities at the terminals or en-route stations for it's operation. The system should be able to handle normal waste and even some foreign objects thrown in (such as bottles, caps, napkins, plastic bags & cups etc.) either by segregating or by processing the same. Any choking should be possible to be rectified on the spot without needing attention of maintenance depot. The water consumption shall be minimum, with 100% wash of the commode (max. 2.5 ltr. Per flush for Indian type and 1.5 ltr. for Western type). The toilet system is required to suit the space constraints of different types of coaches. All parts of the system should be at least 225 mm above rail level (preferably 400 mm). The equipment should not impede free -movement of the bogies, nor the routine inspection & maintenance of various bogie/coach subassemblies.

A. Signalling More Hygienic Toilet System in Trains

The Indian Railways' bid to improve hygiene level in trains by introducing environment-friendly toilets has received a healthy response from companies, including global ones, interested in supplying alternative toilet systems that would keep the bogies, track and their sides and stations clean.

"The problem of open toilets in trains has not been completely solved even in the developed countries. Moreover, introducing alternative models that function in developed countries would have its own share of problems for India," he added.The difference in the sheer population traveling in trains and the profile of passengers using trains in India and developed countries is different.

The Railways' effort is part of the Government's objective to eliminate open toilet systems by 2011-13. A few months ago, the Ministry of Railways had invited proposals from interested parties for finding out an alternative system of open toilets in passenger coaches.[2] The proposals had been invited from parties with experience in supplying environment-friendly toilet system to airlines, railways and with experience in toilet engineering.

B. Improving Cleanliness on the Railway Station

- To improve cleanliness at stations and in trains, General Managers of all the zonal railways have been directed to take special steps. A nationwide cleanliness drive has also been launched. In order to infuse a spirit of excellence, it has been decided to hold inter-divisional competition in which all the railway divisions will be evaluated by the Headquarters' Committees comprising of senior officers of concerned departments. The best divisions will be given the Cleanliness Efficiency Shield. Best stations will also be selected and awarded. Where the cleanliness level is found to be unsatisfactory, responsibility will be fixed on the concerned officers and employees.
- As an environment friendly measure, Railways are discouraging the use of plastics. To this end all the Catering Units have been directed to make available disposable "Kulhars" in place of plastic and thermocol cups. Apart from being more hygienic, this measure will also improve employment in the rural sector.

C. Environment Friendly Toilet System

- As per policy announced by the Ministry of Rural Development, which envisages total sanitation by the year 2012 and elimination of open defecation all over the country, Indian Railways have taken up a project of development of an environment friendly coach toilet discharge system, as a part of RDSO's Technology Mission on Railway Safety.
- The other test toilet has been developed by a group of scientists at the Indian Institute of Technology, Kanpur. These eco-toilets were developed under the Technology Mission on Railway Safety, and are based on chemical treatment. They are "zero-discharge" toilets that separate the solid and liquid part of the human waste. The solid part is collected in a container, and liquid waste is recycled and used for flushing. The system thus avoids depositing the human waste on the rails. This prototype toilet is being tested in one Chennai train.
- When the test phase is complete, the Indian Railways plans to install eco-friendly toilets in its approximately 9,000 trains by 2011-13.

Who has traveled on Indian trains is fully aware that the facilities on board are lacking in more ways than one. Unhygienic toilets reeking of human excreta have left many a traveler with an unpleasant experience, and have been an environmental burden as well. But things are starting to change for the better. Indian rails will soon boast eco-friendly toilets, thanks to an initiative from the Honorable Minister of Railways Laloo Prasad Yadav.

4. SIMULATION BASED DESIGN

Let us consider the following proposal for designing a retention tank. As we know that the retention tank is used in the toilets of the railways to store the human waste. The curve of the size of the tank has been determined. The input of the tank is human waste and water used by the user of the tank.

In reality no reasonable finite sized retention tank can provide an absolute guarantee of meeting the demand 100% because the human waste and water are random variables. To build such a tank which will never fail through its entire life will generally be uneconomical. Therefore, in practice one determines the tank size which will meet the demand with a specified risk of failure. For example 0.1% failure means that once in a year the tank would become overflow. The objective of the study is to determine the tank size with a specified risk of failure. Our aim is to make the railway platform hygienic, when the train stops at the railway platform then the human waste is drop on to the railway tracks. So, to clean the railway platform we use the retention tank There are the possibilities of the overflow of the retention tank:

- When the train is stop for a long time on a railway station and the number of user is high mean that the amount of human waste exceeds the capacity of the tank.
- The distance between the two stations is less.
- The speed of the train is less.

Hence to prevent the tank from the overflow we find the optimum size of the tank. The tank is empty when the train runs at a high speed and the tank is open at that time, the waste is dropped on the railway track.

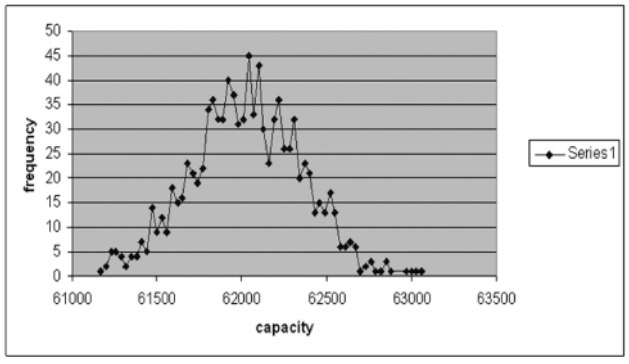
To find the optimum size of the tank, assume the following parameters:

- The maximum amount of the waste is 300ml per person.
- The maximum water used by a single person is 4000ml.
- The maximum time for standing of a train at a railway station is one hour and the single user can take 4-10 minutes in the toilet. So, the maximum 15 person can use the flush in that hour.

5. CONCLUSION

With the introduction of electrics/electronics and software into traditional mechanical engineering products, the usage of embedded systems are greatly increased. As a consequence, existing devices are largely improved and provided with complete new functionalities by integrating mechanical, electronic, software, and control system components. Example products of such integrated embedded systems include different types of vehicles, medical equipments, robotics, and manufacturing equipments. The concept of developing such systems is often referred to as a mechatronics approach in development. Retention tank is one of the mechatronics approach, the retention tank is embedded in the railways for the toilet system, one tank for one toilet bowl. Here we find the size of the retention tank to minimize the cost. The size of tank is found by using simulation. Simulation is an imitation of some real thing, state of affairs, or process. The act of simulating something generally entails representing certain key characteristics or behaviors of a selected physical or abstract system.

In this work, we are finding the size of retention tank by using the simulation through a C++ program. By running of the program the capacity of tank and frequency (number of times a capacity occurs) are obtained. After that the graph between the capacity and frequency is plotted. In the first run of the program, the graph shows that the optimum size is 62,640 ml because its frequency is seven. But in the second run, the graph shows that the optimum size is 62,670 ml because its frequency is six so the previous tank size is failed. In the third run, the graph shows that the frequency of 62,670ml is five and the frequency of 62,700ml is six. So, the optimum size is 62,700ml. In fourth run, the graph shows that the tank size is 62,700ml because its frequency is five. But in the fifth run this size is also failed because 62,730ml occurs nine times, so the failure rate is high. Hence the optimum size of the retention tank is 62,760ml because it occurs two times. The values next to this value occur very rarely. By using the tank size of 62,760 the chances of overflow of the tank should be minimized. There is 0.1% chance of failure of the tank size of 62,760ml. This work will make the railway platform more hygienic and clean. In the train each coach contains 3-4 toilets and in each toilet bowl there is a retention tank, so the proposal of retention tank is costly. Hence by using the optimum size retention tank the cost should be minimized.



The graph between the above capacity and frequency is:

6. FUTURE SCOPE

In future, there is a possibility to recycle the waste after cleaning the retention tank. Majority (about 80%) of the pollution load of waste water is due to human excreta as it has high BOD (Bio-chemical Oxygen Demand) content, pathogenic count etc. The technology of generation and utilization of biogas from public toilet linked biogas plant is an important landmark of the Ministry of Non-conventional Energy Sources, Govt. of India.

The system in addition to providing bioenergy for different uses, also helps decrease in pollution load of waste water (biogas plant effluent), that is also being used for agricultural purposes with due precaution due to presence of pathogens. Although there is a remarkable decrease (80-90%) in pollution load of waste water (biogas plant effluent), it is still higher than the permissible limit of discharge in any water body particularly due to its high BOD and pathogen contents. Since human excreta contain a lot of pathogens even after 98-99% reduction, its absolute bacterial count is much higher. Further its yellowish color, odors and psychological taboo prohibit its reuse. It has good percentage of nitrogen, potash and phosphate, but due to pathogenic content, precautionary measure is required to handle it. To make complete recycling and safe reuse of biogas plant effluent without health risk, a low cost sustainable technology has been developed

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