Progress in Engineering Application and Technology Vol. 2 No. 2 (2021) 1149–1154
© Universiti Tun Hussein Onn Malaysia Publisher's Office

PEAT

Homepage: http://penerbit.uthm.edu.my/periodicals/index.php/peat
e-ISSN : 2773-5303

Design and Development of Combustion Chamber for Portable Food Smoker

Muhammad Faris Hashim[1], Farid Shaari[1]*, Liyana Zamri[2]

[1] Department of Mechanical Engineering Technology, Faculty of Engineering Technology,
Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA

[2]Erul Food Industries, Lot 3264, Kampung Pekan Pedas, 71400, Pedas, Negeri Sembilan, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/peat.2021.02.02.103
Received 13 January 2021; Accepted 07 November 2021; Available online 01 December 2021

Abstract: Smoker's Combustion Chamber is a project that was applied on the portable smoker device to improve the performance of the smoker in addition preventing direct contact of the food from the fire. A thermal resistant layer was applied on the internal part of the combustion chamber to reduce heat escaping from the chamber. A study is conducted to determine what is the most suitable material suitable to applied for the combustion chamber. After deciding the material, a study is conducted to verify the effects before and after the insulation is applied. The results of for the insulation part of the project shows promising result as it was able insulate the heat inside the chamber effectively, however the heat produce in the combustion chamber are lacking to provide an ideal temperature for the smoker to cook food.

Keywords: Smokers, Thermal Insulator, Plaster

1. Introduction

Outdoor cooking grills are popular for its ability to enhanced food flavor as well as for the enjoyment for an outdoor activity. There two types common outdoor cooking, which are grills and smoking. Both use wood and charcoal to produce heat, however the method of cooking is slightly different. Grill use high temperature with faster cooking time while smoking uses lower temperature with longer cooking time.

As for purpose of this project is to further improve the combustion chamber by reducing the heat emission through the outer surface of the chamber while the burning process occur.

2. Materials and Methods

Corresponding author: mdfarid@uthm.edu.my
2021 UTHM Publisher. All right reserved.

2.1 Materials

This project has two main components, first is the burning chamber and second is the thermal insulator. For the chamber, the main materials used for this structure are steel complements, such as steel L bars, steel plates and steel hollow square bar. For the second part, is the thermal insulator which is made out of plaster of paris. Also known as gypsum plaster, it is a building material that is mainly used as protective layer for walls and ceilings [1].

2.2 Research design

Research design refers to an organized plan and scientific investigation into a specific problem, undertaken with the objective of finding solutions to it [4]. The process of research design in this study involves four main phases as shown in Figure 1. The research design begins with the initiation phase, which focuses on defining problem and design solution. The second phase is design and development, which emphasizes on the design specification, part drawing, material selection simulation and fabrication. The third phase emphasizes on evaluation which evaluate the product by through product testing. The final phase is conclusion, which embraces the discussion and conclusion of findings.

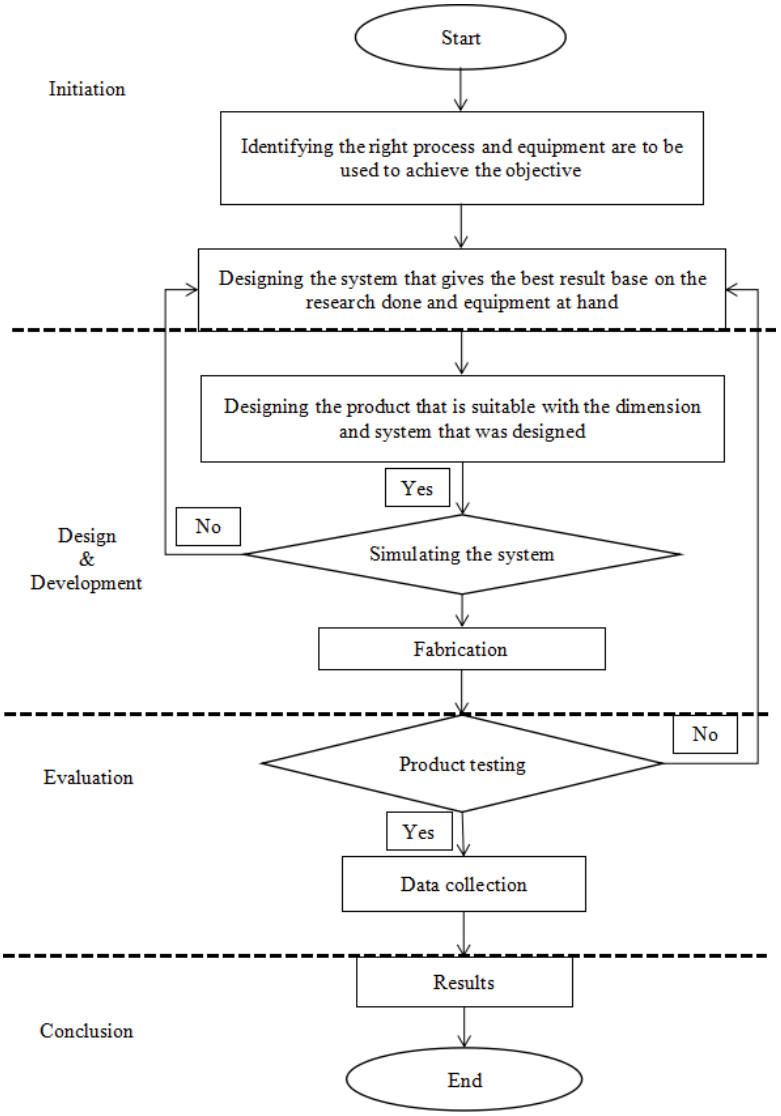

Figure 1: Research design process flow chart

2.3 Burning Chamber Design

To make a suitable burning chamber for the smoker, the concept of how the smoker is used to cook food and how it differs from regular grill is explained. Grills and smokers generally differ on the amount of heat and time used to cook the food. Grilling uses more heat and take less time to cook while smoking uses less heat and more cooking time for the food to be ready. Due to this reason most smokers place their heat source further away from the food compared to grills. To increase the longevity of the fire while give good thermal distribution, the chamber is placed at the bottom middle part of the smoker with a capacity to hold large amount of firewood or coal. Figure 2 shows the design and placement of the chamber of the smoker.

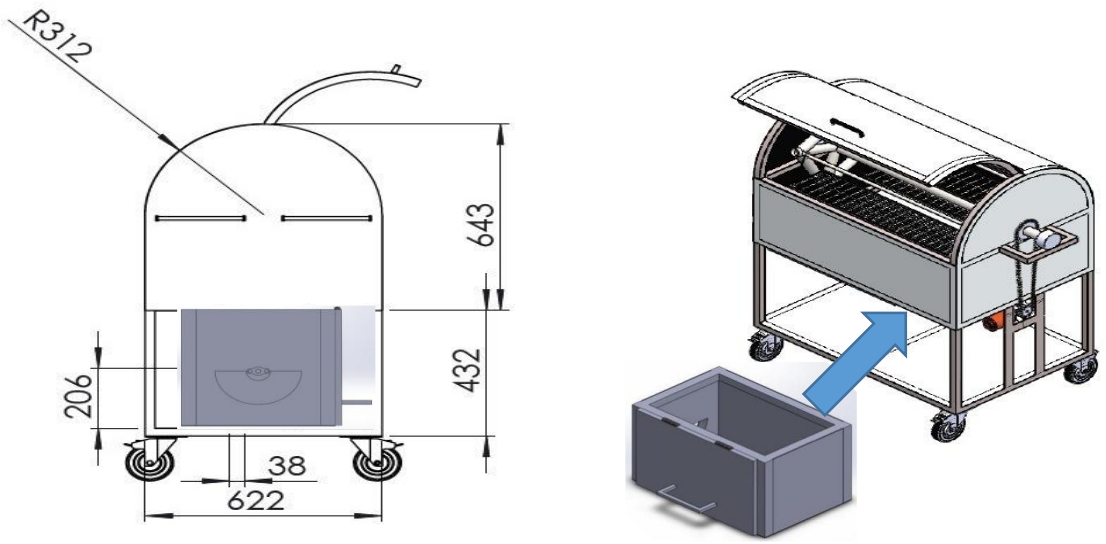

Figure 2: Placement of the combustion chamber into the portable smoker

2.4 Material Selection for Chamber Thermal Insulator

To choose a suitable thermal insulator for the chamber, material's thermal resistance is highly taken account as it increases the chamber's safety as it prevents the chamber's metal frames from absorbing the heat causing them to get deformed. Fiberglass and polyurethane foam are not recommended as they can cause side effects on a person's health, such as trouble breathing and eye irritation.

Firebricks and tiles are good thermal insulators are good options however one is too heavy while the other one is too fragile. Lastly, plaster of paris is decided to be the most suitable material for the chamber, as it can withstand temperature as high as 1,200 °C [2] while having good structural strength. The material can also be moulded easily into the combustion chamber.

2.5 Material Sampling and Testing

Plaster of paris is moulded with two different mixtures of water and plaster to test how it will affect its structural strength. After that, by using the more concentrated mixture of plaster, 2 plates of plaster with different mixture are made for material thermal testing.

2.6 Material Thermal Testing

This experiment is to study how the thickness of the plaster effects its performance as a thermal insulator. Both plates are placed on top of a fire and the temperature of the plates is taken periodically every 30 minutes to see the rate of change of their temperature. The 2 samples are both square with dimension 8cm in length and width however one sample has a thickness of 0.5 cm while the other has 1 cm.

Figure 3: Setup for sample testing

3. Results and Discussion

3.1 Material Thermal Testing

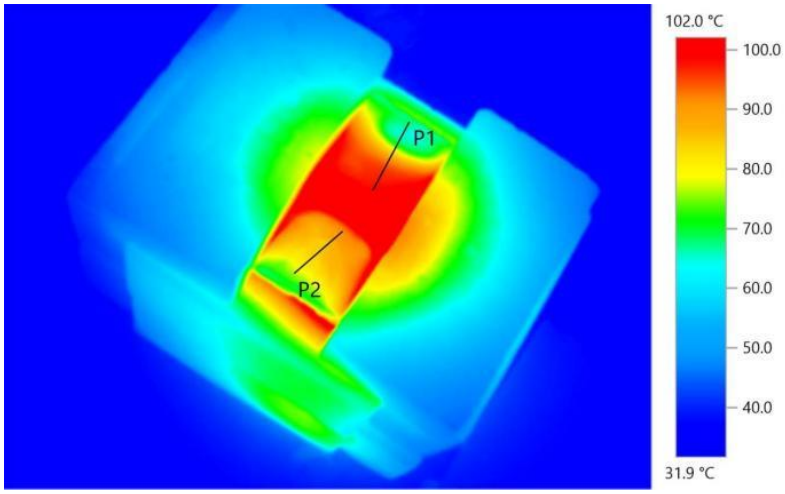

Figure 4: Thermal image of the sample testing process

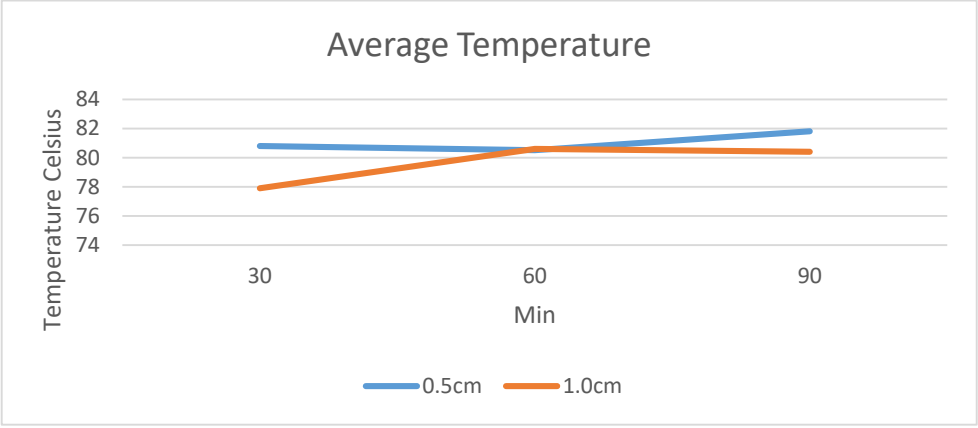

Figure 5: Temperature over time graph between two samples

Figure 4 shows the thermal image of the two samples as it was heated (one has 0.5cm thickness and another has 1cm thickness), giving the results to make the chart in figure 5. As expected, in figure 5 the thinner plaster have an increase temperature at a higher rate than the thicker one, however the plaster's

temperature stopped increasing around 80°C for approximately 30 minutes for both plates. This is due to the material's properties as it reaches a minor thermal stability which prevent the temperature to increase.

3.2 Analysis on Thermal Effects of Plaster Insulator on the Burning Chamber

Thermal data is collected on two different sides of the chamber, one is insulated while the other one does not. Chart in figure 6 shows great improvement on how the insulated side resist heat absorption while the uninsulated side have temperature increase up to 63.10 °C.

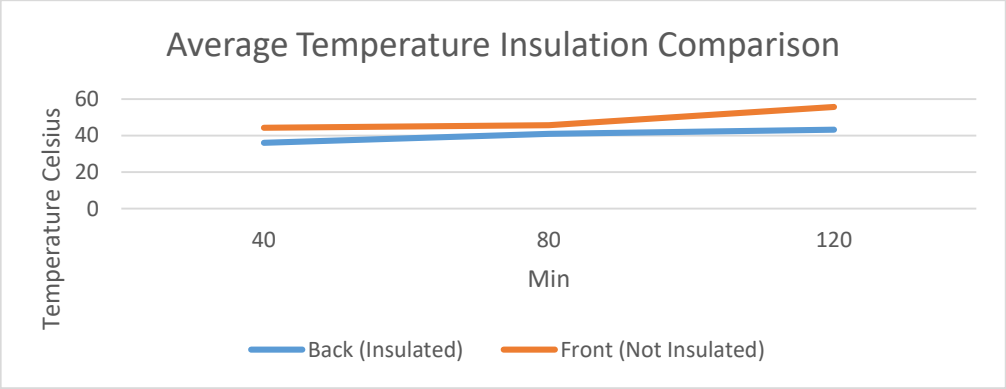

Figure 6: Temperature over time graph between insulated and uninsulated part of chamber

The interior and exterior temperature is also collected for the insulated side of the chamber. This is to observe how much temperature is reduce from inside of the chamber to the outer surface of the chamber. Figure 7 shows the the chart made from the data collected.

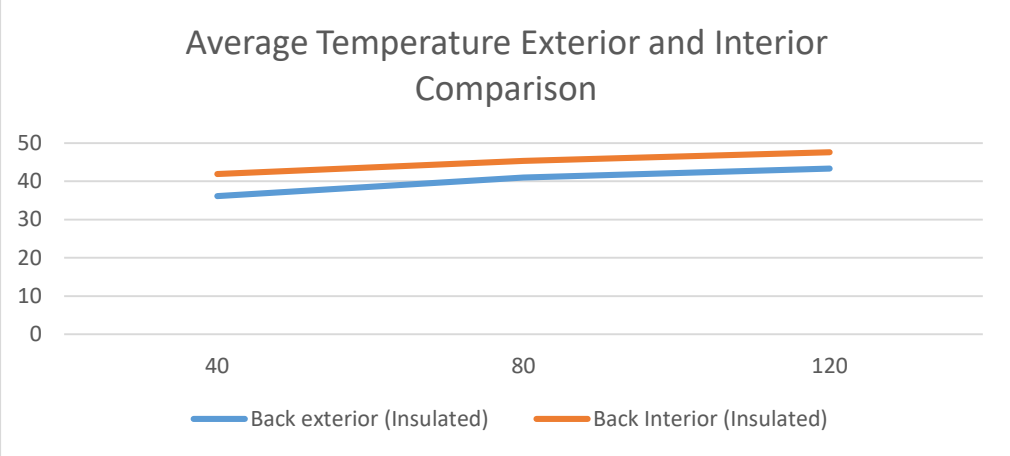

Figure 7: Temperature over time graph between interior and exterior part of the chamber (insulated)

3.3 Thermal Analysis of the Burning Chamber Suitability Usage for the Smoker

The chamber needs to produce enough heat to increase the temperature of the smoker up to 93.3 °C or 200 °F minimum for it to effectively cook food [3]. After heating the smoker for two hours, the temperature inside the smoker couldn't reach the threshold as the max temperature it was able to reach was only 82.3 °C. This problem might be caused by the insufficient amount of wood used inside the chamber as it didn't even fill half the amount of wood that the chamber can hold. Only 0.52 kg of charcoal was used during the experiment. Figure 8 shows the amount of wood used to heat the smoker during the test.

Figure 8: Combustion Chamber during the burning process

4. Conclusion

In conclusion, this project was able to achieve most aspects of the of the objective, such as preventing food from direct contact with fire. Besides that, this project was able to use the most suitable material as insulation for this project which is plaster of paris. Lastly, this project has able to insulate the heat effectively inside the chamber and reducing the heat absorbed by the steel frames of the chamber. However, the downside of the project is, it couldn't prove its effectiveness on a real cooking test due to lack of time and resources available during the Covid-19 pandemic.

As for improvement, the insulator can be made detachable rather than permanently stick to the wall of the chamber. This can greatly improve its ability for maintenance, for example if the insulator were to break, the broken plate insulator can be detached and replaced with a new one with ease.

Acknowledgement

The authors gratefully acknowledge the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM) and Erul Food Industries for its support.

References

[1] Srša, Ivan, eds. (2015). EwaGlos. European Illustrated Glossary of Conservation Terms for Wall Paintings And Architectural Surfaces. Petersberg: Michael Imhof. p. 50.

[2] J. (2019, August 27). Is Plaster of Paris Heat Resistant? Ceramics. https://expandusceramics.com/qa/is-plaster-of-paris-heat-resistant.html

[3] BBQ Smoking 101: Low and Slow Is the Way to Go. (2020) The Spruce Eats https://www.thespruceeats.com/smoking-meat-low-and-slow-331486

[4] Sekaran, U. (1992). Research method for business. United states: Hermitage Publishing Services.