Technium Vol. 11, pp.1-7 (2023)
ISSN: 2668-778X
www.techniumscience.com

Microcontroller based multi-function control system for essential oil refining

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Abstract. The research is to design a multi-function control system using a nodemcu esp32 microcontroller to control the temperature and pressure of the essential oil refining steam boiler. Control aims to obtain the efficiency of the use of LPG gas. To increase efficiency, the controller applies fuzzy logic to each distillation function. The control system is based on the distillation time to get the most optimal essential oil yield. The results and duration of the distillation are based on fuzzy logic. Setting temperature and pressure parameters is based on the characteristics of the type of material to be refined. In nutmeg distillation, the temperature is in the range of 110-120 °C and a minimum pressure of 1.5-2.0 bar. In patchouli distillation the temperature is in the range of 100-110 °C and a minimum pressure of 1.0-1.5 bar. For citronella distillation, the temperature is in the range of 100-110 °C and a minimum pressure of 1.0-1.5 bar. The distillation time for each essential oil raw material is different, and the most optimal time is obtained from. The simulation is based on fuzzy logic. The results of the application of the control system in essential oil refining obtained efficiency in the use of gas. The efficiency of nutmeg essential oil distillation is 17.5% with a distillation time of 12 hours. Patchouli essential oil refining efficiency was 15% with 8 hours distillation. And the efficiency of distillation of citronella essential oil is 10% with distillation for 5 hours. The yield produced in the test of 20 kg of materials, namely nutmeg, patchouli and citronella, obtained a yield of 1.0 kg of nutmeg oil, 350 g of patchouli oil and 220 g of citronella oil

Keywords. Control system, Microcontroller, Fuzzy logic, Gas efficiency, Essential oil

1. Introduction

The focus of research on the process of refining essential oils is also continuously being developed. One of the focus of research in this field is to add a control function based on electronic control. One of the cost components in the refining process is fuel as an energy source. The cost of fuel in the refining process reaches 30% of the total production cost [1]. In addition, the operator costs in the implementation of the refining process. Fuel as a source of energy in the process of refining essential oils is firewood, fuel oil/used oil, gas fuel and electricity. Most of the fuel used is firewood and fuel oil/used oil. To get the quality of essential oil yield, fuel gas and electricity are priorities.

There are two research focuses that underlie this research, namely the ease in the process of refining essential oils and reducing production costs. The second focus of this research is done by adding a control system based on electronic control. Ease of operating the tool is done to

simplify operational procedures. Efficiency in the use of gas and electricity is carried out by controlling the temperature and pressure of the distillery. Temperature and pressure are controlled to stay within a predetermined range. The length of the refining process is also included as a parameter that can save production costs.

Based on research that to get essential oils one way is by distillation [2]. The most effective patchouli essential oil distillation procedure is up to 8 hours at a temperature of 100°C and a pressure of 1 bar [3]. To produce the yield of citronella essential oil, the distillation process is carried out for 5 hours at a temperature of 110°C and a pressure of 1 bar, at 4.5 hours of distillation the yield can reach 1.35% [4],[5]. The process of refining nutmeg essential oil, the most optimal time to produce yield is up to 9 hours with a temperature of 100°C-120°C, and a pressure of 1-2 bar [6],[7].

Some distillation systems with the addition of a control system can save LPG gas up to 15% and systems with wood fuel can save production costs, and systems with electrical energy sources can save 20% electrical power [8],[9],[10],[11]. Control methods can also improve fuel efficiency, one of which has been carried out is the fuzzy logic method [8],[9].

In this research, the application of the fuzzy logic method is based on the characteristics in the process of refining the essential oils of nutmeg, patchouli and lemongrass.

2. Method

In this section, the design of the essential oil refining system consists of the design of the distillation system and the design of the control system.

2.1. Essential oil distillation system design

The design of the essential oil refining system has a refining capacity of 25 kg of raw materials. The design of the essential oil refining system with a control system is shown in Fig. 1.

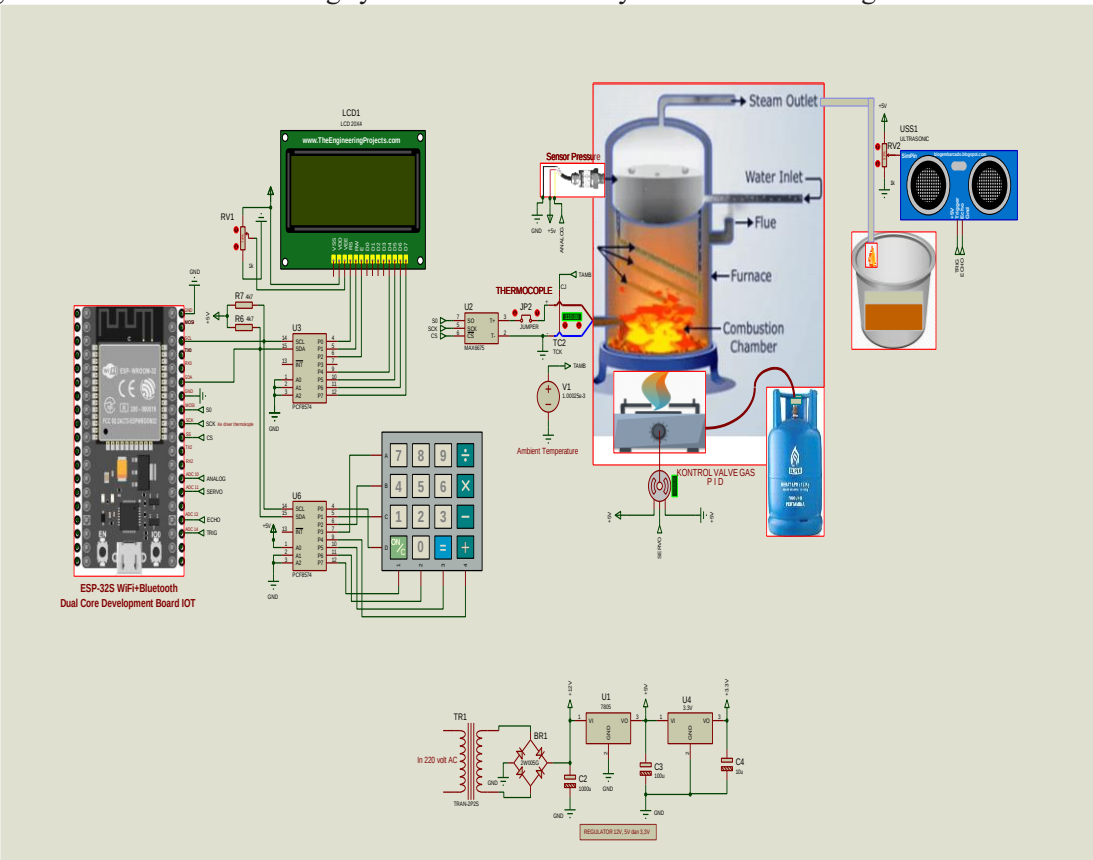

Figure 1. Design of essential oil refining system with control system

Technium Vol. 11, pp.1-7 (2023)
ISSN: 2668-778X
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This essential oil distillation system is divided into 2 main parts, namely the distillation system and the distillation control system. The distillation system consists of a boiler, a distilled boiler (reactant tube), a coolant and a separator. The fuel system uses LPG gas. The electronic-based control system uses an ESP8266 MCU microcontroller module with a 4x20 LCD and 4x4 keypad, Temperature sensor using a MAX6675 K type thermocouple and pressure sensor using a 500PSI pressure transmitter, a gas flow control module.

2.2. Essential oil refining control system design

The membership function of the fuzzy logic control system for essential oil refining is shown in Fig. 2. Electronic-based control system for essential oil distillation equipment, and application in the refining process using fuzzy logic method. The following is a fuzzy logic design in the process of refining nutmeg, patchouli and lemongrass essential oils. The fuzzy logic design is based on the characteristics of each raw material to be refined based on the research results.

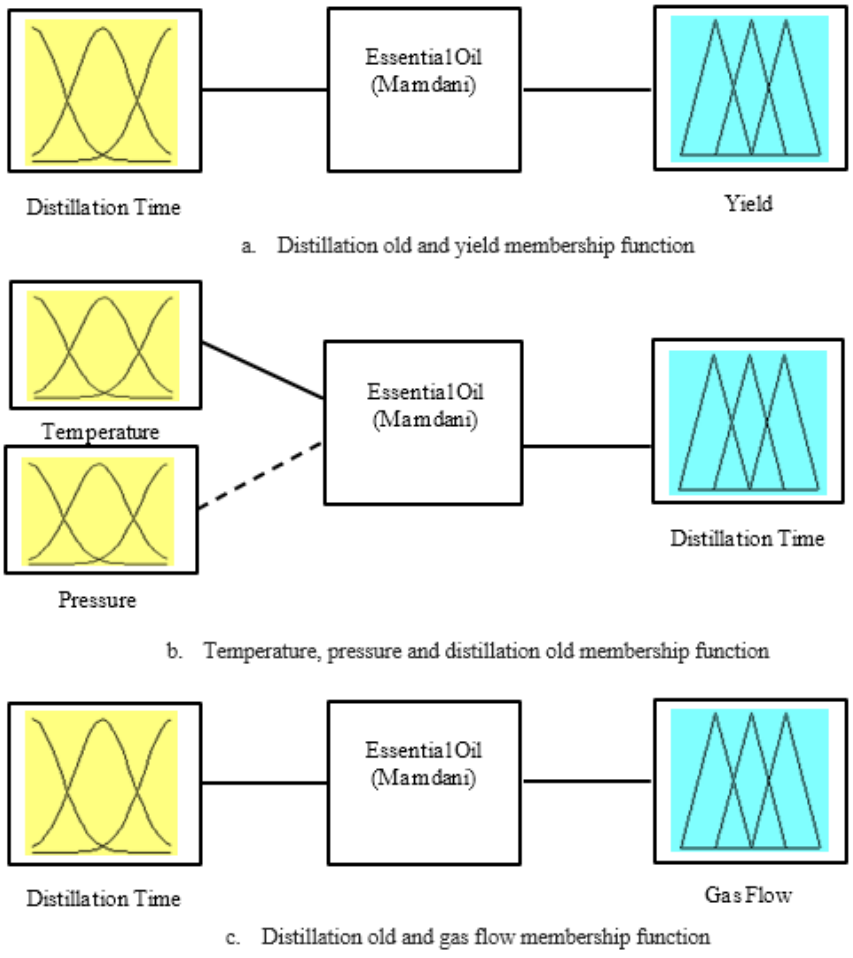

Figure 2. The design of fuzzy logic on the essential oil refining control system

2.3. Manufacturing System

Manufacturing of essential oil distillation systems, namely a distillation system with a capacity of 100 kg of raw materials consisting of a boiler with LPG gas fuel, reactant tubes, condensers, oil and water separators and the electronic-based control system uses an ESP8266 MCU microcontroller module with a 4x20 LCD and 4x4 keypad, temperature sensor using a MAX6675 K type thermocouple and pressure

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sensor using a 500PSI pressure transmitter, a gas flow control module. The results of assembling the essential oil distillation system are shown in Fig. 3. The advantages of this tool are the ease of operation and the efficiency of using LPG gas.

Figure 3. The research result of essential oil distillation system

3. Result and discussion

Based on the results of system testing on each raw material, 20 kg of dry nutmeg were ground first, 20 kg of dried patchouli were ground, and 20 kg of citronella were crushed before being put into the reactant tube. The tests were carried out separately and the characteristics of each distillation process, namely nutmeg, patchouli and lemongrass, were inputted into the control system. The results of the test are in the form of the amount of gas used during distillation for each essential oil and the yield of the distillate.

Table 1. Cconsumption of LPG gas in nutmeg essential distillation

Test number (Hour)	Current temperature and pressure in the boiler		LPG gas consumption	
	Temperature (ºC)	Pressure (bar)	LPG gas consumption (kgs)	LPG gas consumption (%)
1	50	0.5	1.00	8.33
2	80	0.6	1.00	8.33
3	100	0,7	1.00	8.33
4	120	0.9	0.90	7.50
5	120	1.1	0.60	5.00
6	110	1.0	0.60	5.00
7	110	1.0	0.70	5.83
8	110	1.0	0.80	6.67
9	110	1.0	0.90	7.50
10	110	1.0	0.90	7.50
11	110	1.0	0.70	5.83
12	110	1.0	0.80	6.67

3.1. Test results of nutmeg essential oil refining

Based on the test results on the nutmeg essential distillation process for 12 hours, the data obtained as shown in Table 1. The amount of LPG gas consumed for 12 hours of distillation time was 9.90 kg. When compared to the distillation system without controlling the LPG gas consumption for 12 hours the distillation process is 12 kg. So that the efficiency of using LPG gas obtained is 2.10 kg or 17.5%.

Table 2. Consumption of LPG gas in patchouli essential distillation

Test number (Hour)	Current temperature and pressure in the boiler		LPG gas consumption	
	Temperature (ºC)	Pressure (bar)	LPG gas consumption (kgs)	LPG gas consumption (%)
1	50	0.5	1.00	8.33
2	80	0.6	1.00	8.33
3	100	0,8	1.00	8.33
4	120	0.9	0.90	7.50
5	120	1.0	0.60	5.00
6	110	1.1	0.70	5.83
7	110	1.0	0.80	6.67
8	110	1.0	0.80	6.67

3.2. Patchouli essential oil refining test results

The advantages of this tool are the ease of operation and the efficiency of using LPG gas. The test results on the patchouli essential distillation process for 8 hours obtained data as shown in Table 2. The amount of LPG gas consumed for 8 hours of distillation time was 6.80 kg. And when compared with the distillation system without controlling the consumption of LPG gas for 8 hours the distillation process is 8 kg. So, the efficiency of using LPG gas is 1.20 kg or 15%.

3.3. The results of the citronella essential oil distillation test results

The results of the test on the process of distilling citronella essential oil for 5 hours obtained data as shown in Table 3. The amount of LPG gas consumed for 5 hours of distillation time was 4.50 kg. And when compared with the distillation system without controlling the consumption of LPG gas for 5 hours the distillation process is 5 kg. So that the efficiency of using LPG gas obtained is 0.50 kg or 10%.

Table 3. Consumption of LPG gas in citronella essential oil distillation

Test number (Hour)	Current temperature and pressure in the boiler		LPG gas consumption	
	Temperature (ºC)	Pressure (bar)	LPG gas consumption (kgs)	LPG gas consumption (%)
1	50	0.5	1.00	8.33
2	80	0.6	1.00	8.33
3	100	0,7	1.00	8.33
4	120	1.0	0.90	7.50
5	120	1.1	0.60	5.00

3.4. Yield of testing on essential oil refining

The yield produced in the essential oil refining process is shown in Table 4. The yield of nutmeg essential oil is 1.0 kg of essential oil or 5%, for the raw material of 20 kg of dried nutmeg. The yield produced during the process of refining patchouli essential oil is 350 g or 1.75%, for 20 kg of dry patchouli as raw material. The yield of citronella essential oil produced during the distillation process is 220 g or 1.1%, for the raw material of 20 kg of dry citronella.

Table 4. Essential Oil Yield

Test number	Nutmeg essential yield		Patchouli essential yield		Citronella essential yield	
	(kg)	%	g	%	g	%
1	1	5.0	350	1.75	220	1.1

4. Conclusion

Based on the test results on the essential oil refining system with a fuzzy logic-based control system that the system is easier to operate, especially for refining nutmeg essential oil, patchouli essential oil and citronella essential oil. The characteristics and parameters of this essential oil refining process have been included in the control system program. So, for operation by selecting the type of distillation through the keypad provided on the control system module. The use of LPG gas in the essential oil refining process can be reduced in order to obtain efficiency. The efficiency of nutmeg essential oil distillation is 17.5% with a distillation time of 12 hours. The efficiency of patchouli essential oil refining is 15% with 8 hours distillation. And the efficiency of citronella essential oil distillation is 10% with distillation for 5 hours. The yield produced in the test of 20 kg of materials, namely nutmeg, patchouli and citronella, obtained yields of 1.0 kg of nutmeg oil, 350 g of patchouli oil and 220 g of fragrant lemongrass oil.

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