

Design and Simulation System of AHU's Pre-Filter Washing Machine using Microcontroller

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Abstract. Reducing excess water usage on large scale industries is very influential, both in terms of economics and time. An alternative approach proposed to reduce excess water usage to change the process of manual work into machine workmanship. The pre-filter washing machine is a system that can not only reduce the use of excess water discharge but also streamline the work time. However, the pre-filter washers are different from the usual drum-washing machines. The Pre-filter washing machine is designed to follow the cabinets form with 2 vertical stacking racks, so it can accommodate up to 8 Air Handling Unit's (AHU's) Pre-Filter using 2 main valves, 1 water pump, and 1 blower. The washing system designed and simulated by using microcontroller with CIP (Clean In Place) system. This paper expected to save the industrial water usage in terms of Washing AHU's Pre-Filter.

1. Introduction

Water is the source of life [1] because no one can survive without water [2]. With regard the human population in the world, the need of water will increase daily. Among the many clean water sources, around 70% used for the needs of agriculture, 20% used as the needs of the industry and leave only 10% for domestic water needs (including drinking water). There are two main components that form the economic value of water are the energy and capacity [3].

Reduced water sources resulted in the government in some countries make policy to give priority to the needs of domestic water in the water needs of others [4]. As a result, the industry must be able to find other ways to overcome the limitations of the source of the water [5]. One of the other ways to conserve water use. The development of a rapid technology is expected to help in water conservation. By involving the development of technology makes the tendency to live in a practical and economical [6].

Nowadays, the washing machine has become main important part in human life [7]. The washing machine automatically gives freedom for the user to make more working time [8]. It was also used by the industry to save the expenses and the use of water [9]. By adopting from the washing of the pre-filter manually that less effective and efficient from both sides of the use of water, time and expenditures [10]. So this paper's aims to create a pre-filter washing machine. The washing machine pre-filter is one of the washing machines that not only can reduce the use of excessive water intakes can also efficiently working.



2. Methods

2.1. Block diagram

Setting input and output based on the block diagram:

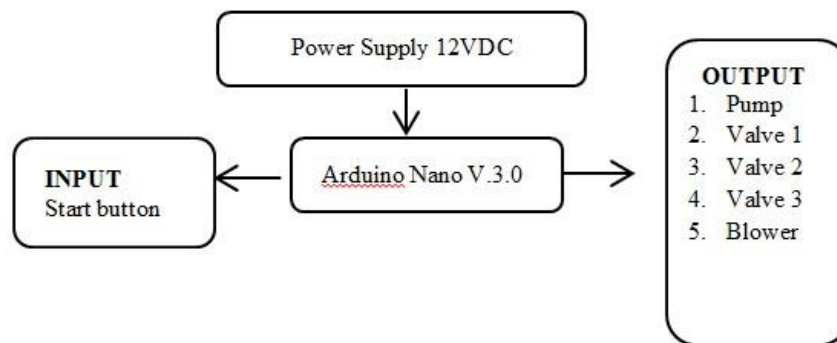


Figure 1. Block diagram.

The block diagram in the figure 1. describes the overall system [11] structure that the input section consists of a start button, the controller uses Arduino Nano, and the output section consists of a water pump, 2 valves, and blower.

2.2. Hardware design

Air Handling Unit's (AHU's) filter is one part of HVAC (Heating, Ventilation, and Air -conditioning) system that serves to filter controlling, controlling the amount of dust or foreign particles such as the organisms contained in the air before entering the room [12]. The pre-filter washers are designed to be shaped cabinets using a vertical shelf 2 racked shelves as a frame, to accommodate up to 8 Pre-Filters using 2 main valves, 1 water pump, and 1 blower. By using polycarbonate and pipe as a separator between pre-filter. Pipe formed several slits every 2cm in order to spray the water into the dirty pre-filter. By Using an inverted T-shaped iron pipe is accompanied by several slits below so that the wind released by the blower can be spread evenly. And also by making each side into a vacuum for water and air to spread evenly. Washing system is designed and simulated using a microcontroller with CIP (Clean In Place) system. This research is expected to save industry cost in terms of Washing AHU Pre Filter.

2.3. Relay 2 channel



Figure 2. Relay 2-channel.

Relays are switches that are electrically operated [13]. Also, an Electromechanical (Electromechanical) component consisting of 2 main parts with Electromagnet (Coil) and Mechanical Set of Switch Contacts / Switches). By using Electromagnetic Principle by moving contacts Switches with small electric current (low power) could conduct higher voltage electricity. For example, with Relay that uses 5V and 50mA electromagnets capable of moving Armature Relay (which serves as the switch) to conduct 220V 2A electricity.

2.4. *Water pump*



Figure 3. Water pump.

The Water pump is a mechanical equipment that serves to raise the liquid from the lowlands to the highlands. In principle, the pumps change motor mechanical energy into the fluid flow. The energy received by the fluid will be used to increase the pressure and overcome the resistance in the channel. The pump that selected in the project is Shimizu PS135E Automatic Small Pressure Tank. The water pressure is 1980L/Minutes. It consume 125Watt. The reason that selected the pump are water pressure and the power.

2.5. *Water valve inlet*



Figure 4. Water valve inlet.

The water valve inlet has main function which to manage water into the washing machine. In addition, the inlet valve acts as a kind of gatekeeper, allowing water to flow to the washing machine while receiving certain electrical signals from the microcontroller. Inside each port there is a special gate. This gate, by default, remains in a closed position. But when you start the wash cycle, the microcontroller sends a signal to the solenoid that controls a particular gate. The solenoid then triggers the gate open so water can enter the engine. The water valve inlet that selected in the project is water valve inlet electromagnetic. It run at 220V AC and 50-60Hz. Water valve inlet is one of the valve type which is usually used in the washing machine.

2.6. *Hair dryer as blower*



Figure 5. Hair dryer rainbow.

The electromechanical devices designed to expel normal or heated air. As usual, it's used to speed up the evaporation of water particles and dry the pre-filter [14]. The blow dryer allows better control by

accelerating and controlling the formation of hydrogen bonds while inside each strand. In addition, hair dryer rainbow runs at 220V-50Hz and 850Watt.

2.7. Software design

The design of the software is the most decisive step [15] in the process of making AHU's Pre-Filter Washing Machine based the Arduino Nano. It is a development board (development board) microcontroller based on ATmega328P chip with a very small shape. The function is no different than Arduino Uno. The main difference lies in the absence of DC power jack and the use of Mini-B USB connector. Called as a development board because this board serves as a prototyping arena of microcontroller circuits [9]. The software using Arduino IDE v.1.8.5. software support with the programming language used is the C++ language with the simplified version with the help of Arduino's libraries. The program has been created and then compiled so that will be obtained file with extension *. This file will be downloaded to Arduino Nano microcontroller.

```
pinMode(valve2, OUTPUT);
pinMode(dryer, OUTPUT);
pinMode(pb_start, INPUT_PULLUP);
digitalWrite(valve1, HIGH);
digitalWrite(valve2, HIGH);
digitalWrite(pompa, HIGH);
digitalWrite(dryer, HIGH);

}

void loop() {
    // put your main code here, to run repeatedly:
    int start;
    start = digitalRead(pb_start);

    if (start == LOW) {
        digitalWrite(pompa, LOW);
        digitalWrite(valve1, LOW);
        delay(7000);
        digitalWrite(valve1, HIGH);
        digitalWrite(valve2, LOW);
        delay(5000);
        digitalWrite(valve2, HIGH);
        digitalWrite(pompa, HIGH);
        digitalWrite(dryer, LOW);
        delay(50000);
        digitalWrite(dryer, HIGH);
    }
}
```

Figure 6. A part of arduino IDE program.

2.8. Flowchart

Program design on AHU's Pre-Filter Washing Machine Based Arduino Nano The following begins with creating a flowchart. The Flowchart will be made in the guidelines create a program for this tool. Flowchart program tool is shown in Figure 7.

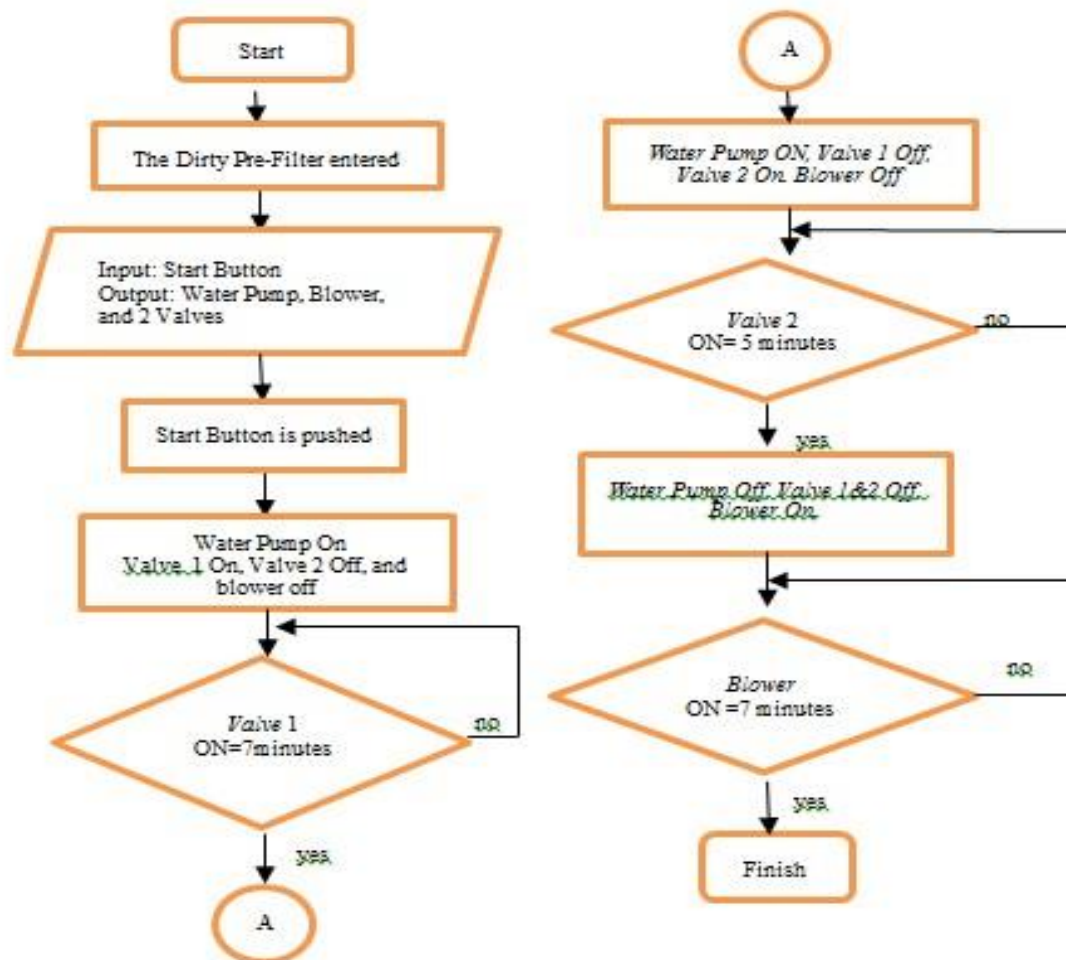


Figure 7. Flowchart.

Based on the flowchart the working principle of AHU's Pre-filter Washing Machine are when the dirty pre-filter entered. When the Start button is pressed then the water pump turning on and valve 1 would open, then water would flow to valve 1 for 7 second. After valve 1 is closed then valve 2 automatically opens and the water would flow for 5 second. After the washing process is complete, the water pump and the valves would off and the blower would light up to dry the pre-filter for 2 minutes. When the blower is ON. When the drying process is complete, it returns to the initial condition where the dirty pre-filters are inserted.

3. Results and discussion

The washing machine could operate for 2 minutes 12 second in a single command from the start button. However, the pre-filter that has been dried on the machine for 2 minutes could not be dried directly. Therefore, it is still necessary for operators to drift filters within a period of at least 1day in a shady place.

In previous, the research used an aquarium pump with a pressure of 300L / H. but the pump does not produce enough water pressure because the water released through the gap does not spray into the pre-filter. Then it replaced with the aquarium water pump with pressurized 800L / H. But, it doesn't work nicely. So with this problem, the pump is replaced with Shimizu SP135E automatic small pressure tank with pressurized 1980L/H. Furthermore, in this study using a hairdryer as a blower, but there are

constraints that the wind pressure on Hairdryer is not enough to dry because the wind pressure is less than the solution uses a pipe of iron that is formed into an inverted T letter with a diameter adjusted to the size of a hairdryer. Which the bottom is made for wind distribution channels. In addition, the machine is secured from all sides or vacuum in order to dry the pre-filter well. To make each side into a vacuum, then the bottom of the machine must necessarily be closed. In this study using polycarbonate as its cover. Where the polycarbonate is tilted to the right and made hollow in the section. Then put the hose towards the disposal.



Figure 8. Inner view of washing machine.

Figure 8 is the inner view of washing machine that there are pre-filters separators. The separators using the pipes which is formed several slits every 2cm in order to spray the water into the dirty pre-filter.



Figure 9. Front view of washing machine.

Figure 9 describes the front view of washing machine. The washing machine using polycarbonate as the cover from another side.



Figure 10. Back view of washing machine.

Figure 10 is the back view of washing machine. On the figure 3.3 there are water stripes using the intervals and its connection.



Figure 11. Valve 1 ON.

Figure 11 is describe when the valve 1 On which showed by spray water from the pipes in the first shelf.



Figure 12. Valve 2 ON.

Figure 12 is describe when the valve 2 On which showed by spray water from the pipes in the second shelf.

4. Conclusions

Based on test results from AHU's Pre-Filter Washing Machine Based Arduino Nano, it could be concluded that AHU's Pre-Filter Washing Machine Based on Arduino Nano, designed from hardware such as Arduino nano, relay, start button, aquarium pump, hair dryer, and water valve inlet. Then the

software that is applied to this system is the program built in Arduino programming language. Based on the test already could work well. The washing machine can operate for 2 minutes 12 second in a single command from the start button. AHU's Pre-Filter Washing Machine Based Arduino Nano 100% performance is in accordance with the planned function.

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