Development of a Sea Water Dispenser Automation System to Improve Distillation Process Efficiency

Engkos Koswara[1*], Hery Sonawan[2], Harun Sujadi[3], Eidelweis Dewi Jannati[1], Dodi Ariandoyo[1] and Faisal Rahmanudin[1]

[1] Mechanical Engineering, Universitas Majalengka, Majalengka, Indonesia
[2] Mechanical Engineering, Universitas Pasundan, Bandung, Indonesia
[3] Informatics, Universitas Majalengka, Majalengka, Indonesia
ekoswara.ek@gmail.com

Abstract. The distillation process that occurs in the distillation dispenser system that has been made is still not efficient. The design is quite simple where the water entering the heater (reactor) is still poured manually which makes the distillation process less efficient. The monitoring system for the distillation process has not been monitored directly, resulting in difficulty controlling each component in the distillation dispenser. In this research, the purpose of creating an automation system is to regulate the feed water input system (seawater) and the distillation output system (fresh water) so that it can occur continuously. This aims to make the distillation process in the dispenser more efficient. In addition, the creation of a monitoring system in each component is needed to see directly the processes that occur. The monitoring system that will be used in this case will look at several parameters including reactor temperature and pressure, temperature and pressure at each condenser, to feed and fresh water flow rates. This research uses Arduino to help the automation system to monitor distillation parameters. The use of Arduino as a microcontroller makes it easier for researchers to create automation systems and monitoring systems. This is because the Arduino system is quite affordable for laboratory research scale and can accept some of the input measurement parameters that researchers need. In addition, other additional components, such as temperature sensors, flow rate sensors and others are quite easy to obtain. The feed water filling system for the evaporator/heater tube uses a float sensor as a trigger for leveling the water level in the evaporator. The sensor is used because it is capable of operating at temperatures above 100°C, so it can work optimally when the evaporator is at temperatures above 100°C. The fresh water storage system is a benchmark for the automation system to work. When the fresh water level reaches 90%, the automation system will turn off all distillation components, starting from the feed water pump, heater to the nozzle spray pump.

Keywords: Arduino, Automation, Distillation, Freshwater, Seawater.

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1.0 Introduction

Humans require clean water to survive. Use of clean water is crucial for domestic, communal, and industrial purposes [1, 2]. There are various ways to satisfy the desire for clean water. The management of the clean water supply in cities must be done either by the drinking water provider or, in some cases, by a private enterprise using groundwater collection. However, in coastal locations far from springs, there are still individuals without access to clean water [3]. Sea water potential exists in coastal locations but cannot be directly absorbed. As a result, there are different approaches of provide drinkable, clean water [4]. A straightforward seawater distillation device using the Multi Effect Distillation technique, which adds a heater from a standard dispenser to a heater tube and an effect tube to a spiral pipe and nozzle as a producer for the distillation effect. With the distillation process, the dispenser can produce water with less salt than it did before [5, 6].

The seawater distillation dispenser, however, is still inefficient because of its relatively straightforward design, which requires human pouring of the water into the heater while preventing the heater from filling the tube to the point where steam may be produced. The distillation water dispenser lacks a monitoring mechanism, therefore supporting factors like temperature, pressure, and water level in the heater cannot be monitored in real time.

Supporting parts for the control system, such as the Arduino Uno R3 microcontroller, sensors, LCD, and relays, are required for the automation system to be implemented in the distillation dispenser. This uses specialized software, mainly the Arduino IDE, to input a programming language to the microcontroller, which in turn controls all of the components. Based on the Atmega 328P microprocessor, the Arduino Uno R3 board is the third revision of the Arduino Uno. Based on Atmel's AVR-RISC, the Atmega 328 is an 8-bit microcontroller device with 32 KB of ISP read/write flash memory, 1 KB of EEPROM, and 2 KB of SRAM. It is called for the flash chip's 32 KB of storage space. Atmega328 [7, 8].

The acronym IDE, or the integrated environment used for development, stands for integrated development environment. In order to build, open, and edit the programs that we include on the Arduino board, we use the Arduino IDE program. The Arduino IDE program is made to make it simpler for users to develop a variety of applications. Even novice programmers can quickly pick up the Arduino IDE's simple programming language syntax and full capability [9, 10].

2.0 Methodology

The stages of the research carried out are as follows (Figure 1):

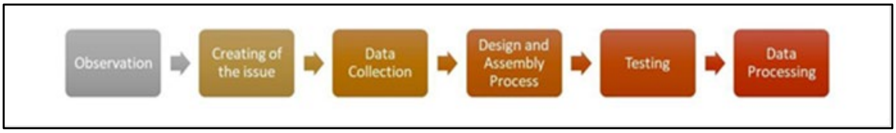

Fig. 1. Research methodology.

Analysis of the distillation dispenser's ancillary parts. This is done to gather data on the state of the current system in order to choose the next design strategy. After completing the first steps, the writers were able to identify the problems' root causes and then formulate the issues that fell within the purview of this study. The instrument requires renewal through modification and development because it is less effective.

The literature study method, which is a set of activities connected to the way of gathering library data, reading and taking notes, and organizing research materials, was used to collect the data for this study [11]. This method involved looking for theoretical references that are pertinent to the situations or difficulties discovered. In general, a method of problem-solving involves tracking down previously made textual sources in order to obtain input or input that can support everything associated with the implementation of the work process.

This design process is an automation process for distillation dispensers that includes an automation process for filling seawater. It involves designing a seawater distillation dispenser using software design and developing an automation scheme using Fritzing software, programming on the Arduino UNO Microcontroller using Arduino software, and PLX-DAQ software so that data can appear in Excel [12]. After which the distillation dispenser automation system's components are assembled, commencing with the sensors and other supporting parts.

This stage involves testing the updated distillation dispenser as a whole, including the automation setup and the distillation procedure. The next step in the event of a test phase failure is to restart the design process. Finding out the outcomes of the test data for the distillation dispenser is possible in this stage. Data collected manually from the LCD or automatically from Excel using the PLX DAQ software, which includes supporting parameters like temperature, water level, and pressure in the heater tube and condenser tube [13].

3.0 Result and Discussion

3.1 Designing an Automation Scheme and Monitoring System

This design process is an automation process for distillation dispensers, which includes an automation process for filling seawater. Software is used to design a seawater distillation dispenser in the process, and Fritzing software and Arduino software are used to program the Arduino UNO Microcontroller [14, 15]. The design approach for the study is shown in Figure 2:

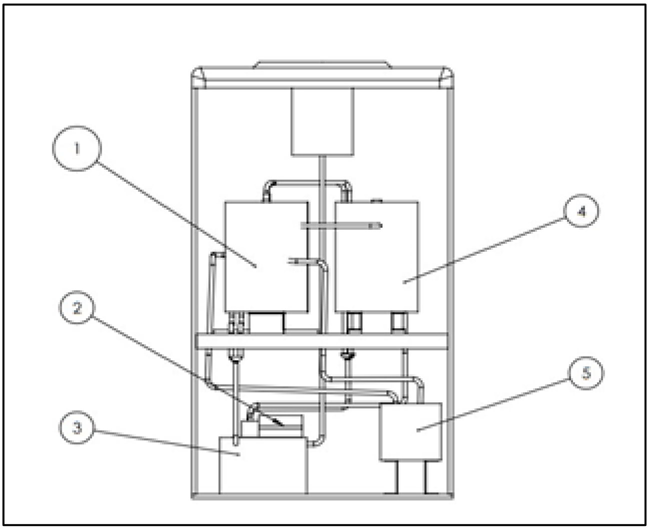

Fig. 2. Dispenser automation system design.

3.2 Making Automation Systems and Monitoring Systems (Arduino)

Condenser/evaporator tube

- Arduinos
- LCD displays
- 12V DC pump
- K type thermocouple sensor
- Float switch sensor
- Pressure transmitters
- Relays

3.2.1 Component. Assembly the first step in component assembly is to program the Arduino system. wiring diagram displayed in the image.

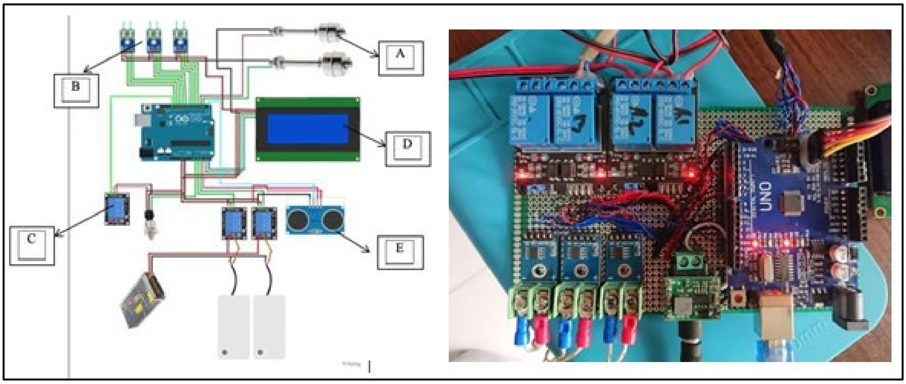

Fig. 3. Arduino system schematic.

From the scheme above (Figure 3) there is an automation system that includes a leveling system that contains a float switch sensor (A) as a reference for the automation system for filling water in the heater tube, then there is a monitoring system and activation of the condenser tube spray pump using a type K thermocouple sensor (B) as a reference for activation, then in addition to monitoring the temperature in the automation system there is also pressure monitoring with a pressure transmitter sensor (C) as a reference for monitoring which will be displayed on the LCD with an I2C module (D) and Excel Software with PLX-DAQ. In addition, the automation system also includes the disconnection of power to the heater or heater and power supply with an ultrasonic sensor (E) as a reference where the ultrasonic sensor is placed in a distilled water storage container where when the container is full, the system will cut off the power to the heater and power supply.

3.3 Testing Procedure

I. Make a reworked distillation dispenser.
II. Connect the Arduino USB cable to a laptop or computer that is running the Arduino IDE and has the Automation System programming language loaded into it.
III. Connect the heater and transformer to the power source.
IV. Run the program to allow data to appear on the LCD screen and the automation process to function.
V. Pump 1 must be able to pump water into the heater tube when it is empty and must cease pumping when the water in the tube is approximately 70% full. Pump 2 must be able to spray water into the effect tube at 90°C.
VI. Starting with the temperature and pressure in the heater tube, all parameters in the Automation process will be shown on the LCD screen and sent to Excel via the PLX- DAQ software.

VII. Pump 1 will restart automatically in accordance with the program entered on the Arduino IDE after the water in the heating tube runs out, and it will keep running until the program is terminated.

VIII. After the test is over, unplug the USB cable and unplug the heater and transformer from the power source.

3.4 System Testing

This monitoring system test aims to determine whether the parameter data on the automation system can appear or not on the LCD and Excel with the help of PLX-DAQ acquisition data. Monitoring system testing can be seen in Figure 4 and Table 1.

Fig. 4. Monitoring data on LCD.

In the tests carried out, it can be seen on the LCD that the automation system parameter data which includes the water level in the tube, the temperature of the heater tube, the temperature in the condenser tube and the pressure in the heater tube can be monitored in real time.

In addition to being displayed on the LCD, parameter data can also be displayed in Excel software with the help of PLX-DAQ acquisition data as shown in the table below.

Table 1. Monitoring data from PLX-DAQ.

Heater Tube Temperature (°C)	1st Condenser Tube Temperature (°C)	2nd Condenser Tube Temperature (°C)	Heater Tube Pressure (psig)
38.50	33	30.5	0
38.00	33	30.5	0
38.00	33.5	30.5	0
38.25	33.5	30.25	0
38.00	33.25	30.5	0
38.00	33.5	30.25	0
38.00	33.5	30.5	0

38.00	33.25	30.25	0
38.00	33.25	30.25	0
38.00	33	30.25	0
38.75	33.25	30.25	0
37.75	33.25	30.25	0
38.00	33	30.25	0
38.00	33.25	30	0
37.75	33.5	30.25	0
38.00	33.25	30.25	0
37.25	32.75	30.5	0
38.25	33	30	0
38.25	33.25	30.5	0

After testing the data displayed on the LCD can be directly transferred to excel through PLX-DAQ software for further processing as a monitoring step in the automation system process. The data obtained in the form of temperature in the heater tube, condenser tube, and pressure in the heater tube. Data that can be processed in the form of data read by sensors that are automatically inputted into Microsoft excel software through PLX-DAQ software, these data include the following:

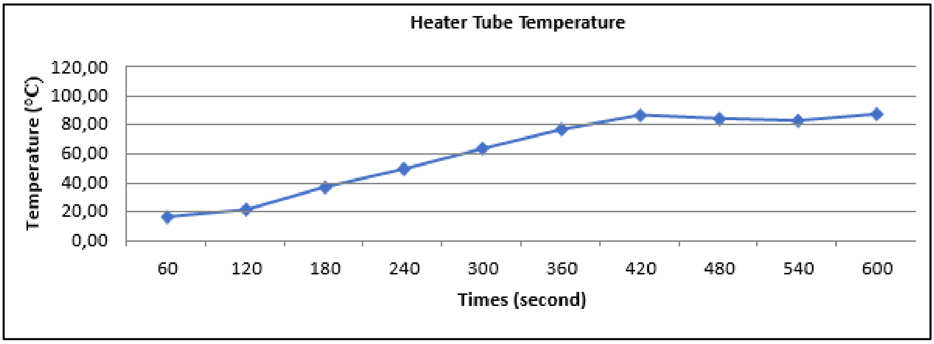

Fig. 5. Heater tube temperature.

The first is the temperature of the heater tube, in tests that have been carried out within 10 minutes with 1 time filling the heater tube, the highest temperature read is 105.75°C with an average temperature during the test is 80.35°C.

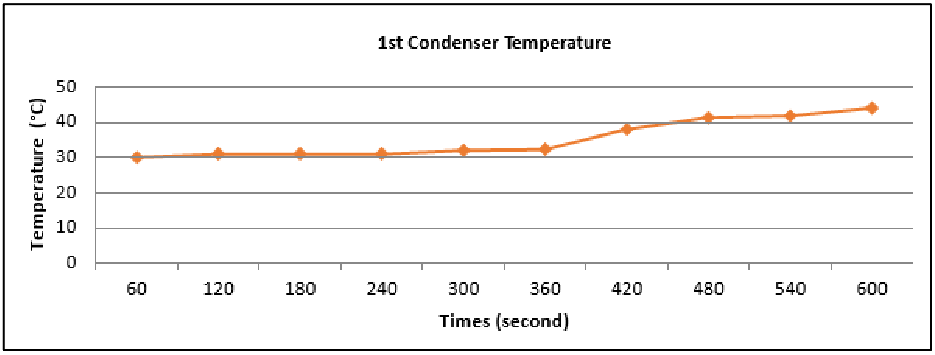

Fig. 6. 1st condenser temperature.

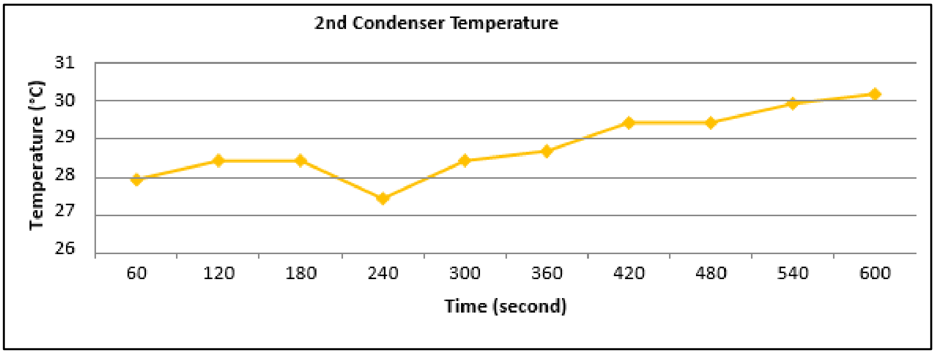

Fig. 7. 2nd condenser temperature.

While in the condenser tube the temperature read by the Thermocouple sensor in the test conducted was 44°C for the highest temperature for the first condenser tube with an average temperature of 30°C, while for the temperature in the second condenser tube the temperature obtained was 30.75°C for the highest temperature and 28°C for the average temperature in the second condenser tube.

Fig. 8. Pressure on heater tube.

While the results of testing the pressure sensor on the LCD are displayed 0.00psi because the program used is the Gauge pressure program. Whereas if you want to use absolute pressure you can use the equation gauge pressure + atmospheric pressure, then for absolute pressure the results obtained are 0.00psi + 14.696psi = 14.696psi where 1 atm is equal to 14.696psi.

After testing the automation system and monitoring system can run well without any errors during testing. C degrees Celsius for the highest temperature and 28°C degrees Celsius for the average temperature in the second condenser tube.

While the test results of the pressure sensor on the LCD are displayed 0.00psi because the program used is the Gauge pressure program. Whereas if you want to use absolute pressure you can use the equation gauge pressure + atmospheric pressure, then for absolute pressure the results obtained are 0.00psi + 14.696psi = 14.696psi where 1 atm is equal to 14.696psi.

After testing the automation system and monitoring system can run well without any errors during testing. The automation system and monitoring system runs with the help of sensors as data input to the microcontroller, the data is in the form of supporting parameters such as temperature obtained by the thermocouple type k sensor, water level from the float switch sensor, ultrasonic sensor and pressure from the pressure transmitter sensor.

From the test, the float switch sensor will detect the water level which will then be used as a reference for the filling automation system, then for the thermocouple type k sensor as a reference for activating the spray pump when the temperature has reached 90°C, then the ultrasonic sensor as a reference to cut off the power to the heater and power supply.

As for the monitoring system, parameter data can be displayed on the LCD and Exel via PLX- DAQ data acquisition software. These parameters include temperature in all tubes starting with the heater tube, condenser tube 1 and condenser tube 2. Then other parameter data is the pressure in the heater tube, all of these data can be displayed continuously before the system is deactivated.

4.0 Conclusion

There are several things that can be concluded from the research that has been done, including: A float switch sensor is used as a trigger in the feed water filling system for the evaporator/heater tube to level the water level in the evaporator. The sensor is employed because it can function at temperatures higher than 100°C, enabling it to function at its best when the evaporator is operating at higher temperatures. For the automation system to function, the fresh water storage system serves as a baseline. The automated system will shut off every distillation component, starting with the feed water pump, heater, and ending with the nozzle spray pump, when the fresh water level reaches 90%.

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Conflict of Interest. The authors have no competing interests to declare that are relevant to the content of this article.

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