Mobile Application and Wireless Sensor Network for Pipeline Monitoring and Control

Sivi Varghese[#1], Anandhu A Panicker[*2], Ashique Sunil Kumar[*3], Sangeeth M[*4], Vibin Varghese[*5]
 # PhD research scholar, Cochin University of Science and Technology
**UG scholar, Department of Safety and Fire Engineering*
Toc H Institute of Science and Technology, Cochin, Kerala

Abstract

Pipelines mainly used for distribution and transportation of petroleum, natural gas, water, and sewage within a facility and between long distances. Damage to pipelines will pose great threat to people, environment and industry. This is why the careful monitoring and control of pipeline systems is essential. Leaks and cracks cause millions of losses in spill control, repair and accidents. Here we have attempted to develop a new system for pipeline monitoring and control. It utilizes a mobile application and a wireless network of monitoring elements and isolation valves. The mobile application receives alerts from time to time whenever a leak is observed and can be used to remotely shut off valves corresponding to that location. It involves the use of a programmable microcontroller, Solenoid valve, GSM modules, Zigbee PRO modules and a resistor based detection system. The system was coded using AVR Studio and mobile application developed in Android Studio with the help of JAVA.

Keywords: *SCADA, Remote control, Solenoid Valve, Mobile Application, AtMega32,Wireless Network, Android Studio, Zigbee*

I. INTRODUCTION

Pipelines are one of the critical infrastructures of a country. They are mainly used for distribution and transportation of petroleum, natural gas, water, and sewage. Oil and Gas transmission pipeline play an important role on transportation of this vital energy to the national economy. Maintaining the economic progress of these countries is strongly depending on protecting these resources and facilities.

Oil, gas, and water pipelines are considered one of the main infrastructures in many countries Many aging Oil, Gas pipelines suffer from various defects such as corrosion, cracks etc. and can cause failure of pipeline then subsequently this may damage to human health and interruption of oil and gas supplies. If something happen to these pipelines it will create great threat to peoples so finding a suitable solution is very important. Pipelines by nature span wide geographical areas and therefore need robust real-time monitoring for adequate security. The advancement in hardware and wireless technologies has resulted in inexpensive low power communication devices that can be deployed throughout a physical space. Sensors usually communicate with each other using multi hop routing or star routing approaches. The flowing data ends at special nodes called base stations or sinks. A base station links the sensor network to other network(s), this disseminates the collected sensed data for further processing and analysis Wireless sensor network (WSN) pose as a suitable candidate for such solutions, since they can be used to measure, detect and provide actionable information on pipeline physical characteristics such as temperature, pressure, oil and gas motion and environmental parameters also, they will be able to locate the exact location of the crack or leak.

II. METHODOLOGY

The objective of this project is to develop a wireless sensor system for pipeline monitoring integrated with a mobile application to provide immediate feedback on leaks and control over the pipeline. Leaks may not be detected in the early stages in an underground pipeline also, even if it is detected through pressure difference or spillage, it is very difficult to find the actual location of the leak. The new system is an attempt to prevent future accidents and losses from pipeline leakage or theft from pipeline systems.

To develop the system and mobile application, we have determined several important steps. They have been rewritten and reorganized until the most suitable solution was found. A block diagram was prepared for the system and the necessary components were identified and purchased based on their performance. The coding of components was done in AVR Studio using Embedded C program. The electronic design

automation was done using Proteus Design Suite. An elaborate circuit diagram was prepared and all elements were connected based on it.

The working of the system is based on several steps. First, the leak must be detected and the location of leak must be found. It must then be send to the application user and an alert must be sounded. The user must then choose to close the isolation valve to that section or not. On giving instruction to shut off the valve, the valve must be remotely closed. The detection of leaks is done by a series connection of resistors. Resistors of different values are connected in series and their relative location in the circuit is noted. The circuit is completed by connecting it to the ADC and current is allowed to pass through it. The output voltage is constantly monitored by the ADC. The resistor strip is coiled

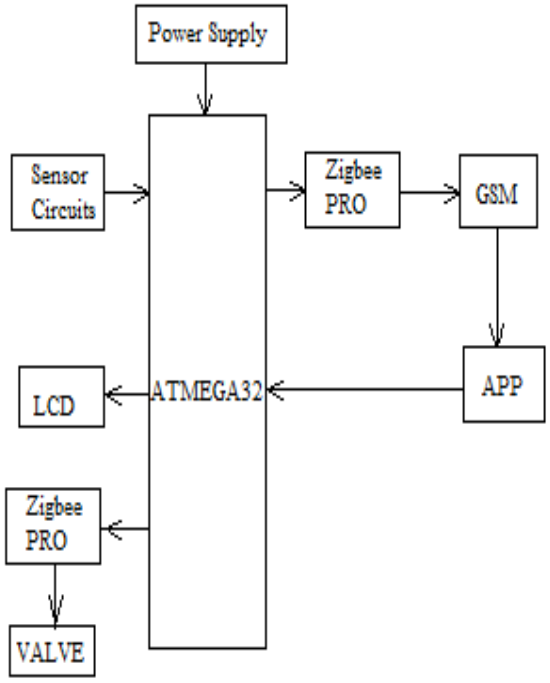

Fig.1. Block Diagram

around the pipeline or within the insulation. When a leak occurs, the liquid flows over the circuit and forms a low resistance electric circuit causing the current to pass through it and not the resistor. This bypassing of resistors will give a rise in output voltage of the circuit. The increase in voltage can be used to determine the decrease in resistance and hence the location of the leak.

The location of the leak is then send to the GSM module wirelessly using Zigbee PRO.

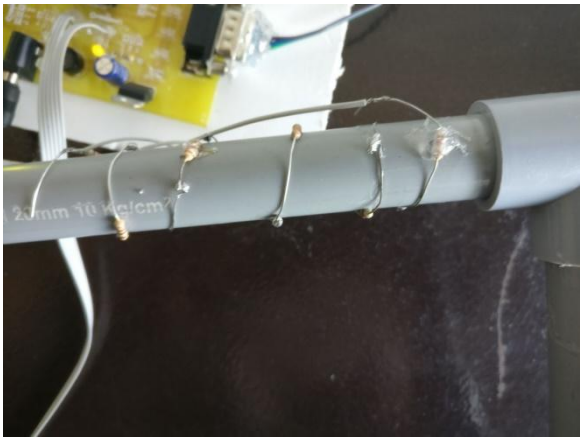

Fig.2. Sensor Resistor coil

To develop the system and mobile application, we have determined several important steps. They have been rewritten and reorganized until the most suitable solution was found. A block diagram was prepared for the system and the necessary components were identified and purchased based on their performance. The coding of components was done in AVR Studio using Embedded C program. The electronic design automation was done using Proteus Design Suite. An elaborate circuit diagram was prepared and all elements were connected based on it

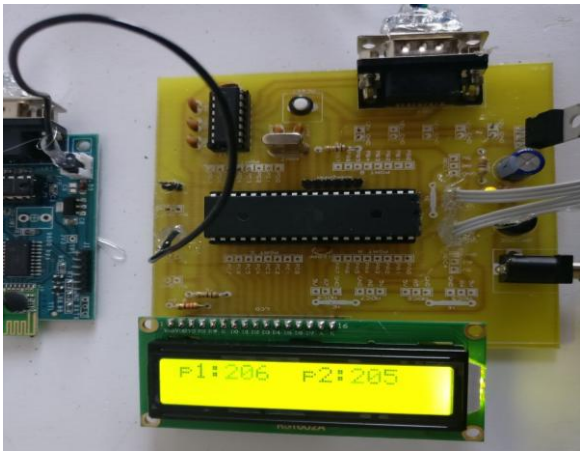

Fig.3.Location of leak displayed on LCD and send through Zigbee PRO module

A message is then send to the registered mobile number and the mobile application reads the message. The application will confirm the sender number and display the leak location and the option to shut off the valve to that location. When the close valve option is clicked, a message is send back to the GSM module. The ADC will confirm the sender mobile number and send instruction to activate the solenoid valve and shutoff the flow. If the sender number don't match, the flow will not be stopped.

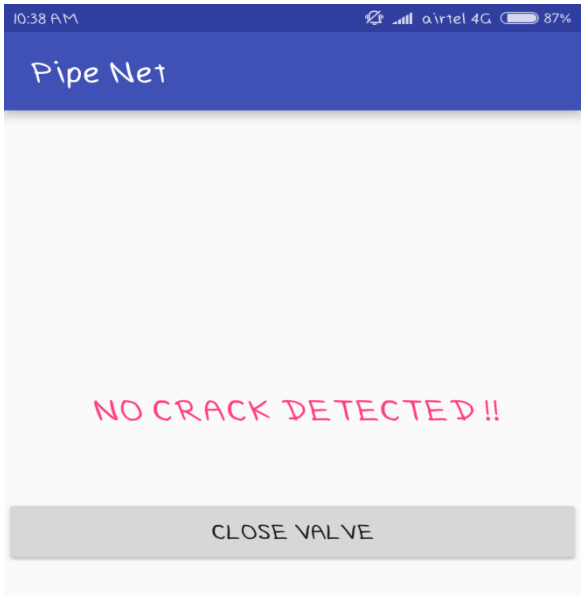

Fig.4.Application at Normal condition.

III. DESIGN AND FABRICATION

All elements of the system were assembled following the circuit diagrams. The microcontroller was programmed for detection and communication after assembly. The functioning of all elements were checked and confirmed to their normal function and datasheet recommendations. The leak detection system was fabricated using the various elements after thorough study of their working, specifications and performance. The system was connected following the pre-determined circuit diagram. There were 2 sensing elements connected to the microcontroller and the data was send to the mobile application. The mobile application would send a response to shut off a valve to the controller via GSM module. Then the signal is relayed to the isolation valve (solenoid valve) through the Zigbee module wirelessly and the valve is energized shutting of flow.

As for the prototype, the system was fitted to a pipe with a solenoid valve at the starting end. A set of sensor circuits are setup downstream to detect leaks, The fault condition arouses when the circuit is shorted with water. In order to show fault condition, a drip of water may be dropped on the coil or may be shorted using a simple copper wire.

The microcontroller was programmed to perform the above functions using Atmel Studio in Embedded C while the mobile application was designed and coded using Android Studio.

IV. ADVANTAGES

- Simple and cheap in construction.
- Quick detection and response.
- Pinpoint the location of leak easily.
- Can be applied to unrefined petroleum pipelines since they contain water and salt.
- Real time alerts not only to SCADA but to important personnel as well .
- Sabotage can be easily detected.
- Less energy required.

V. DISADVANTAGES

- Cannot be implemented on pipelines carrying non conducting fluid.
- Insulation failure could disrupt detection system.
- Require separate protection against cyber-attack.

VI. RESULT

The prototype functioned satisfactorily.When the fault condition was provided,the LCD display showing location of crack and an alert was send to the mobile application. The valve was closed remotely from the application and the response was obtained on the LCD screen.

Fig.5. Idle Condition

Fig.6 Leak location on LCD

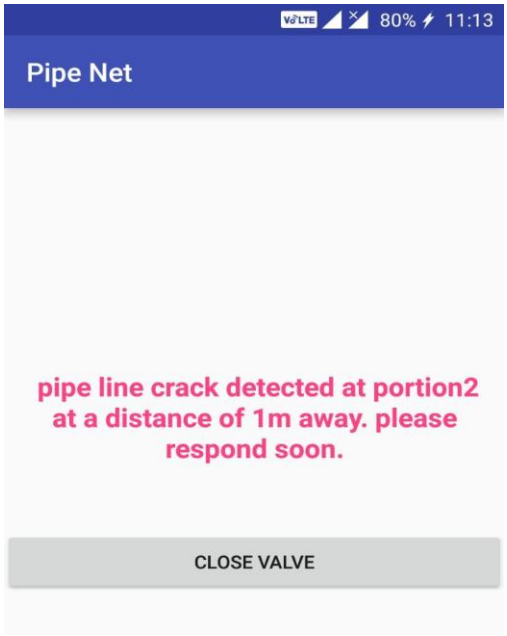

Fig.7.Crack Location on app

Fig.8. Response on closing

VII. CONCLUSION

As the wireless sensor network is under research, there are a number of improvements we can think of like expanding the sensor node network by adding more nodes. This would allow the development and testing of advanced network-layer functions, such as multi-hop routing. We can think of alternative energy sources to extend mote battery life. Which may include solar cells and rechargeable batteries, these systems could provide a long term, maintenance free, wireless monitoring solution.

The project is a simple system for leak detection in pipelines with a large scope for improvement and development. With further research, we can fabricate a more efficient and versatile system which can be used almost everywhere.

REFERENCES

[1] M. Thompson and M. L. Harper, The body is the sensor, Insight - Non-Destructive Testing and Condition Monitoring, Volume: 50, Issue: 2, (2008).

[2] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam and E. Cayirci, A Survey on Sensor Network. IEEE Communication Magazine, 40; 102 – 114, (2002).

[3] Tariq AL-Kadia, Ziyad AL-Tuwaijrib, Abdullah AL-Omrana-b, a *, Wireless Sensor Networks for Leakage Detection in Underground Pipelines: A Survey Paper, 491 – 498, (2013).

[4] Lawrence Boaz, Shubi Kaijage and Ramadhani Sinde, Wireless Sensor Node for Gas Pipeline Leak Detection and Location, Volume 100– No.18, (August 2014).

[5] Milad Golshan1*, Aidin Ghavamian2 , , Ali Mohammed Ali Abdulshaheed3 , Pipeline Monitoring System by Using Wireless Sensor Network, X, Volume 13, Issue 3 Ver. V (May- Jun. 2016).

[6] I. Jawhar and J. Wu., Resource allocation in wireless networks using directional antennas. T, (March 2006)

[7] Augustine C. Azubogu, Victor E. Idigo, Schola U. Nnebe, Obinna S. Oguejiofor, and Simon E.“Wireless Sensor Networks for Long Distance Pipeline Monitoring”, International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering Vol:7, No:3, 2013

[8] Imad Jawhar, Nader Mohamed and Khaled Shuaib “A Framework for Pipeline Infrastructure Monitoring Using Wireless Sensor Networks”. College of Information Technology, United Arab Emirates University, Al Ain, UAE.

[9] Johnson Eze, Christopher Nwagboso, Panagiotis Georgakis, “Framework for integrated oil pipeline monitoring and incident mitigation Systems”. Faculty of Science and Engineering, University of Wolverhampton, Wolverhampton WV1 1LY, United Kingdom

[10] Lawrence Boaz, Shubi Kaijage and Ramadhani Sinde, “Wireless Sensor Node for Gas Pipeline Leak Detection and Location”. Nelson Mandela African Institution of Science and Technology (NM-AIST), School of Computational and Communication Science and Engineering Arusha, Tanzania