Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 142 (2017) 2797–2801

Energy Procedia

www.elsevier.com/locate/procedia

9th International Conference on Applied Energy, ICAE2017, 21-24 August 2017, Cardiff, UK

Technology for public outreach of fuel oil production from municipal plastic wastes

Muhammad Kunta Biddinika[a,*], Mochamad Syamsiro[b], Arip Nur Hadiyanto[b], Zahrul Mufrodi[c], Fumitake Takahashi[a]

[a]*School of Environement and Society, Tokyo Institute of Technology, 4259 Nagatsuta-cho Midori-ku, Yokohama 226-8503, Japan*
[b]*Center for Waste Management and Bioenergy, Universitas Janabadra, Jl. T.R. Mataram 57, Yogyakarta 55231, Indonesia*
[c]*Chemical Engineering Department, Universitas Ahmad Dahlan, Jl. Prof. Dr. Soepomo, Yogyakarta 55164, Indonesia*

Abstract

Improving public understanding and awareness is often considered as one of key factor on the waste-to-energy implementation. In order to improve awareness on plastic separation from household waste, an education and public outreach activity has been initiated by involving the development of pyrolysis technology for producing liquid oil. The technology is an integrated system of pyrolysis machine and shredding machine. The system need to cope with challenge of flexibility and easy transportation from one community-based waste recycle (waste bank) to another for campaign or education purpose. The technology is expected to exhibit the benefit of plastic waste to be converted as an alternative source of burnable oil for household.

Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.

Keywords: waste-to-energy; plastics waste; pyrolysis; recycling bank; waste bank

1. Introduction

An effort to improve public understanding and awareness on the benefit of plastics waste has been initiated by presentation of fuel oil production from municipal plastic waste in waste banks. By improving its understanding, public may have more willingness to participate into 3R (reduce, reuse, recycle) activities of plastic waste. However, the response of attendance showed that the presentation could have been more interesting if the whole process could be seen, including the plastics waste in its original form. Up to now, the presentations have been carried out by plastics

* Corresponding author. Tel.: +81-45-924-5585; fax: +81-45-924-5518.
E-mail address: kunta.m.aa@m.titech.ac.jp, mkuntab@gmail.com

1876-6102
Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.
10.1016/j.egypro.2017.12.424

feedstock for the pyrolysis machine which has been in the form of small size in order to maximize the reactor capacity, while the shredding process from the original form of plastics waste had been carried out separately prior to the presentation. Since the limited number of the machine, it should be easily transportable from one waste bank to another as well as operable without difficulty for education and campaign purposes.

Therefore, in order to fulfill requirement of small size pyrolysis feedstock whilst presentation of plastic waste-to-oil conversion, a shredding machine has been designed and currently being developed

2. Theoretical background

Education and public outreach has been recognized as the essential contributions of scientists and engineers to the community since it provides exciting connections between science and the real world [1]. Several activities are often considered as the outreach, such as exhibition, guided tours or visits, workshop, and film screening [2]. In addition, scientists and engineers giving presentations, tutored, and organized or judged science fairs, developing resources and curricula, interacting with children or lay persons are also considered as outreach participation [3].

Dhokhikah *et.al* [4] defined the waste bank as a bank that is established by local community, it receives recyclable waste from member of the community as the customer/client of the bank. Different types of solid waste materials have different prices per kilogram, while each client has a deposit book containing type of waste, weight, price per kilogram, and total money received. The bank is able to minimize the volume of solid waste from its sources prior to transporting to the temporary disposal sites.

The fuel oil production in this paper employs sequential pyrolysis and catalytic reforming technology which converts municipal plastics wastes into fuel oil [5]. The technology uses commercial and natural zeolite catalysts available in Indonesia. The liquid product of the technology is utilized for fueling diesel engine as a single fuel of blending with commercial diesel fuel, while its gaseous product is used either as a heating source for cooking gas stove application and its solid product is used for co-firing with coal and biomass.

3. Methodology

The study is initiated by designing and fabrication of plastic shredder in a small scale so that it fits for the deployment to community-based waste collection and recycle center. The shredder is designed to have a working capacity of 20-30 kg per hour so that is capable of being used together by some centers within vicinity area simultaneously. The machine is designed to be powered by diesel/gasoline engine due to operational consideration such as the absence of electric power or low electric power available in the waste bank so that it is unable to supply the machine.

The design of the machine was performed part by part of its units for the ease of assembly. They are inlet unit where plastic waste material inserted, shredding unit (knife), outlet unit, and mover.

4. Results and discussions

The work principle of this shredding machine is by rotating blade using gasoline/diesel engine. Power from the engine is transmitted by pulley and belt. The pulley serves to reduce rotation of the engine. Plastic waste materials which has been cleaned were inserted into the machine through inlet unit and the plastic went down to shredding blade. The shredded plastics went out through the filter and then outlet.

The main components of the machine are machine frame, shredding knife, filter, upper casing, and mover. The frame serves as a supporting component of the machine in which the other components are installed, such as gasoline/diesel engine, shredding knife, and upper casing. Design of the frame is shown in the following Fig.1. From the side view of the frame, the bulge part is a holder for the engine.

The shredding knife consists of 5 (five) blades, 3 (three) of them are rotating following the rotation of the shaft, and 2 (two) of them are statically attached on the frame as shown in Fig.2. The shredding process occurs while the position of the rotating blades coincides with the static blades. Shredding blades are the soonest worn-out components of the machine.

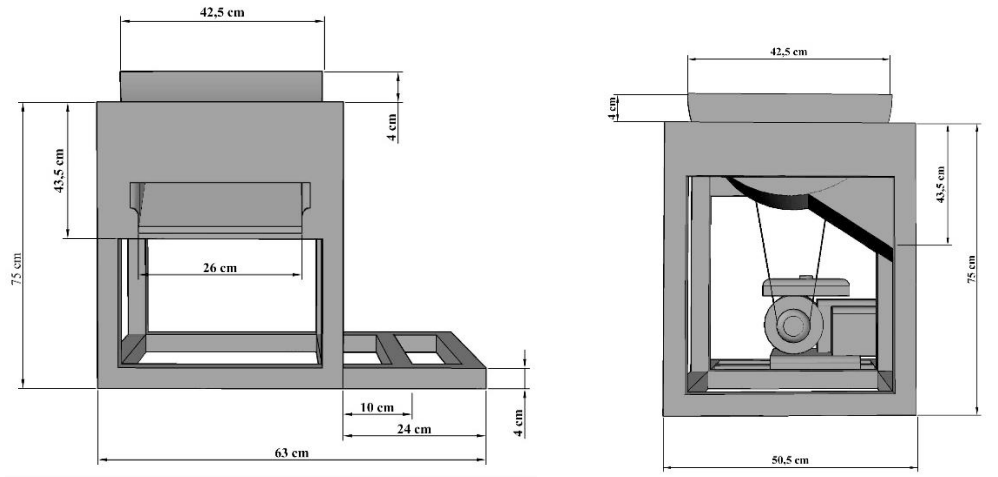

Fig. 1. Design of plastics shredder's frame; side view (right); front look (left)

The filter serves to ensure the plastic material is in small size to maximize the pyrolysis reactor capacity. Each hole of the filter is designed to be 2 cm in diameter and each hole is located by 3 cm in distance as shown in Fig.3. The filter is designed in a U-shaped in order to ease the shredded plastics go out from the machine. The diameter of the hole depends on the size of plastics as the feedstock of pyrolysis reactor, hence the filter may be modified according to the required size of pyrolysis feedstock.

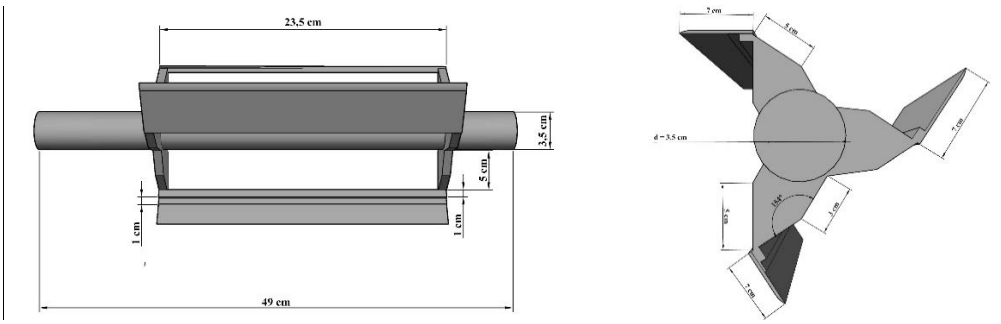

Fig. 2. Design of plastics shredding knife; side view (right); front look (left)

The upper casing serves as the inlet unit for plastic waste materials as well as the protection unit preventing plastic materials from being thrown out due to the rotating force of the shredding knife which may hurt people standing in the vicinity of the machine. The casing is designed in certain angles as shown in the side view of Fig.4 in order to effectively prevent the plastic materials splashed out on upward direction due to rotation force of the knife.

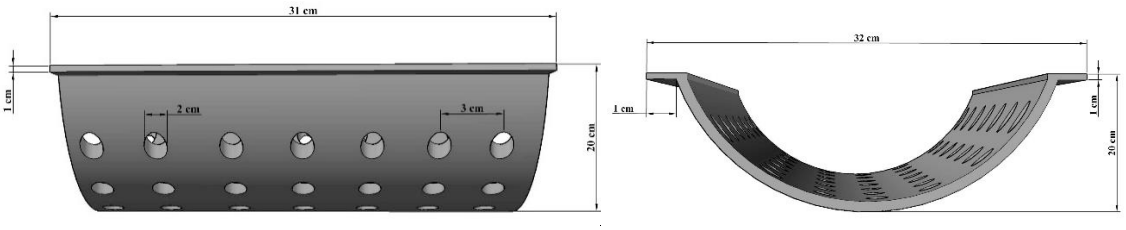

Fig. 3. Design of filter unit; side view (right); front look (left)

The mover unit is a gasoline/diesel engine which is capable of generating 5.5 horse power (hp). It is attached on the bulge part of the lower frame. The engine and the pulley, as the mover of shredding shaft, is connected by a V-shaped belt as shown in Fig.5. The overall arrangement of the machine is also shown in Fig.5. As a whole, the machine has a dimension of 63 cm x 50.5 cm x 136.5 cm (length x wide x height). After design process, the machine was fabricated in a local workshop.

.

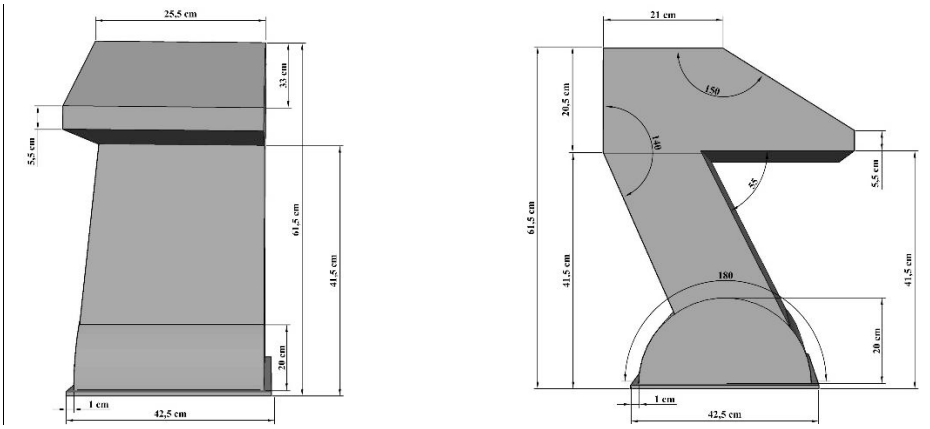

Fig. 4. Design of upper casing; side view (right); front look (left)

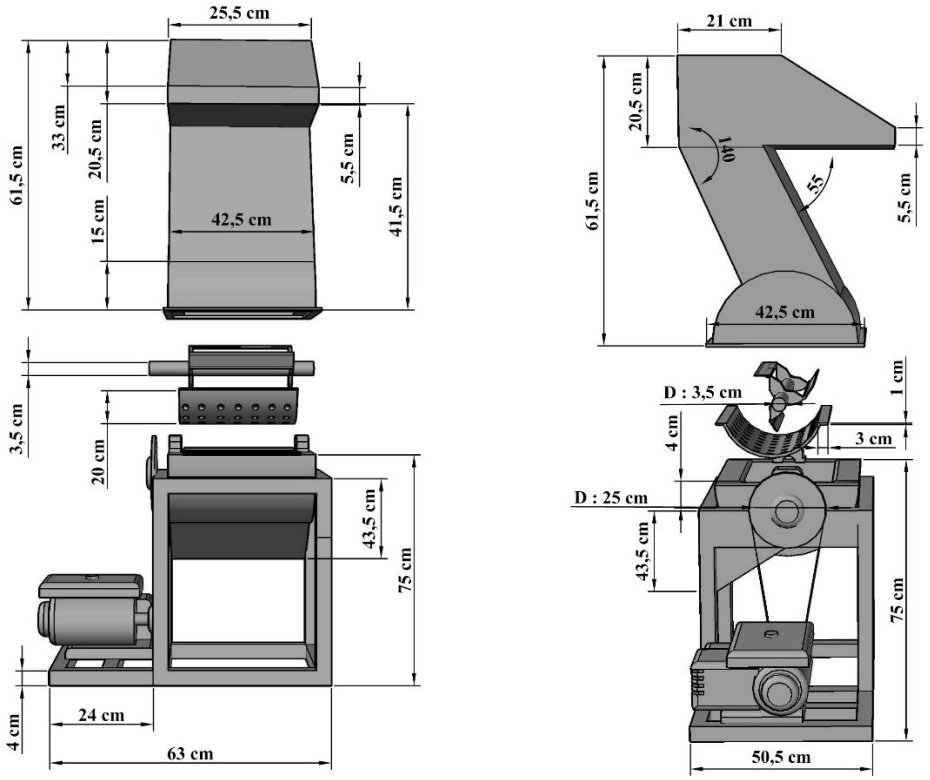

Fig. 5. Design of plastics shredder's frame; side view (right); front look (left)

The machine then underwent operation test in order to observe whether the machine works as designed. The test has been carried out by using PET bottles as the sample of plastic waste materials. The test was carried out in rotation speed of 450 rotation per minute (rpm) without loading. During the shredding process, the speed was decreasing into approximately 350 – 380 rpm due to the loading on the rotating blades. The test showed the machine works well.

The short testing indicates the machine may have the production capacity of 14 kilograms shredded plastic materials from PET bottles within an hour. This production capacity is considered as low capacity because of a little amount of plastic waste as the sample. It caused the plastic waste was unable to be shredded well so that the waste was also difficult to go down from the filter unit. The shredded plastic in the filter unit was supposed to be driven by new plastic waste, however, adding the flowing water into shredding chamber from upper casing inlet was also helpful to drive the plastic waste out from the machine.

5. Conclusions and lesson learned

The design and fabrication of plastic waste shredding machine has been carried out in order to supply the feedstock of pyrolysis process of the waste. The capacity production of the machine depends on the thickness of the plastic waste. The shredding machine has complementary functions with the pyrolysis machine, however, both of them serve for campaign or education purpose on the waste recycle activities. The operational experience indicates that diesel engine emits exhaust fumes and more noise compared with that of electric motor as the knife mover. The exhaust fumes and noise are not convenient for in-door operation since some of the waste banks are located in-door.

Acknowledgements

This study is financially supported by the Ministry of Research, Technology, and Higher Education, Republic of Indonesia through *Iptek bagi Masyarakat* (IbM) scheme, year 2016 and by JSPS KAKENHI Grant Number 15H05228. The authors greatly appreciate the support.

References

[1] C.A. Morrow, P.B. Dusenbery, Workshops for scientists and engineers on educationand public outreach, Adv. Sp. Res. 34 (2004) 2153–2158. doi:10.1016/j.asr.2003.05.061.

[2] A.M.M. Farrona, R. Vilar, How can we turn a science exhibition on a really success outreach activity?, Nucl. Part. Phys. Proc. 273–275 (2016) 1225–1228. doi:10.1016/j.nuclphysbps.2015.09.194.

[3] E. Andrews, A. Weaver, D. Hanley, J.H. Shamatha, G. Melton, Scientists and public outreach: Participation, motivations, and impediments, J. Geosci. Educ. 53 (2005) 281–293. http://cires.colorado.edu/education/outreach/rescipe/papers/andrewsJGE2005preprint.pdf.

[4] Y. Dhokhikah, Y. Trihadiningrum, S. Sunaryo, Community participation in household solid waste reduction in Surabaya, Indonesia, Resour. Conserv. Recycl. 102 (2015) 153–162. doi:10.1016/j.resconrec.2015.06.013.

[5] M. Syamsiro, H. Saptoadi, T. Norsujianto, P. Noviasri, S. Cheng, Z. Alimuddin, K. Yoshikawa, Fuel oil production from municipal plastic wastes in sequential pyrolysis and catalytic reforming reactors, Energy Procedia. 47 (2014) 180–188. doi:10.1016/j.egypro.2014.01.212.