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Artikel Penelitian

Experimental & Numerical study on COVID-19 Waste Treatment Using a Gasification Type Incinerator: Laboratory Scale

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A B S T R A C T

Due to the COVID-19 pandemic, the use of personal protective equipment in the community has contributed to the increasing amount of medical waste. Medical waste from the COVID-19 pandemic is classified as infectious medical waste which is waste related to patients who need isolation from infectious diseases. one of the solutions offered is a medical waste incinerator. By studying the medical waste incinerator model in the hospital, the researchers finally took the initiative to do a simple incinerator design. the incinerator to be used is updraft gasifier type. It is hoped that the use of this incinerator will be able to solve the existing medical waste problem. In this study, the researchers used an experimental approach to get the basic data from the reactor. After gaining the data, then the researcher uses a numerical approach which is using Ansys software to get a better look at the temperature contour on the rector. From both studies, the researcher can conclude that it would take an upgrade on the existing blower to incinerate the medical waste at a safe temperature.

1. INTRODUCTION

The world was shocked by the outbreak of a new virus called Coronavirus Disease 2019 (COVID-19) in 2020 [1]. This virus was discovered for the first time from the diagnosis of a patient with unusual pneumonia at the end of December 2019 in the city of Wuhan, China [2]. The transmission of this virus is so fast that it infects the respiratory tract. There were 11,327,790 cases and 532,340 cases of positive patients and death cases globally due to this virus [3]. Whereas in Indonesia there were 63,749 positive patient cases and 3,171 cases of death patients [3]. Along with the increasing number of cases undergoing health care in hospitals, and patient examination activities also increase, automatically followed by an increase in the amount of medical waste [4]. In the first country to experience the COVID-19 outbreak (China), there was an increase in medical waste from 4,902.8 tons per day to 6,066 tons per day [4] or an increase of 24%. By using the calculation of Director-General of Waste, Waste and B3 Management (PSLB3), Ministry of Environment and Forestry (KLHK), using the calculation of the number of infected patients and medical waste in China, each patient contributes 14.3 kg of waste per day during the outbreak [4]. In Indonesia, based on data until May 2020, the amount of medical waste from the COVID-19 pandemic has increased by 30 percent [5,6]. Data in Riau according to the Head of the Environment and Forestry Service (DLHK) of Riau Province, the amount of medical waste from the COVID-19 pandemic for March was 3 tons, April was 8 tons and May was 18 tons [7].

Medical waste from the COVID-19 pandemic is classified as infectious medical waste which is waste related to patients who need the isolation of infectious diseases [8,9]. Medical waste is waste of Hazardous and Toxic Materials (B3) which must be managed in normal times, especially during pandemic emergencies Coronavirus Disease (COVID-19) [10]

According to Ismawati, there are several ways to manage waste from Indonesian health services such as Puskesmas and Hospitals, 2020, one of which is by burning or incineration [10,11]. This method is also recommended by the Ministry of Environment and Forestry to burn medical waste with temperatures above 800 degrees Celsius to ensure the virus does not pollute the environment [11].

The available technology for burning medical waste is expensive, requires a spacious area, and is energy-consuming. Hence, only major health facilities own the facility for burning the medical waste. Alternatively, the health facilities entrusting the management of their hazardous waste to another company (third party). In this study, we propose a gasification type incinerator that is cheaper, easy to operate, and less energy-consuming for processing solid medical waste especially from Covid-19 treatment in health service facilities. Therefore, in this study, a gasification type incinerator will be designed for processing solid waste COVID-19 from health service facilities such as health centers, clinics, and hospitals.

2. LITERATURE REVIEW

Treatment of medical waste using incineration still creates new problems, namely the formation of ash, crust from combustion, and emissions from furnaces. The development of waste combustion continues by applying various types of furnaces [12]. Based on previous research conducted by Ridwan and Budi, 2018 to produce alternative fuels by measuring the gas that comes out of the combustion reactor at low-temperature conditions (<500 ^{o}C) [13]. From this research, COVID-19 solid waste treatment was developed by combining incinerators with gasification, with the hope that the waste can be overcome with minimal pollutants. The research results obtained will later be of assistance to health services, especially for Muhammadiyah charities. This research is also a research roadmap for proposers based on burning stoves.

2.1. Gasification Incinerator

Gasification technology is a form of increasing utilization of the energy contained in biomass through a conversion from solid to gas using the thermal degradation process of organic materials at high temperatures in incomplete combustion. This process takes place in a device called a gasifier. Fuel is put into this tool to be burned in the reactor (combustion chamber) imperfectly. In other words, the gasification process is a partial combustion process of solid raw materials, involving the reaction between oxygen and solid fuel. Water vapor and carbon dioxide from combustion are reduced to flammable gases, namely carbon monoxide (CO), hydrogen (H_2), and methane (CH_4). These gases can be used as a substitute for fuel for various purposes such as to drive propulsion engines (diesel and gasoline), which can then be used for power generation, moving pumps, rolling machines, and other mechanical devices. Besides, this gas can also be burned directly for drying machines, ovens, and so on which usually require clean combustion.

Gasification is a process of converting solid fuel into a combustible gas (CO, H_2, CH_4) through a combustion process with a limited air supply (20% -40% stoichiometric air). The gasification process is a chemical process to convert carbonaceous materials into combustible gases. Based on this definition, the materials used for the gasification process use materials that contain hydrocarbons such as coal and biomass. The entire gasification process occurs in a gasification reactor which is known as a gasifier. In this gasifier, there is a heating process to a certain reaction temperature and then the fuel goes through the combustion process by reacting to oxygen to produce combustible gas and other combustion products.

2.2. Updraft type gasification

Updraft type gasification is a gasification reactor that is commonly used widely. The characteristic of this gasification reactor is that the airflow from the blower enters through the bottom of the reactor through the grate while the flow of fuel enters from the top of the reactor so that the direction of air and fuel flow has the opposite principle (counter-current).

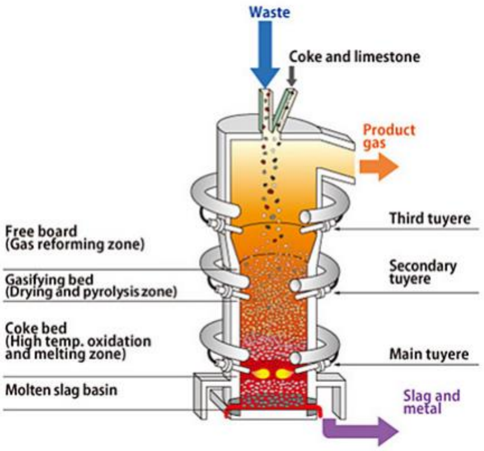


Figure 1. Updraft-type Gasification Reactor

This gasification waste furnace has a system character in the form of updraft fixed bed reactor with continuous slag extractor, has an efficiency of 30%, metals and solid residues can be reprocessed, reactor temperature reaches 1,500 - 1,600 ° C, and types of waste that can be processed are various types solid waste.

Gas production is released through the top of the reactor while the combustion ash falls to the bottom of the gasifier due to the influence of gravity and ash density. In the reactor, there is the zoning of the combustion area based on the temperature distribution of the gasification reactor. The burning zone occurs near the grate followed by a reduction zone which will produce gas with high temperatures.

The gas resulting from the reaction will move towards the top of the reactor which has a lower temperature and the gas will be in contact with the fuel that moves down so that the pyrolysis process and heat exchange between the high-temperature gas and the lower temperature fuel will occur. The sensible heat given by the gas is used as fuel for preheating and drying the fuel. The two processes, namely the pyrolysis process and the drying process occur at the top of the gasification reactor.

The advantage of an updraft-type gasification reactor is that the working mechanism possessed by this type of reactor is much simpler than other types, whereas, with this simpler working mechanism, it turns out that the reactor's tolerance level to the roughness of the fuel is better. Besides, this type of reactor can process low-quality fuel with a relatively low gas output temperature and has high efficiency because the hot gas that comes out of the reactor has a relatively low temperature. While the weakness of this updraft type gasification reactor is the level of tar content in the syngas reaction results is relatively high so that it affects the quality of the gas produced and the relatively low load capacity of the reactor.

3. METHOD

3.1 Flowchart

The research was conducted at the Energy Conversion Laboratory of Muhammadiyah University of Riau, in September 2020. The flowchart is shown in Figure 2.

3.2 Experimental Set up

In this study, the Gasification Type Incinerator used is shown in figure 4. In temperature measurement is using 4 units of type K thermocouple that connect to a Thermocouple BTM-4208SD with 12 channels. Also, the gas that been produce was analyzed by a gas analyzer. This setup is shown in Figure 3.

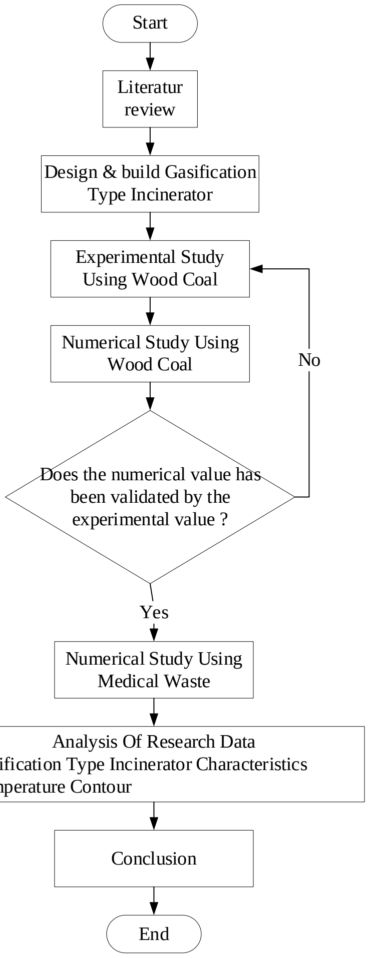


Figure 2. Flowchart

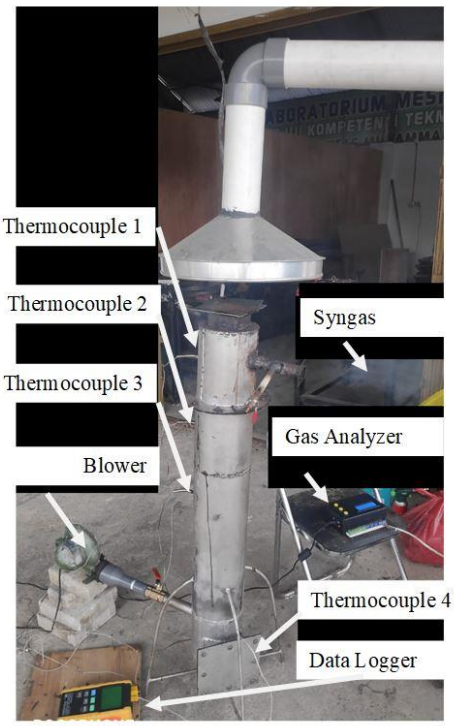


Figure 3. Updraft-type Gasification Reactor set up

3.3 Simulation Set up

In this study, ANSYS workbench software was used in the computational fluid dynamic analysis on Gasification Type Incinerator. A 3D model Gasification Type Incinerator was made using Solidwork & export to ANSYS workbench as shown in Figure 3. Tetrahedral and triangular elements were used to mesh the Gasification Type Incinerator design. The design was modeled with 6728 nodes.

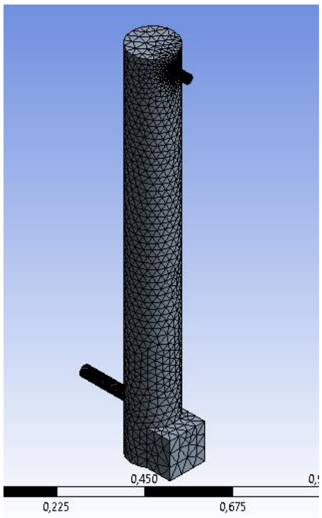


Figure 4. Updraft-type Gasification Reactor simulation mesh

The boundary condition of this simulation showed in Figure 5 below

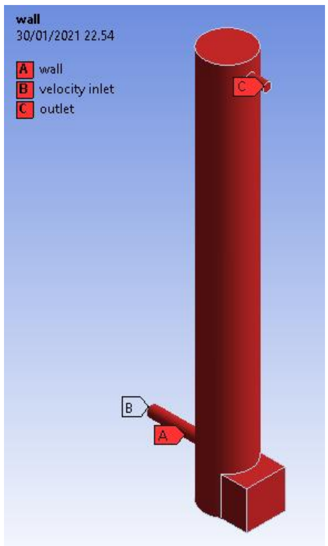


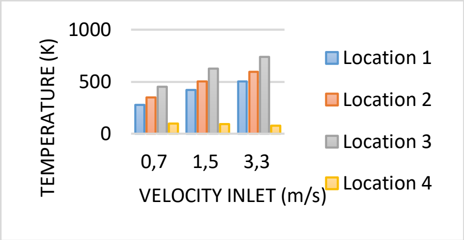
Figure 5.Boundary condition

A wall with the heat transfer coefficient 0 W/m2K is applied to aluminum (i.e. at position “A” marked on Figure 5). A velocity based on blower velocity is applied to the velocity inlet (i.e. at position “B” marked on Figure 5). Atmosphere pressure is applied to the pressure outlet (i.e. at position “C” marked on Figure 5).

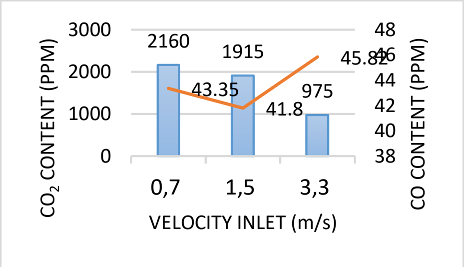
4. RESULT & DISCUSSION

4.1 Experimental Study

From the experimental that has been conducted, the author get the result as shown in table 1



(a)



(b)

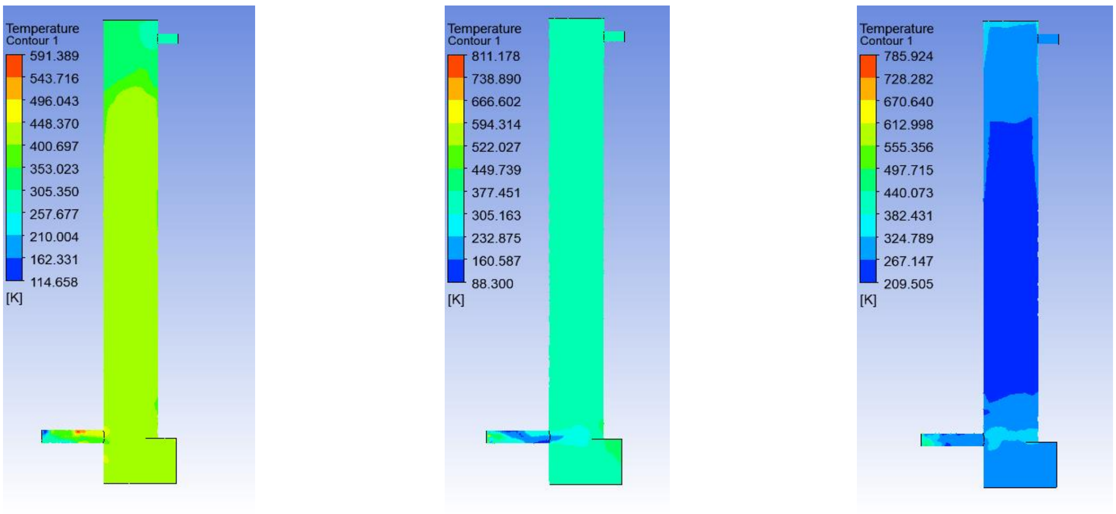
Figure 6. Experimental result based on Velocity inlet; (a). The temperature in each location, (b). CO2 & CO composition,

From this data, we can see that from various locations that the more you add the velocity on the inlet of the reactor the more temperature will be produced.

This happens in locations 1,2,& 3. On location 4 there was the inconsistency of temperature, it can be happened because at the late of the experiment, the ash that covers at the bottom of the reactor change the value of temperature. From the data, to get to incinerate the medical waste at a safe temperature, it would be best to suggest increasing the velocity of air.

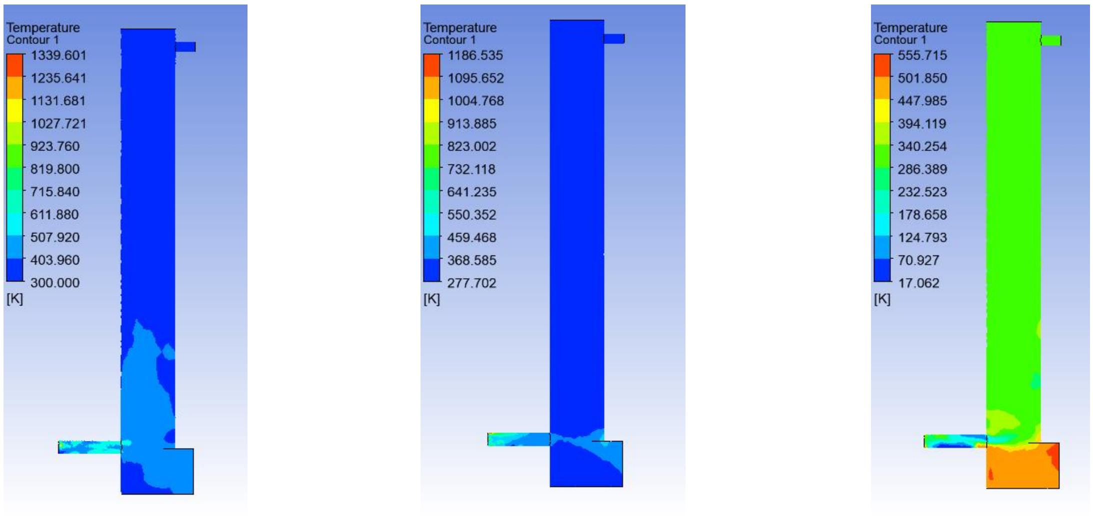
4.2 Numerical Study

From the simulation that been conducted using wood coal, the author get the result as shown in Figure 6. The highest temperature was recorded in the inlet area. The average temperature at 3.3 m/s intake velocity was 393 K, as shown in Figure 7. The average temperature for the other condition was lower, 340 K for intake velocity 1.5 m/s and 274 K for inlet velocity 0.7 m/s. According to the statistics, the number is still below the acceptable temperature for incineration of medical waste. From the simulation that has been conducted on infectious medical waste, the author gets the result as shown in Figure 7.



(a) (b) (c)

Figure 7. Temperature contour using wood coal; (a). Velocity Inlet =3.3 m/s, (b). Velocity Inlet =1.5 m/s, (c). Velocity Inlet =0.7 m/s.



(a) (b) (c)

Figure 8. Temperature contour using infecsius medical waste; (a). Velocity Inlet =3.3 m/s, (b). Velocity Inlet =1.5 m/s, (c). Velocity Inlet =0.7 m/s.

The maximum temperature happened in the inlet area. the average temperature on condition inlet velocity 3.3 m/s was 402 K shown in Figure 8. For the other condition, the average temperature was lower, that is for inlet velocity 1.5 m/s was 327 K & inlet velocity 0.7 m/s was 322 K. From the data, we can get that the value is still below the incinerate the medical waste on a safe temperature

5. CONCLUSION

1. Based on the experimental results, the highest temperature that has been recorded was on location 3 using velocity inlet 3.3 m/s which is 741 K.
2. Based on the experimental results, the highest average temperature that been record was on using velocity inlet 3.3 m/s which is 393 K on wood coal & 402 K on infectious medical waste.
3. From both studies, the researcher can conclude that it would take an upgrade on the existing blower to incinerate the medical waste at a safe temperature of 800 ^{o}C.

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