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Design a WSN Control System for Filter Backwashing Process

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ABSTRACT: *Day by day, there is a higher rate of need for accurate automation system to be used in industries and environment monitoring and control. In water treatment plants during the filtration phase, there is a process called backwashing, which particles suspended in the filter basin are removed. in this process the water are forcedly pumped through the filter in upward direction at enough speed to expand the filter media. Therefore, various types of valves used, which are opened and closed in a time sequencing manner. The paper proposed an automation control system for the backwashing process to be initiated and completed automatically using PLC, level sensors and valves installed inside the filter basin. Practically, a control system has been applied which all valves are opened and closed according to wireless signals coming from PLCs on its suitable time. In summary, the control in the process demonstrated that the proposed system is efficient, effective, and able to be reliable. Besides, the results increase the productivity at a low-cost mode.*
Keywords: *filter backwashing, PLCs, Sensors, Valves, WSN Control.*

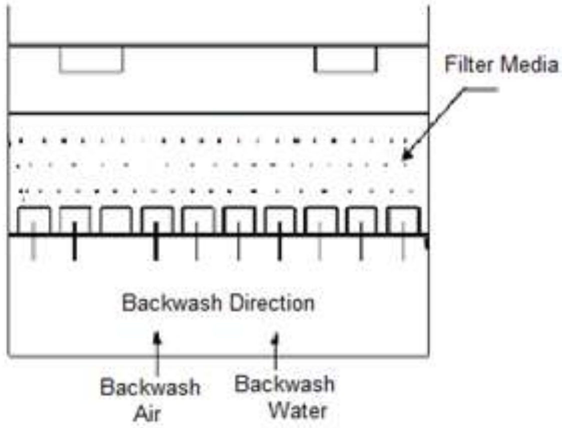
I. INTRODUCTION

Todays, there are varieties of Control devices with supported software available in the markets, provide higher capabilities to monitor and control industries and environments through straightforward configuration of function blocks. These control's devices can do arithmetic and logic operations such as carry out simple addition/subtraction or make a data comparison to a reference points. These Controllers working to accept input data as a signal, process these data, and perform outputs as a control signals (Cecílio, 2013). The programmable logic controllers (PLCs) which have been invented in 1970s, recently became the most common in industrial and environmental control with higher flexibility of use. Most of this due to the advantages they offer: cost effective for controlling complex systems; flexible and can be reapplied to control other systems quickly and easily; computational abilities allow more sophisticated control; troubleshooting aids make programming easier and reduce downtime; reliable components make these likely to operate for years before failure (Chakraborty, 2016). Usually the PLC's inputs and outputs are connected with outside world via wires as a communication medium, while in this work no wires will be used, therefore, the communication between PLC and peripherals components will be through wireless module.

II. BACKWASHING PROCESS

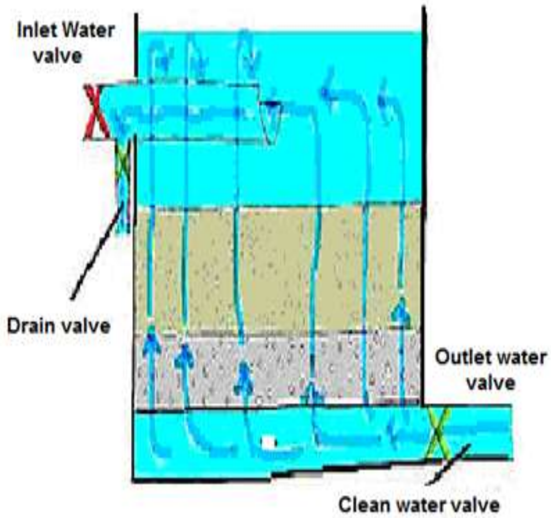
Nowadays, most of countries face severe and rising challenges in their efforts to meet the need for adequate water that is driven by increasing populations (Nkwonta, 2010). Thus, there is a necessity for adequate hygiene drinkable water at the right time with high levels of efficiency in production (Ali, 2015). Accordingly, the automated control system is an important to be applied in the water treatment processes to achieve a desired system response (DORF, 2011). For instant the filtration process which involves passing water through fine granular materials, such as sand (Xue, 2011). As more and more raw water passed through the filter, suspended particles are accumulating within the media, reaching impermissible levels that lead to one of the two destructive events. They can either cause the filter head loss within the filter to reach excessively high levels, or hardly pushed through the media, resulting of bad quality of treated water. Therefore, in order to maximize the use of a given filter within a safe mode, it becomes necessary to remove these entrapped particles from the media itself. Filter backwashing is the process by which this is accomplished. It refers to pumping water and air backwards through the filters media as illustrated in figures 1.

(a)



Washing Filter

(b)



Backwashing direction

FIGURE 1: Filter backwashing process; a) filter basin. b) washing direction.
source: http://www.thewatertreatments.com/water-treatment-filtration/rapid-sand-filters/

III. PLC SYSTEM

Nowadays, the real time operation is essential for automation; hence, several applications of process control are critical mission and possess stringent (Yu, 2012). The PLC is a computational device which can accomplished this process since the output results mostly depend on the input condition within a setting time (Reddy, 2014). The PLC is designed to deal with inputs and outputs of different components, so we can get the data from the sensors, work with it and then rule the actuators (Mousavi, 2016). Before uploaded to the PLC, the control program is written in a computer using especial software. The program can be written using one of three different methods, which are ladder logic, functional block diagram or statement list (Nandgave, 2014). For this purpose the ladder logic has been used.

3.1 PLC System Components

Figure 2 illustrates the system components of a PLC. The function of PLC is to received data from input module, processed it and passes those output control signals to the control unit. The command task is performed by an output module. These controlled PLC signals are suitable to operate and invoke the plant actuators.

3.2 Sensor

Sensor is an electronic instrument widely used for measuring any parameter or controlling the mechanism of any system that is under operation. In simple words it is a device which responds to the physical input applied and gives the electrical output that carries information. Automation is quiet essential in any control system, and it is incomplete without sensors. In any control system sensor plays a vital role in controlling its operations (Cecílio, 2013).

3.3 Valve Device

The wireless sensor is a bi-directional small powered device, which can transmits and receives data. The device is fixed on the valve or actuator, and it capable to send its situation information in appropriate time. The industrial automation using a wireless instead of wire that would normally connect a central control module to the valve, canceled the need of a lot of wire or the expensive civil works (Lewalski, 2011).

3.4 XBee Communication Module

XBee module is the most common in use as a data transmitter and receiver wireless device. It is resilient, easy configurable with other XBees in a network, and compatible interfacing with computers and microcontrollers (Sparkfun, 2016).

3.5Microcontroller

The microcontrollers are programmable input/output electronic circuits that can be used to carry out a vast range of tasks. They can be programmed to be a computing unit. In this system the microcontroller used as an interface device to communicates a data between sensors and valves with communication module. Therefore, it used to help PLC by holding some computations to accelerate the processing so as to decrease the PLC overload.

IV. THE PROPOSED AUTOMATION CONTROL

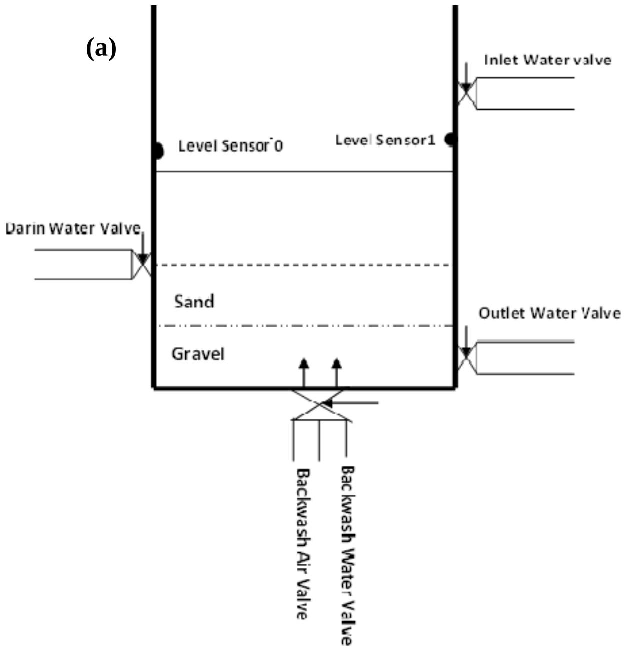
In order to be saved and functioned perfectly with full capacity through a day, the filter efficiency influenced by the effectiveness of the backwashing methods. This efficiency can be controlled by installed water level sensors in the filter basin. When the water level inside the basin exceeds impermissible level, backwashing operation is executed automatically with the PLCs program aid.

To implement the system, the paper used sensors for measuring the water level, XBee as a wireless communication module, microcontroller as a data acquisition before it send, and automated water valves for inlet (Iv), outlet (O¬v), drain (Dv), washing (Wv), and compressed air valve (Av) to be opened and closed according to the received signals from the PLC control module. The proposed systems should work properly to get the ideal use of filters, as well as, will be reasonable if it achieves the minimum human errors and the cost (Wei, 2016).

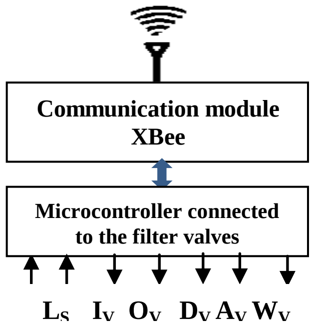
V. RESULTS AND DISCUSSION

This section describes the implementation of the proposed control system. Initially, the control design has been setup as shown in Figure 3. The PLCs has been connected to the basin valves wirelessly through a wireless communication module and microcontroller as illustrated by figure 3 (b). When the water reached impermissible level, the input signal from basin sensors received by microcontroller which checks the data before it sends to the PLC via XBee communication module as shown in figure 3 (c). Accordingly, the PLCs takes a decision and then create outputs to the filter valves in order to be opened and closed automatically as shown in figure 3 (a).

(a)



(b)



(c

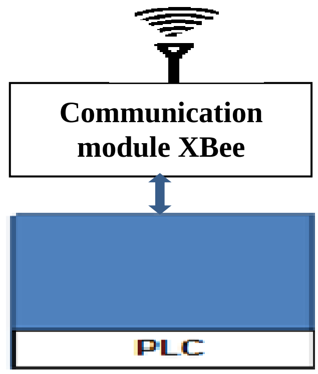


Figure 3: System Model. (a) Filter Basin components (b) Communication Module (c) Control Module.

Therefore, the control runs as it follows: When the PLCs receives a signal coming from the sensors, it determines the start of the washing process, then accomplish the following steps: ***first,*** closes the filter inlet and outlet water valve; ***second,*** opens drain valve and then opens the backwash compressed air valve for 30 second, then closes air valve and opens the backwash clean water valve for 60 second; ***third***, closes the wash valve and the system waits for 15 second until the dirty water pass before terminates the backwashing process; forth, reverse the state of inlet, outlet and drain water valves to restart again the filtration process. The operations time of these valves collected from plant and it was arranged for to be used in the program.
In this test seven timers as shown in Table (1), are set within the PLC program to control the time for each step of the filter washing process. Also five indicators are connected to the outputs of the PLC to represent the valves which are involved in the filter washing process.

Table 1: Demonstrates a complete time cycle of the filter washing process.

Step	Valve	PLC timers configuration		Operation
		timer	**time**	
1	I.W. Valve	TT1	15 seconds	Closing filter inlet water valve
2	O.W. Valve	TT2	15 seconds	Closing of outlet clarified water valve
3	D.W Valve	TT3	15 seconds	Opening of drain water valve
4	A. Valve	TT4	45 seconds	Opening of air valve
5	C.W Valve	TT5	75 seconds	Opening of clean wash water valve
6	Aux Timer	TTC	15 seconds	To closing the washing valve
7	Reset Timer	TTG	30 seconds	To terminate the washing process

The control steps which have been implemented by PLCs can be signified by the following flowchart, figure 5.

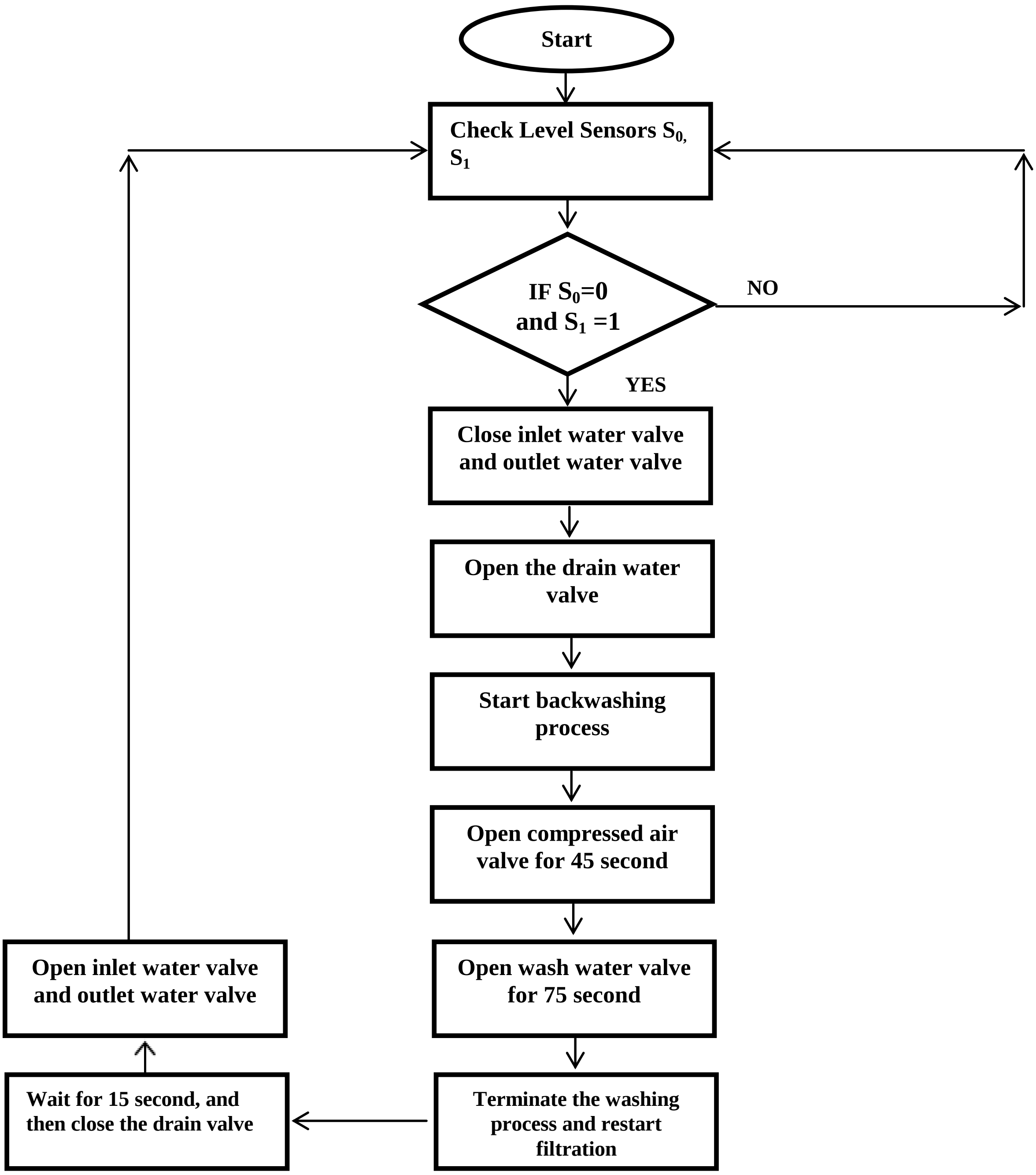
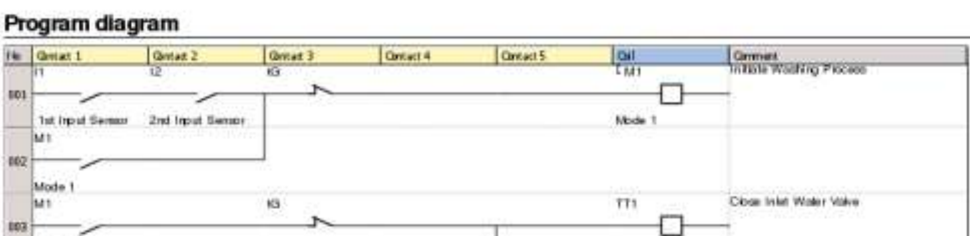


Figure 5: Control Algorithm

A Ladder Logic has been used for programming backwashing process so as to be functioned in the PLCs. The program output represented these processes shown in figure 4 (Schneider, 2015).



VI. CONCLUSION

The paper addresses the problem caused by suspended particles that accumulating within the filter media. These particles reached impermissible levels that lead to one of the two destructive events. They can either cause the head loss within the filter to reach excessively high levels, or hardly pushed through the media, resulting of bad quality of treated water. Automation control has been suggests for these filters; therefore, the backwashing process for these filters accomplished automatically using level sensors installed inside the filter basin, and automated valves. The system based PLC controller that provides a platform for programing the filters valves. When the water reached impermissible level, the sensor send a signal to the controller to start the backwashing, the filter valves are opened and closed according to wireless signals coming from PLCs on in a different sequencing manner. In summary, the backwashing initiated successfully using level sensors; the filter valves are working properly according to PLCs wireless control signals. The obtained results capable to saving the filters, efficient to accelerate the filtration process and therefor the production will be increased with low-cost.

***6.1 Further study*:**

Due to the numbers of higher critical components used, we suggest the use of effective methods and tool to measure and evaluate the dependability for these types of system.

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