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Experimental Study of Distillation Equipment for Making Essential Oils from Citronella Plants using the Fractionation Column Method

Meidy P.Y. Kawulur, Silvy D. Boedi, Artian Sirun, Niko Pinangkaan

Abstract: ***In Indonesia, in general, it has a very abundant natural resource potential, one of which is lemongrass. Lemongrass is still not widely cultivated in Indonesia, this plant is processed and processed into essential oils, it will get a high selling value. Currently, the development of essential oils is a considerable concern of the Indonesian government. Of the various raw materials for making essential oils, one of the raw material plants for essential oils in Indonesia that is good to be developed is citronella. The purpose of this study was to examine experimentally the manufacture of citronella oil (Citronella oil) from the leaves and stems of citronella. Citronella oil is generally used for health, ranging from bacteria and fungi, headaches, to hypertension and is also used as aromatherapy. The advantage of the fractionation column method is the process of separating the components from the Constituent substances of a mixture of solution compounds based on the difference in boiling points by using multilevel distillation, so as to produce good quality essential oils with low water content. From three Tests of essential oil distillation apparatus with fractionation column of citronella, the results of the first test is as much as 940 ml with a mass of 920 gr and a density of 978.2 kg/m3, the second test results obtained as much as 80 ml with a mass of 70 gr and a density of 875 kg/m3, the third test results obtained as much as 70 ml with a mass of 50 gr and a density of 714.2 kg/m3. The average density from the first to the third Test was 855.8 kg / m3. The combustion temperature in the reactor tank is very influential on the duration of combustion and the number of results that come out and the quality of the results obtained.***

Keywords: Essential Oil, Lemongrass, Fractionation Column

I. INTRODUCTION

To obtain essential oils, you can use ingredients from patchouli, vetiver, nutmeg, clove, citronella, ylang, eucalyptus, sandalwood, pepper, and cinnamon. The ingredients above include the leaves, stems and roots. To get essential oils can be from the above ingredients which include leaves, stems and roots. [1].

Citronella oil (Citronella oil) from the citronella plant (Cymbopogon winterianus) which is one type of essential oil that is often also called ethereal oil or flying oil because of its volatile ability and has a different composition and boiling point. Characteristics of essential oils, these oils have certain characteristics, namely having a low vapor point so that they evaporate easily [7] The composition of the compounds contained in this essential oil is very strong, so it is able to affect the human nerves (nose), the impact is a certain psychological effect. [5]

The distillation process is a way to obtain essential oils by boiling the raw materials put into a heating boiler until the heated medium becomes steam until it becomes saturated steam. To produce essential oils is done by distillation process or often called distillation.[6].

The distillation method will make the lemongrass plant as a raw material for essential oils not in direct contact with water, but only in contact with water vapor as a result of boiling at the bottom of the kettle with the fractionation column method. Based on the above, research is needed on the distillation of lemongrass plants using fractionation column method. With the aim of this study is to examine experimentally the manufacture of essential oils so as to obtain better results and quality of any pressure/temperature and time that has been determined [2].

The main difference between laboratory and industrial scale distillation is the continuity system. On a laboratory scale, distillation is carried out one-way. In laboratory-scale distillation, the composition of the mixture is separated into component fractions sorted by volatility, where the most volatile substances are separated first. Thus, the least volatile substances will remain at the very bottom. This distillation technique consists of 3 types, namely steam distillation, hydro distillation and steam - hydro distillation. Steam distillation can produce more yield than using hydro distillation. [8]. Steam hydro distillation has a relatively higher temperature and pressure process, so there is no essential oil mixed in water so that the amount of oil left in the water is small, and also the compounds extracted are more complete [4]. Fractional distillation is a process that is part of the different types of distillation, which is part of the principles of physics but is used in chemistry to separate various mixtures of liquids that generally have a homogeneous consistency.

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That is, it is used when its user needs to separate a liquid solution, taking advantage of the state of matter, managing to bring one of the two liquids that make up its mixture to the boiling point, managing to evaporate and separate them. Distillation of a liquid is thoroughly mixed so that it forms only one layer.

II. METHOD

The manufacture of astiri oil distillation apparatus was carried out at the Mechanical Engineering Workshop of the State Polytechnic of Manado. The materials used in the manufacture of essential oil distillation apparatus are: stainless steel plate, stainless steel pipe, connection and elbow steel. Equipment used, plate cutting machine, cutting grinding, roller machine, welding machine and other supporting equipment needed for the manufacture of oil distillation system astiri. As a raw material for fragrant lemongrass plants. This study was conducted in the following stages:

1. Perform the manufacture of oil distillation system astiri.
2. Examine experimental distillation system of astiri oil to obtain good purification results.

To make and test the essential oil distillation system with steam-hydro distillation process is done with several steps, namely:

a. Preparation of data collection results of previous evaluations of comparative studies and literature studies.
b. Prepare the required materials and equipment.
c. Making astiri oil distillation system with existing facilities at the State Polytechnic of Manado.
d. Perform performance test of essential oil distillation system
e. Analyze / review the results of experiments carried out to produce good essential oils from the results of purification.

In the manufacture of essential oil distillation apparatus, the most important thing to consider is the material. The materials used are tools that do not react/cause contamination to oil products, so that the resulting essential oil products are of good quality. Good Material is with glass/pyrex and stainless steel. For glass material is only capable of laboratory scale, while industrial scale is commonly used stainless steel. In the manufacture of this distillation apparatus, a tank is needed to hold essential oils, which can be made of glass or stainless steel. For glass material, use a dark bottle so that the oil avoids the entry of direct sunlight so as not to lower the oil grade. [3].

III. RESULTS

The stages of the process of making essential oil distillation apparatus are:

1. Tank Manufacturing Process

Provide 2 sheets of stainless plate, with a thickness of 2mm then 1 sheet of stainless plate in bending so that the two sides of the plate are connected and form a circle, after that, connect the two sides of the plate using a welding machine. Then the one plate is cut with a diameter of 62cm, this plate is used as a cover, after cutting the plate to form a tube, using a welding machine. Cut the plate again to form a circle with a thickness of 2cm, this plate is used to make a flange on the top of the tube, then connect the welded way using a welding machine and 2mm stainless welding wire. then make a hole for the Bolt as many as 12 holes using a hand drilling machine and a 10mm drill bit.

2. Tank Cover Manufacturing Process

Cut the plate using a hand grinder so that it forms like a trapezoid, then manual bending. Cut the plate using a hand grinder so that it forms like a trapezoid, then manual bending using solid iron and a hammer, by placing iron on the plate and tapping using a hammer, do it with the appropriate pattern so that it becomes a cone-like shape.then connect the two sides by using welding machine and 2mm stainless welding wire. After forming like a cone, punch a hole in the top of the cone with a diameter of 10.2 cm, then cut another 2cm wide stainless plate to make a flange on the tank cover, when finished connect the flange to the tank cover by welding using a welding machine and 2mm stainless welding wire, then make a hole for the Bolt as many as 12 holes using a hand drilling machine and a 10mm drill bit, then make a hole on the side of the cone to place the temperature thermometer.

3. The Process of Making Air Filter (Filter)

Take a stainless pipe size 4” then cut it with a pipe length of 38cm, after that cut a 4cm wide circle shape plate to make a flange when finished connect the flange to the pipe using a welding machine and 2mm stainless steel welding wire, then make a hole in the flange as many as 8 holes using a 12mm. Connect the pipe to the tank cover by welding using a welding machine and 2mm stainless steel welding wire. Cut 8mm stainless iron with a length of 40cm, then cut a circular stainless plate with a diameter of 3.9” as much as 3pcs then make a hole using a 10mm drill bit with a circular pattern, and in the middle of the plate after finishing connecting the three perforated plates on stainless iron by welding with a distance of each plate 12cm. Iron input with ang plate has been modified in such a way, then in each cavity in the fiber input that serves as a steam filter

4. Condenser Manufacturing Process

Cut the galvanized pipe diameter 1” with a length of 332cm then one end of the pipe is connected to the galvanized elbow by welding, after that cut the stainless pipe diameter 4” with a length of 300cm when finished cut the stainless plate in the form of a circle with a diameter of 4” as much as 2pc, then make a hole in the middle on both plates with a diameter of 1”, then the plate is connected at both ends of the pipe 4” by welding, put the Pipe 1”into the pipe 4". At the end of the pipe without elbow issued a little more or less 30cm, while using elbow issued 2cm, then welded so that the pipe does not come off. Both sides of the pipe end made a hole, on the side of the hole is made on top and one below, it serves to get in and out of the water, as a function of the condenser.

5. Working Principle of Fractionation Column Distillation Apparatus

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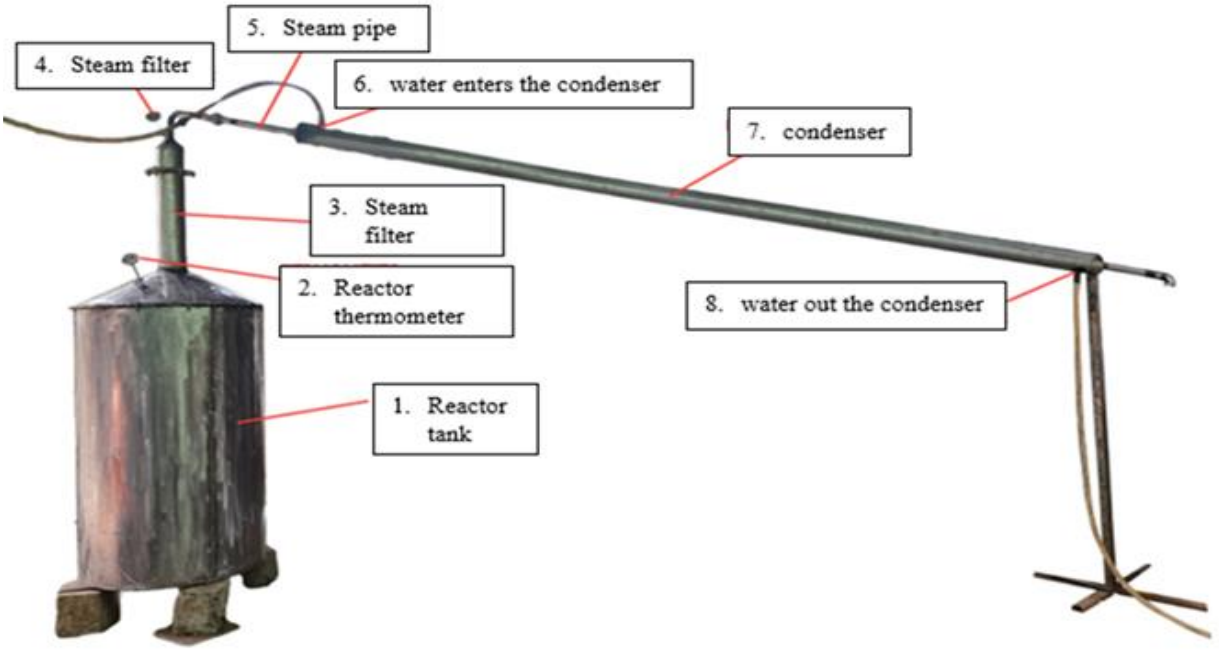


Figure 1. Working Principle of Fractionation Column Distillation Equipment

- The water in the reactor tank (number 1) will be educated and will become steam
- Then the steam will steam the citronella ingredients that are above the filter
- Then the steam passes through the fractionation column or steam filter column (number 3), so that the citronella parts which are lifted along with the steam will be suspended in the steam filter column, and the steam passes through the steam pipe, while water enters (number 6) and exits (number 8) through the condenser pipe (number 7).
- Then the steam passes through the condenser section as condensate, regulated by a certain temperature (number 2), so that the citronella steam or gas will come out into liquid or citronella oil.

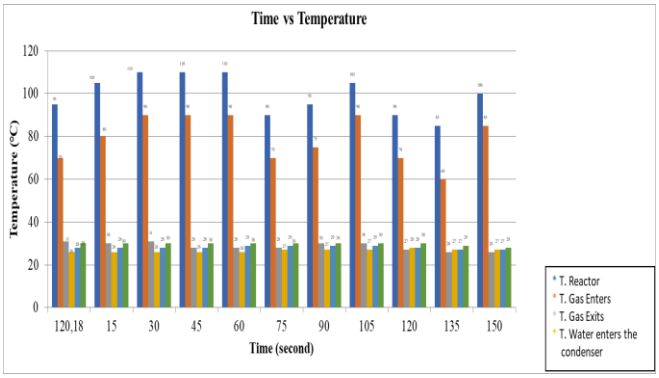
In this study, the distillation process through the distillation of essential oils of water vapor type from citronella. Based on the results of research data can be seen the effect of temperature on the rate of droplets and the number of distillation results obtained in 3 Tests. Data collection is done by recording the time or minutes to how the initial droplets out and after the calculation of the time interval of 15 minutes and record the temperature of the reactor tank, the gas before entering the condenser, the gas out of the condenser, the water into the condenser, the water out of the condenser and air temperature.

A. First Testing

The first Test was carried out all the tests on the important components of the distillation apparatus, namely the condenser pipe, water pump for circulating water in the condenser and a thermometer to measure the temperature of the steam that will enter the condenser. The test is to determine whether the components can function properly. In the first distillation process the components function properly so that the distillation apparatus can continue further testing. The first Test was conducted using citronella with a weight of 7 kg and a volume of water as much as 47,610 cm3 to be used as steam.

Table 1. The first test of 7 kg citronella distillation equipment

No	Time (second)	Temperature (°C)						Volum (ml)
		Reactor	Gas enters condenser	Gas exits the condenser	Water enters the condenser	Water exits the condenser	outside air	
1.	120,18	95	70	31	26	28	30	Initial drops
2.	15	105	80	30	26	28	30	30
3.	30	110	90	31	26	28	30	170
4.	45	110	90	28	26	28	30	380
5.	60	110	90	28	26	29	30	520
6.	75	90	70	28	27	29	30	640
7.	90	95	75	30	27	29	30	700
8.	105	105	90	30	27	29	30	780
9.	120	90	70	27	28	28	30	840
10.	135	85	60	26	27	27	29	900
11.	150 (end)	100	85	26	27	27	28	940
Results obtained								940



Graphic 1. The First Test Of 7 Kg Citronella Distillation Equipment

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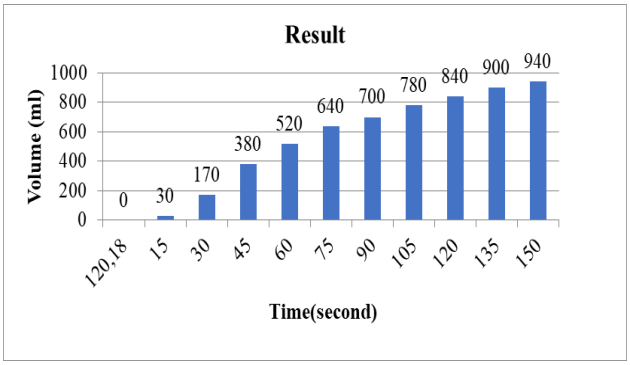
From the graph above shows an achievement of time and temperature obtained during the first test performed. The temperature in the reactor tank tends to change so that it also affects the tempertaur temperature of the gas that will enter the condenser. The highest temperature of the reactor tank reaches 100oC at 30, 45 and 60 Minutes. In Graph 2. Can be seen the first test to get the Essential Oil against the time with the volume.



Graph 2. First Time Test Results Against Volume

From the graph above results expressed a time and volume during which the test was performed. The drip rate of the results is at a time or 30 minutes to 45 minutes which is a total of 210 ml. And the duration of time during the test can be calculated by the initial drip out time is 120.18 minutes plus 150 minutes which is the duration of time each before 15 minutes, so the total duration of time obtained during the first test lasts is 270.18 minutes, with the results obtained is 940 ml.

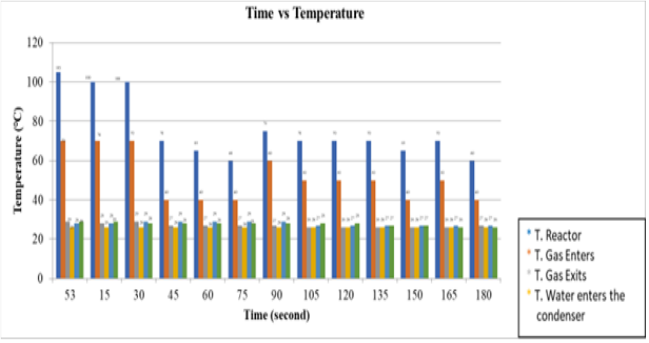
B. Second Testing

The second Test was carried out by the distillation process of essential oil distillation apparatus type of water vapor from citronella. In the second test, using lemongrass weighing 7 kg and a volume of water as much as 25,392 cm3 to be used as steam.

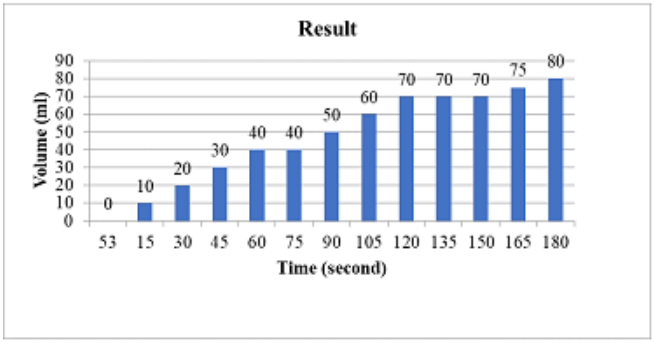
Table 2. The Second Test of 7 kg Citronella Distillation Equipment

No	Time (second)	Temperature (°C)						Volum (ml)
		Reactor	Gas enters condenser	Gas exits the condenser	Water enters the condenser	Water exits the condenser	outside air r	
1.	53	105	70	29	26	28	29	Initial drops
2.	15	100	70	28	26	28	29	10
3.	30	100	70	29	26	29	28	20
4.	45	70	40	27	26	29	28	30
5.	60	65	40	27	26	29	28	40
6.	75	60	40	27	26	29	28	40
7.	90	75	60	27	26	29	28	50
8.	105	70	50	26	26	27	28	60
9.	120	70	50	26	26	27	28	70
10.	135	70	50	26	26	27	27	70
11.	150	65	40	26	26	27	27	70
12.	165	70	50	26	26	27	26	75
13.	180	60	40	27	26	27	26	80
Results obtained								80

The graph above shows the time and temperature reached during the second Test. The results of the initial droplets that come out can be seen after 53 minutes during the test and is the highest temperature point in the reactor tank that reaches 105ºC



Graph 3. The Second Test Of 7 Kg Citronella Distillation Equipment



Graph 4. Second Time Test Results Against Volume

From the graph above results state a time and volume during which the second Test is performed. The most droplets on average that is almost every 15 minutes increased 10ml results obtained. And the duration of time during the test is calculated by the initial drip time out is 53 minutes plus 180 minutes which is the duration of time before each 15 minutes, and the duration of time obtained during the second test lasts is 233 minutes, with the results obtained are 80 ml.

C. Third Testing

The third Test was carried out by the distillation process of essential oil distillation apparatus type of water vapor from citronella. In the third test, using lemongrass weighing 7 kg and a volume of water as much as 25.392cm3 to be used as steam.

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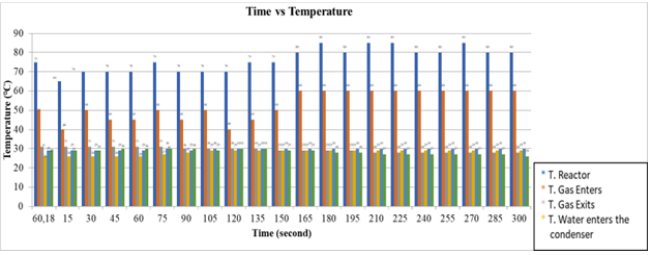
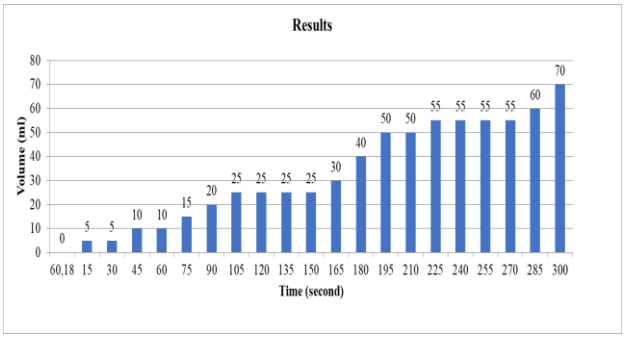
Table 3. The Third Test of 7 kg Citronella Distillation Equipment

No	Time (second)	Temperatur (°C)						Volum (ml)
		Reactor	Gas enters condenser	Gas exits condenser	Water enters condenser	Water exits condenser	outside air	
1.	60,18	75	50	31	26	29	29	Tetes awal
2.	15	65	40	31	26	29	29	5
3.	30	70	50	31	26	29	29	5
4.	45	70	45	31	26	29	30	10
5.	60	70	45	31	26	29	30	10
6.	75	75	50	31	27	30	30	15
7.	90	70	45	30	28	29	30	20
8.	105	70	50	30	29	30	29	25
9.	120	70	40	30	29	30	30	25
10.	135	75	45	30	29	30	30	25
11.	150	75	50	29	29	30	29	25
12.	165	80	60	29	29	30	29	30
13.	180	85	60	29	29	30	28	40
14.	195	80	60	29	29	30	28	50
15.	210	85	60	28	29	30	27	50
16.	225	85	60	28	29	30	27	55
17.	240	80	60	28	29	30	27	55
18.	255	80	60	28	29	30	27	55
19.	270	85	60	28	29	30	27	55
20.	285	80	60	28	29	30	27	60
21.	300	80	60	28	29	30	26	70
Results obtained								70



Graph 5. The Third Test Of 7 Kg Citronella Distillation Equipment



Graph 6. First Time Test Results Against Volume

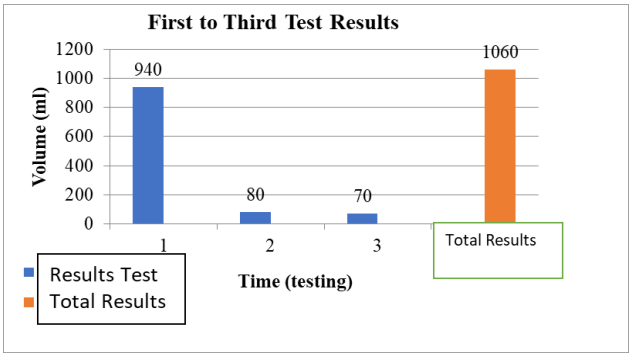
The graph above represents the achievement of time and temperature. The initial droplets that come out in the third Test takes 1 hour exactly at the reactor tank temperature of 75oC. The highest temperature in the reactor tank is at 180, 210, 225 and 270 minutes, reaching 85oC.

The graph of the third test results can be seen that the most droplets exist at the time or minutes 165-195 and minutes to 285-300 that is every 15 minutes the results obtained 10 ml.

The duration of the third Test is up to 360 minutes or equivalent to 6 hours, with the overall results obtained are 70 ml. As for the comparison table of the results of each test.

Table 4. Table of Overall Test Results

Testing	Ingredient	Results (ml)
1	Citronella Plants	940
2	Citronella Plants	80
3	Citronella Plants	70
Total		**1.060**



Graph 7. Overall Results of Distillation Equipment Testing

From the graph above shows that the first test results obtained as much as 940 ml, the second test results obtained 80 ml, and the third test results obtained as much as 70 ml. Then the Total amount of the results obtained is 1060 ml. With the density of the results obtained are:

Known: V = 940 ml = 940 [cm3] = 0.00094 [m3]

m = 920 gr = 0.92 kg

Asked: the mass of the type (ρ)=?

Solution: $\rho = \frac{m}{V}$ = ...

$$= \frac{0,92}{0,00094}$$

$= 978.2$ [kg/m^3]

With the type of each test dudapat can be seen in table 5.

Table 5. Density calculation

Sample testing	Volume [m³]	Massa [kg]	ρ [kg/m³]
1	0,00094	0,92	978,2
2	0,00008	0,07	875
3	0,00007	0,05	714,2
ρ average			**855,8**

And from the density of the first test to the third, obtained the average value of the first test to the third Test is 855.8 kg / m3.

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IV. CONCLUSION

Based on the testing that has been done, it can be concluded several things, namely:

a. From three times testing of essential oil distillation equipment type of water vapor from citronella, obtained the results of the first test is as much as 940 ml with a mass of 920 gr and a density of 978.2 kg/m3, the second test results obtained as much as 80 ml with a mass of 70 gr and a density of 875 kg/m3, the third test results obtained as much as 70 ml with a mass of 50 gr and a density of 714.2 kg/m3. The average density from the first to the third Test was 855.8 kg / m3.

b. The distillation process of water vapor type distillation equipment from lemongrass material is heated water in the reactor tank by using a stove, after the water is boiled, the steam from the water passes through the steaming lemongrass above the filter, the steam passes through the fractionation column or steam filter, so that the parts of lemongrass that follow along with the Steam will get stuck in the Steam filter. Then the steam passes through the condenser pipe as a condensation device that can convert gaseous substances into liquid substances, so that the results that come out have become liquid substances. The combustion temperature in the reactor tank is very influential on the duration of combustion and the number of results that come out and the quality of the results obtained.

c. The manufacture of distillation apparatus greatly helps the people of Wasian Village, Dimembe District, North Sulawesi Regency in the processing of essential oils made from citronella, so as to get more efficient time with more effective results.

DECALARION

Funding	Manado State Polytechnic Institution Funding, through the Center for Research and Community Service (P3M).
Conflicts of Interest/ Competing Interests	Not conflicts of interest to the best of our knowledge.
Ethics Approval	Yes, in conducting research, researchers collaborated with the Wasian Village Government to assist farmers in processing essential oils from citronella plants.
Consent to Participate	The Wasian Village Government participated in this research, with a Statement of Willingness to Collaborate.
Consent for Publication	One of the mandatory output forms of research that is carried out is by sending articles to International Journals until they are published.
Availability of Data and Material	The research carried out is supported by research funds; the need for making a Distillation Equipment for processing citronella plants to produce good citronella oil can be carried out.
Authors Contributions	The task of the team leader is to lead the team in every activity starting from the design of the essential oil distillation apparatus, collection of experimental data, data analysis, evaluation, research seminars, preparation of: - research reports, articles - international indexed journals, - simple patents. Assisting the task of the team leader in designing and building citronella oil distillation equipment and analyzing the resulting electrical output (experiment).
Code Availability	Not applicable.

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AUTHORS PROFILE

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Silvy Dollorossa Boedi, was born in Surabaya, Indonesia, on 2nd of February 1975. She obtained her Bachelor degree in Mechanical Engineering from the University of Sam Ratulangi, Manado, Indonesia and Master degree in Mechanical Engineering from the University of Brawijaya, Malang, Indonesia. She is currently a Ph.D. student under supervision of Prof. Rudy Soenoko. Her research about A Vertical Axis Hinged Blade Kinetik Turbine Performance. In 2008 she received an offer to join the Mechanical Engineering Department, The Manado State Polytechnic, Manado, Indonesiaas lecturer.

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