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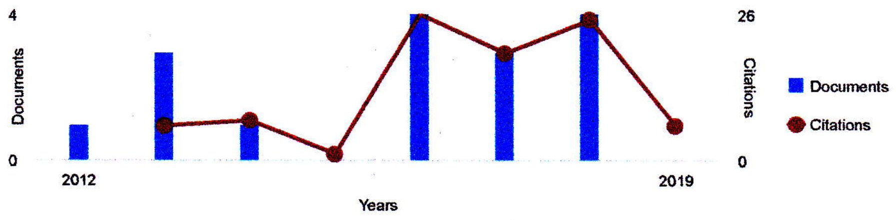


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17

H Index

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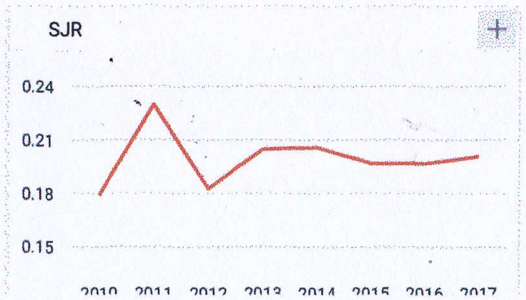


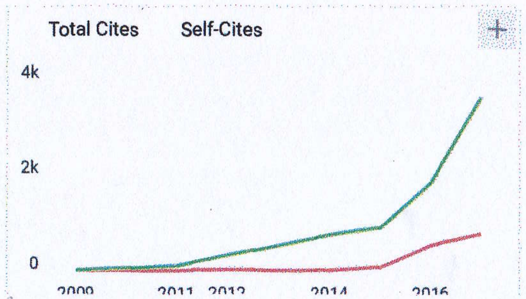


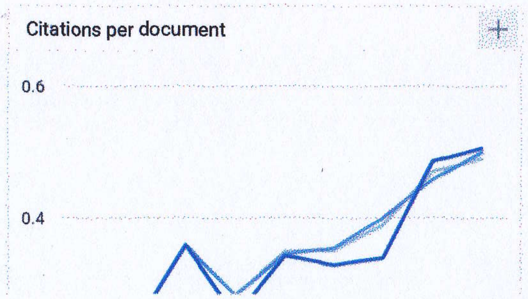

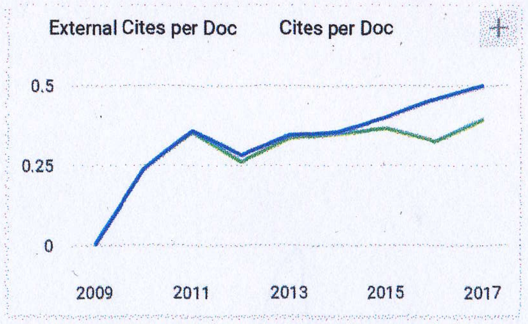


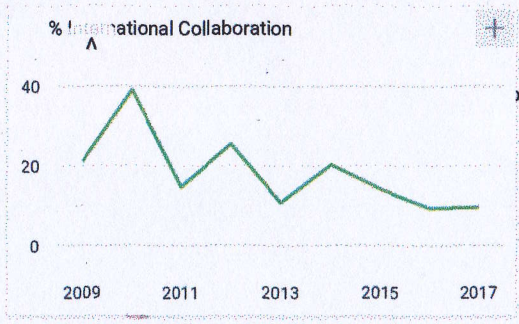


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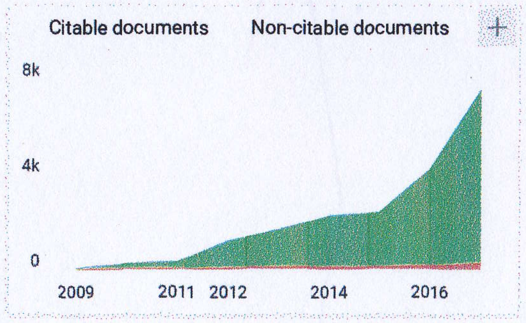


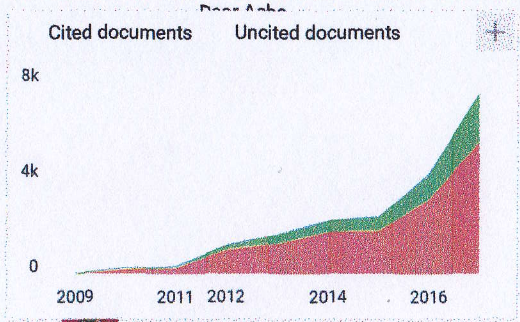



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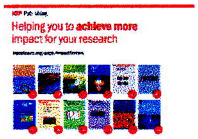


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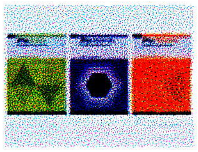

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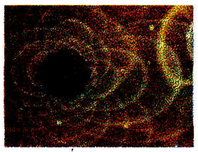

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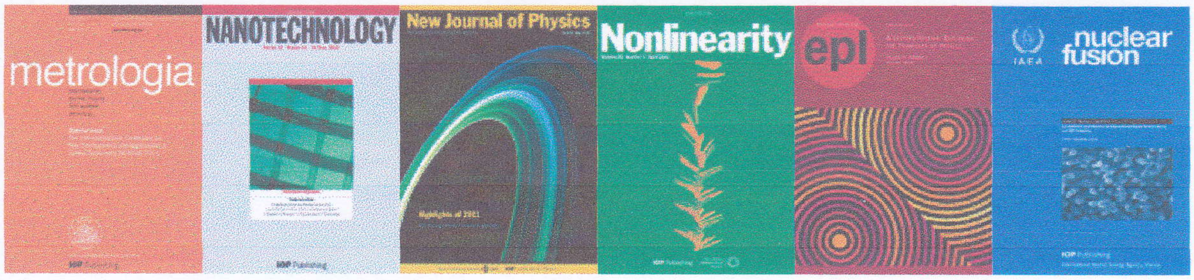


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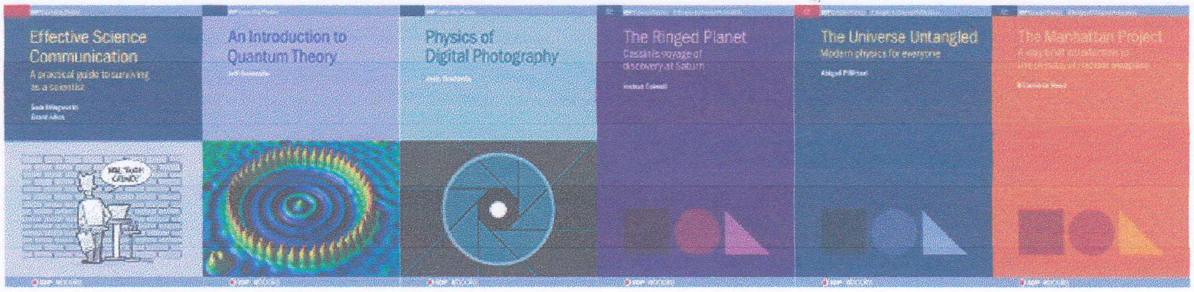


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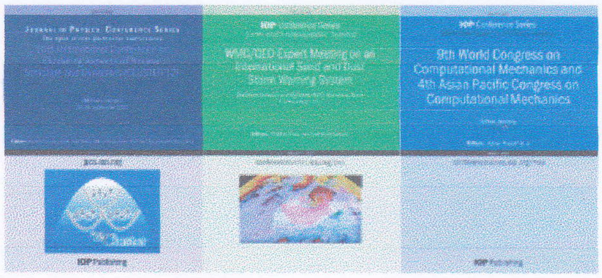


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# 5th International Conference on Mechanics and Mechatronics Research (ICMMR 2018)

IOP Conf. Series: Materials Science and Engineering **417** (2018) 011001 doi:10.1088/1757-899X/417/1/011001

# PREFACE

The 5th International Conference on Mechanics and Mechatronics Research (ICMMR 2018) was held at Morito Memorial Hall of Tokyo University of Science, Japan during July 19-21, 2018.

The conference has received 80 papers, 42 papers are accepted for publication. The participants are from Japan, USA, France, China, Korea, Indonesia, Ecuador, Iran, Pakistan, Kazakhstan, Malaysia, etc. The conference program included keynote, oral and poster presentations from scholars working in the areas to establish platforms for collaboration. This conference covered recent trends and progresses made in the field of mechanics and mechatronics research.

The objective of the conference is to bring academia, industry together to exchange and share their experiences and research results, and discuss the practical challenges encountered and the potential solutions.

International scientific activities, like conference, symposium and workshop are big scientific platforms for knowledge exchange among the scientists from all over the world. International scientific activities are the best opportunities for the students, researchers and engineers to interact with the experts and specialists to get their advice or consultation on technical matters. The theme of this conference was the key issues associated with science and technology in this rapidly evolving field of research and to promote contact between basic researches and technological needs for real advanced mechanics and mechatronics.

We express our deepest gratitude to all members of the scientific committee, invited speakers, reviewers, sponsors, participants in the conference and members of the ICMMR organizing committee for their valuable contribution to the successful organization of ICMMR 2018.

Conference Committee Chair
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# Table of contents

## Volume 417

**September 2018**

◂ Previous issue Next issue ▸

**5th International Conference on Mechanics and Mechatronics Research (ICMMR 2018)19–21 July 2018, Tokyo, Japan**

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### Accepted papers received: 15 August 2018Published online: 19 October 2018Preface



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*Petra Christian University, Indonesia*

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# Combustion Characteristics Behavior of *Pterocarpus indicus* Leaves Waste Briquette at Various Particle Size and Pressure

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# Combustion Characteristics Behavior of *Pterocarpus indicus* Leaves Waste Briquette at Various Particle Size and Pressure

**Willyanto Anggono[1], Fandi D. Suprianto[2], Gabriel Jeremy Gotama[3], Sutrisno[4] and Jovian Evander[5]**

[1,2,3,4,5]Mechanical Engineering Department, Petra Christian University, Surabaya, Indonesia
[1,2,3,4,5]Centre for Sustainable Energy Studies, Petra Christian University, Surabaya, Indonesia

E-mail: willy@petra.ac.id

**Abstract.** As one of the countries with a high variety of plant species, Indonesia becomes a potential source for biomass fuel. One plant that commonly found in the street of Surabaya, Indonesia is *Pterocarpus indicus*. The plant exists in large number and produced litters from its leaves waste. The litters negatively affect Surabaya city cleanliness. The previous study suggested a solution for this problem is by converting these litters into biomass fuel in the form of briquette. The solution may help this problem by reducing the wastes in Surabaya street and avoiding unnecessary handling of these wastes by burning or burying. In order to maximize the potential of *Pterocarpus indicus* leaves waste briquette, two primary parameters of briquette production were investigated in this study. These parameters are particle size of briquette and pressure used for compacting the briquette. This study used four burning characteristics (flame temperature, ignition time, burning time and combustion rate) to determine the best particle size and pressure to obtain the highest quality of briquette. The result of the study indicates *Pterocarpus indicus* produced with particle size of 60 mesh and compacting pressure of 2 MPa yield the best quality of briquette.

## 1. Introduction

One major cause in the decrease of fossil fuel reservoir comes from the growth of human population on earth [1,2]. The decrease of fossil fuel reservoir brings unfavorable condition in fuel market by putting the price of energy resources higher. A new sustainable and renewable energy resources are in demand with the decrease of fossil fuel reservoir. By utilizing new resources of renewable energy, the fluctuation of energy resources' market price will stabilize [3,4].

Biomass is one of many renewable energy sources that has been studied thoroughly. Many sources of biomass include industrial waste, algae, aquatic plants, wood, wastes of wood, urban waste (solid), agriculture crops, agriculture wastes, and animal wastes. The major advantage of biomass is its availability in nature which makes them easily acquired without requiring an exorbitant cost in the process [5]. Another advantage of biomass in term of usage as fuel comes from the capability of its sources (plants) to reduce $CO_2$. The ability of plants to reduce $CO_2$ may cause biomass fuel to leave no additional carbon footprint when utilized and thus be considered as $CO_2$ neutral fuel [5].

There are two processes used to utilize biomass as fuel. These two processes are bio-chemical process and thermo-chemical process. The bio-chemical process works by decomposing biomass material. The thermo-chemical process works by creating high energy products and using biomass as the main material. The thermo-chemical process is divided further into five categories, combustion, gasification, liquefaction, pyrolysis, and hydrogenation [1].

The most regular process for utilizing biomass is by directly ignite biomass and converting them into chemical energy. The chemical energy obtained is used by transforming them into heat, electricity, machine-driving energy and man more. This process is known as direct combustion [6]. Although convenient, directly combusting biomass without pre-processing might not always work. Biomass with water content higher than 50% cannot be burned and it is common to acquire biomass with this level of water content [1]. Pre-processing is needed to reduce the water content of biomass to a suitable level. Another weakness by directly combusting biomass is the transportation issue. Biomass requires more space during transportation because of its low bulk density. In a condition where a large amount of biomass need to be transported, the transportation requires high expenditure [7].

These weaknesses in direct combustion can be subdued by processing the biomass into briquette [7,8]. Briquette is a process to transform biomass into a product with higher bulk density and energy density [8]. Higher heating value, better energy properties, lower moisture content and higher density are some advantages of briquette compared to its raw material [9]. Steps of creating biomass are reducing the water content of biomass, shred the biomass into the desired size and compacting and forming briquette by applying pressure. The energy required to create briquettes is lower than the energy obtained from utilizing them [10]. The effect of briquette in the social environment are also positive. Briquette is found to reduce energy shortages, improving the ecological condition, and growing people's earning [11].

The wastes of plants have been one of many primary sources of biomass [12]. Countries with a tropical climate and myriads of floras varieties have a high level of biomass resources. Developing countries are also known to generate a high number of biomass [5]. Indonesia fits these characteristics and it has many plants wastes ready to be utilized as biomass fuel. One plants that are usually found in Indonesia is *Pterocarpus indicus*. *Pterocarpus indicus* is mainly found in the street of Surabaya (a major city in Indonesia) as greening plants. *Pterocarpus indicus* is a type of plant that generates a lot of wastes from its leaves. The wastes of these plant dropped in Surabaya street and become litters. The appearance of *Pterocarpus indicus* tree and its wastes are presented in figure 1. In taking care of these litters, people tried to burn them. The burning of these wastes results in additional GHG (greenhouse gases) in Surabaya air and exhausting viable source of energy. To avoid these kinds of careless treatments of *Pterocarpus indicus* leaves waste, the leaves waste can be processed into briquette fuel.

**Figure 1.** *Pterocarpus indicus* tree and leaves waste in Surabaya

Processing *Pterocarpus indicus* leaves waste by converting them into briquette may reduce the leaves waste presence in Surabaya street without adding GHG in the environment. Briquette will help the energy potential of *Pterocarpus indicus* leaves waste to be utilized and the high bulk density of briquette helps in distributing the fuel. The previous study has discovered the potential of *Pterocarpus indicus* leaves waste as briquette [4]. To further this solution by increasing the quality of briquette produced, the optimal briquette processing parameters need to be discovered. Parameters in manufacturing briquette such as particle size and pressure affect the quality of briquette [2,13]. This study was conducted to discover these parameters level to obtain the optimum size for *Pterocarpus indicus* leaves waste briquette material, and the optimum level of pressure used in compacting *Pterocarpus indicus* leaves waste briquette.

## 2. Experimental method

The steps of creating briquette begin by obtaining *Pterocarpus indicus* leaves waste. Obtaining *Pterocarpus indicus* leaves waste can be done by simply collecting the fallen leaves beneath *Pterocarpus indicus* plant. After acquiring the leaves waste, the leaves waste was dried in the sun for three days to reduce the water content of leaves waste. Afterward, the dried leaves waste was shredded into various sizes for the purpose of this study. The sized leaves waste was then mixed with tapioca flour mixture to create briquette materials. Subsequently, the blend of these materials was put under pressure to shape the briquette. After acquiring the briquettes, they are tested as part of obtaining data for the study. Final result of *Pterocarpus indicus* leaves waste briquette product is given in figure 2.

**Figure 2.** Briquette from *Pterocarpus indicus* leaves waste

In studying the effect of particle size of *Pterocarpus indicus* leaves waste briquette, three different sizes were used, 20 mesh or 800 µm, 40 mesh or 425 µm, and 60 mesh or 250 µm. These particle sizes were investigated to understand their effect on *Pterocarpus indicus* leaves waste briquette's strength and combustion characteristics. For studying the effect of compacting pressure in briquette, two levels of pressure were used, 1 MPa and 2 MPa. Pressures were applied by utilizing the hydraulic machine to a mold. The mold has 25 mm diameter and 50 mm length [4].

Briquettes created from two various pressures and three particle sizes were tested to investigate the optimum pressure and particle size for producing *Pterocarpus indicus* leaves waste briquette. The effect of this parameter on combustion characteristics was examined. The combustion characteristics investigated were flame temperature, ignition time, burning time, and combustion rate. Temperature evaluated in the briquette's surface when combustion occurred is the flame temperature. the time measured for briquette to continuously burn is known as ignition time. While the time evaluated for briquette to turn into ashes is known as burning time. The rapidity of briquette's change of mass is known as combustion rate.

## 3. Results and discussion

A previous study on *Pterocarpus indicus* leaves waste briquette discovered the optimum proportion of *Pterocarpus indicus* leaves waste and tapioca mixture. This study also conducted proximate and ultimate analyses on *Pterocarpus indicus* leaves waste briquette and determine its calorific value. The study suggested that 90% *Pterocarpus indicus* leaves waste and 10% tapioca mixture ratio is the optimum ratio for highest calorific value. The calorific value of *Pterocarpus indicus* leaves waste briquette was found to reach 4648 kcal/kg, which is higher compared to the other type of biomass briquettes such as sawdust, rice straw and sugar cane [4].

The previous study has also conducted proximate and ultimate analyses of *Pterocarpus indicus* leaves waste briquette. The proximate analysis results are 5.2 % water content, 6.2 %wt ash content, 73.3% volatile matter, 15.3 %wt fixed carbon, and 0.25 %wt total sulfur. The ultimate analysis results are 49.12 %wt carbon. 5.67 %wt hydrogen, 0.19 %wt nitrogen, 0.25 %wt sulphur, and 33.4 %wt oxygen. These two analyses results indicated that *Pterocarpus indicus* leaves waste briquette is a viable renewable energy source [4].

The effect of pressure and particle size to the flame temperature is shown in figure 3(a). The higher is the pressure and particle size, the higher the flame temperature reached by briquette. The highest flame temperature is obtained with a value of 613 ℃ from briquette composed of 60 mesh particle size and compacted with the hydraulic pressure of 2 MPa.

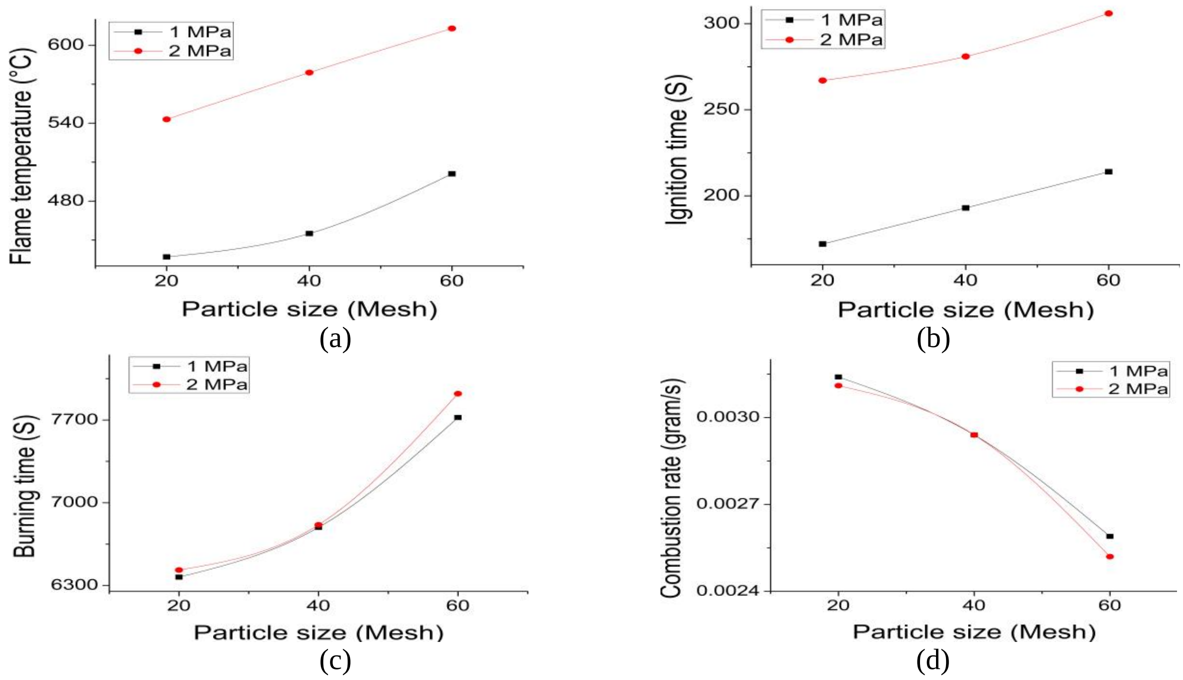


**Figure 3.** Combustion characteristics at various particle size and pressure
(a) Flame Temperature Characteristics, (b) Ignition Time Characteristics, (c) Burning Time Characteristics, (d) Combustion rate Characteristics

The effect of pressure and particle size to the ignition time value is shown in figure 3(b). The higher pressure and finer particle size lead to longer ignition time of *Pterocarpus indicus* leaves waste briquette. The longest duration of ignition time is obtained with a value of 306 seconds from *Pterocarpus indicus* leaves waste briquette composed of 60 mesh particle size and compacted with the hydraulic pressure of 2 MPa.

The effect of pressure and particle size to the burning time value is shown in figure 3(c). The higher pressure and finer particle size lead to longer burning time of *Pterocarpus indicus* leaves waste briquette, similar to ignition time. The longest duration of burning time is obtained with a value of 7823 seconds from *Pterocarpus indicus* leaves waste briquette composed of 60 mesh particle size and compacted with the hydraulic pressure of 2 MPa.

The effect of pressure and particle size on the combustion rate is shown in figure 3(d). The higher pressure and finer particle size lead to lower combustion rate of *Pterocarpus indicus* leaves waste briquette. The lowest combustion rate is obtained with a value of 0.00252 gram/seconds from briquette composed of 60 mesh particle size and compacted with the hydraulic pressure of 2 MPa.

## 4. Summary

This study shows the interaction between compacting pressure and particle size to the quality of briquette produced. As the particle size becomes smaller and compacting pressure rises, the flame temperature, ignition time, and burning rate increase. In contrast, the combustion rate decreases with finer level of particle size and higher pressure. It was discovered that the optimum pressure for compacting *Pterocarpus indicus* leaves waste briquette is 2 MPa. The optimum particle size for shredding *Pterocarpus indicus* leaves waste was found to be 60 mesh (800 µm). *Pterocarpus indicus* leaves waste briquette with these levels of parameters has a flame temperature of 613 °C, ignition time of 306 seconds, burning time of 7923 seconds and combustion rate of 0.00252 gram/second.

Although 2 MPa and 60 mesh are the best parameters found in this study, these levels of parameters might not be the most optimum for the other type of leaves waste briquette. Future research may incorporate broader range of compacting pressure and particle size to provide a more thorough study in hope for supporting the notion to utilize leaves waste as means of alternative renewable energy and promote cleaner environment.

**Acknowledgments**
Thanks to Kementerian Riset Teknologi dan Pendidikan Tinggi Republik Indonesia (Hibah Penelitian Produk Terapan 2016-2017) and Universitas Kristen Petra Indonesia for their support during this research.

**References**
[1] Goyal H B, Seal D, and Saxena RC 2008 *Ren. & Sust. Ene. Rev.* **12** 504–17
[2] Sutrisno, Anggono W, Suprianto F D, Kasrun A W and Siahaan I H 2017 *ARPN J. Eng. and App. Sci.* **12** 931 – 6
[3] Sarkar A and Praveen G 2016 *Biofuels and Bioenergy Int. Conf. (India)* (Switzerland: Springer International Publishing AG) p 117
[4] Anggono W, Sutrisno, Suprianto F D and Evander J 2017 IOP Conf. Ser.: Mater. Sci. Eng. Vol. **241** 012043
[5] Sugumaran P and Seshadri S 2010 *Biomass Charcoal Briquetting Technology for Alternative Energy Based Income Generation in Rural Areas* (India: Shri AMM Murugappa Chettiar Research Centre)
[6] Thipkhunthod P, Meeyoo V, Rangsunvigit P, Kitiyanan B, Siemanond K and Rirksomboon T 2005 *Fuel* **84** 849–57
[7] Sengar S H, Mohod A G, Khandetod Y P, Patil S S and Chendake A D 2012 *Int. J. Ene. Eng.* **2** 28–34
[8] Mwampamba T H, Owen M and Pigaht M 2013 *Ene. Sust. Dev.* **17** 158–170
[9] Stolarski M J, Szczukowski S, Tworkowski J, Krzyżaniak M, Gulczyński P and Melczek m 2013 *Renew. Ene.* **57** 20–6
[10] Sakkampang C and Wongwuttanasatian T 2014 *Fuel* **115** 186–9
[11] Hu J, Lei T, Wang Z, Yan X, Shi X, Li Z, He X and Zhang Q 2014 Energy **64** 557–66
[12] Anggono W, Suprianto F D, Sutrisno, Gotama G J, Evander J, Kasrun A W 2018 ARPN J. Eng. and App. Sci. **13** 1080-4
[13] Anggono W, Suprianto F D, Sutrisno and Kasrun A W 2016 Int. J. Ind. Res. and App. Eng. **1** 11 –4