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Fabrication of Automatic Leakage Detection System for Fluids

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***Abstract*: The leakage of water in pipe lines and distribution of water without any leakage are the major problems in the world. Pipe burst, fault in pipe connection or natural disasters maybe turned out into leakage of fluids (water, petroleum fluids) from the pipe line. This project proposes an automatic leakage detection device which continuously monitors the water flow in the pipe line and cut off flow when leakage is detected. This project reduces man power involvement and also the time used to process the collected information. This project mainly consist of control panel, arduino board, flow meter sensors and a server to control the flow by using android mobile application. The flow meter readings were fed to arduino board to process the data which monitor and control the flow of fluid in pipe by regulating the pump. Whenever leakage occurred, the flow meter sensor shows difference in reading and arduino board sends signal to pump to cut off the flow, hence the leakage can be prevented. The project has manual and automatic pump control mode which can be monitored by wireless sensor network through android mobile application.**

Key Words: Leakage, Flow meter sensor, relay, Arduino board, Wi-Fi Module

1. INTRODUCTION

Managing of water consumption is important for life preservation as water is an essential element for every organism. Thus need for providing a good water distribution is a must in order to save and economize the water. Sometimes, the condition in certain location does not allow the engineers to create a good distribution system on the ground due to restricted space and safety from inflammable liquids. Also development in constructions causes the current water distribution system to residential, offices, and industry premises through pipes under the ground.

Usually water distribution is done by the means of underground pipes, which are very difficult to monitor if any leakage takes place. Water leakages in pipes mainly occur due to pipe's age, improper installation, natural disasters etc. One of the major problems faced by most of the countries is the leakage in distribution systems located underground. The US Environment protection agency (USEPA) has said that one of their biggest needs is replacement or rehabilitation of the water distribution and transmission system. In late 20th century many new technologies came in to existence. In that primary methods include acoustic, infrared thermography, chemical tracer and mechanical methods. New technologies of acoustic methods include ground penetrating radar (GPR), combined acoustic logger and leak noise corelators, digital corelators, and radio-frequency interferometers. Acoustic methods are those who recognize leaks based on the characteristic patterns of sound that leaks create. It has been one of the most successful methods used in metallic pipes for the past decade or so. But low frequency produced by the non-metallic pipes such as plastic and concrete pipes makes it challenging to find the leaks. Although the above mentioned method were expensive and cannot afford by few countries. Hence this project aims to overcome these problems as it can be used in any type of pipe irrespective of the fluid which is flowing through it. This project can also monitor the flow rate of the fluid and cut off the flow (when there is leakage) using an android application.

2. LITERATURE REVIEW

Frank Massa et al., [1] have explained in their report that, ultrasonic flow meter measurement probes are located at spaced intervals along the length of a pipeline carrying a fluid and each probe measures the rate of flow of the fluid at each location along the line.

Lawrence Kates et al., [2] have developed a system and method for detecting and locating a spontaneous leak or break between spaced detecting stations in a pipeline carrying liquid, making use of negative pressure waves propagated through the liquid in the line at the speed of sound when a break occurs.

Sidney Allan Ottenstein et al., [3] have developed a system and method for detecting water and/or gas leaks by monitoring usage patterns.

Dalius Misiunas et al.,[4] have focused on failure management and pipe condition assessment in water supply systems. The aim of the work was to explore the feasibility of using the available low cost measurements and information to improve the operation, reliability, safety and availability of the urban water system.

Andrew F Colombo et al.,[5] have done review of transient-based leak detection methods with the goal of offering a summary of current and past work, describing the state-of-the-art in the area, providing a degree of historic perspective and categorizing the major themes in this line of research.

Wencui Ling et al., [6] have developed an integrated system for the detection, early warning, and control of pipeline leakage to manage the pipeline networks in selected areas of Beijing. A method based on the geographic information system has been proposed to quickly and automatically optimize the layout of the instruments which detect leaks.

Rui Li et al., [7] have represented both an environmental and an economical issue, how to reduce water loss through bursts and leakages. The methods for bursts (or leaks) detection and

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location can be broadly divided into two main categories, one based on hardware and the other based on software.

Abdullah S Al-Ghamdi et al., [8] have done field investigations to identify the relationship between leakage rate and pressure in selected areas of the water distribution system of the Holy City of Makkah, Saudi Arabia.

Z Kapelan et al., [9] have done a review on leakage assessment methods and developed a leakage control model for effective control of water.

D G Eliades et al., [10] have worked on the problem of leakage detection in systems engineering framework, and a solution methodoloagy to detect leakages in a class of distribution systems.

3. METHODOLOGY

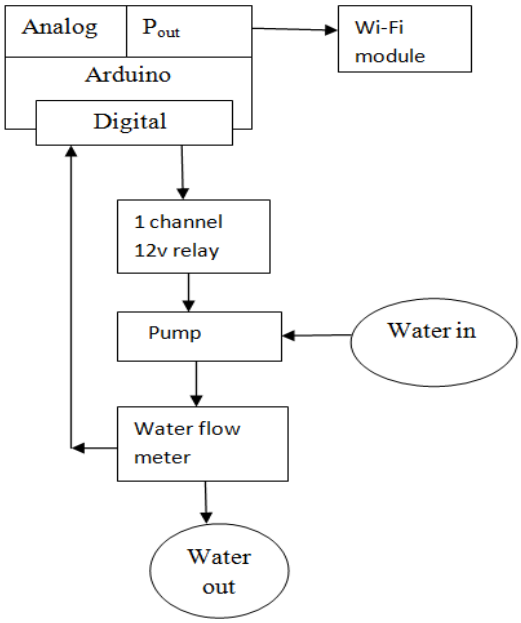

Fig 3.1: Flow diagram

This project is tested on a PVC pipe of diameter 20 mm and length 5 m. An AC aquarium pump of 80cm head and max flow rate of 500 l/hr (Fig 3.2) is used to pump water through the pipe. Two flow meters (Fig 3.3) are attached to the pipe, one at the beginning and the other at the end of the pipe. The flow meters give the flow rate of water flowing through the pipe as input signals to the arduino board (fig 3.4).

Fig.3.2 Pump

Fig.3.3 Water flow meter

A relay of 12V is connected to the arduino board (Fig 3.4). Arduino is a microcontroller which can be programmed by using arduino IDE software. A Wi-Fi module is also connected to the arduino board. If any leakage takes place in the pipes, the two flow meters will give different readings as input signals to the arduino. A gate valves is opened to indicate a leakage. The arduino is programmed in such a way that the relay will be turned off when there are different readings obtained from the flow meters, which indicates a leakage. The pump is controlled by the relay. When a flow rate difference is detected due to leakage, the relay will be turned off which in turn, turns off the pump to cut off the water flow through the damaged pipe. A server has been setup to monitor the flow rate remotely using a Wi-Fi module for arduino. The water flowing through pipe can be monitored using an android application that is developed which monitors the amount of water flowing and also displays a message indicating the leakage when water starts leaking. Using android app the water flow can be turned on or off either manually or automatically. The figure (Fig 3.5) shows the project setup.

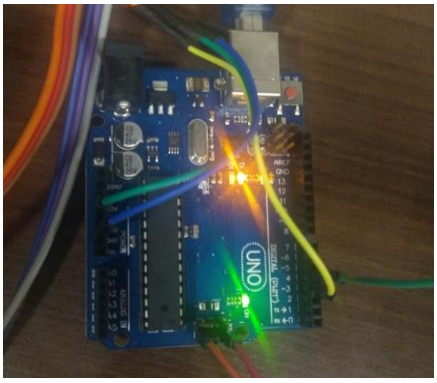

Fig. 3.4 Arduino board

Fig 3.5 Project setup

4. OBSERVATION AND CALCULATION

Flow rate measured using flow meter, Q = 208 litre/hour
= 0.057884 litre/sec
$=0.057884 \times 10^{-3}$ m^3/sec

Area of pipe 1, $A_1 = (\pi \times D_1^2)/4$, where $D_1 = 20$ mm
$= [\pi \times (20X10^{-3})^2] /4$
$=3.1415 \times 10^{-4}$ m^2

Area of pipe 2 (Pump), $A_2 = (\pi \times D_2^2)/4$, where $D_2 = 18$ mm
$= [\pi \times (18X10^{-3})^2] /4$
$= 2.544x\ 10^{-4}$ m^2

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Velocity V = $\frac{Q}{A}$

$V_1 = (0.05788 \times 10^{-3})/3.1415 \times 10^{-4}$
$= 0.1842$ m/s
$V_2 = (0.05788 \times 10^{-3})/2.544 \times 10^{-4}$
$= 0.2275$ m/s

Pressure produced by pump= P =ρgh
$= 1000X9.81x0.8$
$= 7848$ Pa

Minor losses in pipe
Minor loss due to sudden contraction,

$h_c = (0.5x\ v_1^2)/ 2xg$
$= (0.5x\ 0.1842^2)/2x\ 9.81$
$= 8.646x\ 10^{-4}$ m

Minor loss due to sudden expansion,

$h_e = (V_2^2 - V_1^2)/2xg$
$= (0.2275^2 - 0.1842^2)/ 2x\ 9.81$
$= 9.085x10^{-4}$ m

Minor loss due to elbow joints, $h_{elbow} = (KxV_1^2)/2xg$
for elbow joint, K=0.75
$= (0.750.1842^2)/2x9.81$
$= 1.297x10^{-3}$ m
For 6 elbow joints, h_{elbow} $= 6x\ 1.297x\ 10^{-3}$
$= 7.7820x\ 10^{-3}$

5. RESULTS AND DISCUSSIONS

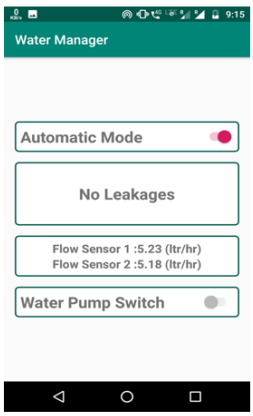

Fig. 5.1: No leakage

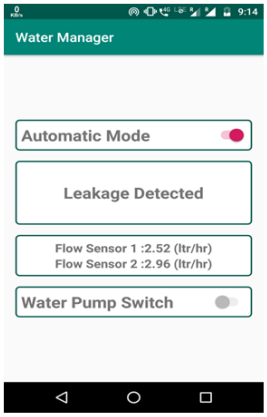

fig. 5.2: Leakage

The above results show the readings of flow meter sensor 1 and flow meter sensor 2 at different conditions. The arduino is programmed in such a way that if the difference between two flows meters is greater than 0.3 the pump will be turned off. Considering the small head losses in pipes due to friction, bents and other losses the difference between two flow meter readings can be neglected till 0.3 The fig 5.1 shows no leakage, where the difference between two flow meter sensor is less than 0.3 and hence the arduino unit sends signal to server through Wi-Fi module that there is no leakage and pump is in on mode. In fig. 5.2 the difference between readings of the two flow meters is more than 0.3, and then the arduino will send a signal to relay to turn off the pump. The message indicating the leakage detection will be shown on the app.

5. CONCLUSION

Leakage is usually the major reason of water loss in water distribution systems. To minimize the water loss an efficient leakage detection technique is needed and the present work is one of the methods to detect the leakage of fluids in the pipe line. This system minimizes the public health risk and economic loss by conserving the water and distributing efficiently to the public. This project detects the leakage of water when there is a difference in flow meter sensors and shows in android mobile application. If the difference is more than 0.3 L, then arduino unit sends the signal to relay and pump to cut off the power supply, hence leakage can be prevented. This device is also able to monitor the flow rate of both flow meter sensors using webpage through laptop or android mobile application. It is also possible to control the functioning of pump either manually or automatically. In manual mode, the pump can be directly turned on or off using the android application. This project will be helpful to reduce water or any other fluid loss due to leakage and save it as much as possible.

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