

The Calorific Value Experiment of Refuse Derived Fuel by Utilizing Residual Waste to Produce Energy

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Abstract

Refuse Derived Fuel (RDF) is excellent process to reuse the wastes from human activities or residual waste becomes renewable energy and also cut off the wastes volumes prior to transporting to landfill, it is an apart of supporting climate change mitigation due to waste generation and green house affect. This study is to focus on: 1. study on ratio of the waste material component to produce the RDF and, 2. testing and find out the RDF properties and calorific value of each material component. Therefore, according to the experiments found that, the mixtures of the plastics and dry leaves, plastics and papers, papers and dry leaves and plastics, papers and dry leaves indicated the calorific value are 14.91(MJ/kg), 14.11(MJ/kg), 15.02(MJ/kg), 14.91(MJ/kg) and 15.39 (MJ/kg), respectively.

Keywords: *Plastics, Residual Waste, Refuse Derived Fuel, Calorific Values.*

A. INTRODUCTION

Management of solid waste in communities, markets, schools, offices and other places are significant issues in modern and smart societies, even though there are planning and organized well landfills may still occur and become problematic on the environment and public acceptance are concerned (Pinto et al. 2014), therefore, RDF is alternative to reduce and use residual waste to be energy (Alter, H,1987), due to the energy is very significant for our living things and also use widely in industrial factories (Guo, et al. 2020), in particular, cement factories, lignite power plant(Fyffe, et al. 2016). RDF is combusted individually or co-fired in the cement kilns (Georgiopolou, M.Lyberatos, 2018), the combustibles that are called “refuse-derived fuel (RDF)” are separated in sorting facilities (Chatziaras, N et al. 2016).

Several benefits of using RDF in the cement industry blended with other fuels are expected, namely ecological, with the reduction of the non-renewable fossil fuels and its environmental extraction impacts, the reduction of greenhouse gases emissions. It is also important to notice that the wastes would otherwise have to be disposed of on waste disposal sites (Garg, et al. 2007).

The ideal composition of RDF is high content in plastics, paper-cardboard, polymeric containers textiles, wood and other organic matter (Pohl, M., Gebauer, K., & Beckmann, M. 2008). Higher heating value is in fact associated with paper/card, plastics, wood and textiles content and, once these materials have in their composition

biogenic compounds (40-80% w/w), they become an interesting alternative fuel to accomplish the reduction of CO₂ emissions. Moreover, meaningful advantages of RDF are low production costs and significant calorific value (Hilber, T et al. 2007).

The energy recovery from wastes can be achieved by direct combustion, gasification or pyrolysis, with the first being more generally allocated (Infiesta, et al. 2019). Nevertheless, pelletization should be implemented once it is the potential way for mass and energy densification of these energetic materials (Tomasek, et al. 2020). In the economic standpoint, in the cement industry, as fuel consumption decreases the production costs also reduce (Caputo, A.C et al. 2002).

RDF is also contained quantities of biodegradable and biomass material, particularly, RDFs are composed majority of paper, cardboard, plastics, dry leaves and other uneven materials, it is contained high thermal values (Galhano dos Santos, 2018) and in other hands, RDF can be called a kind of secondary fuel (Roknizadeh and Nejati, 2014).

Calorific Value was noted that in Finland is 13-16 (MJ/kg), Italy is 15 (MJ/kg) and United Kingdom 18.7 (MJ/kg) (JidapaNithikul, 2007).

Table1. Chemical component in RDF (JidapaNithikul, 2007).

RDF component	%C	%H	%O	%N	%S	%Cl	%H ₂ O	%Ash
Paper	34.4	4.72	32.4	0.16	0.21	0.24	21	4.62
Plastic	56.4	7.79	8.05	0.85	0.29	3	15	8.59
Wood	42.1	5.03	34.5	0.02	0.07	0.09	16	2.82
Textile	37.2	5.02	27.1	3.1	0.28	0.27	25	1.98
Leather, Rubber	43.1	5.37	11.6	1.34	1.17	4.97	10	22.5

B. MATERIAL AND METHODS

The study is conducted and followed the research methodology as indicated in Figure1.

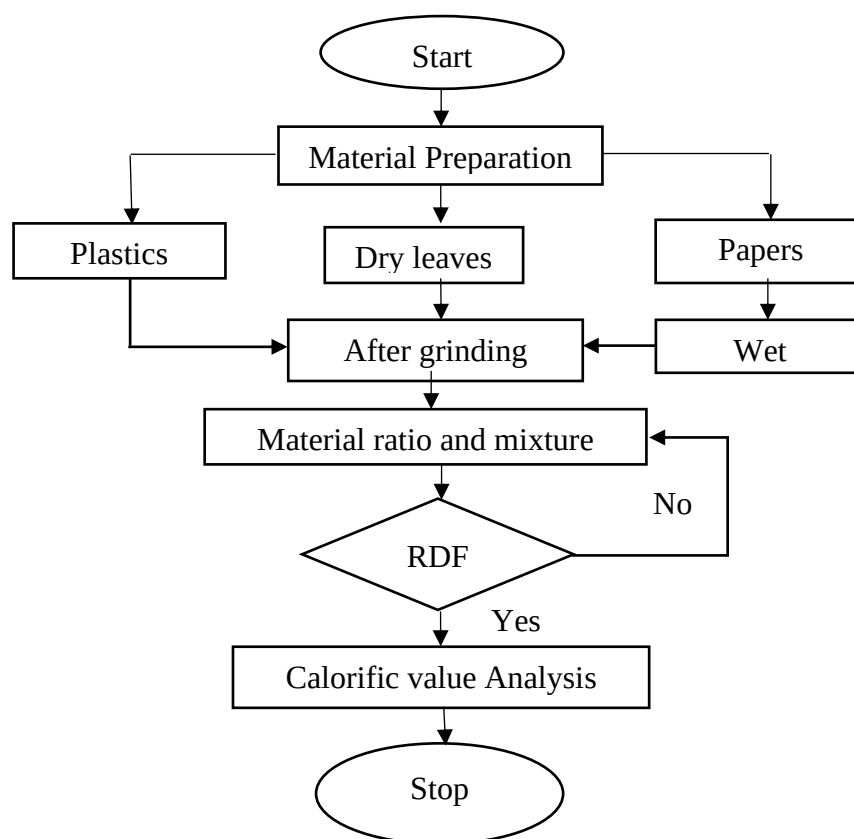


Figure1. Research Methodology

Formulas and Equations

$$\rho = \frac{m}{V} \quad (1)$$

ρ : Material density, ($\text{g} \cdot \text{cm}^{-3}$)

M: Mass of dried briquette, (g)

V: Volume of dried briquette, (cm^3)

$$V = S * h \quad (2)$$

V: Volume of the cylinder (cm^3)

S: Surface area of the cylinder (cm^2)

h: Height of the cylinder (cm)

$$\text{LHV} = \frac{[M_w \times C_{pw}(T_{wf} - T_{wt}) + M_{we} \times H_{fg}]}{M_f \times \eta} \times 100 \quad (3)$$

η : Stove efficiency 13-23.5%

M_w : initial water mass (g)

M_{we} : evaporated water mass (g)

M_f : RDF mass (g)

C_{pw} : specific heat capacity of water (4.186 J/g)

T_{wf} : final temperature of water ($^{\circ}\text{C}$)

T_{wt} : Initial temperature of water ($^{\circ}\text{C}$)

H_{fg} : Heat of vaporization (2260 J/g)

LHV: Low Heating value (J/g(dry) or MJ/kg)

Table 2. Materials Component Trails and Pressure

Material components	Material (g)	Cassava Powder (g)	Water (g)	Pressure (kg · cm ² °C)
Plastics and dry leaves	300	200	150	150
	300	150	150	150
	300	100	150	150
Plastics and papers	300	200	100	150
	300	150	100	150
	300	100	100	150
Papers and dry leaves	300	200	100	150
	300	150	100	150
	300	100	100	150
Plastics, papers and dry leaves	300	200	150	150
	300	150	150	150
	300	100	150	150



Papers



Plastics



Leaves



Hydraulic Machine



Grinding Machine

Figure 2. Material Components and Equipment

C. RESULT AND DISCUSSION

The experiment was conducted and tested in order to find out the appropriate calorific value by applying the proportion of material 1:1, and using different quantity of cassava and water to mix with material component to compare and trials as show in Table1, in the experiment, the pressure is fixed as 150 kg · cm²°C by using hydraulic machine to compress the material and become RDF.

Material densities are calculated by employing the equation (1) based on the ratio of plastics, dry leaves and paper as indicated in Table3, the experiment find out the colorific value in Table4, plastics, papers and dry leaves is 15.39 (MJ/kg) and temperature at burning and completed burning time as indicated in Table 5.

Table 3. Density, Mass and Volume in the Experiment

Material components	Material Ratio			Density ρ (g · cm ⁻³)	Mass (g)	Volume (cm ³)
	Material (g)	Cassava Powder (g)	Water (g)			
Plastics and dry leaves (a)	300	150	150	1.74	239	138
Plastics and papers (b)	300	100	100	1.65	195	118

Papers and dry leaves (c)	300	150	100	1.56	246	157
Plastics, papers and dry leaves (d)	300	150	150	1.54	226	147

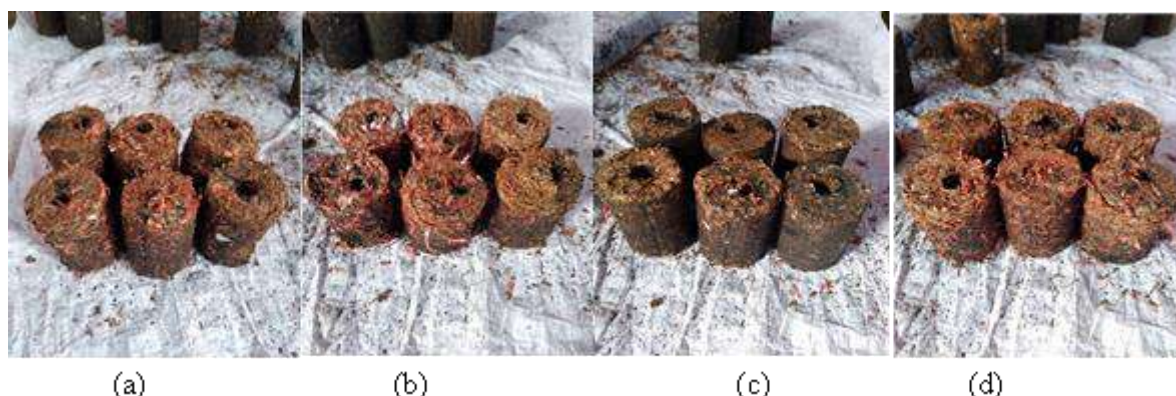


Figure 3. RDF After Completed Compress by Hydraulic Machine

Table 4. Colorific Value After Experiments

Material components	Materials (g)	Cassava powder (g)	Water (g)	Mass (g)	Calorific value (MJ/kg)
Plastics and dry leaves	300	150	150	478	14.91
Plastics and papers	300	100	100	390	14.11
Papers and dry leaves	300	150	100	492	15.02
Plastics, papers and dry leaves	300	150	150	452	15.39

Table 5. Temperature at burning and completed burning time

Material components	No of RDF (Pieces)	Mass (g)	Input Energy (MJ/kg)	Output Energy (MJ/kg)	Temperature at burning (°C)	Completed Burning time (mn)
Plastics and dry leaves	4	956	0.77	14.91	592	85
Plastics and papers	4	782	0.66	14.17	526	78
Papers and dry leaves	4	984	0.54	15.02	645	89
Plastics, papers and dry leaves	4	914	0.93	15.22	568	92



Figure 4. Temperature Experiment and Burning Time

D. CONCLUSION

This paper presents the experiment of using residual waste to produce RDF and test their calorific values of each scenario, the experiments try to find out what is the appropriate calorific value due to their material composition. Based on the testing found that the result in value of properties there is highest heat: plastic and paper and dried leaf which has the value property in 15.39 MJ/kg and mixed materials which has the lowest value of properties is plastic and paper which has the value property in 14.17 MJ/kg, in testing by burning the materials in order to finding the temperature is found mixed ratio between paper and dried leaf is easier in burning which has the high flame in 645°C) and have continuous heating including has least volume of smoke and also found that plastic mixed paper is easy to burn, there is high flame and long heating but has weak point with has more smoke.

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