

Design And Construction Of A Simple Incinerator For Household Waste Combustion

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ABSTRACT

This study aimed to design and construct a simple incinerator that produces minimal smoke, is easy to operate, and performs effectively for household waste combustion. The research used a research and development (R&D) method with the ADDIE development model, consisting of Analysis, Design, Development, Implementation, and Evaluation. At the design stage, five main components were produced: a combustion furnace with dimensions of 360 mm × 590 mm, a frame of 360 mm × 360 mm × 500 mm, a boiler, a fuel container, and a furnace cover. The development stage included fabrication, assembly, and finishing, while the implementation stage involved performance testing using cardboard waste and dry teak leaves, each tested twice with a mass of 2 kg and used oil as fuel. The results showed that the incinerator burned cardboard waste at a combustion rate of 9.545 kg/hour and dry teak leaves at 10.67 kg/hour. The combustion process reached a reported summary temperature of 1075°C. The waste reduction effectiveness was 89.5% for cardboard waste and 91.5% for teak leaves, with an average effectiveness of 90.5%. These results indicate that the device can be used as a controlled small-scale combustion system for household waste management.

1 Introduction

Waste management in Indonesia has become increasingly complex due to rapid population growth and urbanization. This situation has placed Indonesia in a concerning position as one of the world's largest contributors of plastic waste, even being ranked second after China. Several sources have described this condition as a plastic-waste emergency (Putu, 2020). Based on data from the National Waste Management Information System (SIPSN), the total annual waste generation in Indonesia in 2023 reached 38,437,064.87 tons, of which 23,683,867.45 tons (61.62%) were managed and 14,753,145.45 tons (38.38%) remained unmanaged.

Sleman Regency is one of the regencies in the Special Region of Yogyakarta that produces a relatively high amount of waste. Based on SIPSN data in 2023, Sleman generated approximately 601.79 tons of waste per day, with household waste consisting mainly of food residues and plastic waste. The Sleman Regency Government has attempted to address this

problem through the construction of an integrated waste processing facility (TPST) in Tamanmartani Village, Kalasan District, with a capacity of 80–90 tons per day. In 2023, waste management in Sleman reached only 43%, indicating that a considerable amount of waste was still accumulating and had not been properly managed. Uncontrolled accumulation of waste may cause environmental problems such as unpleasant odors and river pollution. In addition, waste can also become a source of health problems because it may provide a habitat for viruses and bacteria.

Open burning of waste in yards, gardens, or similar areas often results in uncontrolled combustion, which can negatively affect the surrounding environment through air pollution, unpleasant odors, and health disturbances. A more controlled approach to waste treatment is the use of a specialized combustion device or system known as an incinerator. The use of an incinerator can reduce the harmful effects of open burning, including excessive smoke, strong odors, and uncontrolled heat radiation, while also allowing the thermal energy produced during combustion to be utilized for other purposes. Therefore, incineration can provide added value in sustainable waste management [1].

A simple incinerator can be one alternative solution for waste management through combustion. This device is advantageous because it can minimize smoke from waste burning and process a relatively large volume of waste in a shorter time than burning without assistive equipment [2], [3]. Smoke can be minimized because the combustion process occurs at high temperature, reaching around 800°C. Such a high temperature supports more complete combustion, accelerates the burning process, and reduces visible smoke, so that waste can be processed more rapidly, particularly for inorganic waste management.

A simple incinerator uses the incineration process to reduce solid waste into residual ash. In general, this process can reduce solid waste by approximately 70% to 90% [4]. The incinerator developed in this study uses used oil as fuel. During combustion, flame intensity is assisted by high-pressure steam generated from boiling water, allowing the flame to produce higher pressure and temperature for more complete waste combustion. The steam is also expected to help control emissions by washing several toxic substances contained in combustion smoke.

2 Method

This study applied a research and development (R&D) method, which is an approach used to design, develop, and test the effectiveness of a product before wider use. The method is applied and systematic. In its implementation, this study adopted the ADDIE development model. The model consists of five main stages: Analysis, Design, Development, Implementation, and Evaluation [5].

The first stage of the ADDIE model was analysis, which involved preliminary research on incinerator devices. The second stage was design, in which the product design was prepared and developed. The third stage was development, which was carried out based on the design results. The fourth stage was implementation, which involved performance testing of the incinerator. The fifth stage was evaluation, which served as the final stage to assess the effectiveness of the incinerator in burning waste.

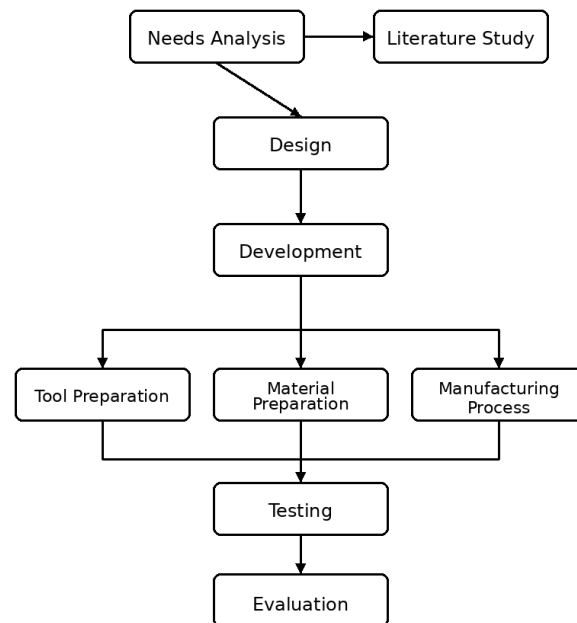


Figure 1. Research flowchart

The study was conducted at the Fabrication Workshop, Faculty of Vocational Studies, Universitas Negeri Yogyakarta. The period required for manufacturing and testing the incinerator was three months. The research activities included sketch preparation, incinerator fabrication, and device testing. The research subjects were cardboard waste and dry teak leaf waste. Four trials were conducted, with each waste type tested twice using a waste mass of 2 kg per trial. Used oil was employed as the fuel. Data collection was carried out through observation to obtain actual data, supported by documentation and literature study. Data were obtained by recording the test results for two types of waste. The recorded data were then calculated to determine the performance capacity of the device, the maximum combustion temperature, the combustion rate, and the effectiveness of waste reduction.

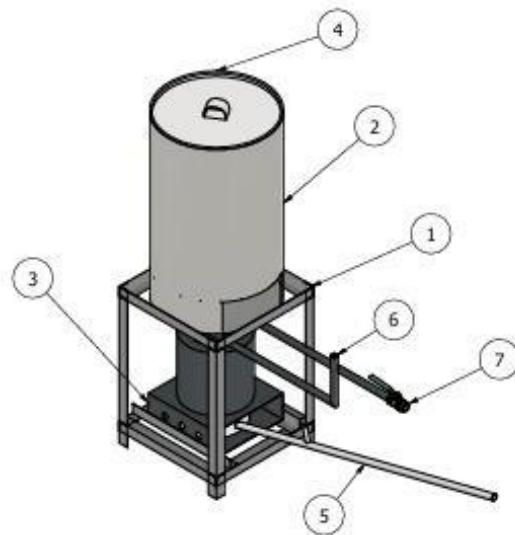
3 Result and discussion

This study, entitled “Design and Construction of a Simple Incinerator for Household Waste,” aimed to produce a waste combustion machine that is effective in reducing waste and environmentally more controlled than open burning. The device was designed as a simple machine using used oil as fuel and high-pressure steam as combustion assistance, following the concept of used-oil-fueled incinerator systems reported in previous studies [6], [7]. The machine uses a batch system, in which waste is inserted up to the device capacity and then burned together.

The first step in this research was needs analysis. This stage was conducted through literature study to obtain information related to incinerator mechanisms, performance evaluation, and previous incinerator designs that could be developed further. The design process was carried out after obtaining relevant information from the literature study. This stage began with listing the machine parts required for the incinerator, followed by manual sketching and digital modeling. Several aspects were considered during design, including function, machine components, material selection, and the manufacturing process. These design considerations are consistent with general product design and development principles [8]. Autodesk Inventor 2024 was used to produce the design.



Figure 2. Incinerator device



No.	Component	Specification
1	Frame	360 × 360 × 500 mm
2	Combustion furnace	360 × 590 mm
3	Boiler	3 L water capacity
4	Furnace cover	—
5	Fuel container	600 mL fuel capacity
6	Plug	—
7	Valve	—

Figure 3. Incinerator components

The manufacturing process was conducted at the Fabrication Workshop, Faculty of Vocational Studies, Universitas Negeri Yogyakarta. This stage consisted of fabrication, assembly, and finishing. The frame fabrication process began by measuring the material using a measuring tape and vernier caliper. The material was then cut using a grinder according to the designed dimensions and joined by SMAW welding to form the frame. The fabrication process produced several components, including the frame, boiler, oil container, and combustion furnace.



Figure 4. Fabrication process

The assembly process was carried out after all components were completed in the fabrication stage. This process involved joining the components by welding to form a complete machine. It included installing the valve and plug on the boiler and placing the furnace and boiler on the frame. The finishing process involved cleaning the machine from welding residue and painting it with black heat-resistant Diton Coating pylox paint.

The implementation stage was carried out to determine whether the incinerator performed effectively in burning waste. Testing was conducted four times using two waste types, namely cardboard and dry teak leaves. Each waste type was tested twice with a waste mass of 2 kg. The data were collected to obtain factual information regarding the capacity and effectiveness of the device. The testing instruments included a thermocouple for temperature measurement, a scale for measuring the mass of waste and combustion residue, and a stopwatch for measuring combustion time.

Table 3. Test results for cardboard waste

No.	Mass	Combustion time	Highest temperature	Ash mass	Char mass
1.	2 kg	0.20 h	1102°C	0.19 kg	0 kg
2.	2 kg	0.22 h	1075°C	0.21 kg	0 kg

Table 4. Test results for teak leaf waste

No.	Mass	Combustion time	Highest temperature	Ash mass	Char mass
1.	2 kg	0.185 h	1060°C	0.16 kg	0 kg
2.	2 kg	0.190 h	1050°C	0.17 kg	0 kg

Table 5. Calculation results

No.	Parameter	Cardboard waste	Teak leaf waste
1.	Combustion rate	9.545 kg/hour	10.67 kg/hour
2.	Highest temperature	1075°C	1060°C
3.	Device effectiveness	89.5%	91.5%

Based on the test results, the incinerator was able to burn cardboard waste at a combustion rate of 9.545 kg/hour and dry teak leaf waste at 10.67 kg/hour. The combustion process reached a reported summary temperature of 1075°C. The effectiveness of the device in reducing waste was 89.5% for cardboard waste and 91.5% for teak leaves.

The effectiveness of the device was influenced by the type and moisture content of the waste. Drier waste burned more quickly, reached a higher temperature, produced less smoke, and left less residue. In contrast, waste with higher moisture content required a longer combustion time because the water contained in the waste needed to evaporate first. This condition also reduced the temperature achieved during combustion and caused less complete combustion, resulting in more ash and residue, as also indicated in prior studies on simple incinerator performance [1], [3].

4 Conclusion

The waste combustion device was designed with five main components: fuel container, boiler, frame, combustion furnace, and furnace cover. During development, the device was manufactured using SMAW welding, vernier caliper, measuring tape, stopwatch, and thermocouple. The main materials included 3 cm × 3 cm angle iron for the frame, a used drum for the combustion furnace, 1/2, 3/4, and 2 inch pipes for the piping system, and steel plate as the basic material for the boiler and fuel container. The development process consisted of fabrication, which included measuring, cutting, and welding materials; assembly, which joined the components into a complete incinerator; and finishing, which involved painting the device using heat-resistant Diton Coating pylox paint.

The device had a furnace capacity of 2 kg for dry waste and 3.5 kg for wet waste, an average combustion rate of 10.1075 kg/hour, a water tube capacity of 3 liters, a fuel capacity of 600 mL, and an average effectiveness of 90.5%. The test results showed that the incinerator burned cardboard waste at a combustion rate of 9.545 kg/hour with an effectiveness of 89.5%, while dry teak leaf waste reached a combustion rate of 10.67 kg/hour with an effectiveness of 91.5%. Based on testing, the incinerator reached a reported highest temperature of 1075°C.

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Conflicts of Interest

The authors declare no conflict of interest.

References

- [1] B. Martana, S. Sulasminingsih, and M. A. Lukmana, "Perencanaan dan uji performa alat pembakar sampah organik," *Bina Teknika*, vol. 13, no. 1, pp. 65–71, 2017, doi: 10.54378/bt.v13i1.22.
- [2] A. Farid and H. Wibowo, "Analisis kinerja alat pembakar sampah portable dengan pengaturan kecepatan blower," in *Prosiding Seminar Nasional NCIET*, 2021, pp. 217–223.
- [3] F. Rhozman and M. M. Ilham, "Analisa dan evaluasi rancang bangun insinerator sederhana dalam mengelola sampah rumah tangga," *Jurnal Mesin Nusantara*, vol. 2, no. 1, pp. 52–60, 2019, doi: 10.29407/jmn.v2i1.13442.
- [4] A. Budiman, "Modifikasi desain dan uji unjuk kerja alat pembakar sampah (incinerator) tipe batch," 2001.
- [5] R. M. Branch, *Instructional design: The ADDIE approach*. New York, NY: Springer, 2009. doi: 10.1007/978-0-387-09506-6.
- [6] A. Lesmana, J. Junaidi, and E. Kurniawan, "Rancang bangun alat pembakar sampah (incinerator) dengan burner oli bekas," *JTRAIN: Jurnal Teknologi Rekayasa Teknik Mesin*, vol. 2, no. 1, pp. 35–40, 2021, [Online]. Available: <https://jurnal.untan.ac.id/index.php/jtm/article/view/44893>
- [7] Z. Rizki, "Perancangan sistem pembakaran/incinerator untuk sampah organik menggunakan bahan bakar oli bekas," 2021. [Online]. Available: <https://repository.uir.ac.id/18792/>
- [8] K. T. Ulrich and S. D. Eppinger, *Product design and development*, 2nd ed. Boston: McGraw-Hill, 2000.