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Review of Water Leakage Detection Approaches

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Abstract- Leakage from water supply is posing a serious problem for the water supply industry that has to supply water to the buildings, houses, offices etc. Water pipes are usually buried underground and it is not rare that a pipe is used for long period (more than forty years). These old water distribution networks are prone to variety of leakages. These leakage detection and localization in water pipes is one of the main concerns for the water management department. So detection of water leakages is necessary to save water from getting wasted. Various techniques have been developed to detect the location and size of leakages previously. Leakage detection is one of the problems because of lack of monitoring, manual work, less man power. This paper presents the recent approaches used for water leakage detection and summarizes the features of some methods. The primary method of detecting and locating leaks is an acoustic method, in which acoustic signal emissions of pipes are monitored in order to detect the sound made by leaks. Most of the techniques of the leakage detection discussed below are based on the variation in parameters in the supply network such as measurement of variation in pressure (using pressure sensor), flow variations, vibration and temperature. It is observed that water leakage can be further reduced by improving leakage detection techniques. The environment could be benifitted from these systems in the form of water savings and the reduction of energy consumption.

Index Terms- water leakage, leakage detection, water management.

1. INTRODUCTION

Water plays an important role in day to day life of all human beings. In fact it is the most precious and valuable resource of life. Due to increased urbanization, water supply department is facing many problems in real time operation such as proper distribution of water, irregular water supply, leakages in pipelines, quality of water, etc.

A leakage is a physical phenomenon caused due damage or hole in pipeline which is of any irregular size, and can occur at anytime, anywhere in the water supply pipeline. The problem of water leakage detection gained much importance in this era because it is not just an environmental issues but it is economic issue as well.

Water distribution network plays a vital role of transporting water from the place of origin to place of consumer. Any leakage in the pipe can cause major financial losses and along with environmental damages. Currently, buried pipelines are only monitored at key points, which can be spaced several kilometers apart. A system with a higher spatial resolution would provide operators with a better understanding of their network. Most of the water pipes are buried underground, making it difficult to find the location of leaks. For this reason, usually water leakages have been detected when water flows out of the ground due to massive leaks in pipes. For this reason review of present water leakage detection approaches and comparative study of these approaches are planned in this work.

2. LITURATURE REVIEW

Ms T. Deepiga et. al. define the water monitoring systems such as Tank water level sensing monitoring, water pollution monitoring and water pipeline leakage sensing monitoring [1]. By using Wireless Sensor Technology they avoids the huge amount of water being wasted by uncontrolled use of large apartments/offices. The microcontroller (PID) based water level monitoring is used to indicate the level of water in the tank to agent. Sensor Based Water Pollution Detection, it will check the water quality by using these parameters such as the pH level, turbidity and temperature are measured in real time by the sensors and it would monitor by an agent. For Leak detection in water pipelines, they measure pressure into the pipes using force sensitive resistors (FSR). The pressure difference generated due to leak is detected, it will be indicated by an LED meter and a rushing sound will be heard in the headset.

Fukushima Kei et. al. demonstrated water leakage detection in the period from September 2013 to March 2014. Authors made a demonstrative test on actual water pipes jointly with KASIX Corporation, local information processing company, and under collaboration from the Gas and Water Supply Bureau of the City of Kashiwazaki (Niigata Prefecture), Japan [2]. As a result of assessment using about twenty sensor loggers under various test conditions, succeeded in detecting four water leak cases with position errors of less than 1 meter.

Athanasios Anastasopoulos et. al. deals with the technical description and the physics of the AE leak detection technique, presents the advantages, limitations and requirements of the method, describes the necessary functions of AE equipment for performing such a task, and, finally, reports on several case-studies of successful leak detection and location of buried pipelines [3]. The case studies cover both new and in-service buried pipelines of different sizes.

Dídia Covas et. al. uses the methodology is the identification of location of leaks in pipe networks using observed pressure data, collected during the occurrence of transient events, and the minimization of the difference between observed and calculated parameters [4]. This approach is presented conceptually and implemented in a software tool. The methodology is tested and verified with laboratory data collected in an experimental facility at Institute Superior Technical (Technical University of Lisbon). Based on this preliminary data analysis, the main practical difficulties of the implementation of this methodology in field network systems are outlined.

Ali M. Sadeghioon et. al. presents the design, development and testing of a smart wireless sensor network for leak detection in water pipelines [5], based on the measurement of relative indirect pressure changes in plastic pipes. A non-invasive (to the pipe) pressure measurement method based on FSR sensors has been presented. FSR sensors detect the changes in pressure and the leak test is based on variations in normal pressure along with the temperature using temperature sensor.

N. Merzi et. al. presents a methodology to estimate, to determine and to locate water losses from water distribution network [6]. Various techniques are used to reduce the losses by employing limited manpower and simple instruments. Alternatives requiring sophisticated equipments are also introduced. Related case studies from Ankara Municipal Water Distribution Network are presented.

Jihoon Choi et al suggested a method of Leak Detection and Location of Water Pipes Using Vibration Sensors and Modified ML Prefilter [7].The proposed method construct a channel model for vibration signals in buried water pipes based on the field measurement data and also, the modified ML prefilter can be applied to correlation-based leak detection systems utilizing the STFT and the wavelet transform. This leak detection method was verified by field measurements using a practical leak detection system. This leak detection system is useful in developing an automatic leakage management solution that collects leakage data, alarms about the risk of leaks, and informs about the specific leak locations.

A. Candelieriab et. al. proposed a study dealing with the application of graph-based analysis to develop an effective computational leakage localization approach [8]. This approach is based on a combination of simulation of different leaks, in terms of location and severity, and the graph-based clustering analysis of the pressure and flow variations. The demonstration of this method performs several simulation runs, through EPANET, by placing, in turn, a leak on a pipe and varying its severity in a given range. At the end of each leakage simulation, the EPANET software outputs pressure and flow value at each junction and pipe, respectively. Only the values in correspondence of the position of monitoring devices in the real network are considered. This method is efficient as compare to the traditional one but it requires a lot of computation.

D. Salaa et. al. presents detection of leaks in a small-scale water distribution network based on pressure data [9]. This method suggests the leak detection based on the adaptation of the VDM-related identification problems in structural mechanics for the leak detection problem in water distribution networks operating at steady state flows. The method uses the relationships between pressures and flows within the network to detect the leakages.

C.M. Giorgio et .al. suggested a methodology for Leakage Isolation Using Pressure Sensitivity and Correlation Analysis in Water Distribution Systems [10]. The proposed method uses the Apulian hydraulic network. A leakage localization method based on the pressure measurements and sensitivity-correlation analysis of nodes in a network has been proposed in the system.

Pranita Vijaykumar Kulkarni et.al. presents an IOT based Water Supply Monitoring and Controlling System with Theft Identification [11]. In their system, they are focusing on continuous and real time monitoring of water supply in IOT platform. Water supply with continuous monitoring makes a proper distribution so that, a record of available amount of water in tanks, flow rate, abnormality in distribution line can be stored. Using Adafruit as free sever data continuously pushed on cloud so observation of data in real time operation is possible. Using different sensors with controller and raspberry pi as Minicomputer can monitor data and also control operation from cloud with efficient client server communication.

3. CLASSIFICATION

The above discussed methodologies are generally classified on the basis of technique used for the leakage detection. In particular type of sensor used for sensing the leakages. It might be invasive or non invasive and so on. All these sensors may be deployed at the field i.e. pipeline.

3.1 Pressure based leakage detection Techniques

So broadly the methodologies discussed based on pressure sensing are systems suggested by Ms T. Deepiga et. al. [1] they are using FSR to detect pressure inside the pipeline which also invasive procedure. DídiaCovas et. al. [4] their method of leak detection is also based on pressure data collection during the occurrence of transient events. The system suggested by Ali M. Sadeghioon et. al [5] also work on the pressure sensing method. N. Merzi et. al.[6] suggested a system which is also based on field measurement along with this Acoustic leak detector is also used in that system, mostly similar Acoustic Emission based technique also used by Athanasios Anastasopoulos et. al. [3]. The graph based leakage analysis method given by A. Candelieriab et.al. [8] also considers pressure and flow variations in their system.The methodologies given by D. Salaa et. al.[9] ,C.M. Giorgio Borta,b [10], P´erez et. al [12] also based on pressure data or sensitivity.

3.2 Other leakage detection Techniques

Jihoon Choi et. al [7] uses vibration sensor in their system. Whereas leakage detection system suggested by NEC, Fukushima Kei et. al. [2] uses loggers also known as Gutermann ZONESCAN sensor. In some of the systems ultrasonic leak detector and temperature sensing also done. E.g. system suggested by Deepiga et. al.[1] also uses ultrasonic sensor (non-invasive to the pipe so that invasive pressure can be sensed from exterior part) along with pressure sensor. Some of the studies described here also suggests about the placement of the sensor(Sarrate et. al. [13], Casillas [14] and D. G. Eliadesa [18]) i.e. positioning of sensor nodes on the field at key points where the probability occurrence of leak event is maximum.

4. DISCUSSION

Increasing urbanization resulting into more population ultimately more resources will be consumed and it is obvious. Water is one of the basic need of all living things. But as number of consumer increases i.e. more civilization results in the improper service, there may be multiple reasons behind it. The concept of water leakage detection is gaining more importance in these days due to its severity to cause harm to the infrastructure, economic losses as well as environmental losses.

There are multiple techniques described here in this paper to detect and locate the leaks caused by water, but currently water leakage detection and control actions are relatively comprehensive. Because most of the techniques are not cost efficient and relatively less power consuming so that the utilization of another resources should be optimal, that is main concern.

Most of the techniques used for water leakage detection are based on the pressure sensitivity, Flow measurement and sometimes ultrasonic as well. But all of these mechanical type of sensing have limitations like ultrasonic sensors are not good for underwater use and it cannot also work in the vacuum along with this, accuracy of these kind of sensor decreases with the temperature. In case of pressure sensor although it is having high output signal level and not needed to amplify but it is sensitive to the vibrations. Although it provides robust system but in practice, pressure measurements can be accessible in to limited number of nodes, which correspond to locations where the sensors are placed. In some of the methodologies, work has been done regarding sensor placement for leak location. Deepiga et. al. [1] suggested a method of leakage detection which interferes with inside pipe system by mounting common pressure sensor inside the water pipe, so it is a kind of invasive technique. Sarrate et al.[12], defines an isolability index and use it to place the sensors in order to maximize the number of isolable node pairs. Closer to this work, P´erez et al. [15] used thresholds on the deference of pressures measured to obtain binary matrices that were used to translate the sensor placement problem to an integer programming optimization problem. In Casillas et al. [14], a new approach for sensor placement for leak location in WDN (Water Distribution Network) proposed that is based on the projection-based location. Actually, leak location and sensor placement should be considered together so that the efficiency of the system of detecting and locating leakages could be optimized.

There is still great room for improvement of leakage detection system since from the above study it is observed that there is a need of such system which provides proper, cost efficient, reliable, regulated and real time detection of the leakages. So that there are not only economic but also other benefits like sustainable development, environmental conditions and energy reduction should be considered. It is important to consider life cycle analysis and method which is required in updated time while developing a system.

As a next step we are planning to design an electronic system beyond these mechanical systems based on IoT which will not only detect but also locate the leakages present at the vulnerable points. The system will be cost efficient, durable and reliable; for the sake of ease of implementation. For now we are focusing on buried pipelines in the building. So that life and health of the building can be optimized.

5. CONCLUSION

Water leakage detection is important aspect of water supply or distribution system for sustainable development of cities. This paper presents the study of different approaches of water leakage detection techniques and aiming to understand the methodologies implemented till now. The various described methods in this paper suggests various leakage detection techniques, majority of the techniques are build up on using acoustic measurements, pressure measurements and also vision based system, flow, temperature variations in the supply. Proper selection and implementation of any of the method should be done according to the need. The system should also be beneficial to the environmental, economic conditions of life cycle. The cost effective, high performance, and reliable leakage detection technique has to be build up. This paper describes the number methods for the finding the leaks and there location. However their real time application founded to be generally limited. The efficiency of each of the method is sensitive to the quality of information provided in the real time environment by the sensors.

REFERENCES

[1]Ms T. Deepiga, Ms A. Sivasankari, "Smart Water Monitoring System Using Wireless Sensor Network at Home/Office," International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056, Volume: 02 Issue: 04, July-2015.

[2] Fukushima Kei, Maruta Yuuji, Izumi Kazuo, Ito Yusuke, Yoshizawa Ayumi, Tanaka Toshiaki, "A Water Leak Detection Service Based on Sensors and ICT Solutions", Special Issue on Solutions for Society - Creating a Safer and More Secure Society, NEC Technical Journal, Vol.9 No.1, January 2015.

[3]Athanasios Anastasopoulos, DimitriosKourousis and Konstantinos Bollas, "Acoustic Emission Leak Detection of Liquid Filled Buried Pipeline," Journal of Acoustic Emmision, Vol. 27, 2009.

[4] DídiaCovas and Helena Ramos, "Hydraulic Transients used for Leakage Detection in Water Distribution Systems," Water Pipeline Systems, BHR Group 2001.

[5]Ali M. Sadeghioon , Nicole Metje , David N. Chapman and Carl J. Anthony, "Smart Pipes: Smart Wireless Sensor Networks for Leak Detection in Water Pipelines," Journal of Sensor and Actuator Network, 2014.

[6]N. Merzi and T. Özkan, "Water Leakage and Detection In Municipal Water Distribution Networks," Water Supply and Drainage for Buildings, 29th International Symposium, Turkey.

[7] Jihoon Choi, Joonho Shin, Choonggeun Song, Suyong Han and Doo Il Park, "Leak Detection and Location of Water Pipes Using Vibration Sensors and Modified ML Prefilter," sensors, 2017.

[8] A. Candelieriab , D. Contibc, F. Archettiab, "A graph based analysis of leak localization in urban water networks," 12th International Conference on Computing and Control for the Water Industry, CCWI 2013.

[9]D. Salaa, P. Kołakowskia, "Detection of leaks in a small-scale water distribution network based on pressure data - experimental verification," 12th International Conference on Computing and Control for the Water Industry, CCWI 2013.

[10] C.M. Giorgio Borta,b, M. Righettia, P. Bertolaa, "Methodology for Leakage Isolation Using Pressure Sensitivity and Correlation Analysis in Water Distribution Systems," 16th Conference on Water Distribution System Analysis, WDSA 2014.

[11]Pranita Vijaykumar Kulkarni, Mrs. M. S. Joshi., “An IOT based Water Supply Monitoring and Controlling System with Theft Identification,” International Journal of Innovative Research in Science, Engineering and Technology, Vol. 5, September 2016.

[12] Myrna V. Casillas, Luis E. Garza-Castan on, Vicen¸c Puig, “Sensor Placement for Leak Location in Water Distribution Networks using the Leak Signature Space,” IFAC (International Federation of Automatic Control),48-21, 214-219, 2015.

[13]Sarrate, R., Nejjari, F., and Rosich, A., “Sensor placement for fault diagnosis performance maximization in distribution networks,” 18th Mediterranean Conference on Control and Automation (MED), 2012.

[14]Casillas, M.V., Puig, V., Garza-Castan˜´on, L.E., and Rosich, A., “Optimal sensor placement for leak location in water distribution networks using genetic algorithms,” Sensors, 13(11), 2013.

[15]P´erez, R., Puig, V., Pascual, J., Quevedo, J., Landeros, E., and Peralta, A,“Methodology for leakage isolation using pressure sensitivity analysis in water distribution networks,” Control Engineering Practice, 19(10), 1157 – 116, 2011.

[16]Qiang Xu, Ruiping Liu, Qiuwen Chen, Ruonan Li, “Review on water leakage control in distribution networks and the associated environmental benefits,” Journal of Environmental Sciences 26, 955–961, 2014.

[17]S. Qi, J. Gao, W. Wu, Y. Qiao, M. Tu, J. Wang,“Research on optimized leakage locating model in water distribution network,” 16th conference on water distribution analysis, 2014.

[18]D. G. Eliadesa, M. Kyriakoua, M. M. Polycarpoua, “Sensor placement in water distribution systems using the S-PLACE Toolkit,” 12th International Conference on Computing and Control for the Water Industry, CCWI 2013, 2014.

[19]S. B. Kakuste, U.B.Bhujbal, S.V.Devkar, “Review Paper on Leak Detection,” International Journal of Engineering Research and General Science Volume 2, Issue 3,April-May 2014.

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