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Proceeding

The 2nd International Conference of the Indonesian Chemical Society 2013

ICICS 2013

Research in Chemistry for Better Quality of Environmental

Universitas Islam Indonesia, Yogyakarta, Indonesia
October, 22 - 23th 2013

Abdul Kahar Muzakkir, Conference Hall
Universitas Islam Indonesia (UII), Yogyakarta.
Kampus Terpadu, Jl. Kaliurang KM 14,5 Sleman, Yogyakarta.

Preface

The international conference is an annual conference of the Indonesian Chemical Society (Himpunan Kimia Indonesia, HKI). In the year 2013, the mandate of the organizing committee was given to the HKI Yogyakarta branch and also supported by Department of Chemistry of Universitas Negeri Yogyakarta (UNY), Department of Chemistry of Universitas Gadjah Mada (UGM), Department of Chemistry of Universitas Islam Negeri Sunan Kalijaga (UIN Suka), National Nuclear Energy Agency (BATAN Yogyakarta), and Volcano Investigation and Technological Development Center (BPPTK Yogyakarta). For the year 2013, ICICS 2013 is hosted by Department of Chemistry, Faculty of Mathematics and Natural Sciences, Islamic University of Indonesia, Yogyakarta from October 22 – 23, 2013. This conference was also prepared to celebrate 70th anniversary of Universitas Islam Indonesia.

The Sicentific Programme of ICICS2013 comprises the following:

1. Invited Speaker 11 papers
2. A total 256 paper for parallels sessions
   a. Organic Chemistry 32 papers
   b. Inorganic Chemistry 43 papers
   c. Physical Chemistry 37 papers
   d. Analytical Chemistry 68 papers
   e. Education Chemistry 23 papers
   f. Biochemistry 43 papers

The breakdown of the presentation is as follows:

Session	**Oral**	**Poster**	**Total**
Invited Speaker	11	0	11
Organic Chemistry	25	7	32
Inorganic Chemistry	38	5	43
Physical Chemistry	31	6	37
Analytical Chemistry	61	7	68
Education Chemistry	22	1	23
Biochemistry	34	8	43
Total	**222**	**34**	**256**

Yogyakarta, 25th November 2013

Editors

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Welcoming Address by The Organizing Committee

Assalamu'alaikum Wr. Wb.

Honorable Rector of Universitas Islam Indonesia
The distinguished invited speakers, and
All participants of the ICICS 2013

Welcome you at the 2nd International Conference of the Indonesia Chemical Society 2013 (ICICS 2013) this morning here at the Auditorium Kahar Muzakkir Universitas Islam Indonesia, Yogyakarta. The international conference is an annual conference of the Indonesian Chemical Society (Himpunan Kimia Indonesia, HKI). In the year 2013, the mandate of the organizing committee was given to the HKI Yogyakarta branch and also supported by Department of Chemistry of Universitas Negeri Yogyakarta (UNY), Department of Chemistry of Universitas Gadjah Mada (UGM), Department of Chemistry of Universitas Islam Negeri Sunan Kalijaga (UIN Suka), National Nuclear Energy Agency (BATAN Yogyakarta), and Balai Penyelidikan dan Pengembangan Kegunungapian (BPPTK Yogyakarta). For the year 2013, the honor of hosting ICICS 2013 has been given to the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Islam Indonesia, Yogyakarta. This conference was also prepared to celebrate 70th anniversary of Universitas Islam Indonesia.

The conference comprises both oral and poster presentation in English and Indonesian with optional post conference publication of full papers in English in the Procedia Chemistry (Elsevier, ISSN: 1876-6196) and Proceeding Conference for Indonesian language. There are 211 papers presented orally and 34 papers presented by poster covering wide-variety subjects of chemistry. We invited 6 Indonesian invited speakers, 2 Japan invited speakers, 1 Australian invited speakers, 1 Saudi Arabia invited speakers, and 1 Malaysian Invited speakers.

We hope you will enjoy a pleasant and valuable seminar at Universitas Islam Indonesia

Wassalamu'alaikum Wr. Wb.

Riyanto, Ph.D.

Chairman

Opening Speech from the Rector of Universitas Islam Indonesia

Assalamu'alaikum Wr. Wb
The distinguished invited speakers, and
All participants of the ICICS 2013

Firstly, I would like to express my great appreciation to the Department of Chemistry UII as one of the organizers of the program The 2nd International Conference of the Indonesian Chemical Society 2013 (ICICS 2013) with the theme "Research in Chemistry for Better Quality of Environmental". I am proud that this interesting event is being organized and held in Yogyakarta.
As the biggest and the oldest private university in Yogyakarta, University Islam Indonesia is committed to the excellence in research and teaching. Recently, we are preparing UII as one of the world class universities.
Knowing that committee has selected outstanding speakers from various prestigious institutions. I believe that all of the participants will enjoy the discussion of issue covered by the topic of this seminar. Scientist have shown that the environment's condition is increasingly critical, and human industrial activities are largely to blame. In fact that environmental damage is a crisis we caused together, therefore, a responsibility we all share together. We are deeply concerned with the issues and opportunities in the internationalization of sciences for better life, sciences have to make better quality of environmental.
Finally, I would once again like to thank the organizer for organizing this event, and to thank all the participants attending this ICICS 2013 event as well as delivering their scientific presentations. I do really hope that you can enjoy this seminar and have excellent stay in Yogyakarta.

Wassalamu'alaikum Wr. Wb

Prof. Dr. Edy Suandi Hamid, M.Ec.
Rector of Universitas Islam Indonesia

Remarks by the Chairman of the Indonesian Chemical Society (Himpunan Kimia Indonesia, HKI)

Indonesian Chemical Society (Himpunan Kimia Indonesia, HKI) is an independent, nonprofit organization founded in February 1962 to facilitate communication among Indonesian chemists and other professionals from chemistry related fields, and to promote the advancement of science, education, and application of chemistry to support the better life of mankind. HKI organize activities to enhance communication and collaboration among chemists in various institutions in Indonesia, to disseminate new knowledge and research results in chemistry and related fields, to improve the knowledge and skills of chemists working in schools, universities, industries, research institutes, and other sectors, to nurture a scientific temper on school children to ensure strong capabilities of future chemists that are needed for humankind, and other activities that support its missions. HKI holds various academic conferences, publishes several journals, supports the development of scientific information systems in Indonesian; organize training for chemists in various sectors, etc.

The 2013 International Conference of the Indonesian Chemical Society will be the 2nd event in the ICICS conference series, started in 2012, that brings together individuals involved in chemistry-related fields (chemistry, pharmacy, environmental science, chemical engineering, molecular biology, material science, education chemistry, etc.) or institution in chemistry-related sectors. The First International Conference of the Indonesian Chemical Society 2012 is organized by East Java Branch of HKI in collaboration with chemistry departments at several universities in East Java: ITS, UB, UIN Maliki, UM, UMC, Unair, Unej, and Unesa.

ICICS 2013 will be organized by the Indonesian Chemical Society Yogyakarta branch. The international conference was supported by the Indonesian Chemical Society (Himpunan Kimia Indonesia, HKI), Department of Chemistry of Universitas Negeri Yogyakarta (UNY), Department of Chemistry of Universitas Gadjah Mada (UGM) and Department of Chemistry of Universitas Islam Negeri Sunan Kalijaga (UIN Sunan Kalijaga). For the year 2013, the honor of hosting ICICS-2013 has been given to the Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Islam Indonesia (UII), Yogyakarta, Indonesia.

Congratulations to the ICICS 2013 committee for this conference.

Dr. Muhamad Abdulkadir Martoprawiro
Chairman of the Indonesian Chemical Society

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CONTENT

Design and Performance Test of a Small Scale Crusher and Briquetting Equipment to Produce Fuel Briquettes from Municipal Solid Waste by Densification Technology

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Abstract

It is generally acknowledged that burning of fossil fuels and deforestation are major contributors to the global warming and anthropogenic climate change. Behind coal and oil, biomass is the third largest energy resource in the world. Biomass from plants can serve as an alternative renewable and carbon-neutral raw material for the production of energy. One of the least-expensive biomass resources are the municipal solid waste. To be suitable used as a solid fuel, the solid waste should be densified in order to increase its density. Pelleting, briquetting, extrusion and agglomeration processing are methods commonly used to achieve densification. The goal of this research work is to design a small scale crushing and briquette-making equipment which is appropriate to produce fuel briquettes from municipal solid waste. The design analysis of the crusher resulted in 1,5 hP power consumption for laboratory scale crusher. The result of the performance test show that the crusher capacity is about 25 kg/h and the dimension of the solid waste cut is in the range of 6,1 – 6,8 mm which is suitable for fuel briquette formation. Bulk density briquettes produced is still low at 113.7 kg/m^3 due to low compression resulted by human power. The resulting fine after shaking the briquetting is quite small , i.e. 9.99%, showed that tapioca starch is acts as a pretty good adhesive. The result of water content measurements indicate the briquette meet the water content standard for briquettes from solid waste, while calorific value obtained from the measurement has also already met the minimum standards of caloric content for briquette originating from solid waste.

Keywords: briquette, densification, fuel, solid waste

Introduction

Burning of fossil fuels is acknowledged as the main contributor of the global warming. Global warming is one of the serious environmental problems facing the world's population today. Global warming causes many changes in natural conditions such as storms, hurricanes, floods, droughts and forest fires. Beside that, it also caused many adverse impacts such as a fast polar ice melts, an increase some pest and disease vectors in a wide range and activities, disruption of water supply in some areas, which all lead to a disturbance of human life.

The cause of the global warming is the increase of the Green House Gas (GHG) concentration in the atmosphere. One of the components of Green House Gases generated from human activities is carbon dioxide (CO_2). Concentration of carbon dioxide in the atmosphere is increasing rapidly due to the combustion of fuel oil / fossil, coal and natural gas.

International conventions related to global warming issue is the Kyoto Protocol On Climate Change, where the convention is intended to reduce Green House Gas emissions, reduce dependence on fossil fuels and encourage the use of renewable energy. Kyoto Protocol also encourages cooperation between developed and developing countries to achieve sustainable development by using a Clean Development Mechanism (CDM).

Behind coal and oil, biomass is the third largest energy resource in the world. Biomass from plants can serve as an alternative renewable and carbon-neutral raw material for the production of energy. One of the least-expensive biomass resources are the municipal solid waste. To be suitable used as a solid fuel, the solid waste should be densified in order to increase its density. Pelleting, briquetting, extrusion and agglomeration processing are methods commonly used to achieve densification. Biomass and waste –based renewable energy technologies can take a key role in combating global warming and other problems associated with fossil fuels.

Production of fuel briquettes from municipal solid waste components is aimed to recover the combustible components of the waste and to be converted to briquettes which is can be used as a substitute or supplement of energy source. In this case the use of fuel briquettes which is produced from municipal solid waste can be seen as the embodiment of clean development mechanism and in line with the Kyoto Protocol.

Fuel briquettes from municipal solid waste become one of an attractive alternative to address both global warming and the problems of urban solid waste management. The benefit gained is not only improving the quality of the world environment, but also reduce loss of the local economy potential (Jidapa Nithikul, 2007).

Research, development and applications of production of fuel briquettes from municipal solid waste in Indonesia could also be viewed as a manifestation of Indonesia's support to the implementation of the Kyoto Protocol, to which Indonesia is one of country which has signed and even has ratified the Kyoto Protocol.

The goal of this research work is to design and to conduct a performance test a small scale crushing and briquetting machine which is appropriate to produce fuel briquettes from municipal solid waste.

Literature Review

Solid waste can be classified into several groups, the largest group is municipal solid waste (MSW) which consist of materials from household/residential waste and waste from commercial activities (commercial waste). Other groups are industrial waste, and construction waste (Nickolas J., et al., 2002). Municipal solid waste is the least homogeneous, because it consist of almost all types of waste / remnants of materials used by the public, ie: food, organic waste, paper, plastics, fibers, rubber, leather, metal, glass and other inorganic materials. Disposal of municipal solid waste become a big problem in many cities in the world, including in Indonesia.

The most desired municipal solid waste management hierarchy are: reduce, re-use, recycle, utilize as an energy source (energy recovery) and disposal into the land (landfill), as shown in Figure 1 (Eduardo Ferrer, et al., 2005).

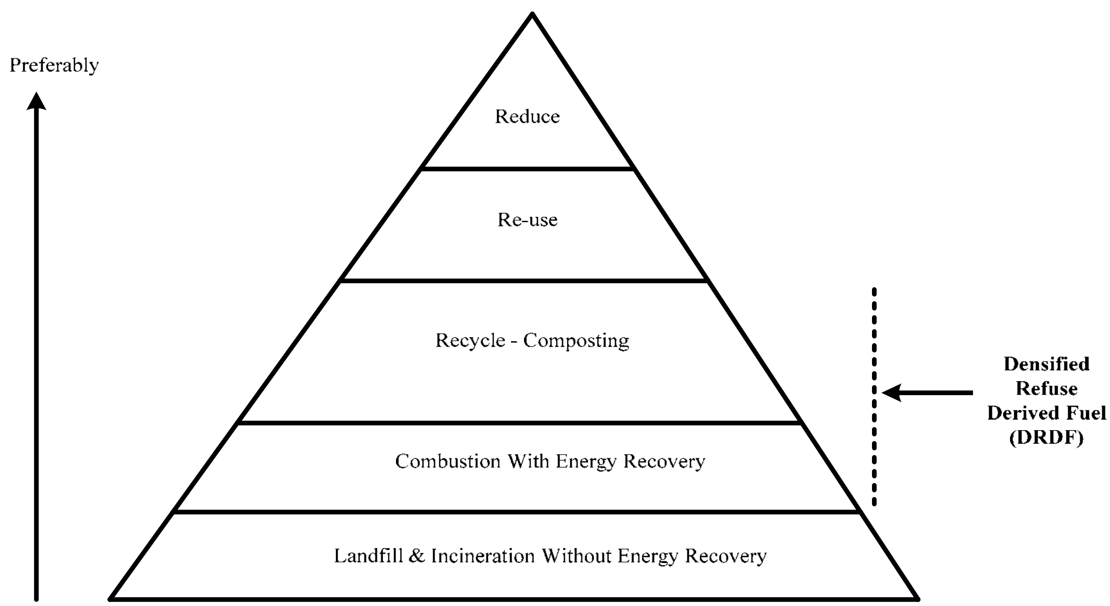

Figure 1: Municipal solid waste management hierarchy

Until now land filling is the most widely used option, but besides require large tracts of land this method also cause environmental problems namely pollution of soil, water and air as well as increase greenhouse gas (GHG) emission due to the production of methane gas.

Increasing the impetus for re-utilization or recovery of materials and energy and the need for alternative disposal other than land filling of municipal solid waste, has been growing interest to convert solid waste into fuel. Utilization of waste into a source of energy has become a serious attention from time to time as the cost for disposal (landfill) and environmental health issues is increasing in developed countries, including in Indonesia.

Indonesia with a population of around 250 million in 2012 and more than 6% economic growth rate has accelerated urbanization and industrialization. Levels of waste production per capita is strongly linked with the economic progress of a country. For countries with medium incomes, waste production rate is approximately 0.80 kg/capita/day (WA Wan, et al., 2009). It requires serious attention of the government to collect, process and dispose of the waste safely.

Commonly, municipal solid waste was collected and managed by local government authorities/municipalities. The waste is mainly derived from household waste, while the rest come from commercial waste and industrial waste (Defra, 2007). Along with the growth of the urban population, the amount of municipal waste is also increasing year by year and resulting in an increase problems related to the difficulty in managing the provision of area for land filling and environmental pollution. Michael H. Eley & Gerald R. Guinn (1994) states that there are several ways to convert municipal solid waste into useful fuels, such as direct combustion (direct burning), pyrolysis and anaerobic treatment (anaerobic digestion).

Production of fuel briquettes from municipal solid waste, in principle, is a separation of components that can be burnt (combustible) from materials that can be recycled (recyclables) and materials that are not flammable (non-combustible). Components that can be burnt are widely known by the term of "refuse-derived fuel" or RDF. Basically, processing the municipal solid waste into fuel briquettes through a series of treatments that include sorting, drying, destruction/size reduction (shredding) and the formation of briquettes (briquetting).

One of the disadvantage that limit the use of biomass as an alternative fuel to produce energy is the low bulk density, which only ranged between 80-100 kg/m^3 for rice straw and grass and up to 150-200 kg/m^3 for biomass sourced of wood (woody biomass). The low bulk density of biomass resulted in difficulties in storage, feeding, transportation, and use. Moreover, the low bulk density of biomass also be a problem when it is used as a companion fuel (co-firing), because it creates difficulties in feeding and cause the combustion efficiency low. Densification became one of promising option to overcome these problems. During densification, biomass is mechanically compressed, increasing its density to be approximately 10 times larger. To make the briquettes component are bind strongly to each other, the use of binder material was needed.

The fuel briquettes which are produced from the waste consists mainly of organic materials such as municipal waste plastics, paper, wood and other organic materials, so that the briquettes containing flammable material fraction higher than the waste materials to be processed.

Fuel briquettes from municipal waste can replace coal in the industrial sector and has been successfully used as fuel steam generators (boilers) with high efficiency and clean emissions. The resulting briquettes considered quite solid, has a heat content of approximately equal to the heat content of coal and economically can be transported to the center of the combustion facility to be converted into energy, such as steam power plant (SPP), steam boiler, and industries that require fuel. Furthermore, monitoring activity in the combustion facilities and pollution control can be integrated (Lai Wei-chum). The process has made fuel briquettes from municipal waste to be potentially used as a fuel and recently seen to be a good alternative solution in the management of municipal solid waste. Another advantage of converting urban waste into fuel briquettes are reduced land requirement for landfill.

Materials and Method

Flow diagram of manufacturing process of fuel briquettes from municipal solid waste was presented in Figure 2. The first stage of the workflow process is screening the municipal solid waste to separate the small particles which mostly consist of sand, soil and food waste. The next stage is manually separate the waste and to be divided into 4 groups, i.e.: 1). The recyclable materials (mainly plastic, glass and metal); 2). The non-combustible materials such as bone, stone, ceramics, etc..; 3). The organic materials which has high water content (fresh leaves, vegetables, and other agricultural products) which are generally derived from household waste and waste from traditional markets.; 4). Material with high calorific value (plastic, paper, rubber, wood, leather, etc..). The group of materials that can be recycled will have economic value in accordance with the price of recycled materials prevailing in the market. While the group of organic material which has high water content is then fed to composting process to produce compost that is also has high economic value as a fertilizer and soil conditioner.

The group that will be processed into fuel briquettes are materials that have a high calorific value, which is generally made up of plastic, paper, rubber, wood, leather, etc.. Against these groups, if necessary drying was performed to a certain moisture content prior to be fed into shredder/size reduction to obtain materials with size less than 40 mm. The final stage is the formation briquettes by densification technology.

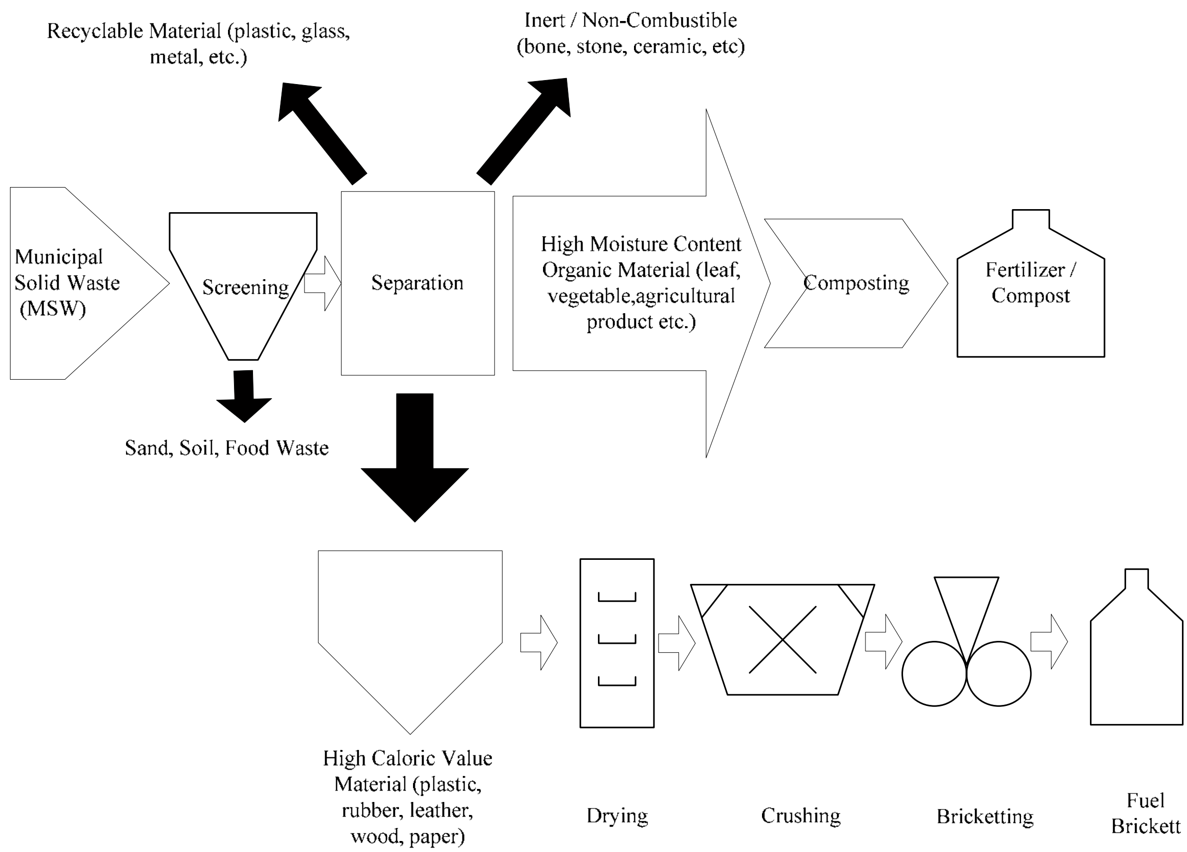

Figure 2: Process flow diagram of the manufacturing of fuel briquettes from municipal solid waste

At this research work design a small scale crushing and briquetting machine which is appropriate to produce fuel briquettes from municipal solid waste was done. Performance test was conducting to examine the ability of each machine, afterward. Artificial municipal solid waste which its composition close to the composition of the combustible component of municipal solid waste was used as was presented in Table 1.

Table 1: The composition of the artificial waste used in the experiment

Component	% weight
fresh organic origin	60
paper	15
plastic	15
wood	5
textile	3
rubber & leather	2

Each component was dried under sun light to reduce its water content up to less than 10 % before it was fed to the crusher. Refer to composition as presented in Table 1, all cut materials then mix. As a binder material, tapioca starch-water mixture was added to the mix material. The final step is to prepare a certain amount of mix material which proper to the volume of briquetting-making equipment's mold. In this work ratio of the starch, water and dry raw material was varied to investigate the best ratio of it.

Results and Disscussion

Design of crushing machine

Based on the identification of crusher requirement for lab scale, it is determined that the crusher specifications is as follow: capacity: 25 kg / h, the maximum propulsion motors: 2 HP, maximum overall dimensions: 90 cm X 50 cm X 150 cm . Diagram of the designed crusher by part and its physical view were presented in Figure 3.

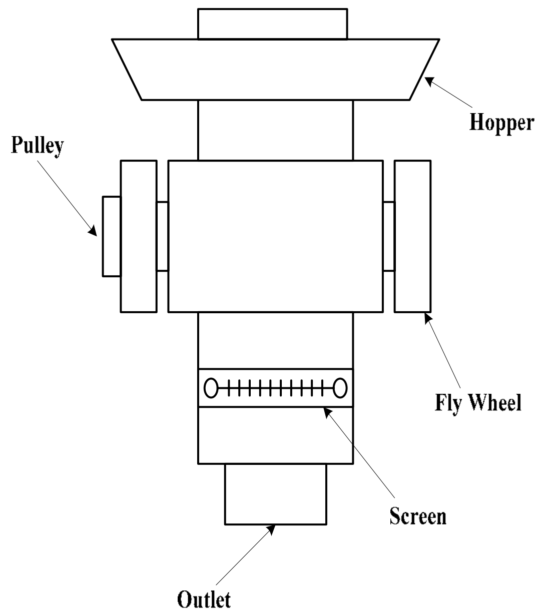

Figure 3: Diagram of the crusher by part and its physical view

At the crusher, there are some parts that receive the critical load which needs to be analyzed the resistance when certain load was applied. The critical load could potentially cause damage to the component itself or other components lead to crusher malfunction. Furthermore, in the crusher there are some parts that can undergo critical load i.e. the cutting systems, and motion systems and the connections of crusher body/frame. Rotating cutter is the most important part of the crusher, because the size reduction process carried out by the rotating cutter blades. Based on the calculation, it need rotation of 280 rpm to proceed 25 kg solid/hour.

At this crusher, cutting system applied multistage shear forces, so that the required cutting force is not as strong as in direct cutting. Because the solid material gradually cut then 1 cm cutting cut was assumed. This crusher is intended to cut solid materials whose have extreme yield strength 55 Mpa. The result of crusher specification was shown in Table 2.

Table 2: The crusher specification

Parameter	Specification
Overall dimension (length, depth, height)	(90 x 50 x 140) cm
Weight	80 kg
Motor power	1,5 HP, 1 phase, 1450 rpm
Cutting bled material	High carbon steel

Number of rotor blade	3 pcs
Number of rotor blade	2 pcs
Transmission system	belt pulley
Number of pulley V belt	1 set
Rotation ratio	1:3

Design of briquetting equipment

Based on the identification of briquette molding requirement for scale research scale, the specification of briquetting equipment was as follows: propulsion systems: manual, cavity number: 2 pieces, mechanisms: moment arm, compression system: compression, overall maximum dimension: 300 mm X 500 mm X 600 mm, length of arm moment: 400 mm.

The briquette-making equipment are designed from the stage of concept development, concept selection by scoring methods and screening matrix using several criteria. The obtained concepts of briquette-making equipment and its physical view was shown in Figure 4.

Performance test of the crusher

The purpose of this prototype testing is to determine whether the crusher is designed and produced can work properly in accordance with defined specifications. The expected performance of the crusher is capable cutting through dense material (organic waste, paper, grass, etc.) to produce 10 mm cut size with cutting capacity of 20 kg/hour.

As much as 1 kg of raw material which is a mixture of solid waste (dry leaves, wood scraps, paper, cardboard, cork, etc..) fed into the crusher. The time (t) during the process of cutting 100 seconds, When the rate of material flow reach steady state, the cut product which was produced for 100 seconds was collected and weighted. Result of the test performance of the crusher was presented in Table 3.

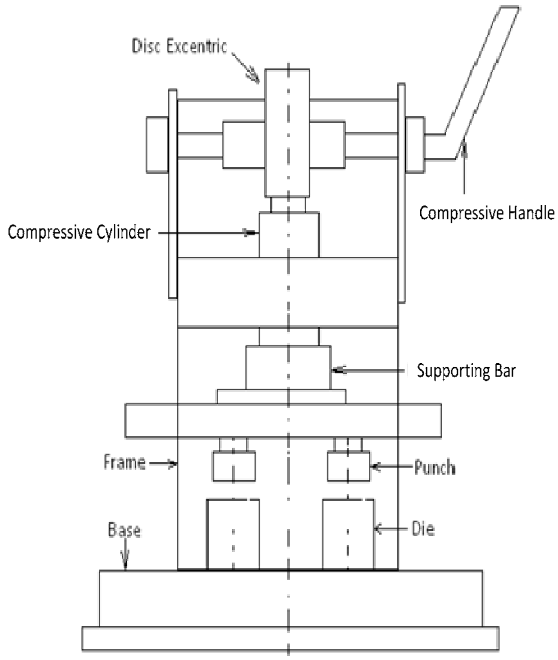

Figure 4: Diagram of the briquette-making equipment by part and its physical view

Table 3: Result of performance test of the crusher

Experiment number	Time, t (seconds)	Mass of cut, G (kg)	Capacity (kg/hr) $Q = \frac{3600}{t}.G$
1	100	0,70	25,20
2	100	0,73	26,28
3	100	0,72	25,92
4	100	0,71	25,56
5	100	0,74	26,64
6	100	0,76	27,35

Crusher capacity test results are shown in Table 3, which ranged from 25.20 kg/h up to 27.35 kg/h. Thus the target of designed capacity, which is 25 kg/h, is reached. Variations of the capacity test results as in Table 3 was due to un-uniformity of solid material to be processed in the crusher during the test.

The expected size of the crusher output is smaller than 10 mm. Target size is strongly influenced by not only the size of the gap (the gap between the barrel wall and the radius of the rotor blades) but also by the size of the hole screen.

Testing of the prototype crusher, with a sampling size by 16 pcs, resulted in cut pieces size varies between 6.06 mm op to 6.80 mm, and the average size is 6.43 mm. Thus the size of the crusher output is sufficient to meet the expected technical specifications which is less than 10 mm.

Performance test of the briquette-making equipment

To produce briquette, three components are mixed which consist of solid waste, and tapioca starch –water mix as a binder. While the solid waste used in this work is artificial waste consisted of a variety of materials prepared to represent the composition of real municipal solid waste and are presented in Table 1. The composition of tapioca starch , water and soild waste was varied and shown in Table 4. The image of raw material cut and the resulted briquette was shown in Figure 4.

Table 4: The composition of raw material and binder

No. experiment	Composition (percent weight)		
	tapioca starch	water	solid waste
1	6,6	26,6	66,8
2	9,9	25,8	64,3
3	12,5	25,0	62,5

Figure 4: Image of the raw material cut and the resulted briquettes

To determine the quality of the resulting briquettes 5 parameters of quality testing that unit/true density, bulk density, amount of fine detached after shaking, water content and heating value. The profile of 5 test results to the parameters presented in Table 5.

Table 5: The profile of 5 test results to quantify the quality of the briquette

No. Experi-ment.	Measured parameters				
	True density (gr/cm^3)	Bulk Density (gr/cm^3)	Fine after shaking (%)	Water content (% w)	Caloric content, Dry Basis (Kcal/kg)
1	0,2307	0,1205	4,84	4,8	4492
2	0,2287	0,1074	12,19	4,7	4098
3	0,2111	0,1134	10,97	6,5	4414
Average	0,2235	0,1137	9,99	5,3	4335

Bulk density measurements resulted in that bulk density of the briquettes produced is still relatively low at 113.7 kg/m3 with average true density per unit briquettes is 223.5 kg/m^3. The low bulk density is due to the low compression pressure because it is done manually by human power. To increase the bulk density increased compression pressure using a hydraulic or pneumatic system is needed. While the durability index measurements showed that after shaking in the plastic tub for 2 minutes flakes (fine) that dislodged of the briquettes is less than 10% i.e. 9,99%. This indicates that the tapioca starch binder/adhesive fit enough to sustain briquettes do not dislodged into pieces when shaking was applied on it.

The result of water content measurement meet the standard briquettes produced from solid waste that is below 25% , while the calorific value resulted from the measurement also satisfy the minimum standards of solid waste briquettes ie. 3600 Kcal/kg. In this experiment, after produced by briquette-making equipment, the briquettes are dried under the sun for about 2 hours to reduce its water content.

Conclusion

Crusher resulted from the process design capable to proceed the municipal solid waste at capacity from 25.20 kg / h up to 27.35 kg / hour. Size reduction by the designed crusher meet the expected technical specifications to produce solid waste cut to less than 10 mm size. Bulk density briquettes produced is still low at 113.7 kg/m^3 due to low compression resulted by human power. The resulting fine after shaking the briquetting is quite small , i.e. 9.99%, showed that tapioca starch is acts as a pretty good adhesive. The result of water content measurements indicate the briquette meet the water content standard for briquettes from solid waste, while calorific value obtained from the measurement has also already met the minimum standards of caloric content for briquette originating from solid waste.

Aknowledment

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