International Journal of Future Generation Communication and Networking
Vol. 13, No. 2s, (2020), pp. 693–696

In-pipe leak detection robot for fluid distribution system.

Aditya Chavan, Abhijit Jadhav, Mohan Gavade, Mukund Ekhe.
Department of Mechanical Engineering,
Smt. Kashibai Navale College of Engineering, Vadgaon,
Pune, Maharashtra, India
adityachavan1@gmail.com, abhijitajadhav143@gmail.com, mukundekhe4@gmail.com,
mohangavade110@gmail.com

Abstract

An autonomous and low-cost system for leak detection in fluid distribution system is proposed in this paper. The proposed robotic system is capable of detecting small leaks. This in-line pipe leak detection robot uses the presence of a radial pressure gradient near the leak site. The pressure gradient creates suction force, which in turn tilts the disc from neutral position. This rotation is detected using gyro-accelerometer sensor. This method does not require skilled operators. Leak signals are sent wirelessly using Bluetooth to computer for inspection.

Keywords— *leak detection, inexpensive, In-pipe, fluid distribution system.*

I. INTRODUCTION

Pipelines are used for long-distance transportation of fluids such as liquid or gas, usually to a market area for consumption. Over the time these pipelines which are buried develop leaks and lead to introduction of contaminants into the pipeline which could deteriorate the quality of fluid and give rise to health risks.

Several methods exist that are employed to detect the location of the leaks. However most of them are detecting leaks from outside pipe system. With many ambient conditions influencing the results, it is hard to accurately locate the leaks and they often require manual work or skilled operators. Thus, most of outside pipe approaches are costly but not effective.

Therefore, it is necessary to fix those leaks and first step in doing so is accurately identifying where the leaks are within the vast network of pipelines. To more efficiently and accurately detect the leak, an in pipe approach is taken.

Shantanu Datta et al [1] Xiao-Jian Wang et al [2] summarizes the various methods used for leak detection. This method is time consuming and also does not localize the leak site. Sniffer gas technique uses coloured or odour gas. The gas is filled in the system. The gas leaks are then monitored using specially designed sensors. This method is expensive and not reliable. Acoustic methods depend on the acoustic signal produced due to interaction of gas or liquid flows past a crack or hole [3], [4], [5]. The main disadvantage is that the method is slow and it requires experience. Peter et al [6] in his work uses Infrared thermography to detect leak in buried pipeline. The basic principle is the difference in thermal conductivity of wet and dry soil. J. H. Goh [7] et al states a method in which Electromagnetic sensor is used. Main drawback is that it can detect only one leak at a time.

The radial pressure gradient has already been used to detect leaks [9], [10], [11]. The MIT Leak detector detect leaks and provides information about position of the leak location. The main disadvantage is the detection is dependent on material characteristics and this requires calibration for every new pipeline. Sutej et al [12] describes about a prototype that uses leavers that can detect the existence of leak. The drawback is sensitivity is not same in all directions.

ISSN: 2233-7857 IJFGCN

II. SENSOR DESIGN

A pressure drop is generated at the leak due to fluid flow producing a suction force. Sensor designed consists of a disc suspended by two springs that are used to maintain the neutral position once it has passed the leak site. The disc has a gyro-accelerometer sensor mounted on it. The periphery of the disc is mounted with long elastic membranes of very small thickness. As the membrane moves near the leak, the rapid change in pressure, forces the membrane towards the circumference of the pipe and gets attached to the leak site. This creates a drag on the disc and the disc tilts. This tilting is detected by the gyro-accelerometer sensor. The sensor data is transmitted to the computer via Bluetooth.

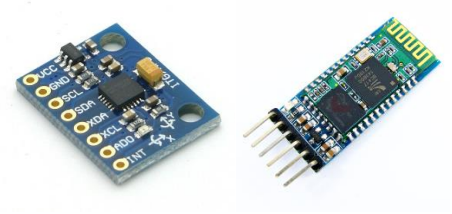


Fig.1 A gyro-accelerometer sensor and HC-05 Bluetooth module

III. ROBOT DESIGN

A Robotic system was designed with the prime objective of moving the sensor inside the pipe. Pipe of diameter “4 inch” (110cm) is chosen. The robot is mounted with two microcontrollers. One microcontroller controls the direction of motion and speed of robots and other processes sensor data.

The sensor designed is mounted to the front of the robot. One battery is used as power supply. This supply is given to the left and the right wheel motors through motor driver. The connection between the robotic segment and an operator is established wirelessly using Bluetooth module HC-05. The proposed system will be tested in the laboratory.

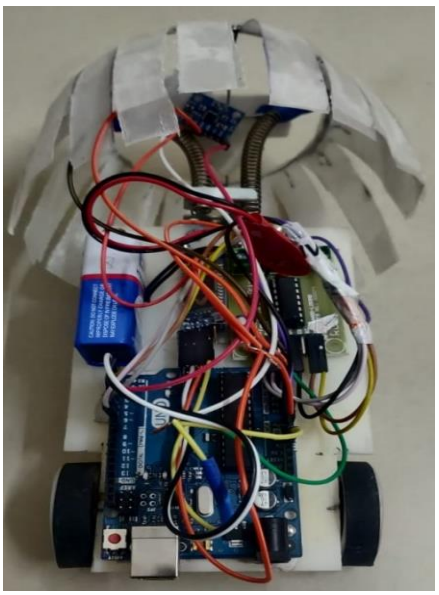
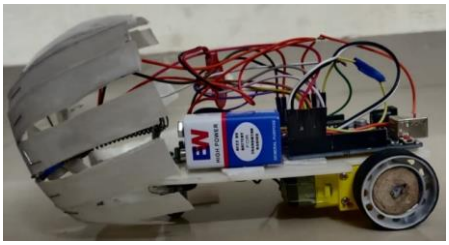


Fig. 2 Top view of robotic system



ISSN: 2233-7857 IJFGCN

Fig. 3 Side view of robotic system

IV. TEST APPARATUS

The robot is placed in the pipe and closed. The pipe is pressurized using a compressor. Pressure regulator can be adjusted to vary pressure inside the pipe, thus serves as a method to measure the sensitivity of designed sensor.

V. DATA ACQUISITION

The sensor designed provides six raw values from gyro-accelerometer sensor. Accelerometer reads both tilt of the sensor disc and acceleration of the robot. Gyroscope integrates angular velocity with respect to time to produce a tilt angle. A wireless connection is established between the two microcontrollers and the sensor data is interpreted in the form of a graph in Arduino IDE software. There exists a sudden change in angle value whenever a leak exists. The time difference between leaks can provide a method to locate the leak.

VI. RESULTS

The system was deployed in a pipe of "4 inch" (110cm) diameter. Leak of relatively small size is accurately measured. The sensor designed was found satisfactory and provided reliable results. The result of leak test in a pipe with two holes separated by a distance using Serial Plotter of Arduino IDE software is shown in the figure.

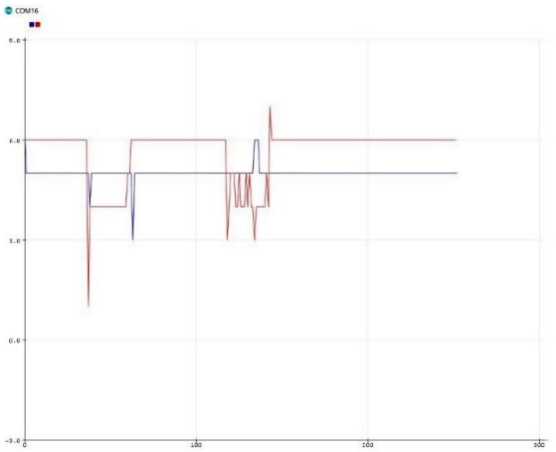


Fig. 4 Leak Monitoring in Arduino IDE

VII. DRAWBACKS AND REMEDIES

- The duty cycle of the robot is very less. It can be increased by making the sensor arrangement self-propelling.
- The location of the leak is not indicated clearly. Bluetooth is not feasible in real time due to its limited range. Adding a GPS to the system extends the range.
- The spring arrangement on which disc is suspended is susceptible to vibrations. Further, research will help in finding proper suspension arrangements.

VIII. CONCLUSION

This research focuses on developing low cost robot that can be used to detect leaks in fluid-distribution pipes.
The prototype built is inexpensive and its making cost is very less. The leak detection method is continuous and can detect leaks irrespective of material properties.
The system does not require any expertise to operate. Once the GPS module is added to the leak location can be accurately determined thus increasing reliability and ease of use. Further, computational algorithms can be developed to analyse the magnitude and nature of the leak.

ISSN: 2233-7857 IJFGCN

REFERENCES

[1] Datta, Shantanu & Sarkar, Shibayan. (2016). A review on different pipeline fault detection methods. Journal of Loss Prevention in the Process Industries. 41. 10.1016/j.jlp.2016.03.010.
[2] Wang,X.J., Simpson,A.R., Lambert, M.F. and Vitokovsky, J.P.(2001). "Leak Detection in pipeline system using hydraulic methods: a review". Conference on Hydraulics in Civil Engineering, The Institutuion of Engineers, Australia,Hobart, 23-30 November, 391-400.
[3] P.-S. Murvay, I. Silea, "A survey on gas leak detection and localization techniques," Journal of Loss Prevention in the Process Industries, vol.25, pp. 966–973, 2012.
[4] Brodetsky, I., & Savic, M. (1993). Leak monitoring system for gas pipelines. In Acoustics, speech, and signal processing, 1993. ICASSP93., 1993 IEEE International Conference on, Vol. 3 (pp. 17e20). IEEE.
[5] Kim, M., & Lee, S. (2009). Detection of leak acoustic signal in buried gas pipe based on the time-frequency analysis. Journal of Loss Prevention in the Process Industries, 22(6), 990-994.
[6] Bach, P. M., & Kodikara, J. K. (2017). Reliability of Infrared Thermography in Detecting Leaks in Buried Water Reticulation Pipes. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, 10(9), 4210-4224.
[7] J.H.Goh, A.Shaw, J.D.Cullen, A.I Al-Shamma'a, "Water pipe leak detection using electromagnetic wave sensor for the water industry", IEEE sumposium on Computers & Informatics,2011,290-295. [8] Abdulshaheed, A., Mustapha, F., & Ghavamian, A. (2017). A pressure based method for monitoring leaks in a pipe distribution system: A Review. Renewable and Sustainable Energy Reviews, 69, 902-911.
[9] Chatzigeorgiou, D., Wu, Y., Youcef-Toumi, K., & Ben-Mansour, R. (2014, May). MIT Leak Detector: An in-pipe leak detection robot. In Robotics and Automation (ICRA), 2014 IEEE International Conference on (pp. 2091-2091). IEEE.
[10] Chatzigeorgiou, D., Youcef-Toumi, K., & Ben-Mansour, R. (2015). Design of a novel in-pipe reliable leak detector. IEEE/ASME Transactions on Mechatronics, 20(2), 824-833.
[11] Chatzigeorgiou D., Wu Y., Youcef-Toumi K. and Ben Mansour R., "Detection & Estimation Algorithms for In-Pipe Leak Detection," American Control Conference (ACC),June 4-6, 2014. Portland, Oregon, USA.
[12] Sutej Pramod Kulgod, Srinidhi S, Satyesh Shanker Awasthi, " Low cost in-line pipe leak detection robot", IEEE Distributed Computing, VLSI, Electrical Circuits and Robotics, 2016,79-83.

ISSN: 2233-7857 IJFGCN