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Design and Prototype of Vertical PVC Pipe Climbing Device for Gas Leakage Detection

Mahesh Buradkar[1], Akshay Hage[2], Pranay Hole[3], Saqlain Raja Jamil Ahmad Sheikh[4], Ajay Sonkatar[5]
Assistant Professor, Department of Mechanical Engineering[1]
U.G. Students, Department of Mechanical Engineering[2,3,4,5]
Rajiv Gandhi College of Engineering Research and Technology Chandrapur, Maharashtra, India

Abstract: *This paper describes the Design and Prototype of vertical PVC pipe climbing device for gas leakage Detection. However, manually it is very difficult to reach up and inspect the vertical pipes for leakage or damage, because the pipe height is too long and sometime it installed in very high places and also the environmental condition is not safe. To overcome this type of problem and carry out the inspection more easily, we developed a PVC Vertical Pipe Climbing device to climb up and down vertically to detect the gas leakage, and when the leakage is detecting, the device is automatically stop on detected place. In this project we used the butane gas from cigarette lighter and check the leakage up to the level of 4 feet on vertical PVC pipe with the help of toggle switch. Here MQ-2 sensor is used with the device to help us for inspection of pipe.*

Keywords: Pipe climbing device, gas leakage, sensor, vertical pipe

I. INTRODUCTION

Most of the areas in industries have difficult to check the gas leakages in the height. If we have to check the leakages in vertical or inclined pipes, then special arrangement is required to go in higher side and it is also expensive and time consuming job. In some areas, it is also very difficult for human to check leakage manually in higher side due to the harmful gases that can be affected by human health. Such as, to check the pressure and temperature inside the boiler, chemical pipe line in chemical plants, gas and oil pipe lines, to check the long pipe of water and steam. But last few decades a rapid development and automation has been done in the device technology with cheap and effective way. In which different types of sensor are also plays a vital role in this robotic technology. This advancement of new high-speed technology and growing computer power it a need to develop a new and accurate method with high performance of the devices. Here, in this project we performed the design and experimental analysis of prototype of pipe climbing device to check the gas leakages in vertical PVC pipe with the use of MQ-2 sensor for gas leakage inspection. Here we use butane gas of cigarette lighter on a particular location for the experiment. The experience was given to motivate for further work.

II. LITERATURE REVIEW

1. Design and Development of Pipe Climbing Robot for Leak Detection- This paper proposed the design and solidwok model of a wheeled pipe climbing robot for another principle. In this model 6 wheels in 2 rows and separate motor is used to every wheel for driving purpose. Spring arrangement is given for the pipes with different diameters, which can move in upward and downward direction.
2. Design and Development of Automatic External Pipe Climber - This paper describes the concept, design and prototype implementation of a wheeled pole-climbing-robot based on Ferromagnetic adhesion principle. Here, the device can stuck on the ferromagnetic surfaces and can move along the surfaces for inspection of the surface with the help of cameras, that is used for external inspection of the pipe. Here 3 wheel robot devices are used to climb the robot on the surfaces. Permanent magnets are used for climbing operations to create the magnetic force based on adhesive force for the robot to stick on vertical surface of the pipe.
3. Design and development of automatic pipe climbing robot – In this paper the design and development a novel climbing robot which can move in forward and backward direction over the pole is describe, also given, this robot can remain stationary based on its own weight. The model consists of 6 wheels mounted in 2 rows.

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4. Design and Development of Pipe Climbing Robot–This paper describe the design of wheeled Pole climbing robots. The prototype model consist of six wheels mounted in two rows, each wheel has its separate motor for driving purpose. Also the spring arrangement is provided for gripping the pipes having different diameters. The toggle switches are provided which control the motion of the wheels either forward or backward. [4].
5. Design of the Out-pipe type Pipe Climbing Robot – This paper presented the experimental approach of out-pipe type Pipe Climbing Robot. This robot can move straight as well as bended pipes in various diameters with autonomously controlled with the help of length adjustable driving wheels. The diameter of the straight and bended pipe is 435 mm, made of polyethylene. The driving module consists of a linear actuator and a driving wheel and generates two degrees of freedom motion: the driving motion in the axial direction of the pipe and the linear motion in the radial direction of the pipe [5].
6. Vision-based pipe-climbing robot for spray-pipe inspection in nuclear plants – This paper says the design and experimental approach to describe a mobile robot to climb up and down vertically and to cross over such pipes for the nuclear power plant. This robot is design to overcome obstacles such as valves, pipe flanges, and T-shaped branches. This robot has a 5 dof manipulator and 2 grippers and moves along the cylindrical pipes bypassing the obstacles.

III. AIM, NEED AND OBJECTIVES

As per the above literature very few researches has done on this area. The aim of this project is to prepare the best design and prototype of vertical PVC Pipe Climbing Device for Gas Leakage Detection. The main objective is that,

1. To study, design and prepare the prototype of the pipe climbing device moving in vertical path in definite distance.
2. Safely detecting of pressurized gas or leakage by the device.
3. After detecting the leakage gas, the device should be automatically stop on detected place.

IV. PROBLEM STATEMENT

Gas leakage hints to various accidents causing into both financial loss as well as human injuries. The reason for such explosion is due to low-standard cylinders, damaged valves, worn out regulators and lack of awareness of gas cylinders and insufficient maintenance of the gas pipe lines. After checking, oil companies found that most of the leakages are found by ignorance of employees about safety checks and in some places it is very difficult to human to check the gas pipeline due to harmful gases. So to reduce human risk and time saving, it is the need for some automated detection system to detect the gas without human in such harmful areas. In previous study, it is shown that only design has been developed on this area, but experimentally is not given. For this reason we prepared the design and prototype to inspect the harmful gas leakages on PVC vertical pipe climbing device.

V. WORKING PRICIPAL OF VERTICAL PVC PIPE CLIMBING DEVICE

This prototype model consist of 3 wheels and it mounted in single row, separate DC motor is used for each wheel to driving the model upward and downward direction . The toggle switch are given to control the movement of the wheels either forward or backward direction. For the rotation of 360 degree movement for the wheel, the DC motors are used. The MQ-2 sensor is mounted on the frame for detect the gas leakage. PVC pipe of diameter 4 inch and length 4 feet is used for this experiment to check the leakages on the particular location. The butane gas is used at bottom, middle and top portion on the pipe by using cigarette lighter for detection of leakage. As the switch of the device is on, the device moves vertically in one direction closed to the PVC pipe with the speed of 4 mm/s. As the gas sensed by the MQ-2 sensor near the pipe, the device will stop for 5 sec. on that area where the leakage is found. The device stopped means that is the indication where the gas is leaked on the particular area. Here bottom, middle and top portion of the pipe has chosen for the experiment to check the leakages. The butane gas is sprayed by the cigarette lighter on this particular area to sense the MQ-2 sensor, when the device is moving vertically, sensor sensed the gas and device stopped at this location. The experiment is found satisfactory result. The design and fabrication has tried to done with minimum weight of the device. The path of the device is selected randomly to move. The prototype model of the device is given in fig. 5.1.

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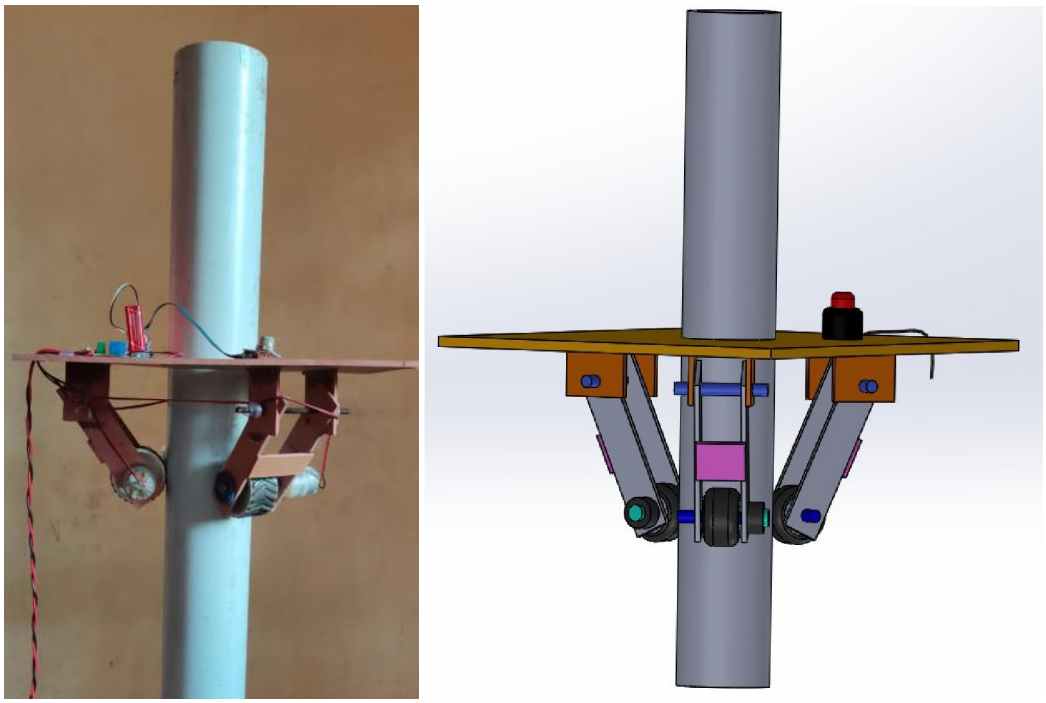

Fig. 5.1 Prototype of PVC Pipe Climbing device with solidwork model

5.1 Fabrication and Assembly

1. The base frame is made of rectangular MDF sheet(Medium Density Fiber Board with 2 mm thickness)
2. Firstly we took the MDF sheet & cut this i.e, L = 440mm and b= 380mm.
3. Prepare the hole in the centre of the main frame (base sheet) for inserting a PVC pipe. Size of centre hole, d=105mm
4. Then insert the PVC pipe D=100 mm and length=1220 mm into the hole in the centre of the main frame.

Fig. 5.2 PVC Pipe

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5. Make a hole in a supported MDF sheet for mounting the motor, attached screw with a base support of the motor.

Fig. 5.3 DC Motor

6. Here we use VETRA as adhesive to stick the support with the main base.
7. Fix a D.C. motor in mounting hole and join the wheels on motor.

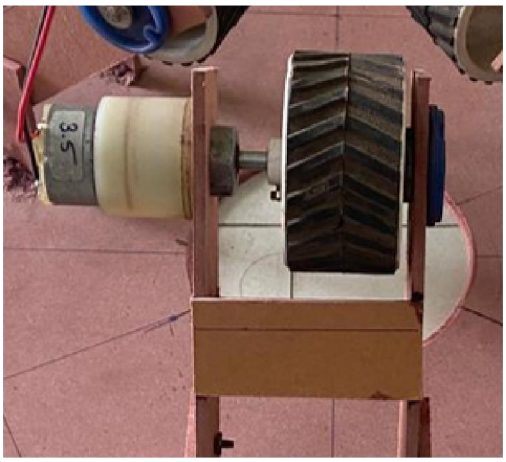

Fig. 5.4 Device Wheel

8. Make a connection of motor with RELAY to connect the ON/OFF operation of motor.
9. Make a connection of MQ-2sensor near the centre hole on the main frame, so it will be able to detect a gas when it sprayed or pressurize from the pipe.

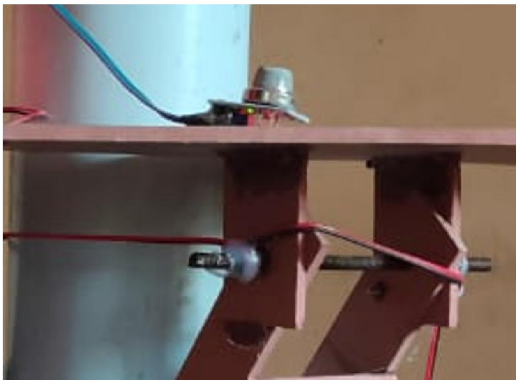

Fig. 5.5 MQ-2sensor

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10. Connect a battery with MQ-2 sensor and connect this sensor with the relay driver

Fig. 5.6 MQ-2sensor

11. After assemble all the components final assembly is ready to test.

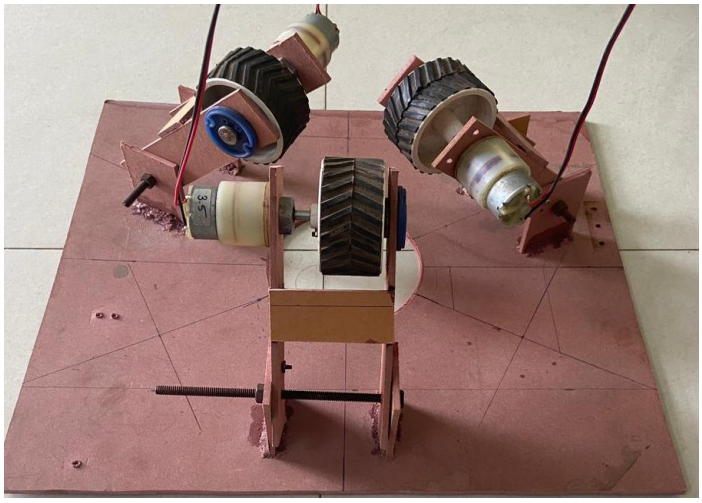

Fig. 5.7 Final model of PVC pipe climbing device

Solid work model of the PVC pipe climbing device

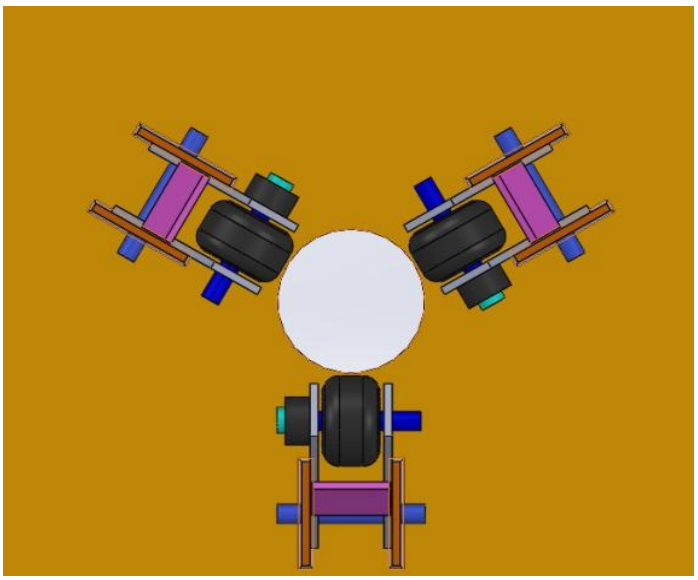

Fig. 5.8 Top view of PVC pipe climbing device

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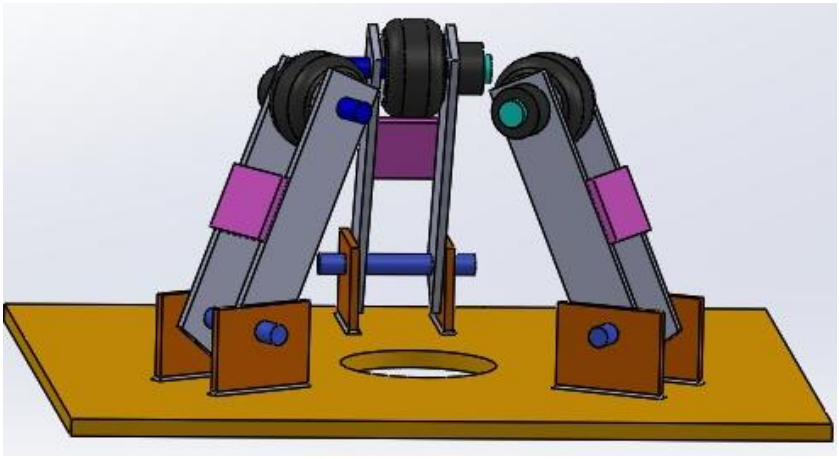

Fig. 5.9 Side view of PVC pipe climbing device

VI. TESTING AND OBSERVATION

There are three locations are selected for the leakage detection near the PVC pipe i.e., bottom, middle and top. In the first steps the gas detection device held in bottom i.e., 145 mm from the ground level as shown in fig. 6.1. The butane gas is sprayed by the cigarette lighter near the pipe with same height. The gas was detected successfully by MQ-2 sensor that is attached with device, and model was stopped at that location for 5 sec.

After 5 second, the device start to move upward vertically for the detection of gas at a speed of 4 mm/s. As the device reached at the middle portion of the vertical PVC pipe at a distance of 609 mm from the ground level, then again butane gas is sprayed near the pipe, gas was detected again by sensor successfully and model was stopped at that position for 5 second.

For the third reading, the device was travelling vertically upward direction till end of the pipe i.e., 1219 mm from the ground level as shown in fig. 6.1, same procedure is applied as above and the same result was found. Testing was done successfully.

Fig. 6.1 Top and bottom position of PVC pipe climbing device

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6.1 Observation Table and Result

Following are the observations that were found at different locations.

Table 6.1: Observation table of gas detection device.

Sr. No.	Gas used	Length of pipe	Model stopped to move
1	No gas	Bottom	No
2	Butane	Bottom (145 mm)	Yes
3	Butane	Middle (609 mm)	Yes
4	Butane	Top (1219mm)	Yes

6.2 Result

The reading is taken manually for this experiment and it is clearly shown that when the gas is found near the sensor, the device it is automatically stopped to move from this position.

VII. CONCLUSION AND FUTURE SCOPE

We developed a prototype of pipe climbing device which can move in upward and downward direction to check the gas leakage. In this project we used the butane gas from cigarette lighter and check the leakage up to the level of 4 feet of PVC vertical pipe. The gas is provided near the pipe at bottom level i.e., 145 mm, at middle level i.e., 609 mm and at top level i.e., 1219 mm. Apart from this, gas is not provided anywhere. At each level where the gas found, the device is stopped for 5 second as the gas sensed successfully by the MQ-2 sensor that is attached with the device. The speed of the device to move vertically upward direction is 4 mm/s and downward direction is 5 mm/s. The speed of the device was a little low. So this is the future work to increase the speed of the device. This project was not given satisfactory result. Lot of improvement can be possible in future. This was a small experiment that we have done and experienced lot of thing with this work to improve our work in future.

It is concluded that the performance testing carried by us is successful but we are not satisfied with this. Hence, in future it can be prepare design and prototype in other ways and can be modified as per the requirement.

In future work, the design can be prepare more functionally to do all the components work in full efficiency. We can increase the speed of the device to detect the gas on long vertical pipe. More sensors and cameras are also used to sense the exact location for the leakage in anywhere around the pipe. We can also use higher weighted device for long vertical, horizontal and inclined distance.

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