Design and Build of a High-Temperature Incinerator for the Disposal of Infectious Waste in Communities

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Received: August 4, 2024; Revised: August 12, 2024;
Accepted: August 20, 2024; Published Online: September 3, 2024

Abstract

This paper presents the design and construction of a high-temperature incinerator for the disposal of infectious waste in communities. The designed and constructed incinerator features the following specifications: 1) The exterior is made of stainless steel. 2) The interior contains an octagonal ceramic fiber with a diameter of 30 cm. and a height of 55 cm. 3) The chamber for placing infectious waste has a diameter of 15 cm., and a height of 50 cm. 4) The air incineration chamber has a diameter of 3.5 cm. and a height of 55 cm. Performance testing results indicate that Stage 1 achieves an incineration temperature of 900°C for the disposal of infectious waste, with an average processing time of 94.06 minutes. In Stage 2, the incinerator achieves a temperature of 1000°C for the destruction of exhaust gases produced from the waste incineration in Stage 1, with an average processing time of 90 minutes. These results comply with the Announcement of the Ministry of Public Health of Thailand. The design and construction of high-temperature incinerators for the disposal of infectious waste in the community offer several significant benefits. These include the reduction of disease transmission. The disposal of infectious waste through high-temperature incineration destroys pathogens that could be harmful to public health, helping to prevent the spread of disease within the community. Additionally, it reduces the volume of waste in the community, as high-temperature incinerators effectively convert infectious waste into ash, which has a significantly lower volume, making the remaining waste easier to manage. High-temperature incineration also reduces the release of toxins such as dioxins and furans, compared to other methods of disposing of infectious waste, such as landfilling, which may result in the release of hazardous chemicals into the environment. Therefore, the use of high-temperature incinerators is an efficient and sustainable method for managing infectious waste in the community safely.

Keywords: High-Temperature Control, Incinerator, Infectious Waste

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Introduction

Due to the ongoing COVID-19 pandemic in Thailand, which has caused significant loss of life as well as economic and social impacts, the Ministry of Public Health has issued regulations defining types of waste or sources of infectious waste related to COVID-19 (Ministry of Public Health Announcement,2022), (Pansets, K.,2021). This has resulted in an increase in infectious waste from patients or those under quarantine in community isolation centers and designated quarantine facilities (Saftec Company,2024),(CCEWOOL Insulation Fiber Company,2024),(Choo, S. ,2022). If this infectious waste is not managed according to the Ministry's regulations on waste disposal, it could lead to improper waste management and become a source of disease spread, making control efforts more challenging (Intamas, P., Ruayruay, W., Wongklang, V., Phrommuang, K., & Boonraksa, P.,2022).

To address this, additional types of infectious waste sources should be specified to ensure safe management of infectious waste and prevent the spread of disease, thereby safeguarding public health and the environment (Announcement of the Food and Drug Administration, 2022), (Phumpreuk, S., 2018), (Olanrewaju, O. O., & Fasinmirin, R. J., 2019), (Wajs, J., Bochniak, R., & Golabek, A., 2019). Infectious waste sources include community isolation centers such as temples, schools, gyms, factories, auditoriums, or construction camps, which are set up for rapid diagnosis, reducing disease spread, and treating infectious diseases outside of government healthcare facilities.

The National Communicable Diseases Committee, as per the Communicable Diseases Act, classifies infectious waste as including materials contaminated with blood or bodily fluids, such as self-test kits for SARS-CoV-2 (COVID-19), masks, sanitary pads, tissues, cotton, single-use food containers, and used personal protective equipment. Sharp materials contaminated with blood or bodily fluids, such as syringes and blades, are also included (Royal Gazette, 2022), (Phawphang, S., 2020).

In response to these issues and needs, the research team has proposed a solution for managing infectious waste at Ban Khao Yai Kata School in Chai Narai District, Lopburi Province, which is under the jurisdiction of Phranakhon Rajabhat University. The solution involves designing and constructing a high-temperature incinerator with a two-step process for waste disposal. The first step achieves a temperature of no less than 760°C for incinerating infectious waste, while the second step destroys exhaust gases from the first step at a temperature of no less than 1000°C, with a temperature display powered by 220 volts.

Objectives

To design and construct a high-temperature incinerator for the disposal of infectious waste for communities under the announcement of the Ministry of Public Health of Thailand.

Conceptual Framework

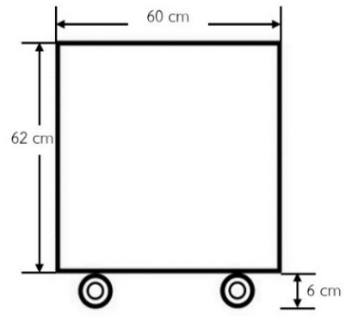
Research on the design and construction of high-temperature incinerators for infectious waste disposal for communities. The researcher focuses on infectious waste disposal. There are 2 steps in infectious waste disposal. Step 1 can provide a temperature of no less than 760 degrees Celsius for infectious waste disposal. Step 2 can provide a temperature of no less than 1000 degrees Celsius for incinerating the polluted air obtained from infectious waste disposal in Step 1. It has a temperature display and can be built to use 220 volts of electricity.

Research Methodology

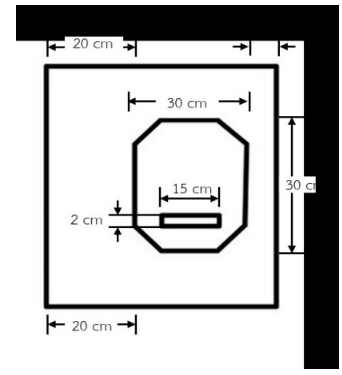
Design and construction of a high-temperature incinerator for the disposal of infectious waste for communities. The research methodology details are as follows:

A. Design of a high-temperature incinerator for the disposal of infectious waste for communities

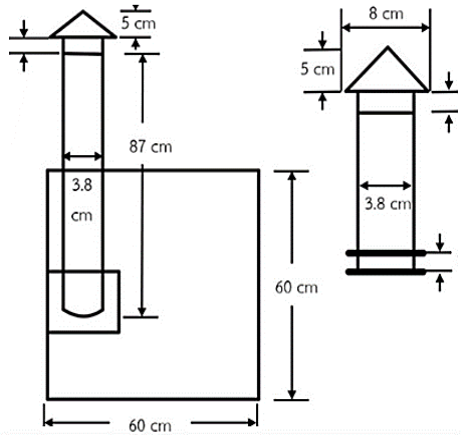
The design of the infectious waste incinerator structure is a square shape with dimensions of 60 centimeters wide, 60 centimeters long, and 62 centimeters high. There are wheels attached to the frame with a height from the floor to the frame of 6 centimeters. There is a lid for inserting infectious waste for inciner-



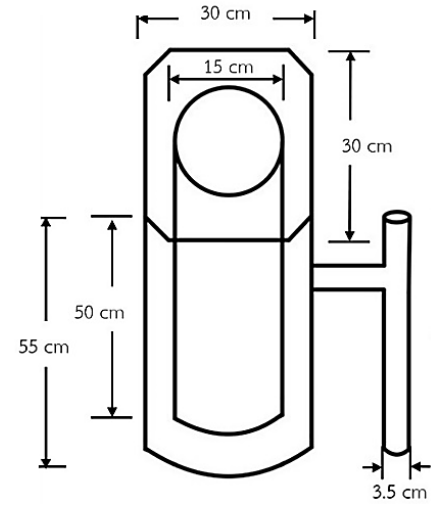
a. Structure of infectious waste disposal



b. Top opening and closing door design



c. Design of smoke exhaust chimney at the top



d. Inside the infectious waste incinerator

Figure 1 High-temperature incinerator structure for infectious waste disposal

ation on the top that is a square shape and has four corners cut with dimensions of 30 centimeters wide and 30 centimeters long. There is a handle for opening the door with dimensions of 2 centimeters wide and 15 centimeters long, as shown in Figure 1.

B. Construction of high-temperature incinerator for the disposal of infectious waste for communities

Build an infectious waste incinerator with an external frame made of stainless steel with a width of 60 centimeters, a length of 60 centimeters, and a height of 62 centimeters. There are wheels attached to the bottom of the external frame for moving with a height of 6 centimeters from the floor. The front consists of an infectious waste incinerator controller on top and a 7-segment display (Primus Company,2024),(Supreme Lines Company,2024). The upper number is the temperature inside the infectious waste incinerator, while the lower number is the desired value for burning infectious waste. The air purification incinerator controller is on the bottom and has a 7-segment display. The upper number is the temperature inside the infectious waste incinerator, while the lower number is the desired value for burning infectious waste, as shown in Figure 2.

The control circuit of the exhaust air combustion furnace consists of an input signal section from a K-type thermocouple, a sensor used to measure the temperature values occurring inside the exhaust air combustion furnace, sending the measured temperature value to the processing section for processing by the controller and then taking the measured temperature value to display on a 7-segment display and controlling the operation of the temperature control system automatically (Mouser Electronics Company,2024), as shown in Figure 3 and Figure 4 shows Circuit diagram of exhaust air combustion control.

Figure 2 Infectious waste incinerator that has been built

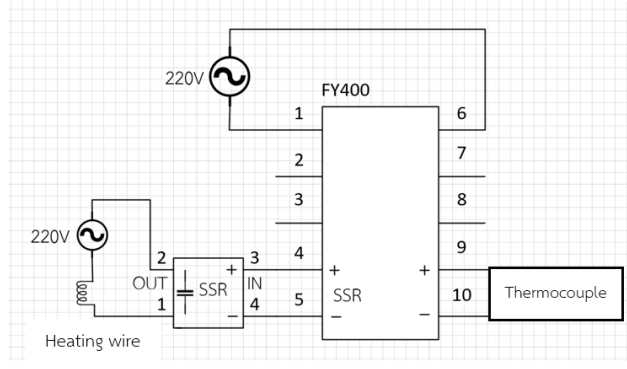


Figure 3 Circuit diagram of Infectious waste incinerator control

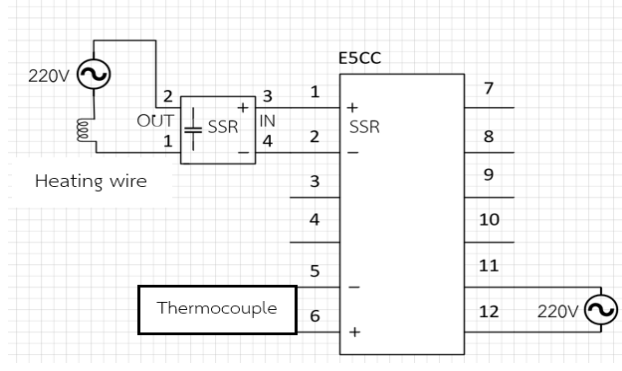


Figure 4 Circuit diagram of exhaust air combustion control

C. Testing the efficiency of the design and construction of high-temperature incinerators for the disposal of infectious waste for communities

In testing the efficiency of the infectious waste incinerator, by testing the temperature control inside the infectious waste incinerator, using the temperature control method by supplying 220 volts of AC voltage to the coil inside the infectious waste incinerator with the internal temperature control value at 900 degrees Celsius (Sangbuathao, S., & Kanjana, R, 2014). The heating coil will work to increase the internal temperature (ADD Furnace Company, 2024), (Makarn, A., 2009), (Hi-Den Heat Tech Company, 2024). The display screen will show the temperature reading in the infectious waste incinerator as shown in Figure 5a. And testing the temperature control inside the air purification incinerator

a. Temperature control display in infectious waste incinerator at 900 degrees Celsius.

b. Temperature control display in infectious waste incinerator at 1000 degrees Celsius.

Figure 5 Temperature control display in infectious waste incinerator

by using the temperature control method for the coil inside the air purification incinerator with the internal temperature control value of 1,000 degrees Celsius. The heating coil will work to increase the internal temperature. The display screen will show the temperature reading in the air purification incinerator as shown in Figure 5b.

Results and Discussion

The results of the research on the design and construction of a high-temperature incinerator for the disposal of infectious waste for communities are as follows: The results of the study of data related to the management of infectious waste for communities. The results of the design and construction of a high-temperature incinerator for the disposal of infectious waste for communities.

A. Temperature control results of incinerators for infectious waste disposal

The results of the design and construction of the temperature control system will consist of Step 1: Disposal of infectious waste by heating at a temperature not less than 760 degrees Celsius (according to the announcement of the Ministry of Public Health of Thailand), (Jinbao, Y.,2024). In the case study of this research, the temperature was set at 900 degrees Celsius using a heating coil, sensor, temperature controller, and display screen. The test was performed 10 times, with the results shown in Table 1. The average of the test temperatures of all 10 times is shown in Figure 6.

Table 1 The average of the test temperatures of all 10 times (When we fix temperature at 900 °C)

Time (min)	Temperature (°C)										
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	Average
0	32	35	37	33	36	34	35	38	36	37	**35.3**
10	250	252	254	251	253	253	253	256	254	254	**253**
20	421	423	425	422	425	424	424	425	423	423	**423.5**
30	505	506	508	506	509	507	506	508	506	509	**507**
40	613	615	617	614	616	615	616	616	614	616	**615.2**
50	691	693	694	691	692	692	694	695	694	692	**692.8**
60	760	761	762	759	760	761	761	762	761	761	**760.8**
70	813	815	816	812	813	813	814	816	815	814	**814.1**
80	856	857	859	855	855	856	856	858	858	856	**856.6**
90	893	895	896	892	891	893	894	895	894	890	**893.3**

Table 1 (Continued)

Time (min)	Temperature (°C)										
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	Average
100	909	909	909	909	909	907	907	907	909	907	**908.2**
110	906	906	903	905	906	906	907	905	902	905	**905.1**
120	909	902	907	909	904	909	909	904	909	906	**906.8**
130	907	907	909	903	909	903	902	907	906	907	**906**
140	909	907	904	909	907	909	907	908	904	909	**907.3**

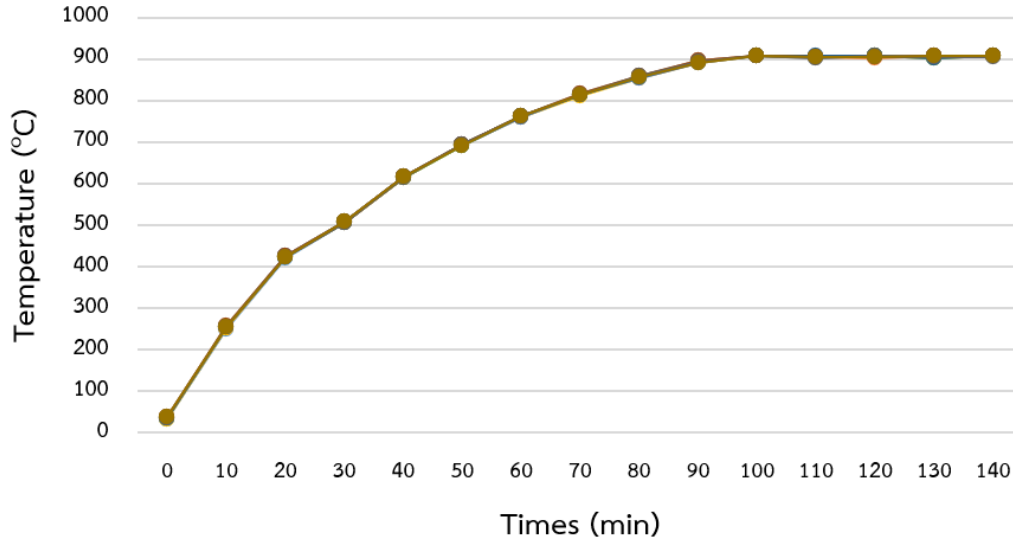


Figure 6 Temperature control efficiency of infectious waste disposal in the incinerator in the first step at 900 °C (average).

Step 2: Provide the temperature for incinerating the waste air from the disposal of infectious waste not less than 1,000 degrees Celsius. The temperature controller, display screen, high-temperature incinerator control system, and waste air incinerator can control the operation by supplying 220 volts of AC voltage to pin 11 and pin 12, causing the E5CC to start working. The E5CC controller receives a signal from a K-type thermocouple at pin 6 (positive pin) and pin 5 (negative pin) and compares the value read from the thermocouple with the value set in the program. In the case that the temperature value read is lower than the set value, the E5CC will send a value from pin 1 (positive pin) and pin 2 (negative pin) to command the solid-state relay to operate and connect pin 3 and pin 4 of the solid-state relay together, causing an electric current to flow through the heating coil, resulting in heat. If the thermocouple reads a temperature value higher than the value set in the E5CC program, it will send the opposite value, causing the solid-state relay to not work. This causes pins 3 and 4 of the solid state relay to not connect, resulting in no electric current flowing through the heating coil, thus causing no heat. In the case study of this research, the temperature was set at 1000 degrees Celsius using a heating coil, sensor, temperature controller, and display screen. The test was performed 10 times, with the results shown in Table 2. The average of the test temperatures of all 10 times is shown in Figure 7.

Table 2 The average of the test temperatures of all 10 times (When we fix temperature at 1000(°C)

Time (min)	Temperature (°C)										
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	Average
0	35	32	36	33	34	37	35	32	33	36	**34.3**
10	339	336	341	337	336	343	338	336	334	340	**338**
20	492	488	494	489	488	496	490	489	486	492	**490.4**
30	600	597	602	598	596	604	598	599	596	599	**598.9**
40	697	694	698	695	694	699	695	696	692	697	**695.7**
50	778	774	779	775	774	781	776	775	773	779	**776.4**
60	846	844	848	845	844	850	846	845	844	847	**845.9**
70	904	902	906	904	902	908	903	903	903	905	**904**
80	955	954	957	957	956	958	958	955	956	960	**956.6**
90	1001	999	1004	998	997	1006	999	1000	997	1001	**1000.2**
100	1009	1009	1009	1008	1007	1008	1008	1009	1009	1009	**1008.5**
110	1009	1009	1008	1004	1005	1003	1005	1009	1003	1006	**1006.1**
120	1008	1007	1006	1006	1003	1004	1004	1006	1005	1002	**1005.1**
130	1007	1009	1004	1009	1009	1009	1009	1004	1009	1008	**1007.7**
140	1009	1008	1007	1008	1009	1007	1007	1009	1007	1009	**1008**

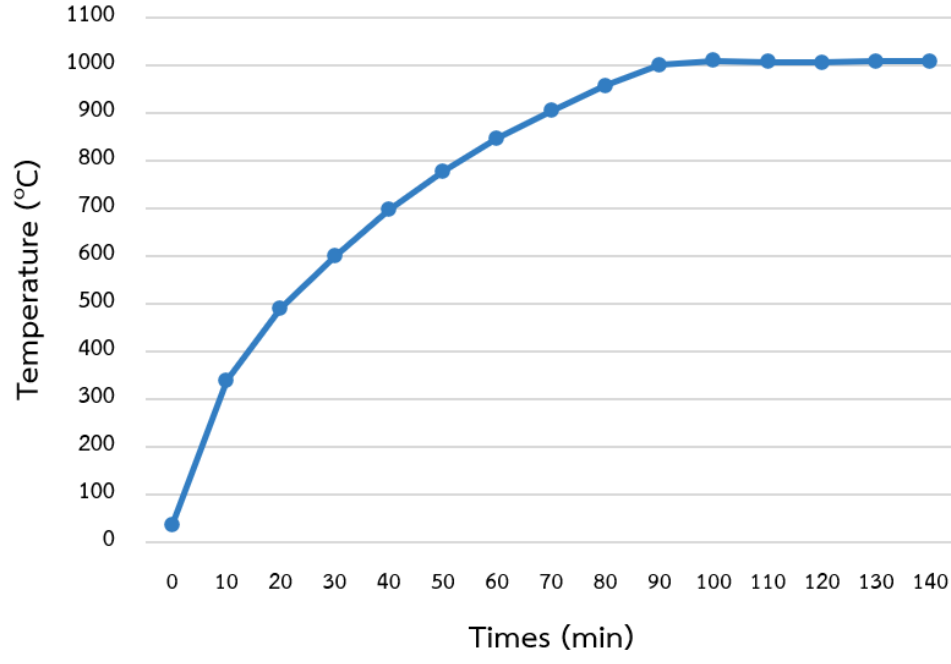


Figure 7. Temperature control efficiency of the furnace temperature in removing exhaust air in the Second step at 1000 °C (average).

Conclusions

This research aims to design and construct a high-temperature incinerator for the disposal of infectious waste in the community. The designed and constructed incinerator has important features and complies with the requirements of the Ministry of Public Health as follows: Design and Structure: This incinerator is designed to have 2 steps of infectious waste disposal, which are: Step 1: The incinerator can provide heat to eliminate infectious waste at a temperature not less than 760 degrees Celsius, and Step 2: It can destroy the polluted air from the disposal of infectious waste in the first step at a temperature not less than 1000 degrees Celsius. In part of temperature control and energy use: The incinerator has a clear temperature display system and can be used with 220 volts of electricity, which allows for precise temperature control. The Materials and Construction: The incinerator is made of stainless steel, measuring 60 cm x 60 cm x 62 cm., with wheels installed for easy movement. The working area consists of ceramic fiber and infrared ceramics to collect and increase heat energy, with a thickness of 1 cm. Design details: The top of the incinerator is square with a cover for infectious waste. The smoke vent has a diameter of 3.8 cm and a height of 87 cm. The temperature control and display system on the front of the furnace has a 7-segment display for checking the internal temperature and setting the desired value.

The design and construction of this high-temperature furnace have been developed to meet the need for efficient management of infectious waste in the community, in compliance with the standards and requirements of the Ministry of Public Health to effectively protect public health and the environment.

Acknowledgement

The researcher would like to thank Phranakhon Ra-jabhat University which provides funding for research. We would also like to thank the Rajamangala University of Technology Suvarnabhumi for granting time to researchers until this research was completed.

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