Ethanol Distillation Heating Mantle with Timer and Temperature Display

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Abstract. Heating mantle or isomantle is a laboratory equipment used to spread heat to containers designed to distill or separate chemical fluids using heat. In the laboratory, distillation is generally used to perform fluid separation with low boiling points such as Ethanol. Ethanol has health benefits such as antiseptics, solvents of various chemicals, and more. However, the distillation process using an open fire will be perilous because the fire can break out towards organic solvent vapor. So the author innovating the heating mantle tool for distillation by using a dry heater as a heater that will heat the tube as well as monitoring the liquid temperature using the LM35 sensor with a digital timer and LCD. The study results obtained the temperature measurement results of 79 °C with an average of 79.6 °C and an error value of 0.7 %. This value is still at the permissible threshold of +/− 1 °C. For 2 hours 30 minutes, the timer obtained an average of 2 hours 28 minutes, and errors of 1.3 %. For ethanol amount with an average of 144 mL, after general testing, it can be concluded that heating mantle for Ethanol distillation equipped with a timer and temperature display can be appropriately used and keep on within the tolerable threshold value.

1. Introduction

Ethanol is an important material used as an organic solvent, a chemical reagent, and supporting other raw materials in the chemical and pharmaceutical industries[1]. Ethanol is a mixture of water and Azeotrope, so it is hard to separate by distillation. Distillation is one of the purification methods by separating two or more components in a liquid-based on the difference in steam pressure of each component[2][3]. Distillation is a method commonly used in laboratories to separate solutions with low boiling points such as Ethanol. If ethanol liquid to be separated has a small concentration in the solution, then the energy needed is quite large. The main problems that affect the distillation process are the type of material to be distilled, the temperature, volume of the material, and distillation time. However, the most influential factor is temperature[4]. In order to produce notable distillate (distillation result), the temperature must be maintained continuously and evenly distributed throughout all parts of the liquid in the boiling flask so as not to overheating and produce maximum distillate [5][6].

Ethanol includes organic solvents having a boiling point between 78C to 80C or below 100C, so heating with open fire will be exceedingly unsafe since the fire can strike towards organic solvent vapor, as is the case with hot plates, as surface temperatures can far exceed solvent flames[7] [8]. Therefore, a heating process safely processed by using a heating mantle is necessary. Heating mantle or isomantle is one of the laboratory equipment used to apply heat to containers, as an alternative to waterbath. Waterbath uses water as its propagation medium, while in the heating mantle, the glass container can be
placed directly in contact with the heating coat without substantially increasing the risk of the glass breaking since the heating element of the heating mantle is insulated from the container to prevent excessive temperature gradients\cite{9}\cite{10}. Based on the background, the author is interested in making a heating mantle tool for ethanol distillation with LCD to display the temperature and distillation time so that during the distillation process, the user can monitor the temperature and time so that the distillation process does not occur overheating and produce good distillation results.

2. Methodology

2.1 Software Design

Following the instrument's design, a flow diagram image to describe the process, starting from turning on the instrument until the complete process, was arranged. The process flow diagram is presented in Figure 1.

![Figure 1. Process Flow Diagram](image.png)

The process starts by pressing the ON button; then, the microcontroller will initialize the LCD; when pressed the On button, the heater will be active to reach the temperature set and the heater indicator lit. Once the temperature is attained, the timer is on. If the timer reaches the time that has been set, the heater will stop along with the heater indicator. The buzzer is then triggered, and the system is complete.

2.2 Hardware Design

The hardware design stage created a series of blocks, consisting of a minimum system microcontroller ATMega328 series and a driver heater series.

2.2.1 Minimum System Circuit

The component specification used in the minimum system circuit are as follows: ATMega 328 [11][12] to input the created program, Crystal 16.000 MHz with a working voltage of +5 volts, and ground, pushbutton, resistor 10k, 330k, LED, and capacitor 10uf, 22pf. Figure 2 following is a series of Minimum Systems.
The minimum system circuit serves as the module system controller created, a data viewer, and a data processor. The minimum circuit consists of ATMega 328, Crystal, and reset button.

2.2.2 Driver Heater Circuit
The component specification used in the driver heater circuit is the TIP31 Transitionor as Switching to turn Solid State Relay (SSR) on or off [13]. SSR is used to turn the heater on or off. Diodes are used as SSR safeguards to prevent backflow. LEDs serve as heater indicators in on or off conditions. Figure 3 is a Series of Driver Heater

The driver heater's series that functions to turn on the heater is Arduino by connecting the circuit's base leg with one of the Arduino circuit pins, namely pin PB.0, to activate the SSR, then the heater will turn on.

2.3 Data Collection Techniques
Data collection was conducted by measuring the liquid's temperature using a thermometer, timer measurement using a stopwatch, and measuring ethanol liquid using a measuring glass. Data collection was carried out five times, while the liquid temperature is done in five minutes periods.

2.4 Instrument Design
Figure. 4 depicts the created research module. This research module has two pushbuttons as the Start button to start running the tool and the reset button to repeat or stop the process. While to display the temperature and timer using a 16x2. LCD.

Figure 2. Minimum System Circuit

Figure 3. Driver Heater Circuit
3. Results and Discussion

3.1 Temperature Measurement

Temperature measurements are administered to perceive the process during distillation by comparing the display on the LCD with the observed thermometer for 5 minutes. The initial heating process is not displayed in the retrieval of this data; here is a temperature measurement of 79 °C displayed on the LCD compared to the measuring instrument in the form of a thermometer shown in Table.1

| No. | Minutes | Thermometer (°C) | No. | Minutes | Thermometer (°C) |
|-----|---------|------------------|-----|---------|------------------|
| 1   | 0       | 79,3 °C          | 17  | 80      | 79,7 °C          |
| 2   | 5       | 79,7 °C          | 18  | 85      | 79,3 °C          |
| 3   | 10      | 80,2 °C          | 19  | 90      | 80,2 °C          |
| 4   | 15      | 79,7 °C          | 20  | 95      | 79,3 °C          |
| 5   | 20      | 80,2 °C          | 21  | 100     | 79,7 °C          |
| 6   | 25      | 79,3 °C          | 22  | 105     | 80,20 °C         |
| 7   | 30      | 80,2 °C          | 23  | 110     | 79,3 °C          |
| 8   | 35      | 79,3 °C          | 24  | 115     | 79,3 °C          |
| 9   | 40      | 79,7 °C          | 25  | 120     | 79,7 °C          |
| 10  | 45      | 79,3 °C          | 26  | 125     | 79,3 °C          |
| 11  | 50      | 79,7 °C          | 27  | 130     | 80,2 °C          |
| 12  | 55      | 80,2 °C          | 28  | 135     | 79,3 °C          |
| 13  | 60      | 79,3 °C          | 29  | 140     | 79,3 °C          |
| 14  | 65      | 79,3 °C          | 30  | 145     | 79,7 °C          |
| 15  | 70      | 80,2 °C          | 31  | 150     | 79,3 °C          |
| 16  | 75      | 79,7 °C          | Mean | 79,6 °C |
|     |         |                  | Correction | 0,6 °C |
|     |         |                  | Error     | 100,70% |

Table 1 presents the observed data collection of the temperature degree when the liquid is heated. The average result is 79,6 °C with 0,6 °C correction and 0,7 % error. This value is still within the permissible threshold limit of +/-1 °C. The temperature and timer display on the instrument are presented in Figure 3.
3.2 Timer Measurement

Timer measurement when the tool works measured by a stopwatch for five times; obtained data shown in Table 2. This test was conducted to compare LCD display with Stopwatch. Timer measurement results during the tool work for 2 Hours 30 Minutes (150 Minutes) and the result of timer measurement from the initial temperature to the temperature reached using a stopwatch. Here is the timer's measurement in 2 hours 30 minutes compared to the Stopwatch shown in Table.2

Table 2 Timer measurements at the time the tool is working

| No. | Measurement No. | Stopwatch Readings       |
|-----|-----------------|--------------------------|
| 1   | X1              | 2 Hours 28 Minutes       |
| 2   | X2              | 2 Hours 28 Minutes       |
| 3   | X3              | 2 Hours 29 Minutes       |
| 4   | X4              | 2 Hours 28 Minutes       |
| 5   | X5              | 2 Hours 29 Minutes       |
|     | Mean            | 2 Hours 28 Minutes       |
|     | Correction      | 2 minutes.               |
|     | Error           | 1.3 %                    |

From the measurement results that have assessed by using a stopwatch to find out the time comparison between the tool and the Stopwatch when the tool works from data five times retrieval, it resulted in the average of 2 Hours 28 Minutes (148 Minutes) with a correction of 2 Minutes and an error of 1.3. Table 3 represents timer test data from the initial temperature until the temperature is reached.

Table 3 Timer Measurement from initial temperature to Reached temperature

| No. | Measurement No. | Stopwatch Readings       | On Instrument Temperature display |
|-----|-----------------|--------------------------|----------------------------------|
| 1   | X1              | 8 Minutes 40 Seconds     | 79.3 °C                          |
| 2   | X2              | 8 Minutes 41 Seconds     | 79.3 °C                          |
| 3   | X3              | 8 Minutes 39 Seconds     | 79.3 °C                          |
| 4   | X4              | 8 Minutes 40 Seconds     | 79.3 °C                          |
| 5   | X5              | 8 Minutes 39 Seconds     | 79.3 °C                          |
|     | Mean            | 8 Minutes 39 Seconds     | 79.3 °C                          |

The measurement results that have been done by a stopwatch to find out the time needed to reach the desired temperature from the data retrieval done five times obtain the average result of 8 Minutes 39 Seconds (519 Seconds). Temperature and timer display during distillation is shown in Figure. 4
3.3 Ethanol Measurement Result

Measurement of the total Ethanol measured by measuring glasses. To test whether the tool can function to produce Ethanol according to boiling point or temperature limit set. Here is a measurement of ethanol results obtained and measured using measuring glasses shown in Table 4.

| Measuring Glass (mL) | Total Ethanol Produced | Average instrument temperature |
|----------------------|------------------------|--------------------------------|
| X1                   | 145 mL                 | 79.5 °C                        |
| X2                   | 144 mL                 | 79.5 °C                        |
| X3                   | 144 mL                 | 79.6 °C                        |
| X4                   | 143 mL                 | 79.6 °C                        |
| X5                   | 144 mL                 | 79.6 °C                        |
| Mean                 | 144 mL                 | 79.5 °C                        |

The results of measurements conducted by measuring cups within 2 Hours 30 Minutes from the five times data records resulted in an average of 144 mL.

4. Conclusion

After conducting the process of creating and studying the literature of planning, testing tools, and data collection, it can be concluded that the Heating Mantle instrument for ethanol distillation equipped with a timer and the temperature display operates well after measurement and testing using a measuring instrument. By comparing the value produced by the prototype with a thermometer measuring instrument for the display temperature on the LCD obtained an average result <x79.6°C> correction of 0.6 °C and error of 0.7 %. This value is still within the permissible threshold of ±1 °C. Timer testing with Stopwatch for timer display obtained an average value of 2 Hours 28 Minutes (148 Minutes), correction of 2 Minutes, and error of 1.3 %. Moreover, measuring glasses to measure Ethanol's results from the separation between water and alcohol obtained the amount of Ethanol measured using measuring glasses carried out five times in the results with an average of 144 mL.

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