IoT based Detection and Control of Leakage in Water Pipeline with a portable kit

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***Abstract*— Water is without a doubt the most precious resource in the world. Tremendous amount of water is wasted all over the world due to leakage in water pipelines. In order to utilize this resource wisely wastage of water should be avoided. This paper proposes better method to monitor the pressure of water flowing through the pipeline and detects leakages over the pipeline. Observatory kit which includes Raspberry Pi and pair of pressure sensor and water quality sensor is mounted all over the pipeline. Processor uploads the output of sensors on cloud server continuously. If it finds pressure below the predefined level; also despite the constant pressure if quality of water detoriate, then processor sends the alert message to concerned staff. We need internet connectivity in order to upload on cloud. But even in the absence of internet, alert message can be sent through SMS service which works on GPRS. This paper also sheds a light on taking preliminary measures on leakage reduction. Water flow is been supplied and controlled through valves which are situated at the junction of pipelines. In order to reduce water loss due to leakage processor controls the position of control valve so that water flow through the same pipeline will be reduced resulting in less loss of water.**

***Keywords*— Internet of Things, Cloud computing, leakage detection, pressure sensors, quality sensor.**

I. INTRODUCTION

Oil and gas was always key part and crucial element for the progress of the country, so monitoring of oil and gas pipeline had been received lot of attention. On the contrary future water scarcity was always been neglected. Lots of water wastage occurs due to ignorance of fact that there have been taken no major steps to prevent water loss all over the world. Few countries like China, Germany, U.K, U.S has employed different techniques and platforms in order to prevent water leakage. Depending on complexity of pipeline network, weather conditions around the pipeline and causes of specific errors generation due to weather conditions appropriate method of monitoring is preferred.

In Mumbai there are close to 2000 slum structures on either side of the water pipeline of which 90% are illegal.
Brihanmumbai Municipal Corporation suffers losses worth of Rs.400 crore annually due to water theft and illegal connections.
Also there had been many incidents in Mumbai in which pipeline busted due to bad conditions of old pipelines.

Due to considerable amount of water leakage and tampering of pipeline BMC, Thane Municipal Corporation has appointed manual surveillance over the pipeline network. But due to unavoidable manual errors water loss continues which finally ends up in water supply shortage and hence regular water cuts with low pressure water supply.

This project suggests simple and economical way of monitoring the pipelines. It just not only provides the monitoring but also informs concerned staff member about the approximate location of leakage through SMS. It takes the necessary but preliminary measure once water pressure goes down below the desired value. This paper also suggests way to detect the crack on the pipeline using a portable kit which may consist of acoustic or radio waves transmitter and receiver. Once exact location of crack on pipeline is identified beep sound will be buzzed.

II. OVERVIEW OF VARIOUS TECHNIQUES

Many different techniques and platforms have been discovered for pipeline monitoring. In general leakage detection is mostly done by acoustic sensor (using either microphone or geophone). [3], [5], [14] uses these devices, resort to sensing mechanisms or sensing elements (like piezoelectric materials). This paper has also used gateways to send the sound received by acoustic sensor to backend server for further processing. FFT is one of the technique used to process the sound or noise of water. It analyses the difference between normal sound and abnormal sound condition if leakage has occurred. [5] uses microprocessor ARM M4 to collect the acoustic sensor output whereas [3] uses PIC microcontroller for the same purpose. But acoustic is only applicable for small diameter pipeline with pressure 2-3 bars. There are many other methods discussed in [6], [13] like detection using tracer gas technique, thermography etc. other than acoustic sensors. Leakage can be detected based on Time domain Reflectometry (TDR) where high measurement accuracy, high versatility, and robustness, relatively low implementation costs, and thanks to the possibility of carrying out continuous, automated, remotely-controllable, real-time measurements are demanded.

[7] is also based on TDR but it uses application and reflection of electromagnetic signal. Reflection coefficient is calculated which is proportional to flow difference through pipeline. Transmission line i.e. metallic wire is laid on the road which allows electromagnetic signal to pass through the soil and reflects back from pipe surface. [1] have used this method not only to detect the location of leakage but also quantity of water wastage. [8] uses Ground Penetrating Radar (GPR), but here reflected waves are recorded, digitized and then B-scan images are formed. 3 step method is developed to analyze these B scan images. [2] suggests a statistical filter for the images of cracks. It describes in depth study of behavior of crack detector based on image processing. Images are taken by visual inspection or by CCTV videotape. [4] discusses theoretical analysis about double island-beam structure sensor. The position for sitting resistances values and width of resistances are analyzed in detail. It utilizes finite-element method (FEM) and simulation software analysis, static and dynamics analysis and computer simulation are carried out for strain diaphragm of piezoresistive micro-pressure sensor. [9] uses Smartball and [10] uses Explorer, 4 wheeled camera carrying in pipe robots. Both flow with the water in pipe, [11] detects the crack which finally results in leakage using Wireless Networked Sensors. Reliable communication takes place by ZigBee technology. Vision based system PIG (Pipeline Inspection

Gauge) are used to form images. [12] This method is based on vibration sensor and generalized cross-correlation technique. Method employs a modified Maximum-liklihood (ML) prefilter with a regularization factor and better method of estimating time difference in all types of pipeslines.

III. PROPOSED METHOD FOR LEAKAGE DETECTION IN PIPELINE

A. Proposed Block Diagram

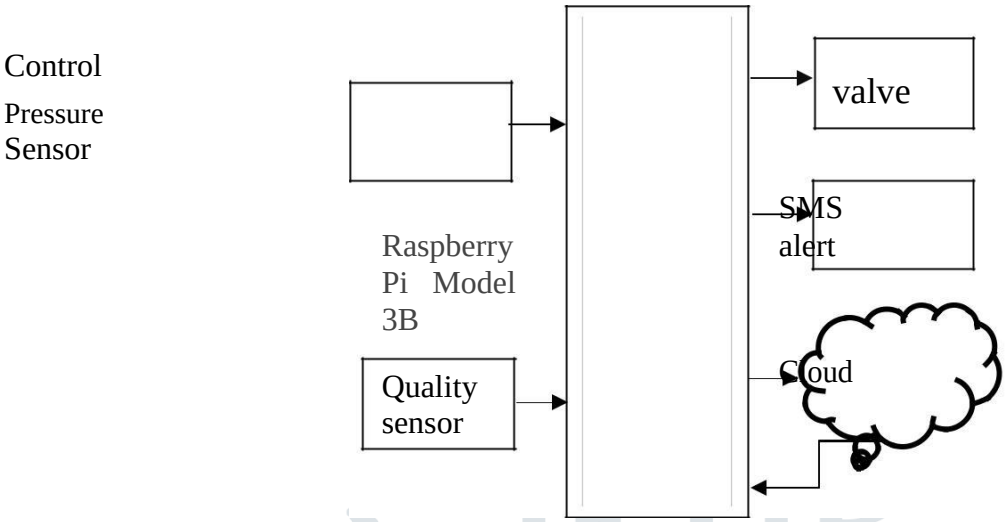

Fig. 1.Block Diagram of observatory kit at every node for e.g. node A

Fig. 2.Test bed layout of observatory kits all over the pipeline.

This project suggests simple method to monitor water pipeline, detect leakage and the crack and initiate preliminary measures as shown in figure1. Pressure sensor is going to sense the pressure of the pipeline continuously. Sensed data is given to a processor which compares the sensor output with expected pressure of water. This comparison has to be executed continuously in order to maintain the required pressure in the pipeline. This live data (sensor output) is continuously updated on cloud network.

Due to this, manual supervision at the very remote places can be avoided. ThingSpeak is a cloud network which has a support from MATLAB software initiated by MathWork which can collect data from private channels like individual sensors. It can share the data with public channels using IoT platform. Most interesting part to know about cloud is that it can analyse the data collected as well without requiring Matlab licence from Mathworks.

If pressure sensor and water quality i.e. sensor output is not as per the desired value then control action is taken by the processor. Also alert message (SMS) is sent by GSM900A connected to raspberry pi to concerned staff sitting far from water pipeline. SMS provides record of time and place of leakage since nearest processor is supposed to send the SMS. Each GSM900A is interfaced with separate raspberry pi3B model. Through GPRS network SMS will be sent which will mention Sensor output and IP address of raspberry kit which will indicate the approximate location of leakage. Keeping moderate distance between two observatory kits exact location of leakage can be determined.

Water supply is prominently given by two lines. Feeder line and Distributive line. At every cross-section out of grid of the pipelines water supply control valve is mounted. Using plunger, water flow to different distributed pipelines from feeder pipeline is manually adjusted. Once leakage is detected, to avoid further wastage water flow can be reduced. As a part of initial measures plunger can be rotated in such a direction so that water flow can be slowly minimised. Nearest Raspberry pi would rotate this plunger without manual intervention. Some amount of water wastage can be avoided till further solutions are applied on permanent basis.

Figure2 shows approximate idea of observatory kits at nodes A, B, C situated on pipeline. Leakage will be identified and informed to staff via SMS by nearest RPi. But to identify exact location of leakage (between any two observatory kits) without digging the road portable and handy kit is rolled down manually. This kit would consists of the sensor which will predict exact location of the crack on the pipeline.

B. Working of proposed block diagram

Traditionally in various municipal corporations like Pune Municipal Corporation, BrihanMumbai Municipal Corporation, Thane Municipal Corporation etc. layman known as *Gangman* roam all over the pipeline and check the leakage personally. Due to widespread length of pipeline monitoring becomes very tedious. Proposed block diagram suggests automatic leakage detection

which is known due to drop in water pressure as well as rise in impurity level of water detected by quality sensor along with RPi which will be located at each node A, B, C etc (figure 2). All these nodes are situated all over the pipeline which consist of observatory kit as shown in figure1. Pressure alias flow sensor counts number of pulses per minute which is equivalent to flow of water in litres per minute. These pulses are counted by RPi and equivalent reading is uploaded on cloud.

Many a times it is observed that pressure of the pipeline do not drop down even in the presence of leakage and considerate amount of water loss. Due to slight crack on pipeline and especially when pipeline is surrounded by sewage pipeline or contaminated water puddles pure filtered water gets mixed with impure water. That maintains the pressure of pipeline as earlier. To shed a light on this water quality sensor value uploads turbidity count of water on cloud. That indicates clearly that if turbidity value has increased but pressure sensor output remains constant, water is contaminated due to crack on the pipeline. In both the situations alert message is sent through SMS using GSM900A and raspberry kit processor.

To avoid further water loss preliminary action will be taken by RPi by shutting down the valve which will be responsible to reduce the water flow through the respective pipeline. SMS sent to staff will be able to describe time and approximate location of leakage. Since each RPi will hold unique IP address, cloud will already have the knowledge about location of RPi kit on pipeline with its IP address.

In order to study the pattern of location, time or quantity of leakage sensor data is loaded on cloud server. In this paper ThingSpeak service by Mathwork is been used. Pattern can be analysed in future in order to take permanent measures against the places where leakages occurs frequently.

In order to reduce the leakage plunger which is responsible for a supply of water through the respective pipeline is unscrewed so flow of water can be reduced through the pipeline where leakage has occurred. Raspberry Pi gets the feedback from cloud network which gives the graphical or pictorial representation of sensor showing drop in pressure. If leakage is of considerable amount RPi will rotate the Stepper motor which is connected to nearest plunger. RPi will rotate the stepper motor in such a way so that plunger will unscrew and water supply flowing through the same pipeline will be reduced which will lead to reduction in leakage amount.

Feedback from cloud to RPi is in indirect way. This paper do not suggest data analysis by cloud network. But once valve position is adjusted by nearest RPi to reduce supply flow, water pressure will drop but will be stabilised at a constant level. Hence pressure sensors will update this constant low pressure on cloud which will indicate valve position is been adjusted and further major action has to be taken in order to reduce the leakage. Only after remedial solution is implemented water supply can be started with original pressure by adjusting the valve manually.

Also, in case of water shortage water supply is provided for limited number of hours to the colonies. Rest of the time there will no water flow through respective pipeline. According to this schedule processor can be programmed.

To pinpoint the exact location of crack mobile unit is designed which will be rolling down over the ground. Acoustic or electromagnetic sensor can be used on mobile kit to detect the crack between the two points estimated by pressure sensors situated underground along with RPi.

IV. RESULT

Time (every 15sec)	Water pressure in Ltr/min
	Pressure Sensor1 at Node A
3:00:40	25.50
3:00:45	25.50
3:01:00	25.20
3:01:15	18.30
3:01:30	2.20
3:01:45	25.50

Table. 1 Live data update i.e. pressure sensor output on CLOUD

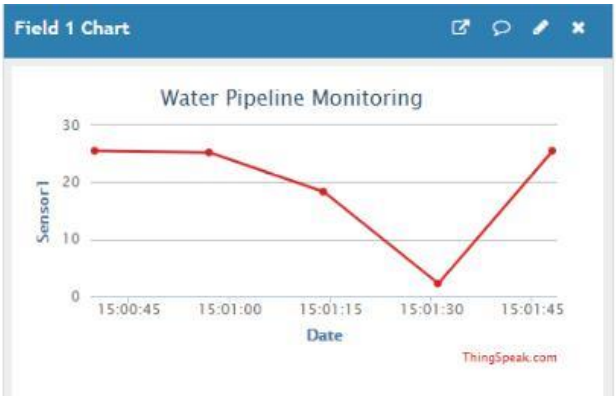

Fig. 3.Graph on CLOUD after uploading 5 readings of pressure of pipeline

Water pressure sensor not only continuously monitor the pressure but also data is uploaded on CLOUD server every after 15 seconds. CLOUD is capable of showing the readings in the form of graph which gives idea of situation more quickly. It is also capable of performing data analysis which is helpful in identifying most repetitive leakage pattern. From the position of the sensor, location of leakage can be recognized which is helpful to decide either short term or long term solution. Prototype will show only two sensors, but practically more than one sensor along with RPi can be mounted over the pipeline.

If number of observatory points over the pipeline are increased then location of the leakage will be able to be determined more accurately. Graph shows readings taken by pressure sensor mapped against time. Every after 15 seconds output noted by sensor is updated on cloud server by RPi kit. This gives immense flexibility for a concerned staff which may observe the readings from remote place. Pictorial representation brings the drop into pressure into notice more easily. Right now only pressure sensor output is shown. Number of graphs will be increased as we go on increasing number of sensors all over the pipeline.

Referring to these graphs cloud also can do some analysis part which is helpful in determining patterns for a specific place where leakage occurs repetitively. Once such places are known permanent solution can be implemented to avoid further leakage.

V. CONCLUSION

SMS is generated using GSM900A kit to alert the concerned faculties. Live data i.e. both sensor's output will be updated on ThingSpeak. RPi will be taking the preliminary measure in order to reduce the water loss due to leakage before manual intervention is applied. More than one kit will be mounted all over pipeline for monitoring purpose where each kit will include Raspberry Pi, Pressure sensor and Quality sensor. To know exact location of leakage between two observatory kits one portable kit will be designed, so that without digging the ground crack or leakage can be determined.

FUTURE SCOPE

Observatory kit consists of pressure and Quality sensor which will be turbidity sensor, these are connected to RPsi kit. Water Load shading and area wise water supply for only limited number of hours or water shut down is scheduled well in advanced. This schedule has to be taken care while controlling valve. Proper casing has to be provided for observatory kit since those are to be mounted under the ground. Electromagnetic wave sensor on portable kit will pinpoint exact location of crack on pipeline.

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