Module Based Real Time Solution to Underground Water Leakage Detection and Alert Provider using Android Application.

Prof. (Dr.) N. R. Wankhade
Computer Technology, Late G. N. Sapkal College of Engineering, Nashik, India.

Mr. G. N. Joshi
Computer Technology, Late G. N. Sapkal College of Engineering, Nashik, India.

Mrs. S. J. Suryawanshi
Computer Technology, Late G. N. Sapkal College of Engineering, Nashik, India.

Mrs. R.R. Mahale
Computer Technology, Late G. N. Sapkal College of Engineering, Nashik, India.

Mr. M.A. Shah
Computer Technology, Late G. N. Sapkal College of Engineering, Nashik, India.

Abstract

In order to save our future, we must learn to conserve what limited resources we have. But, we are facing major problems in water conservation and Underground Leakages of pipes is one of them.[3] Effects of leakage lead to serious human efforts to the respective government workers. Therefore, leakage must be detected, located and monitored. Various factors like bad quality roads, airlock, which forces water to moves it from its actual leakage point to another can mislead them & increases the repairing efforts of workers. So, to overcome all such problems we have proposed a module which can detect the leakages and also its level using IOT sensors, monitoring i.e. giving alert to authorities, which will informs the real time situation regarding pipelines using android application which would help concerned authorities to take appropriate action so that water loss and human efforts is minimized.

Keywords - Water Leakage Detection, Water Management Using IoT.

I. INTRODUCTION

Most of the area in the planet earth is covered with water. But only less percentage of water is actual in use. Water management plays very important role in our day to day. Conservation of water is very important. Some facts regarding water wastage is dangerous to human kind. The loss of water in domestic sector on account of leakage is approximately 30 to 40 of the total flow in the distribution. These facts are very harmful. This leads to high risk in public health. In local state and in city to city water leakage problem is increased day by day. In city area, lots of people complained about water leakage problem in their respective area. Water supply authorities receive so many complaints regarding that and this lead to so much trouble to workers this is a one scenario.[2] Another one is detection of underground water leakage and also monitoring. Therefore, leakage must be detected, located and monitored. Again there is problem in detecting water leakage when the pipe leaks underground and various factors like bad quality roads, airlock, which forces water and it moves from its actual leakage point to another, which can increases the repairing efforts of workers and can mislead them.

This situation must be solved with due respect to water supply workers and their efforts. There work should be minimized and water consumption should happen. There are different solutions to these problem in which some of them are optimized, or so costly or effective. Some past experience has shown that in pipe inspection is more accurate, less sensitive to external noise, and also more robust. Some techniques uses or detect leakages in underground pipelines. One of them is sound which is comes through pipes because of water pressure after leakage happens. These sound is detected by devices like microphone, sound rods etc. on the ground by a person. But there is a problem of accuracy. However there is another method which used electric transmission

line formulation rather than acoustic wave equation to detect water leakage. Another method which uses two pressure sensors which finds the leakage using pressure waves.[6][2] Apart from these techniques there are other techniques have also been implemented to detect water leakage. But, real time scenario problem for water supply workers is different. Situation after underground water leakage is far more different than what actually it seems. Various factors under road and also airlock and bad quality roads, water pressure forces water to another point of its original. Some techniques deployed leakage detecting robots into pipeline which used to collect data and send to server using wireless sensor network. But, again the wireless network is not reliable and can cost too much. Moreover, scenarios may come when robot gets stuck in the pipe which would create pressure problem. Some method uses electric flux based leakage detector and ultra-sonic based leakage and damages in the pipeline. Another method proposed by some universities uses radical pressure to detect the location of the leakage by using pressure sensor. These method also has some serious issue regarding its reach and pressure sensor issue.

However, these methods are so complex and not provide proper solution to ground level workers as mentioned, which would help the water distribution department workers. Hence new module or approach is required to help authorities and ground level workers, which would not only detect water but also generate some meaningful data, also sends this information to admin as an alert which provides an new module to operate on this problem and avoid any serious issue.

The water leakage system can be deployed in newly pipeline with the water flow sensors attached to the both sides of pipe. And at the same time information about deployment is entered into an application for e.g. pipeline no, it's deployed location. The sensor does not stops the water flow but just collects the flow rate and according to that principle appropriate action is taken. These module or we can say approach contains arduino microcontroller which constantly reads the data from water flow sensor. It compares the flow rate by calculating the difference in data from subsequent sensors and takes the necessary action. For e.g. if 10L of water is flowing from the pipe and some amount of water is leaked out of it i.e. 1-2L so there is a less amount of water flow gets out from other end and this difference is measured by sensors and send by microcontroller to the android application. Then further issues are handled by admin and application will help authorities by continue monitoring of situation.

II. LITERATURE SURVEY

Water lost through leaks, waste, or simple theft is referred to as non-revenue water, in that it fails to provide revenue to the water supplier because it never reaches its customers. These can be physical losses of water escaping the system, or unaccounted-for water that is not measured due to faulty meters and meters that have been tampered with, poor accounting and bookkeeping, or as a result of human error when reading and recording the water system flow meters. Available and emerging technologies are designed to detect and prevent physical water losses. These will continue over time until they are detected.

Acoustic detection remains the primary means of detecting and locating pipeline leaks. The method of acoustic leak detection is described as "the systematic method of using listening equipment to survey the distribution system, identify leak sounds, and pinpoint the exact locations of hidden underground leaks."[8][5] Water escaping under high pressure from a pipe leak or crack makes a distinct rushing or hissing sound that can carry considerable distance along the length of the pipe itself (in contrast, the loose soil surrounding the pipe in its backfilled trench makes a poor conductor of sound). In this sense, the pipe acts as a medium for transmitting sound. In doing so, it can act like the strings on a guitar, vibrating with different pitches for different pipe lengths, diameters, and materials. Small diameter metal pipes carry sound the greatest distance, up to 1,000 linear feet, while large diameter polyvinyl chloride (PVC) pipes can carry sound only 100 feet.

The ZigBee networking method includes initialization networking and triggered networking. The topological structure of the network provides an important basis for ZigBee networking; in view of the structural characteristics and distribution of water supply pipelines, this paper employed a network topology. To achieve initialization networking, the first step was to determine the coordinator nodes and set their signal channels and network ID numbers, which would initialize the network. Non-coordinator nodes were then added to the network. Figure 3 mainly interprets how the nodes join the network. To ensure that the number of terminal nodes installed at each relay node (i.e., router node) was balanced, it would add received signal strength indicator (RSSI) information to each Beacon_request frame when each terminal node in this solution sends a network join request. In accordance with the RSSI values, routing nodes provided joining service to the terminal nodes. To collect leakage signals effectively and reliably, it is necessary to set reasonable threshold values for the RSSI. If the RSSI values of the terminal nodes are smaller than the threshold, the routing nodes will not process the request of terminal nodes. If the RSSI values are greater than the threshold, the routing nodes will record the terminal node's information and ensure that they can join the network.

The pressure point analysis leak detection method is based on the statistical properties of a series of pressure or velocity pipeline measurements at one point being different before and after a leak occurs [11]. A

leak changes the hydraulics of the pipeline, and therefore changes the pressure or flow readings. The method detects leaks by monitoring pipeline pressure at a single point along the line and comparing it against a running statistical trend constructed from previous pressure measurements. The pressure wave source spreads out from the leak point to the leak upstream and downstream ends. Taking the pressure before the leak as the reference criterion, the wave generated by such a leak is called the negative pressure wave. When the negative pressure wave reaches the pipeline terminal end, it will cause the drop of first the station inlet pressure and then the station outlet pressure. Based on pressure difference that pressure sensors on both sides detect, pipeline length and negative pressure wave velocity, the leak point can be determined [12]. Pressure point analysis can detect small leaks which cannot be detected by other methods. However, it is difficult for this method to localize leak points [1].

Mass or Volume balances are in effect the same technique based on the principle of conservation of mass. The principle states that a fluid that enters the pipe section either remains in the pipe section or leaves the pipe section [13]. For a normal cylindrical pipeline the flow entering and leaving the pipe can be metered. The mass of fluid in the pipe section can be estimated from the pipe dimensions and measurements of state variables such as pressure and temperature. A leak is identified when less fluid leaves the pipe than is expected from the measurements of input flow and estimates of the pipe contents. Although the principle of mass balance method is simple, this method is very sensitive to arbitrary disturbances and dynamics of the pipeline, which may lead to false detection issues [11].

Some methods [10] used electric flux-based leakage detectors and others used ultra-sonic based leakage detectors which to find the location of the leakage and damages in the pipeline. Whatsoever, these methods typically depended upon the material of the pipeline and equipment's used were power thirst, not suitable for long networks and were big. Another method proposed by MIT [11] uses radial pressure to detect the location of the leakage by using a pressure sensor. It was observed and proved that the radial pressure close to the leakage is more and decreases as moved away from it.

However, these methods have not got successful yet which would help the water distribution department to get the location to deploy repair staff in real-time. Hence, a robust system is required which would not only detect theft and measure quantity but also to generate data that would help generate insights about demand and supply of water in a particular area.

III. SENSORS & TECHNOLOGY

A. Micro-controller

The implementation has been done by using NodeMCU which is an open-source LUA based firmware developed for the ESP8266 wifi chip. By exploring functionality with the ESP8266 chip, NodeMCU firmware comes with the ESP8266 Development board/kit i.e. NodeMCU Development board. NodeMCU Dev Kit has Arduino like Analog (i.e. A0) and Digital (D0-D8) pins on its board. Using such serial protocols we can connect it with sensors, it gives us easy environment to connect with hardware and operate[6].

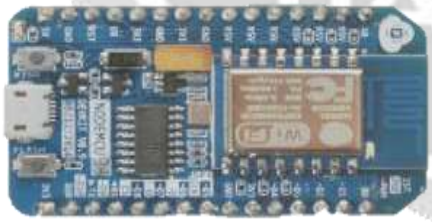


Fig. 1. Nodemcu

B. Flow Sensor

Water Flow Sensor is used here, they are installed at the water source or pipes to measure the rate of flow of water an calculate the amount of water flowed through the pipe. Rate of flow of water is measured as liters per hour or cubic meters. A water rotor along with a hall effect sensor is present the sense and measure the water flow. When water flows through the valve it rotates the rotor. By this, the change can be observed in the speed of the motor. This change is calculated as output as a pulse signal by the hall effect sensor. Thus, the rate of flow of water can be measured. The main working principle behind the working of this sensor is the Hall effect. According to this principle, in this sensor, a voltage difference is induced in the conductor due to the rotation of the rotor. This induced voltage difference is transverse to the electric current. When the moving fan is rotated due to the flow of water, it rotates the rotor which induces the voltage. This induced voltage is measured by the hall effect sensor and outputs are sended to nodemcu to display.

Fig. 2. Water Flow Sensor

The sensor should have minimum following properties:

- Working Voltage: 5 to 18V DC (min tested working voltage 4.5V).
- Max current draw: 15mA @ 5V.
- Working Flow Rate: 1 to 30 Liters/Minute.
- Maximum water pressure: 2.0 MPa.
- Flow rate pulse characteristics: Frequency (Hz) = 7.5 * Flow rate (L/mi

Sensor should have following connection:

- Red wire: +5V.
- Black wire: GND.
- Yellow wire: PWM output.

C. Xamapp Server

XAMPP helps a local host or server to test its website and clients via computers and laptops before releasing it to the main server. Apache HTTP is a remote server(computer) if someone requests files, images, or documents using their browser they will serve those files to clients using HTTP servers. Mainly hosting companies use this application to create a VPS server and shared hosting for their clients. MYSQL is open-source software. It is actually a relational database management system(RDBMS). This SQL stands for Structured Query Language. It is the most popular and best RDBMS used for developing a variety of web-based software applications. With the help of MYSQL, it is possible to organize the information, manage, retrieve, and update the data whenever you wish to do it.

IV. WATER DETECTION & ALERT

Leaks in resource transmission pipelines is a growing concern for the water transmission industry. Here, detection of water leakage is one of the solutions which can bring a lot of change and solve the water deficiency problem. We can detect the leakage and also its level by using some IOT sensors. This is also giving the alert notification and real time situation of pipelines using an android application to the respective authorities. The proposed method is the idea and concept about the use of wireless communication technology and uses of Apache server and phpMyAdmin console to manage database along with the use of flow sensors to mitigate leakage.[3] Input and output commands to sensors are managed by nodemcu which is a micro-controller unit. It helps us to connect our IoT module to specially targeted application. Application is provided to handle the all query's of database to manage all resources graphically in well manner. The basic concept of system is on law of conservation of mass which states that mass can neither be created nor be destroyed, hence we conclude the amount of water going into and coming out of the pipe should be same. Again, this mass is nothing but it is related to mass flow rate.

To monitor the amount of water being supplied and used, the rate of flow of water has to be measured. Water flow sensors are used for this purpose. Water flow sensor consists of a plastic valve from which water can pass. A water rotor along with a hall effect sensor is present the sense and measure the water flow. When water flows through the valve it rotates the rotor. By this, the change can be observed in the speed of the motor. This change is calculated as output as a pulse signal by the hall effect sensor. Thus, the rate of flow of water can be measured, as shown in fig. 3.

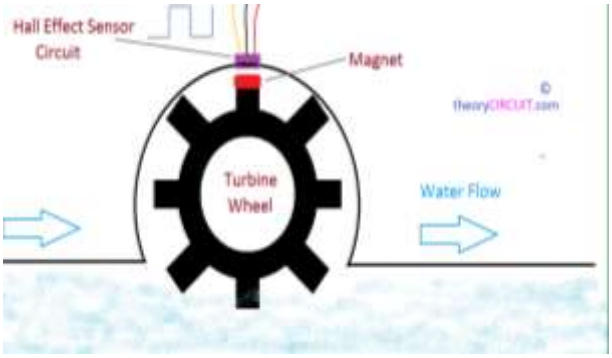


Fig. 3. Hall Effect (Rotar Working)

The main working principle behind the working of this sensor is the Hall effect. According to this principle, in this sensor, a voltage difference is induced in the conductor due to the rotation of the rotor.[11] This induced voltage difference is transverse to the electric current. When the moving fan is rotated due to the flow of water, it rotates the rotor which induces the voltage. This induced voltage is measured by the hall effect sensor.
It's quite simple inside. The main components are the Hall Effect sensor, turbine wheel, and magnet. The water flows in through the inlet and out through the outlet. The water current drove the wheel to turn, and the magnet on the wheel turned with it. Magnetic field rotation triggers the Hall sensor, which outputs high and low level square waves(pulse). For every round of the wheel, the volume of water flowing through is a certain amount, as is the number of square waves output. Therefore, we can calculate the flow of water by counting the number of square waves(pulse).

These sensors can be easily interfaced with microcontrollers like Arduino and Nodemcu.
Connecting the water flow sensor to arduino requires minimal interconnection. Connect the VCC (Red) and GND (Black) wires of the water flow Sensor to the 5v and Gnd of Arduino, and link Pulse Output (Yellow) wire of the water flow sensor to Arduino's digital pin 2. Note that the water flow sensor is not a power-hungry type; it draws a maximum of 15-20mA at 5V DC input! Shown in fig. 4.

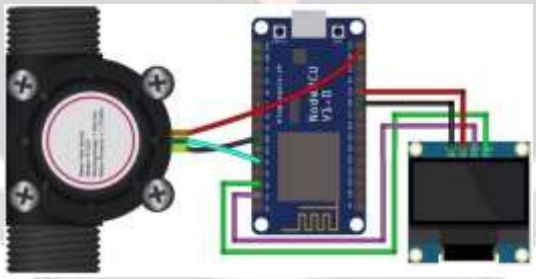


Fig. 4. Hardware Connectivity to Nodemcu

The sensor contains three wires. Red wire to connect with supply voltage. Black wire to connect to ground and a yellow wire to collect output from Hall effect sensor. For supply voltage 5V to 18V of DC is required.
The water velocity depends on the pressure that forces the through pipelines. The cross-sectional area of the pipe is known and remains constant, thus we calculate the average velocity that indicates the flow rate.Let us consider Q is the flow rate/total flow of water through the pipe, V is the average velocity & A is the cross-sectional area of the pipe. In such a case the basis relationship for determining the liquid's flow rate in such cases is Q=VxA.
Sensor Frequency (Hz) = 7.5 * Q (Liters/min)
Litres = Q * time elapsed (seconds) / 60 (seconds/minute)
Litres = (Frequency (Pulses/second) / 7.5) * time elapsed (seconds) / 60

Litres = Pulses / (7.5 * 60)

How to start with NodeMCU?

NodeMCU Development board is featured with wifi capability, analog pin, digital pins, and serial communication protocols.To get started with using NodeMCU for IoT applications first we need to know about how to write/download NodeMCU firmware in NodeMCU Development Boards. And before that where this NodeMCU firmware will get as per our requirement.There are online NodeMCU custom builds available using which we can easily get our custom NodeMCU firmware as per our requirement.

IDE SETUP

Ardunio setup IDE allows us installation of third party platform packages using board manager.

- Install Ardunio latest version from ardunio
- Star ardunio and open preference window
- Enter
- Open board manager from tools Board menu and install nodemcu drivers and select respective board.
- Select board (Tools-> Board-> Ardunino)
- Install libraries for esp8266
- Now we can load our program on board using Ardunio IDE

In same way, there will be an android application which has registration of admin and also pipe entry which include pipe information such as pipe_id, pipe_name, pipe_work, pipe_address, etc. User will able to add information as he deploy many number of pipes. As shown in fig. 5. Pipe_id will automatically incremented as pipe entries are done, similar to the roll numbers we get in colleage. Each pipeline will have a unique code which will be stored in the database with an exact address attach to it. Whenever the micro-controller will send any info it will search for the code and will give exact location, present in the database, it will show exact location of leakage on web application making it easier for operators to understand the system.

V. RESULT

Apart from that application has several tabs such as home tab, search tab, pipe adding tab, Profile tab shown in fig. 5.1 Home screen has notices board, it will shows notices from NMC and image slider to show related images to have good experience while using application.

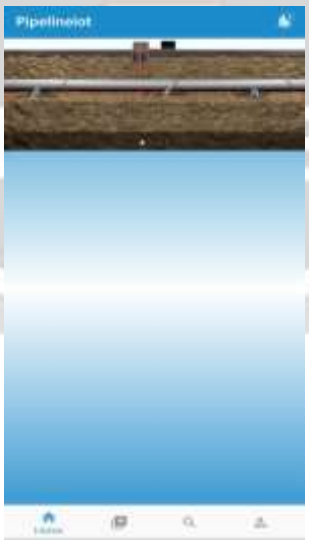


Fig. 5.1. Home Screen

Next tab is search tab, which provides functionality to search entries of pipes in database, so it will more benifical to user to experience application After that profile tab is displayed which have user details, pending work, help section, share option which include all social media platform and sharing app option to enhace and make sharing easy, about section which contain information about application, done work etc shown in fig. 5.2

- CPU Usages: 5-6% off computer or mobile processors.

- Network Consumption: Minimal data will be used.
- Response Time: 10-15 seconds (Approx.)It can depend on our mobile or computer RAM if the RAM is higher it will take less response time if the RAM is low-end then it will take more time

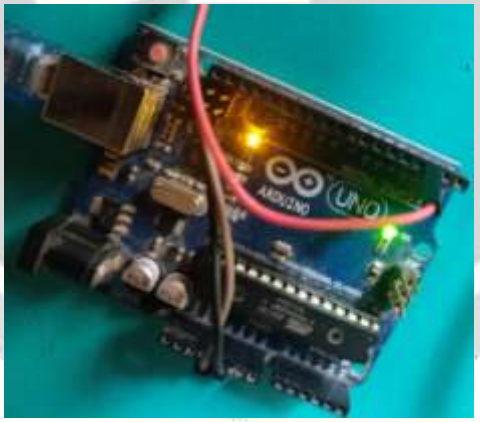
Fig. 5.2 Pipe Details

Suppose any leakage is happen in pipeline then the sensor which is connected to that pipeline will send that data to the databse and also to application. These will help admin to get notification on mobile phone for example shown in fig. 5.2. Application is provided with a small bell icon on the right top corner of the screeen. After clicking on that icon user will able to see following content in application as shown in fig. 5.3Also, application have feature of providing count of added pipes, pending task count, so that it will help user to perfom his task rapidly. This is shown in fig. 5.4

Fig. 5.3. Notification Screen

Fig. 5.4. Count Screen

Here, we are discussing ardunio part in which we have our arduino board. Arduino board Usb cable which is required for power connection or we can also provide external power supply to an arduino. Also we required to connect our flow sensors wires to the board, there are three wires as shown in Fig. 6.0 Red – For 5V, Black – For Ground, Yellow – For Signal. They all are also required to connect with an arduino board shown in Fig. 6.0.



We have taken two pipes to implement this project/system and as per instructions on sensor, we had connected it with pipes (considering Inflow & Outflow). Water Flow sensor is nothing but it measures the flow of rate which is flowing from it. Water flow sensor has hdrulic input. With all connection and pipes we have designed our IOT module.

When water flow from sensor, rotar spins and it has coil which induce analog output. Output is in integer from like 234,345,66,442,998. In our android module these outputs are compared and respective output is displayed on android application.

VI. CONCLUSION

The System proposed in this paper is about providing alert of leakage pipe and help authorities by providing application to manage and monitor the real time situation of pipelines. Again, when the pipe leaks out underground and various factors of road like bad quality roads, airlock, which forces water to move it from its actual leakage point to another, which can increases the repairing efforts of workers and can mislead them. Managing and maintaining pipes is very complex task but, proposed system helps respective authorities to manage all huge pipelines easily. Hopefully, this project will bring change and save water and also reduce efforts of government workers.

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REFERENCES

[1] bin Md Akib, A., N. bin Saad, and V. Asirvadam. Pressure point analysis for early detection system. in Signal Processing and its Applications (CSPA), 2011 IEEE 7th International Colloquium on. 2011. IEEE.
[2] Ma, C., S. Yu, and J. Huo. Negative pressure wave-low testing gas pipeline leak based on wavelet transform. in Computer, Mechatronics, Control and Electronic Engineering (CMCE), 2010 International Conference on. 2010. IEEE
[3] Wan, J., et al., Hierarchical leak detection and localization method in natural gas pipeline monitoring sensor networks. Sensors, 2011. 12(1): p. 189-214
[4] Martins, J.C. and P. Seleghim, Assessment of the performance of acoustic and mass balance methods for leak detection in pipelines for transporting liquids. Journal of Fluids Engineering, 2010. 132(1): p. 011401.
[5] Mirats-Tur, Josep & Garthwaite, William. Robotic Devices for Water Main In-Pipe Inspection: A Survey. J. Field Robotics. 27. 491-508. 10.1002/rob.20347. (2010).
[6] Chatzigeorgiou, Dimitris, Kamal Youcef-Toumi, and Rached Benmansour. "Design of a Novel in-pipe Reliable Leak Detector". IEEE/ASME Transactions on mechatronics, 20155, volume:20, Issue:2, pp.824-833
[7]https://www.electronicwings.com/nodemcu/introduction-to-nodemcu
[8]https://how2electronics.com/iot-water-flow-meter-using-esp8266-water-flow-sensor
[9]https://www.electroschematics.com/working-with-water-flow-sensors-arduino/
[10]https://www.researchgate.net/profile/Lawrence_Kalubu/publication/266557667_An_overview_of_pipeline_leak_detection_and_location_systems/links/54341d010cf2dc341daf3531
[11]https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6929193/
[12]https://www.waterworld.com/home/article/14070706/successful-water-leak-detection-and-audit-methods