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Monitoring and Controlling Water Pipelines in Buildings

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Abstract

Building design was always important in engineering field which embraces many different branches for great number of specialty engineers to work on one of the important aspects of the building is the water pipelines. It provides the building with heat, water, cooling and so on. It is important to control and monitor the pipelines in order to achieve maximum efficiency, minimal losses and maintenance costs. If the leak is not detected in time, it can bring huge costs to the building as internal building cavities and interior in general are not designed to withstand constant water contact. Monitoring and controlling water pipelines in buildings system is proposed to solve this issue within buildings and with some configuration it can be adapted in other fields such as oil transfer systems, gas pipelines, cooling systems in powerplants and others.

Introduction

Liquid/gas leak detection system is crucial part of sustainable system. System needs to be autonomous as much as user defined it to be. The leak detection system must detect the leak before it can damage the property and may even cause injuries.(see Figure 1)

Figure 1 – Leak damaged ceiling tiles

There are certain techniques and methods to detect the leak and gain full control of the pipeline, but no technique exists which would be universally applied to every scenario. There are Pigging, Volume and Pressure, Mass Flow and Acoustic methods. Several papers were selected to research these methods more thoroughly. Mass Flow method measures flow rate at two points in the system where rate should be the same, leak are detected if the rates are differen. (G Quarini, 2010). Volume and Pressure method is similar to Mass Flow method. Instead of comparing to rate of flow, volume difference is compared. Pressure sensors are also implemented to increase accuracy (Dr Nagham H. Saeed, D. M. 2017). Pigging method is the most advance, but it can not be easily implemented in building pipelines. Pigging consist of small probe with various sensors attached to it. It flows through the pipe and senses cracks in the shell, blockages and other faults via video/audio/proximity sensors (Konstantintos Marmarokopos, 2018). Acoustic method employs the sound created by the leak. When the leak in the pipe occurs, it sends vibrations through the pipe to the sensor let it be attached to the pipe itself or if the pipe is underground, the sensor can be dug underground. The most suitable method was selected which was "Mass flow with Solenoid Operated Valve" analysed and implemented. Stage 1 of the prototype includes only leak detection system while Stage 2 includes Automation, Data transfer and User interface aspects.

Aims and Objectives

The aim of the project is to develop a system of rapid control and flow monitor of building pipelines. Objectives are:

1. Demonstrate working principle of leak detection
   - a. Receive signal from Flow Meters continuously
   - b. Compare signals
   - c. Send it to main device via wired/wireless connection
2. Demonstrate principle of rapid control of the pipeline
   - a. By analysing data decide the position of the valves
   - b. Act by closing or opening the valves
   - c. Redirect the flow
3. Demonstrate the state of the system and graphical user interface (if possible)
   - a. Visualise:
     - i. Flow meter activity
     - ii. Solenoid state
     - iii. Pump activity
   - b. Intuitive control of the system

Methodology

By comparing the volume of liquid/gas at point A (FLW1) and point B(FLW2) where B is further than A, a difference in liquid can be found which would mean a leakage. If leak occurs and automation software detects it, the flow of liquid/gas gets diverted and loss minimised. During the leak, SOV2,SOV3 are closed while SOV1 is open. Solenoid operated valves are controlled by microcontroller and powered by power supply unit. Figure 2 shows prototype block diagram while Figure 3 shows the system's flowchart and Figure 4 shows leak detection pseudocode.

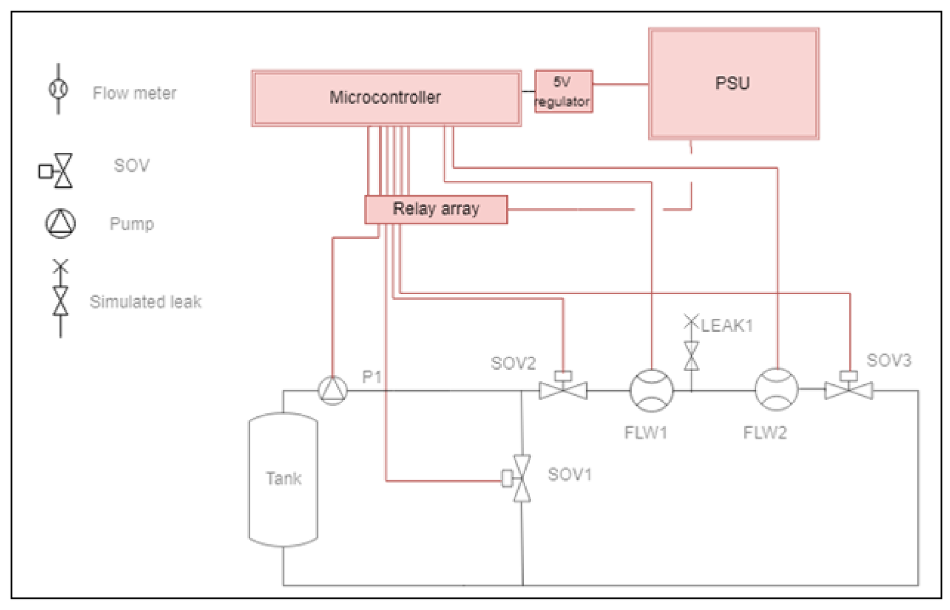


Figure 2 – Proposed prototype solution block diagram

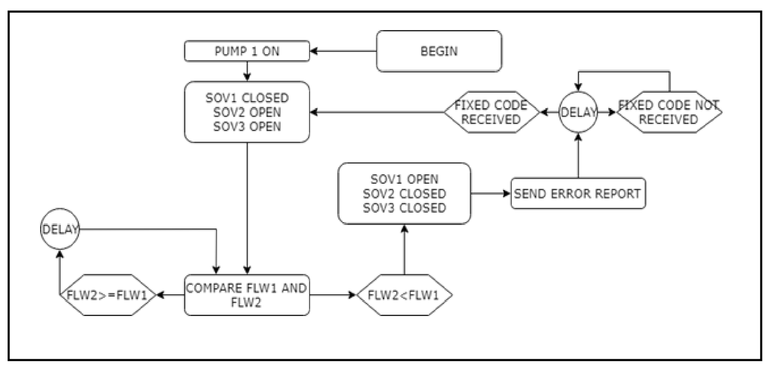
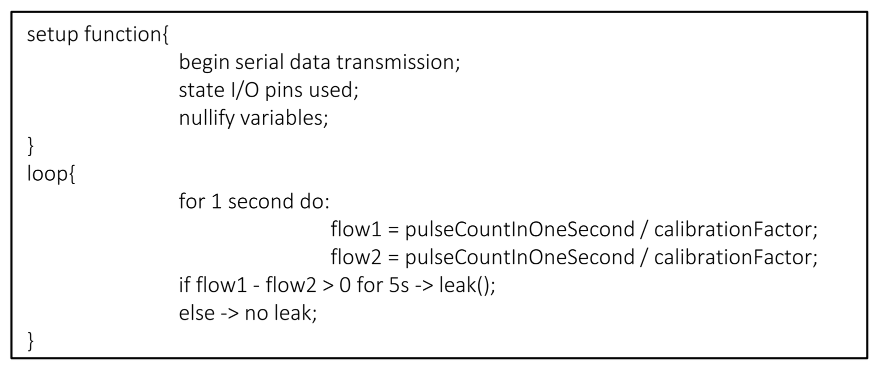


Figure 3 – Prototype flowchart



```
setup function{
        begin serial data transmission;
        state I/O pins used;
        nullify variables;
}
loop{
        for 1 second do:
                flow1 = pulseCountInOneSecond / calibrationFactor;
                flow2 = pulseCountInOneSecond / calibrationFactor;
        if flow1 - flow2 > 0 for 5s -> leak();
        else -> no leak;
}
```

Figure 4 – Microcontroller pseudocode

Implementation

Stage 1 implementation consist of leak detection system (Figure 5). It was built with 15mm diameter pipes and 5W pump. The Python code was implemented to measure the flow rate and compare it. Figure 5 illustrates the two flow meter rates graph. The leaks were simulated in stages where first drop is 10ml/s, second is 15ml/s and so on. The difference in the rates clearly shows the difference in flow rate while leak is present

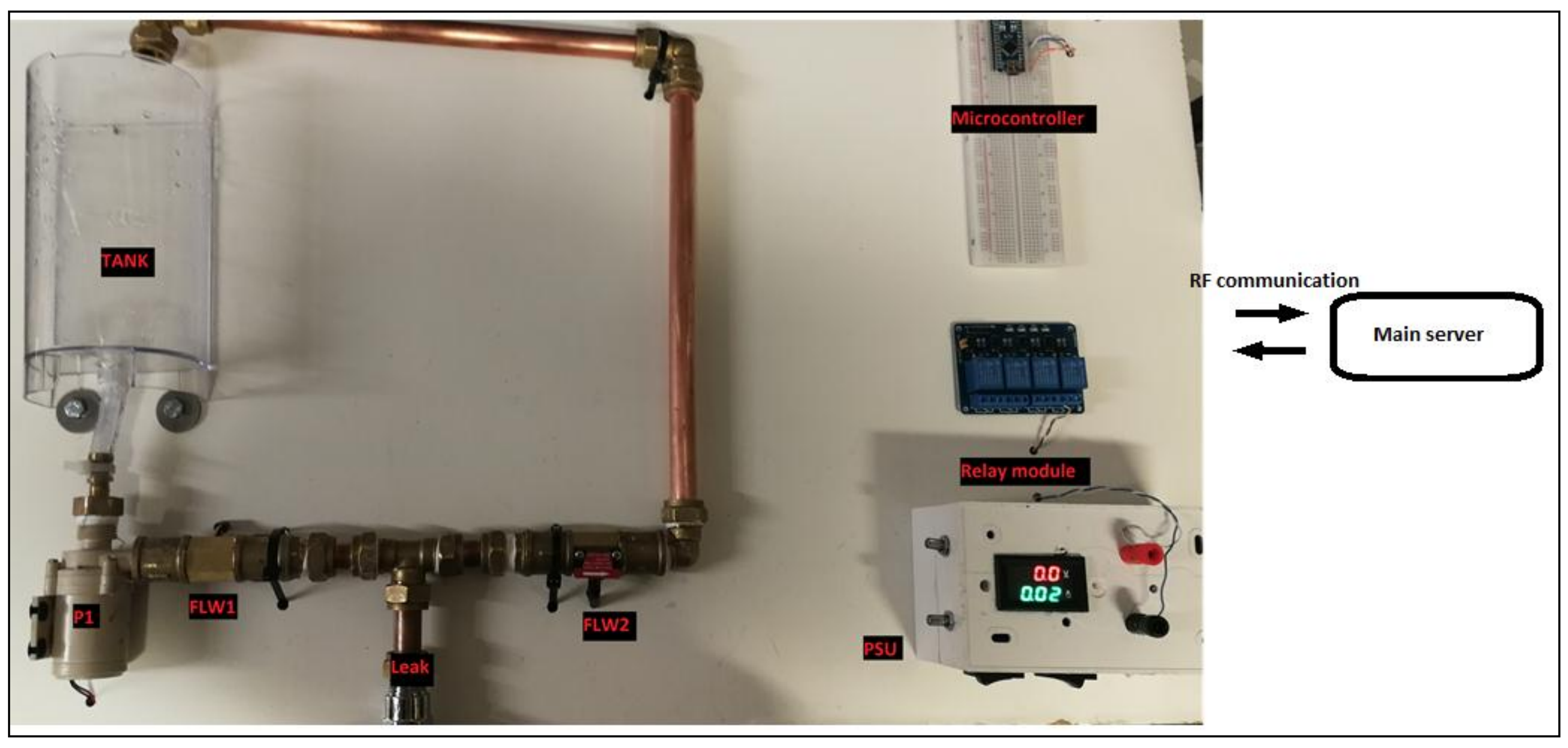


Figure 5 – Implementation in progress of leak detection system

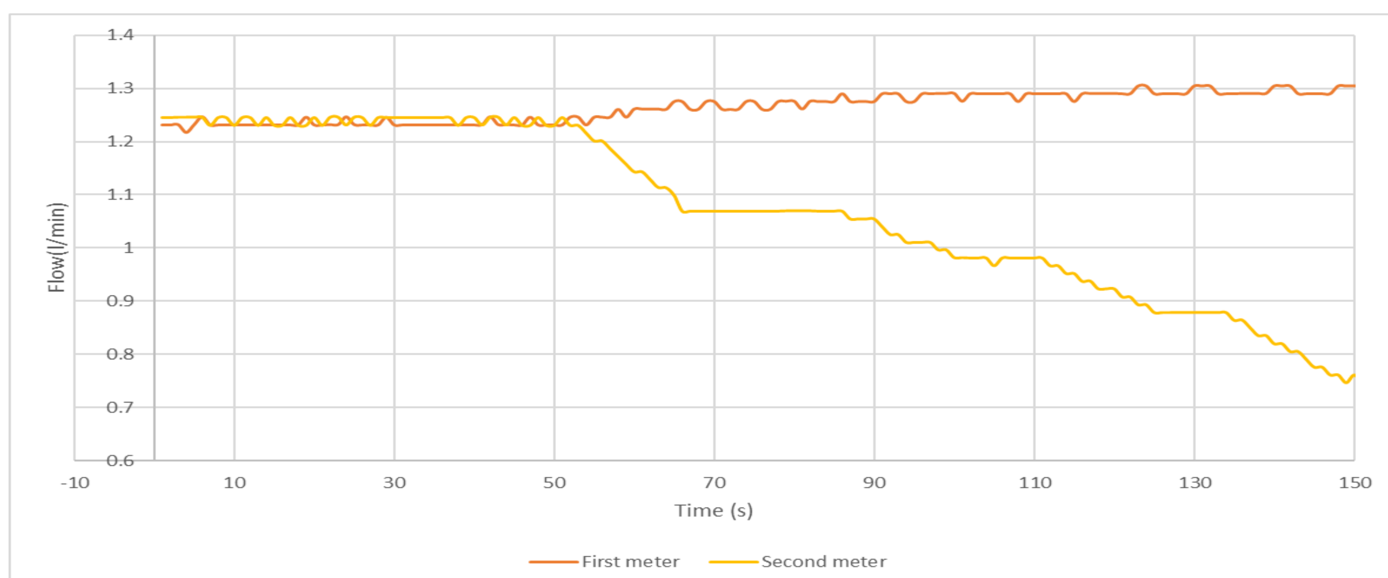


Figure 5 – Flow meter rates comparison graph

Results

The concept works and the system does detect leak. The results was improved by averaging values every ~0.1s. The system can detect leak if its higher than 5ml/s while medium is water @20 °C.

Conclusions

The concept was proven to be promising. Further work to be done on wireless connection, implementing IoT, and user interface. The concept can be integrated into existing building system and constructed as new. The medium can be dense gases, water, oil, which means the concept can also be implemented in other various disciplines that require pipeline management.

References

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