Development of an Intelligent Based Water Pipelines Damage Control System at the Supply Unit of the Federal Polytechnic Offa, Kwara State

O. Olaboye Yinusa [a], Olanrewaju E. Abikoye [a] and Abdullateef O. Alabi [b*]

[a] *Department of Mechanical Engineering, Federal Polytechnic Offa, P.M.B.420, Offa Kwara State, Nigeria.*
[b] *Department of Computer Engineering Technology, Federal Polytechnic Offa, P.M.B.420, Offa Kwara State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. Author OOY conceived of the presented idea. Author OEA developed the theory and performed the computations. Author AOA verified the analytical methods, then investigated the study site on Federal Polytechnic offa for this study and supervised the findings of this work. All authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Water is the most valuable means of life sustainability because it is a basic need of all households. The incessant water leakage levels in the water supply network on the mini campus, Federal Polytechnic Offa, is one of the most vital issues to address by the work unit on the School campus. Works unit provides services to all departments on campus, covering an area of the landmass of 1050 hectares with a population of staff and students of approximately 13 000. The work unit is in charge of correctional facilities and operation. The sub-service of the work unit on water supply system comprising a network of 1km of water pipes and 1500 litres capacity storage tower across units. The input system volume in the lose of water supply is approximately 56%, from which a significant proportion is about physical losses. This paper focused on intelligent-based leakage control to replace the traditional method used on campus parameters for backtesting tracing when physical damage becomes visible. However, the result of the study revolves around the design and implementation of a prototype system. The study created a management console as an intelligent

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Corresponding author: E-mail: kitfad4u@gmail.com;

decision support system. The realism of the study summarizes various operations by developing intelligent reporting software with data warehouse techniques to facilitate underground leak line pipes tracking.

Keywords: Intelligent; leakage; control system; water supply; network.

1. INTRODUCTION

The pipeline Water leakage from pipeline networks has long been joint operational management in Federal Polytechnic Offa (FEDPOFFA), even at the state level in Kwara State, with well-planned operational practices and infrastructural development. "The key to studying a water leak strategy is finding a new approach and understanding the causes of leaks and the factors that mitigate them. The procedures can then be introduced and validated for specific network characteristics and local causal factors to resolve each of the causes in order of priority services" [1].

"Water leakage in a pipeline occurs in all water distribution systems; only the leakage volume varies. The leakages depend on the topology configuration of the pipe network and other prevailing conditions, the traditional water utility's operational or co-ordinational practices and the type of technology and technicality techniques to controlling leakage. Therefore, one of the water leakage strategy majors is knowing the actual leakage's significance. This physical water leaks from the supply pipeline network, and to develop an approach to fix the leakage rate" [2].

This study highlights four methods for solving the problem of visual leakages in water distribution networks: Active Leakage Control and Pressure Management (PM), Speed. However, the water distribution network's sub-system is a control unit managed through DMAs (District Metered Areas).

"The DMA's attribute usage varies out of use, including water detection, the instantaneous monitoring of water leakage rate and the systematic applied PM. This paper presents a case study of the Federal Polytechnic Offa mini campus. It describes all the actions that which work unit is taking to reduce and control Real Leakage through the construction of the infrastructure required for effective intelligent-based leakage control and management" [1,3].

2. ESTABLISHMENT OF DMA AT WORK UNIT

The water distribution network in the work unit of Federal Polytechnic Offa is divided into hydraulically discrete sectors (DMAs) using ground contours in relation with the digitised maps of the water supply network. DMAs established in the water supply network. The DMA's energised to water pressure metering to the consumer unit of the FEDPOFFA campus. PMAs (Pressure Management Areas) are used to control the water pressure. Installation of the sensor devices in real-time on campus will require suitable land topography, existing boundaries, eco-system features like rivers, major and minor roads and others [4].

In the research design, a model called ' Dead-end' or 'Tree Distribution system' is used to position DMAs. The inlet water flow and branching are carried out off the trunk mains supply; this is one of the corrective measures used to improve the control of the DMAs and considered mains network flexibility, not affected. However, Water Flow Sensors (Switch Hall Effect Flowmeter Fluid Meter Counter) is used to measure the inlet and outlet of water flow [5].

The deviation in the pipeline elevation in the water pressure zones ranges from 25 to 50 m. In addition, The land topology on the mini campus is sloppy, making the network sufficiently convey water in a network to three routes within the campus unit which comprises 13 sub-unit in the surrounding areas (see Fig. 1). The condition of the terrain was factored in the design to prevent flow back or loss of pressure in a very steep sub-unit [6].

PMAs is charged with signal to monitor water service from the centre reservoir to the distribution zone. Masood [7] investigated how monitoring water flow in these pipelines networks helps detect illegal connections, vandalisation, or leakages, which form an integral part of using high Non revenue water. In this case study, the supplies to various campus units used in the sample study area using electronics valves (e-values).

The researcher intends to improve design through the design of an automated valve to control water flow to recognise leakage and when leakage fault is within the distribution operation of the pipeline network. However, all the joints' e-valves activeness check for water tightness and firmness of the joints to secure leakage. The actual flow rate output sensed the faults made over the Arduino serial monitor. Hence, another study describes an intelligent water monitoring system that can predict the user's water usage over time. The author aimed to discuss active approaches to developing innovative water applications, so the balance calculation of the analysis of flow impulses determines water balance calculations [8-14].

2.1 Intelligent Based Leakage Control system (INTLEADCS)

This is a subside of a programmable electronic controller employed to regulate e-values used at the inlet spot to the DMAs. The application of INTLEADCS is to detect leakage or loss end of the pipeline. Water pressure measuring water flow rate at the vulnerable spot of the DMAs, considering points with the lowest pressure range in the DMA/PMA, usually the highest or the remotest area [3-7]. Most approaches of operating an IBLCS and detecting the system pressure are as follows.

> ➤ Time-Based Pressure Modulation, in which the INTLEADCS's pressure is modulated as a function of time, imparts the force day and night when water flow rates are low.
> ➤ Water flow-based pressure modulation where different pressures are set on INTLEADCS to maintain the minimum required forces in the zone and detect where over pressure is manifested. The detection aspect is essential to learn the behaviour of the network to define the best

setpoints for the different conditions and flow demand profiles in the supply.

> ➤ They have closed-loop modulation where the INTLEADCS outlet water pressure is continuously adjusted via a telemetry transmitter and read from pressure sensors at one or more critical points. The voltage at the crucial point is constantly recorded, checked and transmitted in real-time to the electronic control system INTLEADCS. The electronic controller acts on INTLEADCS to change the inlet pressure of the DMA in real-time to compensate for pressure changes at a critical point.

Time-based modulation does it applied at the beginning of all DMAs. By monitoring and understanding the behaviour of isolated DMAs, flow modulation or closed-loop modulation does apply. In all monitoring cases, the alarms do use to convey message status when a threshold water flow (e.g. water out-flow) does exceed. It does expect that after the evaluation of the flow and pressure measurements, the optimum operational pressures did apply to the pipeline distribution network, the leakage levels to reduce, and active detection of leakages will be possible.

2.2 Sub-Distribution Active Leakage Detection and Control Infrastructure

"It is a well-known strategic approach to the early detection of hidden leaks and the application of active leak detection. The control is based on flow, pressure and noise monitoring. The control requires the use of the acoustic sensor to monitor the sensed water flow pressure level. in addition to the flow, pressure monitoring at the inlet point of each DMA, and pressure monitoring at critical value points of DMAs" [12-14]. "The researcher connected further network data
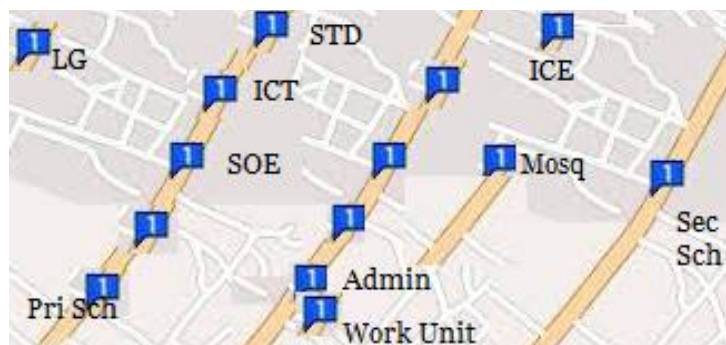

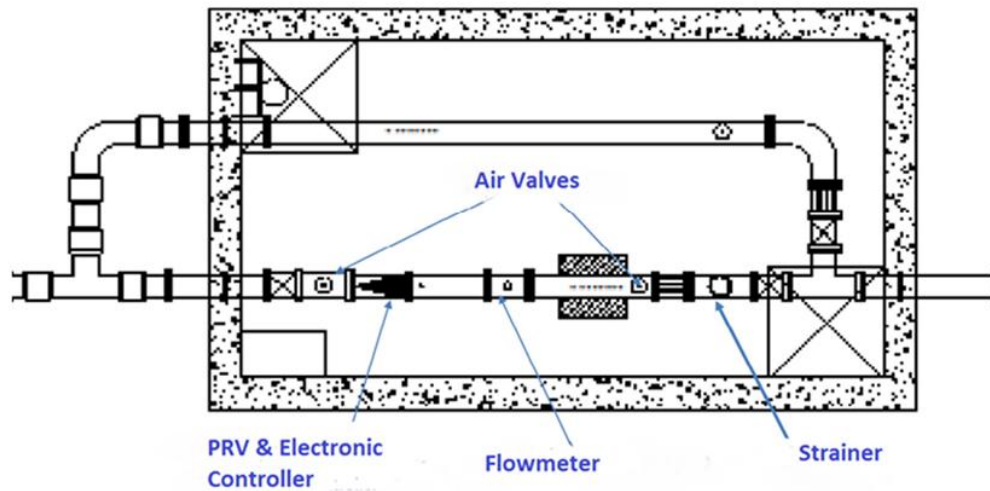**Fig. 1. DNs Layout with FEDPOFFA campus unit**

Fig. 2. Typical inlet regulating pipeline with a bypass, flowmeter sensor, filter, pressure regulated values control prvc and electronic controller in the pipeline network

during the project implementation with ten portable flow meters (built-in and ultrasonic), forty pressure data loggers, ten flow and pressure data loggers and a ground microphone. In addition, the project is considering purchasing 40 noise loggers for full implementation. As already mentioned, all equipment remains with DEYAP and includes the infrastructure for Active Leakage Control" (IWA 2007).

According to [13-15], one study describes water leak detectors that enable the finding and localization leaks in a water network under paved and unpaved surfaces. These authors find discussions of groundwater leakage using metal and non-metal. Avoid unnecessary earthworks. A related study uses the water leakage system to monitor many areas in a building for water leaks continuously, using cable or point probe sensors for detection [16-19]. The author to provide early warning of a potentially harmful leak, the water leak detector has also become a necessity in data centres, retail, banks and other mission-critical areas [20].

3. GIS-BASED NETWORK REGISTER STRUCTURE

GIS, called Geographic Information System, is a type of system that contains a database of the heterogeneous source of geographic data, which involve the use of software tools for managing, and analysing a suspected spot in the leakage within the water pipes distribution network. The Information requires determining the number of DMAs and the number of pipelines to detect water leakage management [9,20]. And any

piece of information in a water network has location as an inherent part of its value. Therefore, a GIS-based network cadastre is currently being developed, which transfers existing CAD drawings of the water distribution network into a GIS environment. Queries are created to link characteristics and historical data, e.g. Date of construction, Diameter, material, personnel or contractors involved, photographs, pump characteristics, as-built drawings etc., down to the associated assets (pipes, valves, pumps, pressure-reducing valves etc.) of the pipeline network.

Department and other department heads from another unit on the FEDPOFFA campus address the nozzles set up using the water meter coordinates that connected the identified team on the operating unit to consumption in DMAs and segment the appropriate distribution pipes. In addition, the intelligent-based leakage control system is related to the GIS, so all the water flow, pressure, and volume data (real-time and historical values) are available along with the digital landscape to obtain an aerial view of the water supply system. Finally, a database holds information about all network disruptions and damage. This database is the basis for remediation work and leak detection activities [16,18].

3.1 Evaluation of Telemetry in the Transmitting the Leakage Readings

Telemetry uses the recording and transmission of pipeline leak values; this data is transmitted via radio telemetry to the shore station within the

network – a valuable tool for an efficient leak control system. The water flow and pressure data collected at the inlet point of the DMAs and the physical damage points are transmitted every 8 hours via GSM/GPRS to the control room on the mini-campus. The operators can evaluate the data and make corrections to the person responsible. In the event of an increased water flow, an instant alarm remains active to generate a sound, and the operator can immediately respond to the appropriate troubleshooting crew.

3.2 Integration of Software

At a higher level, night flow is proactively communicated to campus unit operators with pressure charts, DMA data, end-user data, performance metrics and targets. Intelligent reporting software is developed at a strategic level. , The intelligence automatically correlates the water flow and volume data (measured or estimated) from all data sources at different time bases and depths, from original and DMA bulk meters to domestic water meters. Calculations are then performed to provide an annual top-down water balance and a bottom-up assessment of actual water losses and effort. The system consists of an Arduino board, an LCD, an ESP8266, a GSM module, a flow sensor and a power supply; each block detail is below. We are working on a prototype model. The following block diagram shows the hardware used in the system.

4. IMPLEMENTATION RESULTS

The connections are made according to Fig. 3 and created as a prototype system. First, the motor turns on after activating the power supply to the water flow sensor through the pipeline from the sewer inflow. The water flows out through the drain of the water pipeline network. Then the LCD will display the inflow and outflow rate of the water. There won't be much difference. When there is a leak between the water pipes, the inflow and outflow will have a more significant fluctuation in value, so observation is made that a leak is detected and displayed above the LCD. After the leak is detected, the LED will display the activity status, then the GSM can send the message to mobile phones, and the motor will shut down accordingly to prevent water from flowing through the pipeline. The display of the project board with all connections made and connected to the Arduino board.

The flow of water in the pipeline from inflow to outflow according to the position of the sensor. The LCD of the water inlet and outlet with the unit L/H. Here we have a slight discrepancy due to improper pipeline placement.

To show whether there is leak detection in the pipeline or not, we have set up a leak area. When leakage is on, the water leakage will be detected. Otherwise, the engine is off when there is no water flow.
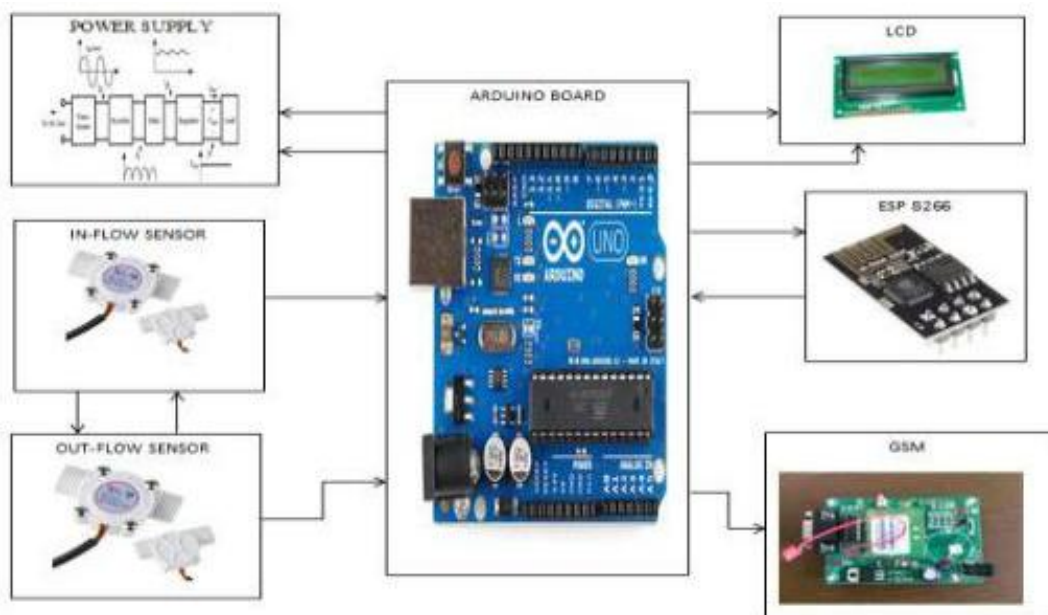

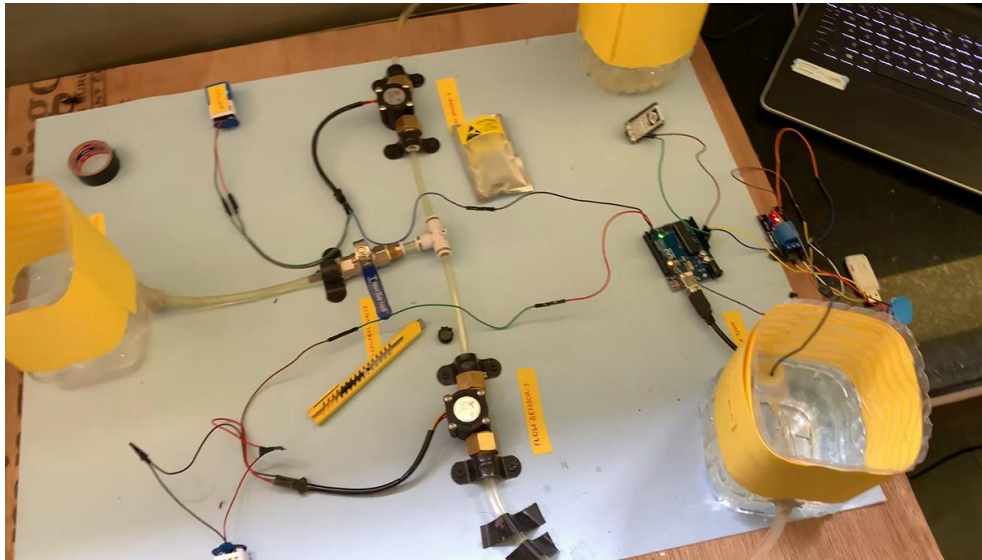**Image 1. Block diagram of water system**

Fig. 3. Board with connections

Fig. 4. Shown the display of water Inlet flow and outlet

5. CONCLUSION

Considering the system setup in section three above, use active sensors. The approach method uses advanced machines that perceive and respond to signals from decision-making processes from external input, and this makes water leakage detect water leakages quickly. The monitoring of the water also can be done. The water leakage not be visualized over the display without knowing the flow through the pipeline during the supply. The water supplied from tanks to different houses storage through channels sometimes leaks due to that leakage there may be a lot of water wastage. The water supply control would only be achieved with the automatic off of the motor when the leakage is detected in the pipeline so that the water flow will also be off. Using modern technology and equipment, the prototype in this study helps detect and monitor water pipes' leakage. The main advantage of this intelligent sensor network system is that it provides a real-time monitoring system with fewer truncations and a leak detection system that repairs damage to the pipeline.

6. RECOMMENDATION

This can be seen from the flow and pressure data collected during project implementation:

- Visual water pipes leakage in the network is considerably high.
- The integration of DMAs at various units on campus and water flow monitoring at the inlet points are worthy of prioritizing the actions for leakage location activities.

- Pressure Management is one of the integra part to crate a very efficient way of decreasing actual water leakage.

1. In addition, the study planning follows a structured plan. Establishing practical and efficient operational procedures to effectively manage the network and maintain the reduced levels of leakage within the campus unit is considered important. To this end, the FEDPOFFA work unit will be given responsibility for capacity building and will adopt protocols, practices and methods for the optimal operation of the network as follows:Analysis of the water flow rate within a given region is determined, while each DMA determines the estimation of the level of physical losses.
2. Overview of flow measurements and other relevant records, supply and consumption, water flow calculation and total volume according to the control system methodology
3. The pressure measurement of the DMA system and the application software of the pressure control method form the basis of the analyses
4. There is a need to set up control procedures to monitor the performance of the DMAs in all sub-units on campus.

The study has already gone through the forms of evaluation that could determine the overall performance of the pipeline leakage detection in the network. Hence, the artefact for the analysis can further improve operational efficiency.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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