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Study of Prototype Making of Liquid Smoke Production Equipment From Tree Trunk Waste and Used Wood

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Abstract

Making use of natural trash is crucial. Examples of such garbage include maize cobs, worn wood, and tree trunks. As part of this community service project, used wood and tree trunk waste will be used as raw materials to create prototype tools for producing liquid smoke. The process starts with tool design and ends with tool construction. A conical tube-shaped pyriolysis device is part of the liquid smoke production apparatus, and it is linked to a connecting pipe through which it is connected. The installation of an ionometer, storage container, gas exhaust hose, and bierate fraction sedimentation tube follows. The effective capacity of the apparatus, the temperature increase rate test during the pyrolysis process, the yield test, the charcoal weight test from the combustion residue, and the temperature increase rate test during the distillation process were among the equipment performance tests that were conducted. The findings showed that: (1) this pyrolysis device's average effective capacity was 0.5 L/hour; (2) the yield was 35.34%; and (3) experiment 3 produced the maximum output of liquid smoke, at 1.9 L, while experiment 2 produced the lowest yield, at 1.65 L. (5) The computation yielded a density value of 1.01 kg/L for liquid smoke; (6) Three attempts of pyrolysis combustion with a pyrolysis tool produced 4.3 kg of residue (carbon) or charcoal. (7) From 1000 mL of liquid smoke to be distilled, 400 mL of liquid smoke was obtained after 80 minutes of distillation.
Keywords: Apparatus for Producing Liquid Smoke; Used Wood Waste; Tree Trunk Waste; Pyrolysis; Distillation.

Abstract

Pemanfaatan limbah-limbah natural sangat penting seperti limbah batang pohon, limbah kayu bekas, bonggol jagung dan lainnya. Pengabdian Masyarakat ini dengan memanfaatkan limbah batang pohon, dan limbah kayu bekas untuk digunakan sebagai bahan baku untuk pembuatan alat prototipe produksi asap cair. Metode diawali dengan desan alat tersebut dilanjutkan dengan pembuatannya. Komponen alat produksi asap cair terdiri dari reaktor pirolisis berupa tabung kerucut, dihubungkan dengan pipa penghubung yang menghubungkan kondensator dan pipa pirolisis. Selanjutnya dipasang tabung endapan fraksi berat, kondensor, wadah penampung, dan selang pembuangan gas. Dilakukan pengujian performa alat meliputi kapasitas efektif alat, uji laju kenaikan suhu pada saat proses pirolisis, uji pembakaran dengan proses pirolisis, uji rendemen, uji berat arang dari sisa pembakaran, uji laju kenaikan suhu pada saat proses destilasi. Diperoleh hasil (1) Kapasitas efektif rata-rata pada alat pirolisis ini adalah 0,5 L/jam, (2) Rendemen yang diperoleh sebesar 35,34%, (3) Hasil asap cair terbanyak diperoleh

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pada percobaan 3 yaitu sebesar 1,9 L, sedangkan hasil terendah diperoleh pada percobaan 2 yaitu sebesar 1,65 L, (5) Nilai massa jenis asap cair yang diperoleh dari perhitungan adalah sebesar 1,01 kg/L, (6) Pada sisa pembakaran pirolisis dengan menggunakan alat pirolisis menghasilkan residu (karbon) atau arang total sebanyak 4,3 kg dari 3 kali percobaan, (7) Hasil asap cair yang terdestilasi sebanyak 400mL selama 80 menit dari 1000mL asap cair yang akan didestilasikan.
Kata kunci: Alat Produksi Asap Cair; Limbah Batang Pohon; Limbah Kayu Bekas; Pirolisis; Destilasi.

INTRODUCTION

Furniture and forestry industry waste is usually not managed well. For example, wood waste from the furniture crafts sector only ends up where it is not burned, is transported by city rubbish trucks and collected at the intended rubbish dump (Albaki et al. 2021). The requirements for sustainable industry and clean and environmentally friendly production methods are not met through the method of burning and storing wood waste (lignocellulosis). Burning lignocellulosis waste produces higher CO2 emissions, thereby slowing global warming. Wood waste can be converted into bioenergy using pyrolysis technology. The temperature and duration of the pyrolysis process, air content, and the varying composition of the results from various types of wood waste all influence the bioenergy products achieved (Budiaman and Rahmat 2009).

According to (Nurhayati, Pasaribu, and Mulyadi 2006) To maximize product production and eliminate reaction residues, the temperature and duration of pyrolysis must be determined precisely. High air content changes the ideal temperature for decomposing wood waste, and the process will take longer if the material has a high air content. Small amounts of air burn more easily and more quickly than large amounts of air. The aim of this research is to determine how the shape and physical condition of wood waste affects the amount and condition of liquid smoke.

According to (Abbas and Tjiroso 2021) liquid smoke is a product of condensation or cooling of steam resulting from the combustion process, either directly or indirectly, from materials that include lignin, cellulose, hemicellulose and other carbon compounds. The main materials used to produce liquid smoke include various types of wood, corn cobs, oil palm cobs, coconut shells, candlenut shells, rice husks, bagasse, wood sawdust, and the like (Biomassa and Hasil 2022). This combustion and condensation process produces liquid smoke which can then be used in various industrial applications such as food, pharmaceuticals and chemistry (Pradhana, Trivana, and Palma 2018).

Liquid smoke results from the carbonization process or burning of lignocellulose-containing materials with limited air, known as pyrolysis. The pyrolysis process is the process of heating raw materials in the reactor which causes smoke to form and passes through the cooling medium so that it changes phase to liquid or is referred to as liquid smoke (Afrah et al. 2020). During the pyrolysis process, the material is subjected to heat which causes various reactions, including decomposition of organic materials, polymerization, and condensation of the resulting smoke. As a result, the smoke turns into a liquid form known as liquid smoke (Haryanti et al. 2014). This process is used in industry to produce liquid smoke which can have various applications, depending on its composition and properties. Liquid smoke is useful as a pesticide for spraying

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fruit and vegetables, a natural food preservative such as fresh fish, meat, wet noodles, meatballs, tofu, tempeh, as well as eliminating bad odors sometimes and the use of rubber (Lukmana, Alexander, and Iswahyudi 2022).

Considering the things above, the author decided to take the initiative to innovate a tool to create liquid smoke from waste tree trunks and unused furniture wood. The construction is quite simple so novice users do not need any special knowledge or training.

The reason for creating this tool is because in Cangkringmalang village there is a fairly serious problem of wood waste and the waste ends up in the final disposal site then burned for free and some of it is dumped in the river, this can cause flooding during the rainy season. With the socialization of the use of wood waste to the residents of Cangkringmalang Village, it is hoped that this can be overcome with this tool.

The tool known as pyrolysis devices, combine materials at high temperatures and minimal oxygen in a process called pyrolysis combustion. The results of pyrolysis combustion will be in the form of smoke which is condensed through a condenser into liquid. The liquid will be heated again to a high boiling point using a distillation apparatus so that liquid smoke comes out which can be used as a food preservative (Asfiyah 2020).

GENERAL DESCRIPTION OF THE COMMUNITY, PROBLEMS AND TARGET SOLUTIONS

General description

Liquid smoke is a product of condensation or cooling of steam resulting from the combustion process, either directly or indirectly, from materials that include lignin, cellulose, hemicellulose and other carbon compounds. The main ingredients used to produce liquid smoke include various types of wood, corn cobs, palm oil cobs, coconut shells, candlenut shells, rice husks, bagasse, wood sawdust, and the like. This combustion and condensation process produces liquid smoke which can then be used in various industrial applications such as food, pharmaceuticals and chemistry.

Liquid smoke results from the carbonization process or burning of lignocellulose-containing materials with limited air, known as pyrolysis. During the pyrolysis process, the material is subjected to heat which causes various reactions, including decomposition of organic materials, polymerization, and condensation of the resulting smoke. As a result, the smoke turns into a liquid form known as liquid smoke. This process is used in industry to produce liquid smoke which can have various applications, depending on its composition and properties. Liquid smoke is useful as a pesticide for spraying fruit and vegetables, a natural food preservative such as fresh fish, meat, wet noodles, meatballs, tofu, tempeh, as well as eliminating bad odors sometimes and the use of rubber.

Tabel 1. Target description

No	Name of target	Characteristics of target	Amount	General problem or targets
1	Non-Economic target	Local people *etc*	30	Environment Sector, Education Sector
2	Economic target	Young entrepreneurs *etc*	20	Economy Sector

Problem

Cangkringmalang Village has a problem that needs to be resolved

1. A lot of wood waste is wasted
2. Lack of public awareness of the benefits of wood waste
3. Use of chemical pesticides which are always used in the agricultural sector

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Tabel 2 Problem and solution

No	Problem	solution	Indicators of goal
1	Education: Knowladge level Environment wood waste processing	Knowledge transfer Mentoring empowerment	Increase skor knowladge /skill/ behaviour
2	Decrease of income	Digital Marketing	Increase digital marketing skill/ desain packing etc

Target solution

1. Use of pyrolysis equipment to utilize wood waste
2. Socialization of the use of wood waste
3. Utilization of liquid smoke resulting from pyrolysis equipment as an organic pesticide to replace chemical pesticides.

METHOD

Method of this activity in general, the plan for community service activities is as follows:

1. Place and time of activity
   In this activity, testing was carried out in the village of Cangkringmalang, Pasuruan, East Java.
2. Preparation of tools and materials
   The materials used in this case are water, dry tree branches, leftover furniture pieces and sawdust, steel tools, iron plates, measuring cups, burners, stainless pipes, thermometers, hoses, iron pipes, plastic bottles, ice cubes, bolts, Furthermore, the tools used in this test are writing tools, hacksaws, wrenches, grinders, hammers, welding machines and drilling machines.
3. Tool Design
   In the process of making tools, a design is needed for the workpiece concept with the aim that the tool designer can make tools easily to carry out the work carried out by the designer.

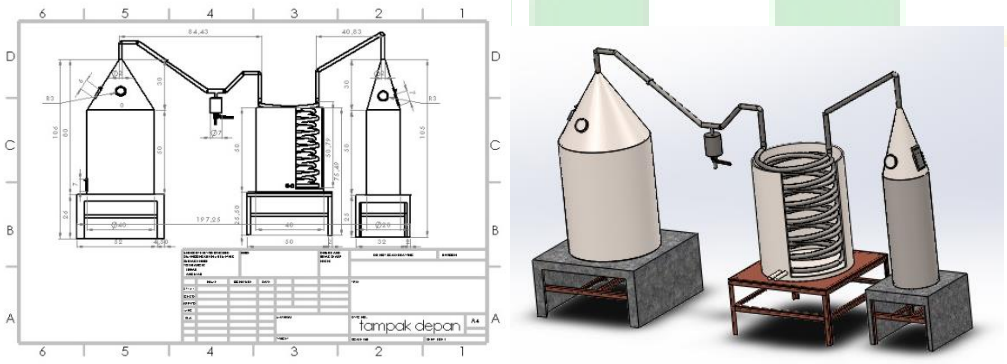

Figure 1 : 2D Design and 3D Results

4. Tool Components
   The main components of the tool are as follows
   - Pyrolysis Tube.
   - Analog Thermometer.
   - Connecting Pipe.
   - Sediment Tube.
   - Condenser which contains a spiral pipe and a smoke outlet pipe.
   - Distillation Tube.

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5. Equipment Testing Procedures
   The raw materials are put into the pyrolysis reactor in the form of dry tree twigs and 5 kg of leftover furniture wood pieces/sawdust in a ratio of 50:50. Water flows into the condenser drum using a 150 L centrifugal pump. Turn on the burner or gas stove. Combustion is carried out by pyrolysis of the materials contained in the pyrolysis reactor. Burning is carried out until the temperature reaches 400°C. Collect the liquid smoke condensation in a container or measuring cup. Liquid smoke is settled so that the mixed heavy fractions can be separated from the liquid smoke. The volume of liquid smoke produced per unit weight of material put into the material container is measured. Parameter observations were carried out
6. Analysis of Test Results
   The test results above include testing the effective capacity of the tool and calculating the yield, which is carried out to obtain the results from testing the liquid smoke production tool, which is then processed by calculating the effective capacity of the tool to determine the amount of liquid smoke produced (liters) per unit of time required during the combustion process (o'clock). And find out the comparison between the liquid smoke produced and the waste material from tree trunks and processed used furniture wood.

RESULTS AND DISCUSSION

1. Results of Prototype Making of Liquid Smoke Production Equipment
   The following are the components of a prototype liquid smoke production tool

Figure 2 : Results of making a prototype liquid smoke production tool

The following are the components and working systems in the prototype liquid smoke production tool.

1. Pyrolysis tube as a place to burn raw materials in the form of tree trunks and used wood.
2. Analog thermometer to determine the combustion temperature that occurs in pyrolysis.
3. The connecting pipe functions as a place for combustion smoke vapor to flow.
4. Sediment Tube to store heavy fractions such as tar, ash, sand carried during combustion through the connecting pipe.
5. This condenser functions to cool the smoke vapor which contains a spiral pipe and an outlet pipe for melted smoke.
6. The distillation tube functions to store liquid smoke from pyrolysis combustion and then evaporate it again to become pure tar-free liquid smoke.

2. How the Tool Works

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The working mechanism of the Prototype Liquid Smoke Production Equipment from Waste Tree Trunks and Used Wood is shown in Figure 3 below

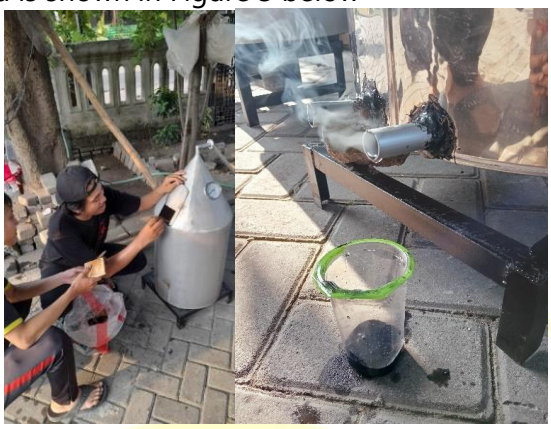

Figure 3: Tool working mechanism

First, prepare the raw materials of wood and tree branches that have been dried, then first weigh the raw materials that will be burned. After that, put the raw materials into the pyrolysis tube. Install the stove at the bottom of the pyrolysis then turn it on and start burning the raw materials. Next, fill the condenser tube with water to cool the smoke vapor in the spiral pipe. Then wait until the smoke undergoes a condensation process and comes out with the liquid droplets and observe the thermometer on the pyrolysis tube. After the thermometer shows the desired degree limit, turn off the stove, let the liquid come out of the output pipe, accommodate it in a temporary container and wait until the liquid drops stop coming out.

3. Tool Test Results

Figure 4: Pyrolysis Combustion Results

From the picture above, liquid smoke is obtained from the pyrolysis combustion of 5 kg of raw materials each and the results obtained are an average of 1.75 liters in 3 hours.

The distillation process produces 400 mL of distilled liquid smoke in 80 minutes from 1000 mL which is put into the distillation tube.

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Figure 6: Remaining Combustion Results

The remaining pyrolysis combustion using a pyrolysis tool produces a total of 4.3 kg of residue (carbon) or charcoal from 3 experiments.

4. Tool Performance Test Results

Performance testing is carried out to determine the performance of the liquid smoke production equipment that has been made. Performance testing of this liquid smoke production equipment includes testing the effective capacity of the equipment and yield.

- Effective capacity of the tool

  The effective capacity test of the liquid smoke production tool is measured by dividing the volume of liquid smoke produced from the pyrolysis tool by the time required during operation of the tool.

Table 1: Data on the rate of temperature increase during the pyrolysis process

Temperature(°C)	Temperature Rise Time (minutes)								
	30°C	50°C	100°C	150°C	200°C	250°C	300°C	350°C	400°C
5 Kg	8	12	23	33	58	93	155	173	182
5 Kg	8	13	22	35	57	93	160	175	181
5 Kg	8	12	20	32	57	90	155	168	178
Average	8	12,3	21,6	33,3	57,3	92	156,6	172	180,3

During the pyrolysis process, we can find out the rate of increase in temperature during the pyrolysis process. From the data above, we can see that the pyrolysis process takes an average of 180.3 minutes to reach a temperature of 400°C. In this pyrolysis process, liquid smoke is first produced at a temperature of 110°C with a heating time of 26 minutes.

Table 2: Data on combustion results using the pyrolysis process

Test (Kg)	5	5	5	Average
Volume (L)	1,7	1,65	1,9	1,75
Burn Rate (hours)	3	3	3	3

The process of burning raw materials using a pyrolysis device in this study took 3 hours. Liquid smoke is not immediately produced in the first minute of combustion because it takes time to produce smoke during combustion. Liquid smoke condensate will gradually come out through the condenser slowly after undergoing a condensation process. The pyrolysis process is declared complete when liquid smoke is no longer produced in the pyrolysis process. In the research that has been carried out, liquid smoke obtained using a pyrolysis device in experiment 1 was 1.7 liters, experiment 2 was 1.65 liters, and experiment 3 was 1.9 liters, so that the average volume of liquid smoke produced was 1 .75 liters with a burning time of 3 hours.

The effective capacity of a tool shows the productivity of the tool during operation per unit time. In this case, the effective capacity of the tool is measured by dividing the volume of liquid smoke produced from the pyrolysis tool by the time required during operation of the

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tool. Based on the results of research conducted in Table 2, the effective capacity of this pyrolysis tool is 0.5 L/hour from the following calculations

$$KA = \frac{Volume\ of\ liquid\ smoke(L)}{Time\ (hour)}$$

$$KA = \frac{1{,}75\ L}{3\ hours}$$

$$KA = 0{,}5\ \text{L/hours}$$

Meanwhile, the pyrolysis equipment on the market does not state the value of the effective capacity of the device, so it cannot be compared with this pyrolysis equipment.

- Yield

  Yield calculations are carried out to find out how much yield is produced by a tool in producing liquid smoke per unit amount of material processed.

Table 3: Data on the weight of liquid smoke produced

Test (Kg)	Weight of Liquid Smoke produced (Kg)
5	1,717
5	1,665
5	1,919
Average	1,767

From the data above, a yield of 35,34% was obtained, namely by dividing the average weight of liquid smoke of 1,767 kg by the weight of the material used, which was 5 kg, then multiplying by 100%.

$$Rend = \frac{Weight\ of\ Liquid\ Smoke\ produced}{Weight\ of\ material\ used} \times 100\%$$

$$Rend = \frac{1{,}767\ Kg}{5\ Kg} \times 100\%$$

$$Rend = 35{,}34\%$$

Meanwhile, the charcoal or residue (carbon) produced from the combustion in this experiment can be seen in the table below.

Table 4: Charcoal weight data from combustion residue

Test (Kg)	Weight of charcoal produced (Kg)
5	1,4
5	1,6
5	1,3
Average	1,43

The condensation results in the form of liquid smoke from waste tree trunks and used wood are collected, settled, filtered and then distilled. Testing the distillation process was carried out by adding 1000 mL of liquid smoke, boiling it to 120°C, then observing the temperature rate in the distillation tube.

Table 5. Data on the rate of temperature increase during the distillation process

Temperature	Temperature Rise Time (minutes)									
(°C)	30°C	40°C	50°C	60°C	70°C	80°C	90°C	100°C	110°C	120°C
1000mL	3	7	10	16	23	30	45	73	-	-

During the distillation process, we can find out the rate of increase in temperature during the distillation process. Based on the results of observing the temperature rate in the distillation process, it does not reach a temperature of 120°C, it only reaches a temperature of 105°C in

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80 minutes. This is where the compounds or elements The liquid smoke contained in the liquid smoke has evaporated first, the distillation process produces a total of 400 mL. The resulting yield is 40%, namely by dividing the liquid smoke produced by the liquid smoke put into the distillation tube then multiplying by 100%.

$$Rend = \frac{400\ mL}{1000\ mL} \times 100\%$$

$$Rend = 40\%$$

So, the amount of liquid smoke that is not distilled is 100% - 40% = 60%.

5. Impact on Society
   With this tool is very useful for people who want to process it so that wood waste that was originally thrown away or unused can be processed into liquid smoke which is useful as an organic pesticide for farmers to reduce the use of chemical pesticides, and the remaining combustion in the pyrolysis process can be used as briquettes or charcoal. This requires a process and public awareness of sustainable wood waste.

CONCLUSIONS AND SUGGESTIONS

Conclusion

After conducting research on the study of making prototypes of liquid smoke production equipment from waste tree trunks and used wood, the following conclusions were obtained:

- The average effective capacity of this pyrolysis device is 0.5 L/hour.
- The yield obtained in this research was 35.34%.
- The highest liquid smoke yield was obtained in experiment 3, namely 1.9 L, while the lowest result was obtained in experiment 2, namely 1.65 L.
- The density value of liquid smoke obtained from calculations is 1.01 Kg/L.
- The remaining pyrolysis combustion using a pyrolysis tool produces a total of 4.3 Kg of residue (carbon) or charcoal from 3 experiments.
- The resulting distilled liquid smoke is 400 mL for 80 minutes from 1000 mL of liquid smoke to be distilled.

Suggestions

After conducting research on the study of making prototypes of liquid smoke production equipment from waste tree trunks and used wood, at the end of this report the author would like to provide suggestions as follows:

- It is necessary to carry out further development of the Study on Prototype Making of Liquid Smoke Production Equipment from Tree Trunk Waste and Used Wood which has been made in this research. Where the combustion process from pyrolysis can be further innovated, so that in the process of 1 test or combustion 2 types of tar-free or pure liquid smoke can simultaneously be released.
- For further research, the length and diameter of the connecting pipe needs to be carried out further research because it is suspected that there is an influence of the length and diameter of the connecting pipe on the amount of liquid smoke produced.
- Use materials according to standards to maintain the quality and performance of the equipment in good and long-lasting condition.

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