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Rice Straw Eco Icebox (RSEI)

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Abstract: Non-biodegradable waste is material which does not decompose, decay, or dissolve by natural phase which categorize such as plastic, glass, metal and another else. As non-biodegradable waste can contribute to the impact on the environmental pollution and human health. At the same time, in Malaysia is well known as a major rice producer in the economic sector produced by paddy cultivation. However, the rice straw will be burned after harvest season which produces combustion that contribute to air pollution. Therefore, in this study was the development of a biodegradable product in replacing polystyrene container namely Rice Straw Eco Icebox (RSEI) was proposed. This product was design by three combinations of agricultural waste which are rice straw with other natural component such as clay soil, corn flour and water in different ratio which were assigned as RSEI 1, 2 and 3, for first, second and third combination ratio, respectively. The combinations of rice straw, clay soil, corn flour and water mixture were tested for comparison with polystyrene with regards to their strength, water absorption, heat transfer, load capacity and combustible test. Based on the testing conducted on all three RSEI samples, water absorption and heat transfer testing showed that RSEI 1 had the best performance compared to RSEI 2 and RSEI 3 as the water absorption determined 20.00 % and the heat transfer based on five hours of ice melting was 20.5 kJ/kg. In terms of load capacity and combustible test, RSEI 1 was found to have the similar capacity and fire retention properties as RSEI 2 and RSEI 3. However, comparison made to polystyrene found that the water absorption of polystyrene is 0.00 % with the heat transfer of 26.2 kJ/kg. Due to the findings and based on five hours usage this Eco icebox was found to be comparable with polystyrene purpose as a food container. The biodegradable components of RSEI make this product can be used to replace polystyrene however with some modifications to enhance the properties comparable to polystyrene in the future.

Keywords: Pollution, Biodegradable, Rice Straw, Eco Icebox.

1. Introduction

In Malaysia was popular with solid waste disposal of polystyrene. Polystyrene is widely used in Malaysia and also used in packaging food. Malaysian's government has been implemented "Free Plastic" campaign which launched by the Federal Government by launching Road Map Towards Zero Single Use Plastic on October 2018. Material ice box polystyrene which contributes waste pollution on the environmental solid waste disposal. Since the 1950s, plastic production has outpaced that of almost

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any other material due to its durability and flexibility, and 9.00 % of the nine billion tons of plastic produced in the world has ever been recycled [1]. The impact of plastic waste on the health and the environment contributes on human and wildlife because the chemicals mainly contained in plastic.

Also, in Malaysia, paddy in Malaysia's third most commonly grown crop after oil palm and rubber. Open burning of rice straw is one of the causes of particularly haze air pollution. Affected of air pollution exposure by short and long term from air pollution tend to poses different toxicological impacts on living things [2]. Effects air pollution in long term exposure to lower concentrations of air pollutants cause more damaging to public health than higher concentration in short term exposure [3]. Air pollution can become the worst as it reaches each country, unless it avoids it as soon as possible, because it will have an effect on the various sectors of the country's growth such as economy, road transport, developing and developed country, tourism and other else.

1.1 Problem Statement

Material icebox polystyrene which contributes waste pollution on the environmental solid waste disposal. Polystyrene is not breaking down and is often burned for disposal. Burning polystyrene, however, releases styrene gas into the environment, which creates a combination of toxicants that can damage the nervous system [1]. These all contributes negative effects on human and animal health, mainly affecting the environment ecosystem. Also, in Malaysia, paddy in Malaysia's third most commonly grown crop after oil palm and rubber. Open burning of rice straw is one of the causes of particularly haze air pollution. Rice straw inhibition can remove pollutants which can affect human health. Carbon monoxide (CO), sulfur dioxide (SO_2), and suspended particulates (PM_{10}) are among the pollutants released into the air [4]. Burning a ton of straw is estimated to produce 3 kg of particulate matter, 60 kg of carbon monoxide, 1460 kg of carbon dioxide, 199 kg of dust and 2 kg of sulfur dioxide [5]. Therefore, in this study to make a biodegradable product to reduce pollution of polystyrene container. Biodegradable product commonly using formulated by natural sources such as rice straw, corn flour, clay soil and another else. This to make the process decomposed by the action microbial activity such bacteria of fungi which through process assimilated in a natural environment [6].

1.2 Objective

The project aims to produce a rice straw eco icebox (RSEI) consisting rice straw waste as a raw material in replacing polystyrene as a food container. The objectives of this study are:

i. To produce a Biodegradable Eco Ice Box (RSEI) by using three different ratios of rice straw waste as a raw material with, corn flour (CF), clay soil (CS) and water as a mixture.
ii. To investigate the physical properties such as strength, water absorption, heat transfer, load capacity and flammability of the produced Biodegradable Eco Ice Box (RSEI) through experiment and observation
iii. To compare the effectiveness between the RSEI and the polystyrene icebox in terms of water absorption, heat transfer, load capacity and combustible test.

1.3 Scope and Limitation Project

The study was using paddy straw which collected from the paddy field located between Bukit Gambir and Gersik is also called Kampung Sawah Ring. The preparation of biodegradable eco icebox using mixtured by paddy rice straw (RS) corn flour (CF), clay soil (CS) and water. After the mixing, the process was compact in mold with the pressure load on the surface sample. The structure mold was designed as polystyrene icebox.

The limitation of this project are:

This project aimed to identify the properties product with comparison the polystyrene icebox. However, the project still had limitation to generality the of the finding. The experiment was conducted at home due to limited access of Malaysian Movement Control Order (MCO) and the significant results from an experiment can deduce a general cause within specific limits.

i. Only use rice straw (RS), corn flour (CF), clay soil (CS) and water.
ii. Only 3 different ratios were used in the production of a biodegradable product.
iii. The experiment was conducted with testing in terms strength, water absorption, heat transfer, load capacity and combustible test.
iv. Compression Strength test cannot be performed due to limited movement by Movement Control Oder (MCO) implemented by the Malaysian government.

2. Materials and Methods

To accomplish the study objectives, the methods were used to obtain the information. The steps were taken as to achieve the objectives of this project as shown in Figure 1 flow chart for planning the Project.

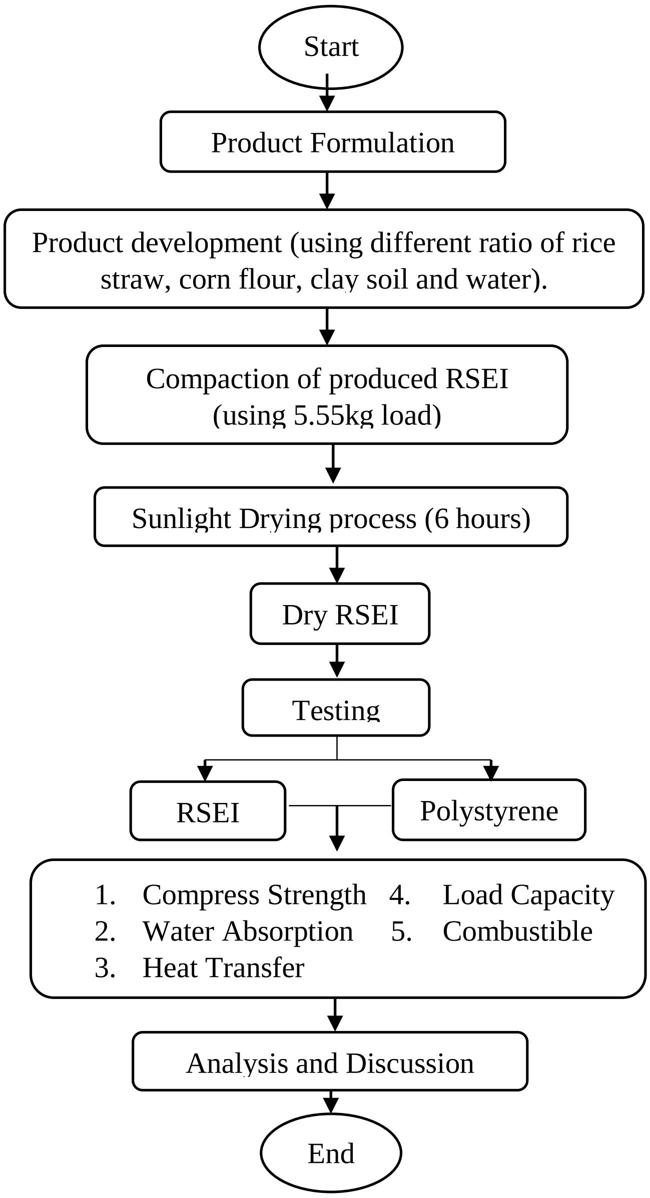

Figure 1: Flow Chart for planning the Project

2.1 Preparation of Biodegradable Eco Icebox

The preparation of this product uses natural material such as rice straw, clay and corn flour. This product mixes all the material so that the physical product can be the shape and strength of all the material. The three samples of product used different amount quantity of rice straw, clay soil, corn flour, and water in as shown in Table 1 with ratio weight by weight (w/w). Assume 1 L of water is having 1 kg of water mass.

Table 1: Quantity of Material in Sample

Material	RSEI 1	RSEI 2	RSEI 3
Rice Straw (RS)	1kg	1.5kg	2kg
Clay soil (CS)	1.5 kg	800 grams	600 grams
Corn Flour (CF)	200 grams	400 grams	600 grams
Water (W)	1 liter	1.5 liter	2 liters
Ratio of RS:CS:CF: W	5:7.5:1:5	7.5:2:1:3.75	10:1:1:10

The mixture has been placed into a mold dimension of 20 cm x 20 cm x 2.5 cm. The compaction of product was using 2 block bricks with tray that the weight is 5.55 kg. The natural method of drying consists basically of using sunlight to removing water and residual moisture required approximately six hours for the surface of the material to be completely dry. After compaction and drying process took place, the pieces of the sample were combined together with the use of clay as adhesive and form into as a box.

2.2 Design of Rice Straw Eco Icebox (RSEI)

The Rice Straw Eco Icebox (RSEI) have been designed with the size of 25 cm x 22 cm x 19.5 cm and the thickness of 2.5 cm as Figure 2. The volume of RSEI is 0.0170 m^3 and the area is 0.0429 m^2. The design of RSEI made by combination the pieces of the sample with used of clay as adhesive and form into as a box.

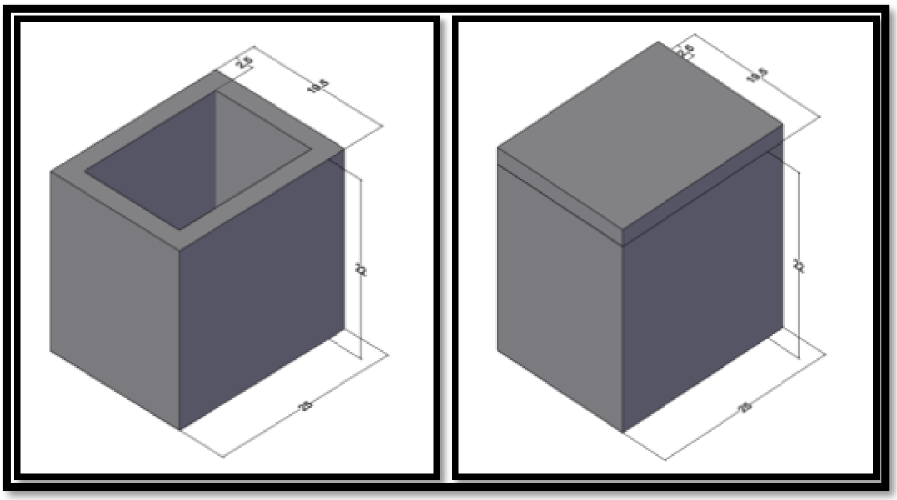

Figure 2: Design by Software Sketchup Rice Straw Eco Ice Box

2.3 Eco Icebox Test

The tests were performed to identify the effectiveness of this product in terms of compressive strength, water absorption, heat transfer, load capacity and combustible. To obtain the value, each test performed was used the calculation formula method in which to identify the level of effectiveness of this product by doing a comparison of polystyrene containers. Table 2 shown the summarize of the performed test at home and outsource lab. The test performed on the product were to make a comparison between polystyrene with the product to evaluate the difference data of each test performed. In addition, test performed ware to identify good insulation for each sample produced through different ratios. The experiments conducted are very important to monitor the effectiveness of the products produced to achieve the objectives.

Table 2: Summarize Test on Product

Test	Equipment	Location
Compressive Strength	Digimatic Compression Machine 2000kN	Seremban Soil Asphalt Lab Sdn.Bhd
Water Absorption	Water and Weighing scale	In-house
Heat Transfer	Ice 500g	In-house
Load Capacity	Dumbbell 10kg	In-house
Combustible	Kitchen	In-house

i. Compressive strength

Compressive strength refers to the ability of a particular material or structural element when applied to withstand loads that reduce the size of that material or structural element [7]. On top and bottom of a test sample, a force is applied to identify the strength of the sample before breaks or is crushed. The measurements to be estimated are the maximum force attained before breakage or the load at displacement.

$$\mathbf{F = P/A} \qquad \textit{Eq. 1}$$

Where:

F = The compressive strength (MPa)

P = Maximum load (failure load) applied to the specimen (N)

A = Cross-sectional area of the specimen resisting the load (mm^2)

ii. Water Absorption

The test was conducted at home which to identify the ability of the sample to absorb water when immersed in it. The ratio of the weight of water absorbed by a material in a saturated state to the weight of the dry material is known as the water-absorbing ability [8]. Water absorption is measured as a percentage of dry mass by calculating the change in mass. The test was performed for one hour in measurements every 10 minutes taken to read the sample data.

$$Water\ Absorption\ (\%) = \frac{Loss\ of\ weight\ (g)}{Initial\ Weight\ of\ sample} \times 100\% \qquad \textit{Eq. 2}$$

Where:

Loss of weight = Final Weight (g) - Initial Weight (g)

Initial Weight = Initial sample of weight sample drying

Final Weight = Wet sample of weight

iii. Heat Transfer

The calculation was using method heat transfer conduction [9] as shown in Equation 3 to determine the heat transfer through the wall sample. Besides, to calculate heat to melt the ice [10] was used as shown in Equation 4 formula to determining heat to need ice melt. This approach involves the processing conversion of use and exchange of energy heat between physical systems.

Heat Transfer formula:

$$Q = \frac{kA(T_f - Ti)}{d} \qquad \textit{Eq. 3}$$

Where:

Q	:	Rate of heat entering through the walls (J/s)
K	:	Thermal Conductivity (J/s·m·◦C)
A	:	Area (m^2)
T_f	:	Temperature inside (◦C)
Ti	:	Temperature outside (◦C)
d	:	Thickness (m)

Heat to melt ice formula:

$$H = \frac{t}{(\rho)\left(\frac{v}{Q}\right)}. \qquad \textit{Eq. 4}$$

Where:

H	:	Heat to melt ice
t	:	Time
ρ	:	Density of Ice kg/m3
v	:	Volume of ice
Q	:	Hate rate

3. Results and Discussion

3.1 Compressive Strength

RSEI 1, RSEI 2 and RSEI 3 then were brought to Seremban Soil Asphalt Lab Sdn.Bhd to compress all RSEI samples in order to investigate the strength of the materials using Digimatic Compression Machine with 2000kN which was typically used for cube test. During the testing, compression on the RSEI samples however were failed as the samples became denser and elastic. Yet, no results on compression was gained due to the elasticity characteristic of RSEI mixture. Then, Seremban Soil Asphalt Lab Sdn.Bhd suggested to use another type of testing using a Universal Testing Machine to determine the tensile force of pressure to the RSEI samples. However, none of this testing was conducted due to the limited access of the equipment during MCO.

3.2 Water Absorption

The time set for this experiment was 60 minutes. The dry weight and the wet weight of the RSEI samples and the polystyrene were measured in 10 minutes time interval. The additional weight of the RSEI was taken as the water absorbed into the materials. By using Equation 2, the percentage of water absorbed into the materials were calculated and then distributed in Table 3.

Table 3: Percentage Water Absorption of Sample Rice Straw Eco Icebox

Time (Min)	Water Absorption (%)			
	RSEI 1	RSEI 2	RSEI 3	Polystyrene
0	0	0	0	0
10	3	7	12.5	0
20	4	14.5	26.5	0
30	9.5	19	38	0
40	12.5	24.5	47.5	0
50	17	28.5	58	0
60	20	35.5	67.5	0

As shown Table 3, amongst the RSEI samples, RSEI 1 had indicated the lowest percentage of water absorbed which is 20.00 % compared to RSEI 2 and RSEI 3 with 35.50 % and 67.50 %, respectively, within 60 minutes. This is due to the highest quantity of the clay soil and lesser rice straw used in RSEI 1 compared to RSEI 2 and RSEI 3 which had lesser amount clay soil and highest of rice straw. Figure 3 shown the water absorption compared RSEI 1, RSEI 2 and RSEI 3.

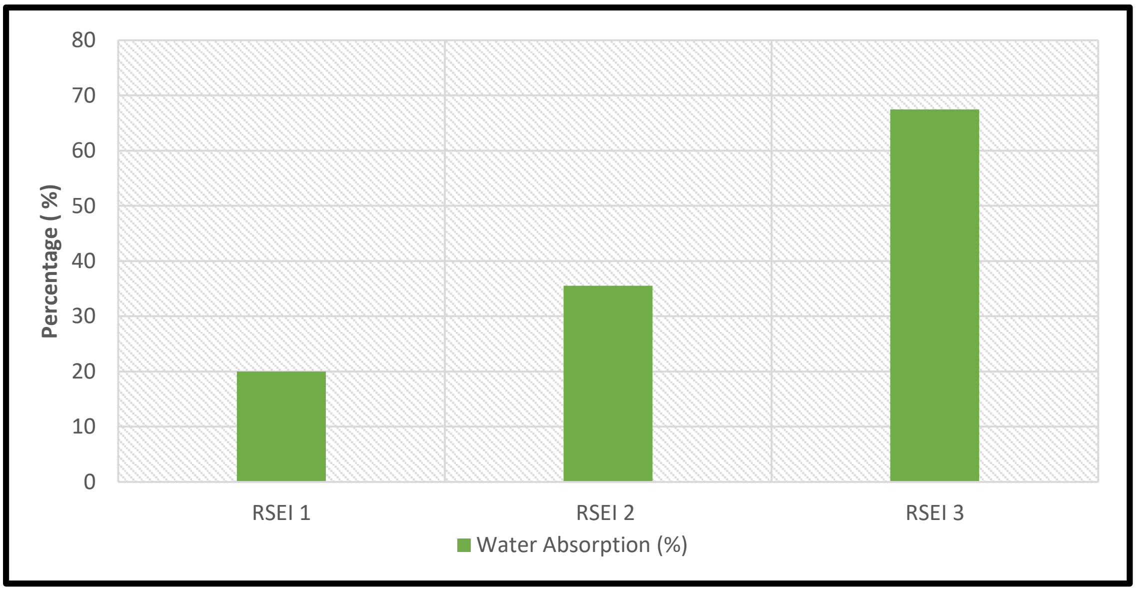

Figure 3: Water Absorption (%) against RSEI 1, RSEI 2 and RSEI 3

3.3 Heat Transfer

Determining the heat transfer through the inside and outside wall after five hours of ice was placed into the icebox. From the observation, the calculation heat to melt the ice through by three samples RSEI compared to polystyrene icebox. Data showed that RSEI 1 needed heat 20.55 kJ/kg to melt the ice to water than RSEI 2 and RSEI 3. However, for the heat result by polystyrene is 26.15 kJ/kg is higher than three of sample RSEI 1. RSEI 2 and RSEI 3 were 11.71 kJ / kg and 14.80 kJ / kg respectively that the heat energy required to melt ice is very low and not suitable for use as cold insulation. RSEI 2 and RSEI 3 were not performed because the mixture in RSEI 2 and RSEI 3 used less amount quantity material of clay soil than RSEI 1. Figure 4, shown the heat transfer into RSEI compared to the polystyrene.

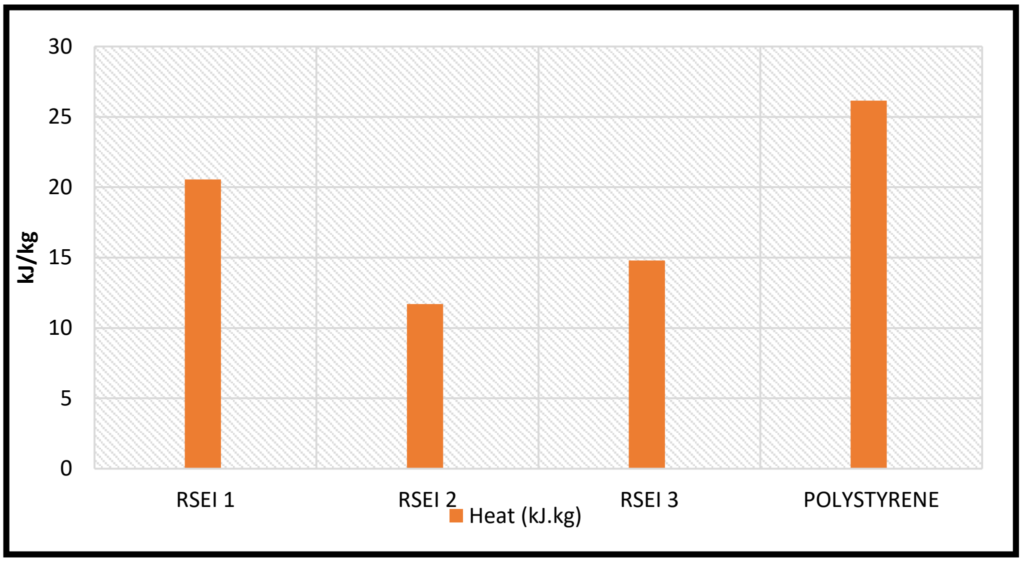

Figure 4: Heat Transfer of RSEI against Polystyrene

3.4 Load Capacity

All the of sample box respectively have different weight. This due to the mixture by material quantity as shown in Table 1. The weight of clay soil influenced to sample weight box but different with rice straw due properties of rice straw quite light than clay. The capacity of the three sample RSEI can input three bags with size 2.5L and the polystyrene icebox can input five bag with size 2.5L. The load of three sample RSEI and the polystyrene icebox can accommodate the load weight item 10kg as shown in Table 4.

Table 4: The Weight of Sample RSEI and Polystyrene Icebox

Variables	RSEI 1	RSEI 2	RSEI 3	Polystyrene
Weight (kg)	1.2kg	0.8kg	0.6g	0.12kg
Load Item (kg)	10kg	10kg	10kg	10kg
Capacity		3 bag (2.5L)		5 bag (2.5L)

The weight of sample RSEI and Polystyrene icebox approximately similar on the load item that could accommodate the load 10 kg. However, the weight of the sample had different sequentially according to the Table 1 due to quantity material used influenced to sample of weight. RSEI 3 much lightly than RSEI 1 because the RSEI 3 using clay soil 600 g and rice straw 2 kg which differ with RSEI 1 used 1.5 kg clay soil and 1 kg rice straw.

3.5 Comparison of Combustible Properties RSEI and Polystyrene Icebox

The sample of RSEI is not combustible product because the composite used for this sample is clay soil mixture rice straw. Based on the experiments conducted, the sample is placed firing with a temperature of more than 100 ◦C within 25 min. Different with polystyrene which was highly flammable when did not withstand fire and the surface became melt and releases styrene gas into the atmosphere, which creates a combination of toxicants that can damage the nervous system as shown on figure 5. This because clay soil properties, such as composition, texture, porosity, wettability, infiltration rates, and water holding capability, may not be altered by burning [11].

(a) Burning test on RSEI (b) Burning test on Polystyrene

Figure 5: Combustible Test on (a) Burning test on RSEI and (b) Burning test on Polystyrene

4. Conclusion

In this study, the aim to produce a biodegradable Eco Ice Box (RSEI) using rice straw was achieved with three RSEI samples with different ratio of 5:7.5:1:5, 7.5:2:1:3.75 and 10:1:1:10 was mixed and molded as a container. Investigation on the physical properties such as strength, water absorption, heat transfer, load capacity and combustible were performed, and the results showed that amongst the RSEI produced. RSEI 1 was examined to have better achievement with the water absorption of 20.00 % and the heat transfer of 20.55 kJ/kg. Other two mixture ratio of RSEI were found to have higher water absorption and heat transfer compared to RSEI 1. In terms of load capacity and combustible test, RSEI 1 was found to have the similar capacity and fire retention properties as RSEI 2 and RSEI 3.

By comparison to polystyrene, it still showed the best performance amongst RSEI as the water absorption is 0.00 % and the heat 26.15 kJ/kg but for term fire retention of polystyrene was not withstand fire and the surface became melt compared to product RSEI. Although polystyrene was becoming the best materials as a container, however produced RSEI is having an advantage to the environment due to its biodegradable materials. At the same time, the usage of RSEI could reduce the energy used for non -renewable product and reduce the bad impact of polystyrene disposal.

5. Recommendation

This project needs some improvement for the future. As shown Table 1, the mixture material must need some modifications to enhance the properties comparable to polystyrene in the future. Also, the use of a dried oven plays an important role in obtaining reading accuracy when conducting sample experiments. In addition, the equipment should be sufficient for when conducting experiments so that the sample used can measure accuracy to achieve accurate results.

Preliminary planning for material mixture should be emphasized in order to identify the abilities of a suitable material to be used to avoid mistakes when experiments are conducted. Lastly, this project can be carried out while studying for the future. This project aims to produce a design based on biodegradable products that can prevent pollution to the environment. Various natural resources that can be used as biodegradable products to protect the well-being of the environment.

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