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Automatic Back-Wash Filtering System

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Abstract- **Water is a vital resource for the chemical, paper, steel and petroleum refining industries. Usually, industries use an enormous amount of water to flush the impurities and to cool down the products. As the industries are in need of water for multiple purposes, they tend to reuse water by a mechanism called Filtering. In the existing conventional filters, the filter elements are cleaned manually when it gets clogged, leading to more manpower and longtime. In Automatic back-wash filtering system, when filter elements get clogged, a pressure difference is created between inlet and outlet valve. This is sensed by a differential pressure sensor connected to the Programmable Logic Controller which initiates the backwash cycle that automatically cleans the filter elements. An alarm and Human Machine Interface display are also provided for the purpose of continuous monitoring and troubleshooting. The proposed Automatic back-wash filtering system is more efficient and overcomes the constraints of conventional filters.**

Index Terms— Back-wash, Clogged, Filtering, Programmable Logic Controller.

I. INTRODUCTION

The basic need for every individual is clean water. Due to urbanization and industrialization enormous amount of water is being used for various purposes. The waste water from industries are polluting the pure water. Water being vital resource, has to be preserved for future generation else leading to scarcity of water. The water pollution can be prevented by wastewater treatment. One such water treatment includes filtration.

Especially the steel plants use a tremendous amount of water for cooling, wastewater transfer and dust control. The plants have sintering mills, water-cooled rolls, pumps, slab furnaces and extrusion equipment's that needs pure water. The water filters separate the solid and chemical impurities by using strainers. The earlier conventional filters are cleaned by a manual method which is less reliable and requires more manpower.In the modern strainers, the filtering mesh is cleaned automatically by a mechanism called back-wash. This mechanism reduces the need for manpower, improves the capacity and efficiency of filtration.

The term Back- wash refers to pumping water backward through the filters using media like water. Thus, the auto back wash system is an ideal situation which cleans the filter at regular intervals of time. As well it provides the most productive and labor free solution to overcome the above constraints in the manual methods. This is done by continuous monitoring and controlling the system through the human-machine interface (HMI) connected to Programmable Logic Controller (PLC). The proposed work ensures effective water treatment which will be helpful to society and industries as well.

RELATED WORK

The reported work developed an automatic cleaning strainer. Where cleaning of the strainer is done by a back-wash process. Whenever strainer gets clogged, it is sensed by the differential pressure gauges and backwash process initiates thus saves the cleaning period & it automates the filtering process.[2] developed the water purification system by using a plasma technology to transform liquid water into a plasma to eliminate the pathogens from the water by the exposure of ultraviolet radiation, shock waves and electric fields, that cleans the filter consisting of pollutants. It is efficient and less expensive.[3] developed the Electrospinning mechanism, It uses the nanofibrous composites membranes for removing all types of contaminants including bacteria/viruses, heavy metals and ions.[4] developed an intelligent control and monitoring system using "Raspberry Pi" for the automation of small water treatment plants and to control the system comes with advantages like low cost and compact size. [5] developed an automation for monitoring and controlling a micro hydropower plant (MHC) using the specified HMI and PLC, which produces about 120 kwh of green energy.[6] developed a biological aerated filter (BAF), in order to the optimal performance after backwash that needs 5 ~ 6 h to recover with the backwash period 24 hrs.[7] developed an advanced technical process for polymer-containing wastewater in the oilfield. It is equipped with an automatic backwash unit, which may timely and thoroughly backwash and prevent the filtering material from hardening. [8] developed a high-speed filtration system using HTS magnet for purifying the used wastewater. This water is made to flow close to HTS bulk magnet and the flock is filtered by magnetic force. It is less expensive because of the simple construction.[9] This paper reports the design, fabrication, and testing of a new MEMS micro filter developed from a flexural plate wave (FPW) device uses self-cleaning mechanism for microfilters presents exciting possibilities for reduced filter fouling, allowing larger volumes of fluid to be filtered and extends the filter lifetime.

PROPOSED METHOD

Fig.1 shows the proposed block diagram of Auto Back-Wash filtering System. This system consists of various sensors, actuators and programmable logic controller.
A three phase 415v AC supply is given to the DC motor through contactor. The motor rotates the segment drum nobe/arm and detects each filter element using proximity sensor, these sensors sends the signal to the PLC through relay I/O and stop the motor for a period to initiate the filtering process. Differential pressure of input and output valves are compared using differential pressure sensor that sends the signal to PLC which initiates the backwash process.

There are two phases of operation:
A. Filtration phase
B. Back-wash phase.

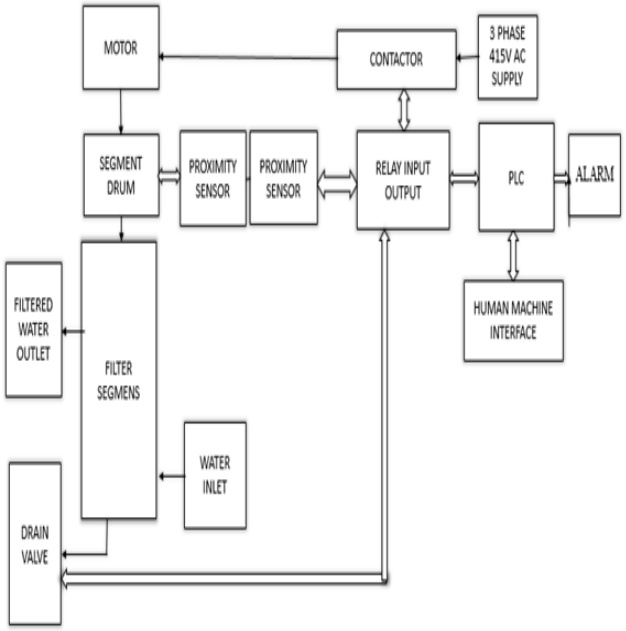

Fig.1: Block Diagram of Proposed System

A. Filtration Phase

This duration of this filtering phase is about 40-45 minutes. The working steps of filtration phase is as follows:

- The source water which may contain dirt or impurities enters the filter through the inlet valve.
- The impurities in the water get separated and these impurities get collected in the lower bottom of the filter.
- These impurities can be drawn out by opening drain valve for 2-3 seconds or after a certain period.
- The filtered water enters the outlet valve for further use.
- The impurities in the filter segments will go on clogging due to deposition of impurities on it.

A. Back-wash Phase

The duration of this phase is approximately 2 to 3 minutes. The working steps of back-wash phase is as follows:

1) Due to continuous filtering, the filter segments/ elements i.e. the strainer gets clogged.
2) Due to this, the pressure differential across the inlet and outlet valve increases. When this difference exceeds the threshold value, backwashing is triggered.
3) In this phase, drain valve opens for 3 seconds.
4) The opening and closing of the valve are governed by the actuator.
5) This actuator actuates the signal sent by sensors sensing the differential pressure.

B. The proposed Genetic algorithm.

Fig.2 shows the flow chart of the Auto Backwash process flow that can be built on the SIMATIC manager software tool. The main function of back-wash cycle is to clean the filter element/strainer when it gets clogged above the certain limit. Hence a differential pressure across the strainer should be measured regularly at every 45 minutes time interval. When the filter is not clogged, a pressure drop across the filter is approximately 0.197728 bar. During filtration phase, filter element/strainer starts to get clogged. When it gets clogged to 50%, then a pressure drop becomes 0.358734 bar. At that duration of time, drain valve gets opened and back-wash phase starts.

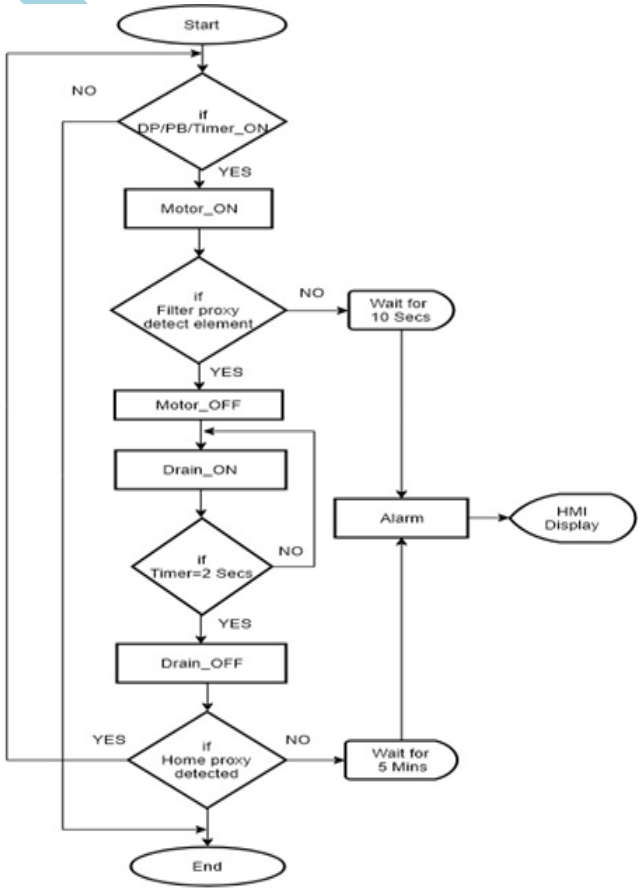

Fig.2: Proposed Genetic Algorithm

During backwashing, a filtering phase does not get interrupted. Backwashing will go on till it completely cleans the strainer. When differential pressure across filter reaches normal value then a drain valve gets closed and the back-wash process ends for that particular strainer and continues the process for the rest 32 strainers of the filter.

MODES OF OPERATION

There are two modes of back-wash process which can be easily switched by using selector switch and the threshold value of a differential pressure is pre-set in the PLC. In an automatic mode, when a pressure difference between inlet and outlet valve is strainer 0.19 bar i.e., when the strainer is not clogged and when the strainer is clogged up to 50% a pressure difference is 0.35 bar, so that pressure switch will override and the cycle timer starts which initiates to backwash until differential pressure is reached to its threshold value.

Whereas in manual backwash operation, the water media can be reused as a cleaning agent. When the selector switch is in the manual position, continuous back-washing is encountered by opening and closing of drain valve to perform back-wash operation. In both the operations a motor rotates with as low speed as 2-4 rotation per minute.

IMPLEMENTATION

Fig.3 represents interfacing of input/output module to a programmable logic controller by using PROFIBUS for assigning the input/output addresses respectively.

Benefits of PROFIBUS

1) PROFIBUS is a powerful, well-built and open bus system that ensures hassle-free communication.
2) The system is completely standardized, which enables effortless connection of standardized components from different manufacturers.
3) Configuration, commissioning, and troubleshooting can be carried out from a different location. This results in user-defined communication relationships that are very flexible, simple to implement, and easy to change.
4) Continuous observing and checking of network components through a simple and powerful signaling concept. Existing networks can be extended without any adverse effects.

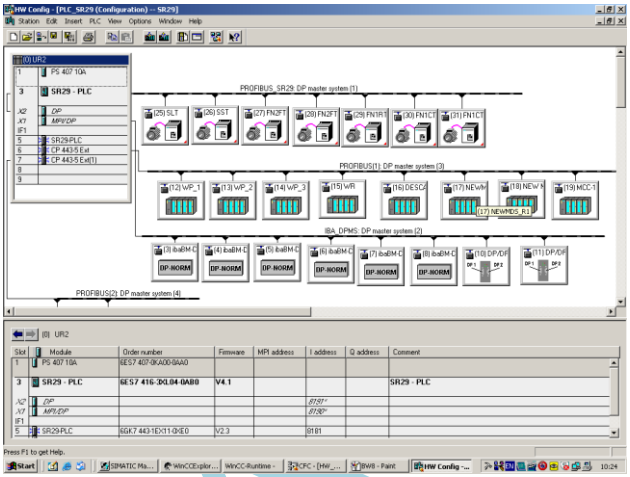

Fig.3: PLC Hardware Configuration

To create CFC charts we need to insert blocks located in the "PCS 7 Library V6.0" in the CFC charts. These include single blocks such as blocks for controlling a process or for monitoring measured values. The inputs and outputs of these blocks are then interconnected directly in the CFC Editor and are given parameter values. These CFC charts must be compiled into a language so that they can execute on a CPU. Obviously they must also be downloaded to the CPU so that the CPU can run the program. The compilation and download are started in common dialog box and run one after the other.

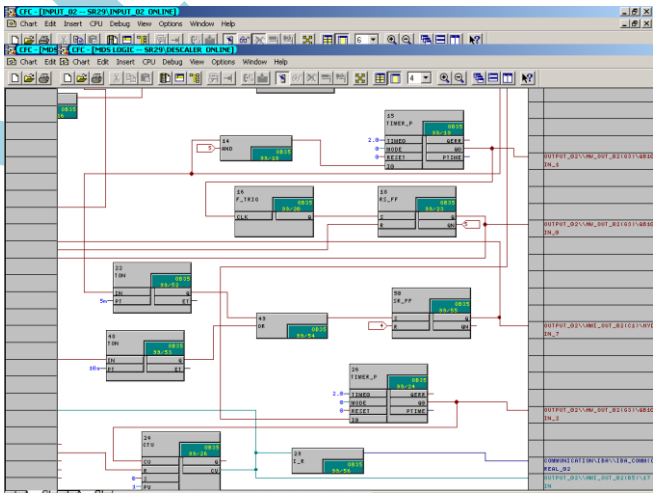

Fig.4: Simulation of the Back-Wash Logic

Fig.4 shows the back-wash logic configuration for the proposed system using continuous function chart (CFC) in process control system (PCS 7). The entire operation of a plant is described by continuous processes. This is achieved by creating CFC charts in the CFC Editor of PCS 7.

RESULTS AND DISCUSSIONS

The operator station in the process mode provides various options for controlling and monitoring the process with the following options:

Monitoring the status of the valves: valve open or closed

Monitoring the status of the pump: pump active or inactive.
Changing from a block icon to the relevant faceplate
Selecting the reactor.
Selecting whether the operator sets the setpoint externally.
HMI display with NO fault
Fig.5 shows the result of automatic back-wash filtering system in HMI display with NO fault (under normal operation). It represents the various parameter values and their updates continuously for monitoring purpose of the system for the remote engineers.

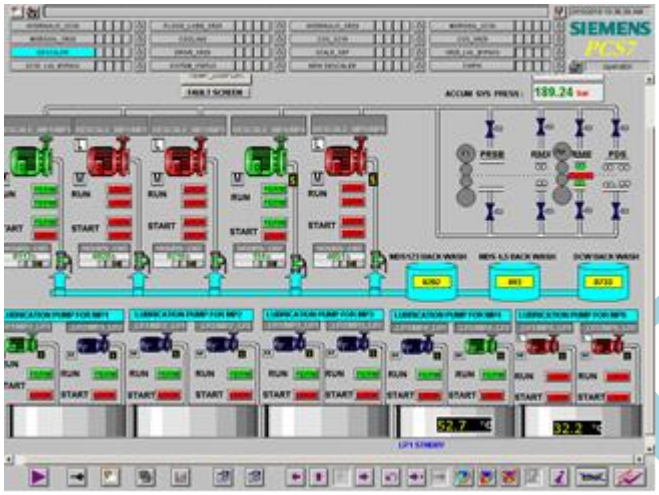

Fig.5: HMI Display Indicating NO Fault

B.HMI display with fault
Fig.6 shows the result of automatic back-wash filtering system in HMI display with fault generated message. This alert message is generated whenever proximity sensor either failed to detect a filter element or a home position (full cycle) in the system.

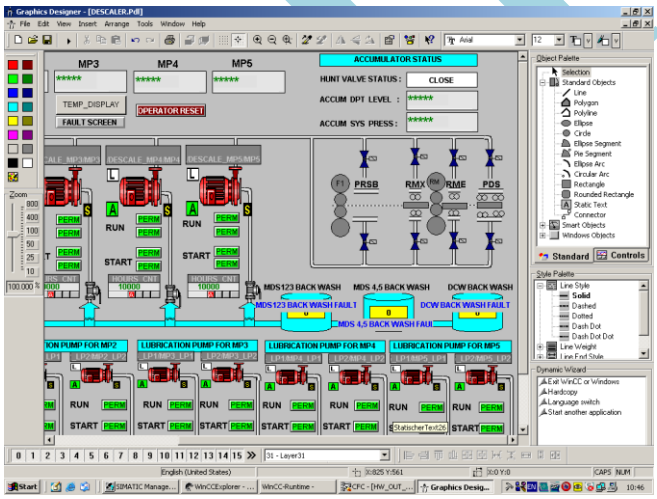

Fig.6: HMI Display Indicating Fault

An alarm is also generated which helps the remote engineers to detect the faulty system for troubleshooting. Thus, reduces the downtime and increase the productivity.

CONCLUSION AND FUTURE SCOPE

The scope of our project is limited to filtration involved in waste water treatment. The proposed Automatic back-wash filtering system developed can be used to clean the filter automatically with real time monitoring and controlling that improves plant efficiency by providing stability and continuity to the water treatment process.

It also provides the most productive and labor free solution to overcome the constraints in the manual methods by continuous monitoring and controlling the system through human-machine interface (HMI).The proposed work ensures effective water treatment in steel, power, paper, sewage and water treatment plants. Hence, the proposed work will be helpful to society and industries as well.

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