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RESEARCH ARTICLE
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Intelligent Gas Detection and Elimination of Blockage in Sewer Using Robot Mechanism

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ABSTRACT

Employment of people as manual scavengers was banned in India during 1993. Following this ban, the government proposed a suction lorry for cleaning the manhole on the roads. This lorry was capable of removing only the water from the sewage and not the blockage. Then, a sewage cleaning vehicle was proposed whose usage was confined to the manholes only on the roads. Most of the sewage deaths that were recorded in the past few years have happened at private institutions, schools, colleges, shopping malls, etc. which are not permitted to use the sewage cleaning vehicle. The most important reasons behind these sewage deaths have been asphyxiation and inhaling of hazardous gases such as ammonia, hydrogen sulphide, carbon monoxide, carbon dioxide and methane. This project is proposed to reduce deaths due to manual scavenging using a semi-automatic machine that cleans the manhole using a double bucket arm which is controlled by the user with the help of a pendant. After this process of cleaning is completed, a module with a gas sensor array and a temperature sensor is placed at the manhole head so that the hazardous gases are sensed and the information about the concentration of the sensed hazardous gases is transferred wirelessly through ZigBee. If the concentration level of any of the hazardous gases crosses the threshold set in the Arduino, it raises an alarm in the buzzer. The whole setup is portable.

Keywords: *manual scavenging, sewage, hazardous gas, sensor*

INTRODUCTION

General

Manual scavenging is a term that refers to the manual removal of untreated human waste from toilet or latrines by hand using buckets. It involves moving human waste using brooms and tin plates into baskets which the workers carry to disposal places several kilometers away. The workers are called scavengers and they rarely have any self-protective equipment. Manual scavenging is a caste-based occupation with the majority of workers involved being women. The employment of manual scavengers in emptying a certain type of dry toilet that requires manual daily emptying was prohibited in India in the year 1993. The law was extended and clarified to include insanitary latrines, ditches and pits in the year 2013.

According to Socio Economic Caste Census 2011, 1,80,657 households are engaged in manual scavenging for a livelihood. The 2011 Census of India found 7,94,000 cases of manual scavenging across the country. The state of Maharashtra, with 63,713 tops the list with the largest number of households working as manual scavengers, followed by the states of Madhya Pradesh, Uttar Pradesh, Tripura and Karnataka.

The official definition of a manual scavenger in the Indian law from 1993 is as follows: Manual scavenger" means a person engaged or employed, at the commencement of this Act or at any time thereafter, by an individual or a local authority or an agency or a contractor, for manually cleaning, carrying, disposing of, or otherwise handling in any manner, human excreta in an insanitary latrine or in an open drain or pit into which the human excreta from the insanitary latrines is disposed of, or railway track or in such other spaces or premises, as the Central Government or a State Government may notify, before the excreta fully decomposes in such manner as may be prescribed, and the expression "manual scavenging" shall be construed accordingly."

The International Labor Organization describes three forms of manual scavenging in India as follows:

- Removal of human waste from public streets and also dry latrines
- Cleaning of septic tanks
- Cleaning of gutters and sewers

Manual cleaning of railway lines of human waste dropped from toilets of trains is also a form of manual scavenging in India.

LITERATURE SURVEY

Jingwen Tian, Hao Wu and Meijuan Gao (2008) has proposed a technology for measurement and control system of sewage treatment based on wireless sensor networks. This model is used to collect needed locale information to complete sewage treatment and monitor the power of the machine. The performance of model was proved only through simulation. The project needs a more improvement in experiment and implement.[1]

Heshamm H. Aly, Abdel Hamid Soliman and Mansour Mouniri (2015) has proposed a fully automated monitoring system for manhole cover. In this model, manhole cover issues were not detailly discussed and it has limitations to various manhole cover size. [2]

Vaani I, Simerna J. Sushil, Vani Kunjamma U.S, Akshaya Ramachandran, Dr. Thulasi Bai .V and B. Thyla (2017) has designed and modelled an inspection robot for pipe cleaning named BhrtyArtana. This robot is used to inspect and clear the blockage in the sewer pipe. But the hazardous gases in the sewer pipe were not discussed. [3]

Mahyar Mohaghegh Montazeri, Niels De Vries, Akpedze Afantchao, Pouria Mehrabi, Eujin Kim, Allen O'brien, Homayoun Najjaran, Mina Hoorfar and paul kadota (2017) has modelled and fabricated a sensor using highly-selective microfluidic gas channel coupled with a sensitive metal oxide semiconductor (MOS). In this fabrication, a complex technique was used and it is limited to one particular gas i.e. H2S. [4]

R. Vijayalakshmi and Dr. D. Sengeni (2017) has proposed a simulation model that detects the harmful gases in underground sewage and also human heart rate. If the threshold level is exceeded an alarm is raised and also an alert message is sent through GSM. The performance of the proposed system was proved only through simulation not using any hardware. [5]

Design

General

A simple and portable machine was designed and fabricated. It consists of double bucket, two pneumatic cylinders, single phase induction motor, pedestal bearing and bevel gear arrangements. Mild steel is used for fabrication because it is very strong due to its low amount of carbon content. Arc welding is used in fabrication.

Motor

Single phase induction motor shown in the fig 1 is used for lifting and dropping the double bucket arm and also another single-phase induction

motor is used with the bevel gear arrangement for left and right movement of the arm.

FIG 1: Single phase induction motor

Pneumatic cylinder

The Two pneumatic air cylinders are used, one is for collecting the sewage and the other one is for lifting the double bucket arm. Pneumatic cylinder is a mechanical device which uses the power of compressed gas to produce a force in a reciprocating linear motion. Like hydraulic cylinders, it forces a piston to move in the desired direction. The piston is a disc or cylinder, and the piston rod transfers the force developed to the object to be moved. Engineers sometimes prefer using pneumatics because they are quieter, cleaner, and do not require large amounts of space for fluid storage. Once actuated, compressed air enters into the tube at one end of the piston and imparts force on the piston. Consequently, the piston becomes displaced. Fig 2 shows the pneumatic cylinder.

FIG 2: Pneumatic Air Cylinder

Double bucket arm

It consists of two bucket arm with saw teeth arrangement to collect the sewage waste. It is made up of aluminium steel. It's opening and closing operation is controlled by a pneumatic cylinder. When the double bucket arm opens, it collects the waste and when it is closed it holds the waste. Fig 3 shows the double bucket arm.

FIG 3: Double bucket arm

Hand lever valve

The 5/2-way pneumatic valve as shown in the fig 4 has five connection ports and two switching positions. It has one pressure port (P, 1) for incoming air, two ports (A, 2) and (B, 4) that connect to the pneumatic cylinder that needs to be controlled, and two exhaust ports (EA, 3) and (EB, 5). The 2 represents the number of positions of the valve i.e., normal position where the valve removes the actuating force and other is the working position where the actuating force is applied. This valve is to control the air going into the pneumatic cylinder from the air compressor. The setup consists of two valves with one for each pneumatic cylinder.

FIG 4 5/2: directional control hand lever valve

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Working

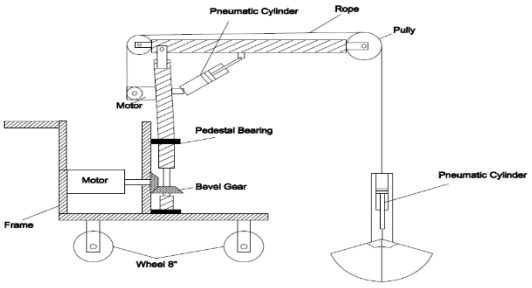

FIG 5: Layout diagram

Fig 5 shows the layout diagram of the mechanical setup. The setup consists of a double bucket arm tied to an iron rope to collect the waste from the sewer system. There are two induction motors. One for the pulley and other for the bevel gear. The one coupled to the bevel gear is for right and left movement of the setup to collect the waste from the sewage and drop it on the outside of the sewer system. The other motor is for lifting the double bucket arm with the waste inside it. There are also two pneumatic cylinders. One for the extension and contraction so as to position the double bucket arm right above the manhole. The other pneumatic cylinder is for opening and closing of the double bucket arm. The frame is to place the whole setup and the wheels are for the movement of the entire setup from one place to another.

Hardware module

The hardware module consists of an Arduino microcontroller interfaced with the gas sensors, ZigBee module and a temperature sensor. The gas sensors are MQ3, MQ4 and MQ8. A buzzer is used for safety purpose. Fig 6 and fig 7 shows the proposed block diagram.

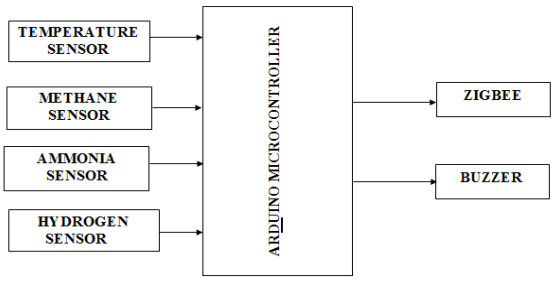

FIG 6: Block diagram for hardware module

Receiver side

On the receiver side is the device on which the data is displayed, interfaced to the ZigBee receiver. The device on which the data is displayed is a personal computer.

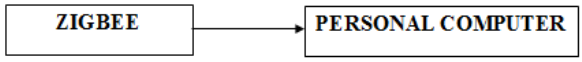

FIG 7: Block diagram for receiver side

Working of hardware

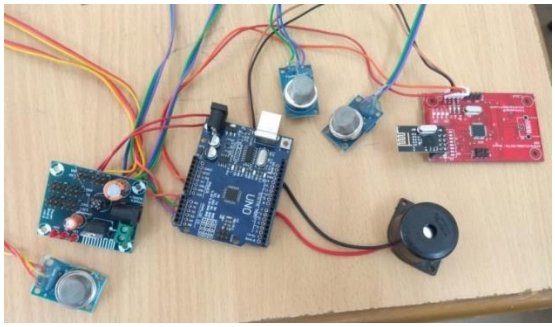

FIG 8: Hardware module

Fig 8 shows the hardware working module. After the process of cleaning is completed, the hardware module is placed at the manhole's head. The module consists of MQ2, MQ5, MQ8 sensors and a temperature sensor interfaced to the Arduino UNO. The module senses the concentration level of the toxic gases i.e., MQ2 senses the level of carbon monoxide, MQ4 senses the level of methane and MQ8 senses the level of hydrogen sulphide.

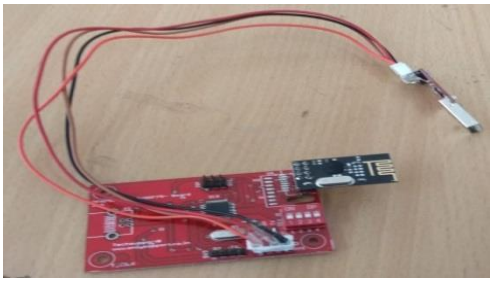

FIG 9: ZigBee Module

This data is sent wirelessly to the personal computer through ZigBee module. Fig 9 shows

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the receiver side of the hardware module. If the concentration level of any of the gases crosses the threshold limit set in Arduino, the buzzer is turned on and it raises an alarm. The temperature sensor (LM35) gives the temperature inside the manhole. This module is to ensure safe entry of man into the manhole if required.

RESULTS AND DISCUSSION

The mechanical model was fabricated and implemented successfully in real-time environment. The machine removes the blockage up to 2 kg waste. It took 10 minutes for clearing the blockage mentioned above. The hazardous gases are sensed and monitored on the PC using ZigBee technology.

FIG 10: Mechanical setup

Electronic module was tested in the manhole and it is observed that hazardous gases have higher concentration. Due to this an alarm raises and in PC it displayed “detected”. After sometime the concentration of those gases are reduced and the alarm stops.

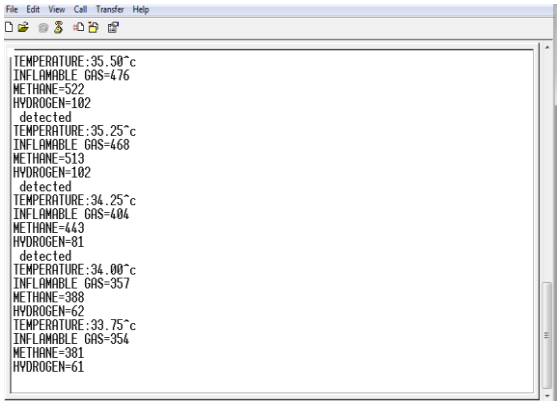

FIG 11: Output for electronic module

CONCLUSION

The developed machine is simple and portable to remove blockage in the manhole and the hazardous gases concentration level are monitored after the cleaning process. The developed machine is economy and easy to implement. The same project can be extended further using various emerging technology such as Fuzzy logic, Nano technology, etc. This machine potentially reduces the death in sewage.

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