The Production of Liquid Fuel from Plastic Wastes by Using Waste Garbage Power Plant: Study on the Effect of Electric Load and Fuel/Gasoline to Solar Ratio

by Kiagus Ahmad Roni Zahrul Mufrodi, Imam Mustakim

Submission date: 11-Oct-2020 09:23PM (UTC+0700)
Submission ID: 1411658734
File name: 23231-64999-1-PB.pdf (624.2K)
Word count: 3586
Character count: 18228

JBAT 9(1) (2020) 55 – 60

Jurnal Bahan Alam Terbarukan

p-ISSN 2303 0623
e-ISSN 2407 2370

Accredited by Directorate General of Strengthening for Research and Development - SK No.: 36b/E/KPT/2016
http://journal.unnes.ac.id/nju/index.php/jbat

The Production of Liquid Fuel from Plastic Wastes by Using Waste Garbage Power Plant: Study on the Effect of Electric Load and Fuel/Gasoline to Solar Ratio

Kiagus Ahmad Roni[1,✉], Zahrul Mufrodi[2], Imam Mustakim[1]

DOI: https://doi.org/10.15294/jbat.v9i1.23231

[1] Departemen of Chemical Engineering, Universitas Muhammadiyah Palembang, Indonesia
[2] Departemen of Chemical Engineering, Universitas Ahmad Dahlan, Yogyakarta, Indonesia

Article Info

Article history:
Received
January 2020
Accepted
May 2020
Published
June 2020

Keywords :
PLTSa;
Polyethylene Terephthalate (PET);
Electric generators

Abstract

The type of plastic waste that is often a problem in many cities in Indonesia is Polyethylene Terephthalate (PET), his is due to the plastic waste plastic waste bags has no longer economic value. One of the goals of plastic waste processing is usng it as a raw material for the Waste Garbage Power Plant (PLTSa). The most profitable in handling plastic waste by converting plastic waste into fuel oil as an alternative energy source because plastic is basically derived from petroleum. Plastic also has a fairly high heating value equivalent to gasoline and diesel fuel. Some studies related to plastic processing have not been integrated from the production process to downstream products in the form of electric products to get the overall level of plant efficiency. Therefore a research of plastic waste power plants needs to be done at the prototype level to determine the performance of the fuel and the level of efficiency of the resulting assemblers. The Pyrolysis Reactor Prototype Unit can be used to convert plastic bottle waste into liquid fuel with a yield of 56.26% carried out at a process temperature of 170 °C and the resulting heating value reaches 19644 Btu/lb close to the heating value of Pertamina Gasoline. The generator system performance test for the liquid fuel mixture (BBC) with Gasoline and Diesel has an optimal mixture ratio in the BBC - Bensi / Solar mixture 3: 2 with an optimal load of 800 Watt. In the generator system performance test for liquid fuel mixture (BBC) with Gasoline/Diesel is more optimal for comparison of BBC fuel with Gasoline, because for the BBC mixture with Gasoline in all generator system comparison values occur ignition. Whereas BBC with Solar does not ignite at a ratio of 0: 5, 1: 4 and 2: 3.

INTRODUCTION

The increasingly limited availability of fossil fuels requires us to look for other alternative fuels. Therefore it can fulfill the needs of fuel in the community. One way to produce alternative fuel is using plastic waste as raw material (Nindita, 2015). Processing plastic waste into fuel oil is conducted by using the pyrolysis method. Pyrolysis method is a method of recycling plastic waste through thermal and catalytic degradation processes(Syamsiro, 2015; Syamsiro et al., 2014). Pyrolysis is considered as one of the best methods because in addition to reducing the amount of waste produced, pyrolysis can also produce high economic products value by offering the potential for greater efficiency in energy production and minimal pollution. Plastic also has a fairly high heating value equivalent to gasoline and diesel fuel (Surono, 2013).

Cracking fuel oil will be used as generator fuel. Generator set is a device that functions to produce electrical power. It is a set of combined equipment from two different devices, namely engine and generator or alternator. Engine as a rotating device while the generator or alternator as a power generation device. (Maindra et al., 2014)

✉Corresponding author:
Departemen of Chemical Engineering,
Universitas Muhammadiyah Palembang, Indonesia
E-mail: kiagusaroni@gmail.com

ISSN 2303-0623
e-ISSN 2407-2370

According to Palembang City Environment and Forestry Research and Development Center (BP2LHK), from 17.5% of the plastic waste or 189 tons/day, 50% of total plastic waste is plastic bottles or (PET) day or around 94 tons. Therefore PET plastic waste has a very high volume. Ironically, according to BP2LHK, it is estimated that only about 10-15% of the accumulated plastic waste is collected. Meanwhile 60-70% is buried in landfills and 15-30% has not been managed and disposed to the environment, especially rivers, lakes, beaches and seas. To overcome this problem, a synergy between environmental protection, economic growth and social stability is needed in order to carry out sustainable development. (Wijayanti et al., 2013)

Plastic is a type of macromolecule formed by the polymerization process. Polymerization is the process of combining several simple molecules (monomers) through a chemical process into large molecules (macromolecules or polymers). Plastic is a polymer compound of which main constituent elements are carbon and hydrogen. Plastics also contain additives, which are substances used to improve the properties of plastics. Additives is in the form of substances with low molecular weight that can function as dyes, antioxidants, absorbent of ultraviolet light, non-sticky and so on. (Syamsiro et al., 2014)

Polymers are compounds made up of very large molecules formed by repeated fusion of many small molecules. Small molecules called monomers can consist of one type or several types. A polymer is a long molecule which contains chains of atoms that are combined through covalent bonds formed through a polymerization process in which monomer molecules react chemically together to form a linear chain or three-dimensional network of polymer chains. The classification of polymers is based on their origin, which is derived from nature (natural polymers) and polymers that are intentionally made by humans (synthetic polymers). (Efan, 2015)

Bond energy is the enthalpy change needed to break certain bonds in a mole of gas molecules. "The higher the bond energy level, the more difficult the bond is to be released because more energy is needed to release it (Kyaw, Su, and Hmwe 2015)

Fuel is a combination of hydrocarbon compounds obtained from nature and artificial. Liquid fuel generally derived from petroleum. In the future, the possibility of liquid fuels derived from *oil shale*, coal and biomass will increase. Petroleum is a natural mixture of liquid hydrocarbons with little sulfur, nitrogen, oxygen, very little metal, and minerals. (Dwi Nurhayati & Wigiani 2014)

Thermal decomposition of plastic material is an endothermic process so that takes a minimum energy equal to the energy of dissociation of C-C chain bonds in the plastic chain. Dissociation energy is the energy needed to break a bond in a molecule. For example the dissociation energy to release H_2 bonds to $2H^+$ is 436 KJ / mol. (Syamsiro, 2015)

Conversion of Polyethylene Terephthalate (PET) plastic waste has been carried out and has obtained various operating conditions and yield values. Recorded since 2012 Moinuddin from the United States Department of Research and Development, carried out the degradation process in the Pyrolysis Reactor at the temperature of 150 °C and the yield was 50%. (Sarker et al., 2012)

Generator set is function to produce electrical power called a generator set with the understanding of a set of equipment combined from two different devices namely engine and generator or alternator. The engine can be a diesel engine or a gasoline engine, while the generator or alternator is a copper coil or coil consisting of a stator (static coil) and rotor (rotating coil) that can generate electricity. Guan et al., 2009)

Generator is a combustion engine (diesel engine or gasoline engine) which convert fuel energy into mechanical energy, then the mechanical energy is converted to produce electrical power, generators have two types, namely AC generators or commonly called alternators and DC generator. An AC generator (alternator) is a generator that generates alternating electric current (AC), while a DC generator is a generator that produces direct current (DC). AC generators have the same working system as DC generators, which produce electricity from electromagnetic induction, even though both AC generators and DC generators actually basically produce alternating electric current, however AC generators and DC generators have differences in construction design . DC generators use a split ring or commonly called a commutator which acts as a rectifier. (Maindra et al., 2014).

METHODOLOGY

The variables In this study are fixed and non-permanent variables. This research was conducted with data obtained from the measurement results to determine the performance test of generator sets using light-fraction liquid fuels (BBC2) with the type of plastic bottles (PET) on the prototype of a plastic waste power plant output unit from Separator 2 (SP-02) 1000 Watt capacity.

PP Plastic Waste Conversion Process Into Liquid Fuels

Flow diagram process of the PLTSA unit prototype used is shown in Figure 1.

In the process of generating electricity from plastic waste, it begins with cleaning plastic waste from dirt and then dried with sunlight in the field. After drying, the waste plastic bottles were rolled by squeezing so the plastic volume does not change. The total mass of plastic bag waste raw material put into the reactor was 15,464 kg and then the pyrolysis process was carried out by heating the reactor in the furnace using coconut shell fuel. Next, the fuel product in the form of gas from the top of the reactor is sent to Separator I (SP-01) to separate steam and liquid. In Separator I (SP-01), the product Separator II bottom was obtained in the form of Product 1 (BBC1) which was still mixed with wax and top of the steam product that was fed to the Cooler (C-01. After setting the temperature, the crude liquid fuel product was carried to Separator II (SP-02) for further separation between liquid and vapor.From Separator II (SP-02) obtained product Separator II in the form of Product 2 or (BBC2) and top Separator II in the form of steam to be condensed in the condenser. bottom product was obtained in the form of liquid which would be combined with product 2 and in the form of gas Separator product 2 or (BBC2) after calculating the volume and weight, the composition, characteristics, heating value and rendment Characteristics, heating value and fuel composition were tested. The oil produced will be compared with Pertamina's processed petrol products.

The liquid fuel product in the form of fuel oil will be used as fuel in the Generator Set. And the parameters observed in the generator set performance test were the electrical load, the duration of ignition of the generator, the electric current generated, the Generator set shaft rotation in RPM units, the fuel consumption per hour of the generator, and the amount fuel used to start the generator set. The results of observations and measurements during this process are presented on tables and graphs to be evaluated to see various scientific phenomena that occur in accordance with the research objectives.

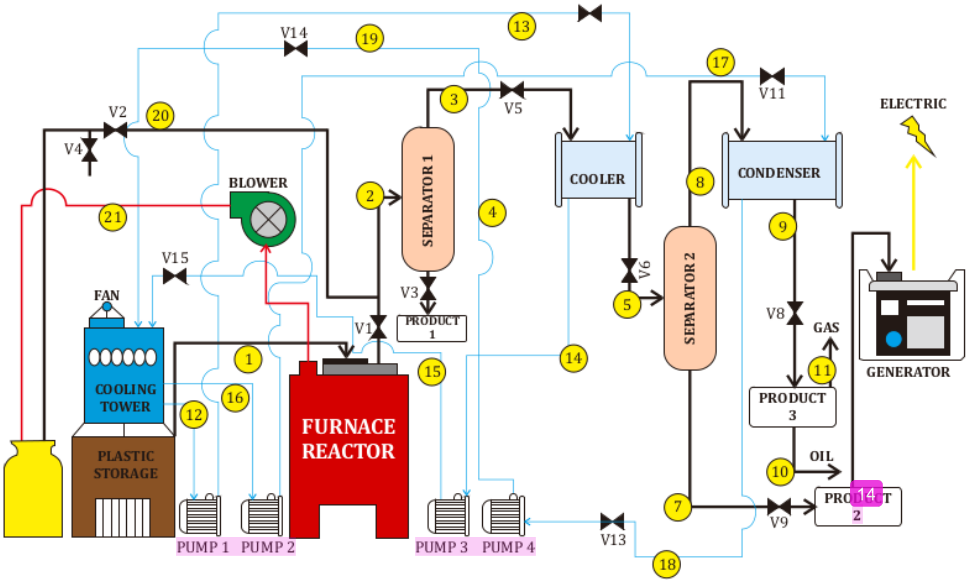

Figure 1. Flow Chart of the Prototype PLTSA unit.

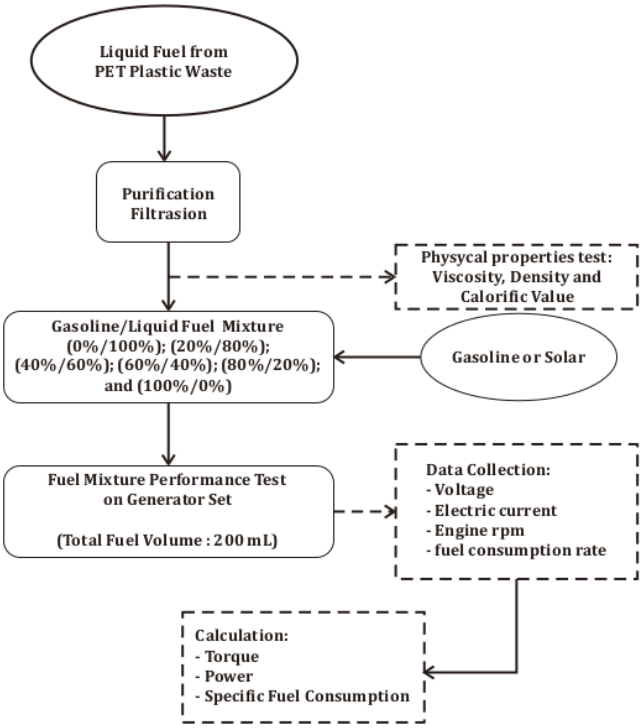

Figure 2. Flow chart liquid fuels performance test on the generator system (Genset)

Liquid Fuel Performance Testing Process on Generator Set

The diagram of the testing process and the performance of liquid fuels on the Generator set is shown in Figure 2.

The product of plastic waste pyrolysis process was liquid fuel, then the liquid fuel will be used as fuel in the Generator Set (genset) to see the performance of the liquid fuel. The parameters observed in the performance of the liquid fuel are electrical, the time of ignition the generator, the electric current generated, the genset shaft rotation in RPM units, the fuel consumption per hour, and fuel consumption in starting up the generator set. The results of observations and measurements are presented on table and graphs which were evaluated to see various scientific phenomena in accordance with the study objectives.

RESULT AND DISCUSSION

Quantitative Product Analysis of Plastic Waste Degradation Results

Quantitative analysis of various product mass flows resulting from the degradation of plastic waste in the pyrolysis reactor prototype unit was carried out on the product for an optimal process temperature of 170°C.

It can be analyzed that BBC 2 products have more quantities than other components including BBC1, so BBC 2 is the main product of the process of degradation of plastic bottle waste. However, considered from the fuel that can be used not only BBC2, but BBC 1 fuel can also be used primarily for fuel motor fuel use. The total yield of BBC 1 and BBC 2 was 56.26%.

Another comercial product was solid fuels in the form of wax with a quantity of 26.38%. This wax component is a heavy hydrocarbon component obtained from Separator 1 equipment on the prototype pyrolysis reactor unit used. Whereas the residue is in the form of a non-degraded hydrocarbon solid which is at the base of a high molecular weight reactor and is difficult to break into a lower molecule. It requires greater effort by providing a greater amount of heat to increase the temperature of the reactor so that it can provide enough energy to break the larger and stronger molecular chains. For the gas component and loss or missing component, it is obtained from

the calculation result and not the observation result. This is difficult in determining the mass of gas that occurs and can not be determined the actual mass of the missing component of the product.

Comparison of Fuel Calorific Value

The comparison of the heating value of the liquid fuel with the heat value of the other hydrocarbon fuelsis shown on Table 1.

Table 1. Comparison of Fuel Calorific Value..

Fuel	Calorific Value (Btu/lb)
Avigas *	20,500
Avtur *	18,400
Pertamax *	20,500
Premium *	19,800
Kerosene *	19,200
Solar *	18,600
Fuel Oil *	19,300
BBC1 ^	19,149
BBC2 ^	19,644

Notes: *fuel produced by Pertamina Oil and Gas
^ Liquid fuel from this research

Table 1 shows that the average heating value of BBC 1 was 19149 Btu/lb so that it can be categorized for BBC1 fuel as kerosene equivalent. For BBC 2 had an average heating value of 19644 Btu /lb, it can be categorized for BBC2 fuel as gasoline or premium equivalent.

Analysis of Effects of Electric Load and BBC: Gasoline and Diesel Ratios on Ignition Times

The quality of the fuel will affect the duration of ignition of the generator set the amount of fuel used. In addition to the quality of fuel used, the amount of electrical load used also has an effect on the duration of ignition of the generator. The quality of the tested fuel is a liquid fuel product which is the result of research mixed or mixed with gasoline and diesel fuel which was conducted separately (BBC-Petrol and BBC-Solar). In this study changes were made to the electrical load of 200 W, 400 W, 600 W, 800 W, and 1000 W. and the ratio of liquid fuel: gasoline or diesel were 0: 5, 1: 4, 2: 3, 3: 2, 4: 1, check out 5: 0. Visually the ignition of the ratio and changes in electrical load is shown in Figure 3. For liquid fuels-gasoline mixture.

In Figure 3, the duration of ignition decrease as the increase of electricity load. the optimal electrical load obtained in the study is the 800 W electricity load which will be the basis for the analysis of the use of light fraction liquid fuels as generator set fuel for lighting (lighting) because the 800 watt electricity load provides a proportional ignition time and stepped on a load of 1000 watts, the ignition time tends to decrease slightly sharp for each fuel ratio used. Analysis various ratios provides an optimal fuel-gasoline ratio at a ratio of 3: 2, this shows a flow that is increasingly coincide with fuel without BBC products. As for the BBC-Gasoline ratio (4: 1) and without gasoline (5-0) the ignition time is far below the flow chart for other ratio comparisons and for all electricity loads. The engine generator automatically stabilize the engine RPM when the load changes and the fuel consumption was higher, so that the engine remains stable with the risk of higher the fuel consumption and faster ignition time as electrical load used increase.

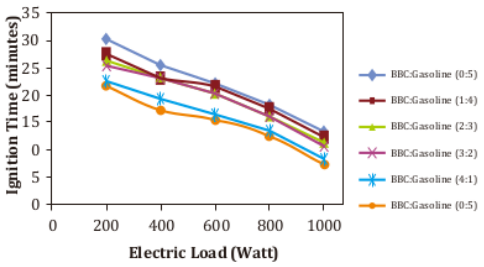

Figure 3. Corelation of Electric Load (watts) vs Ignition Time (minutes) to BBC: Gasoline ratio.

At a load of 800 watts with a ratio of BBC – Gasoline of 3: 2 generator sound is still in a stable condition and the lights are still stable, when the load was increased the generator sound becomes rough and unstable and the tested lamp lights become dim and unstable and long generator set ignition dropped dramatically. The heating value is one of the factors that make the generator's flame last longer, when fuel's heating value is high, the heat consumption of the fuel would be low. This is due to the increasing weight of the generator's ability to produce work.

Ignition analysis of the use of liquid fuel (BBC: Solar) has a different behavior with the BBC-Gasoline mix. In BBC-Solar mix, the ignition of the generator only occurred in solar mixture (3: 2 to 5: 0). This situation was due to the dominant amount of diesel fuel in the mixture resulting in the difficulty of the engine undergoing the process

of entering the heat in the combustion chamber due to sparks of electric spark from the spark plugs was difficult to ignite the mixture of air and fuel was compressed and this is also caused by generators used is a generator made from premium fuel or gasoline. Graphically the relationship of ignition duration for the BBC-Solar mix is shown in Figure 4.

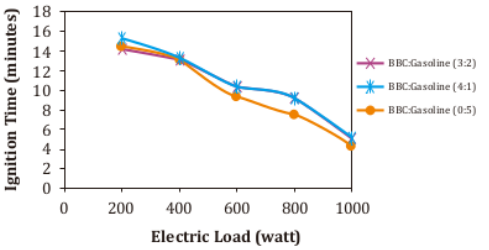

Figure 4. Corelation between Electric Load (watts) vs Ignition Time (minutes) to BBC: Solar ratio

CONCLUSION

From the study and its quantitative and qualitative analysis, it can be concluded that the Pyrolysis Reactor Prototype unit can be used to convert plastic bottle waste into liquid fuel with a yield of 56.26% conducted at a temperature of 170°C and the heating value was 19644 Btu / lb, closed to heating value of Pertamina Gasoline. In Genset performance test for liquid fuel mixture (BBC) with Gasoline and Solar showed optimal BBC-Gasoline to pertro diesel ratio of 3: 2 with an optimal load of 800 Watt. In Genset performance test for liquid fuel mixture (BBC) with Gasoline/petroDiesel is more optimal for comparison of BBC fuel with Gasoline, due to BBC mixture with Gasoline in all the Genset comparison values occur ignition. Whereas BBC with Solar does not ignite at a ratio of 0: 5, 1: 4 and 2: 3.

REFERENCES

Dwi Nurhayati, N., Wigiani, A. 2014. Sintesis Katalis Ni-Cr/Zeolit Dengan Metode Impregnasi Terpisah. Seminar Nasional Kimia Dan Pendidikan Kimia VI Makalah Pendamping Kimia Anorganik dan Kimia Fisika.

Efan, A. N. 2015. Bahan Ajar Perkuliahan Polimer.

Guan, Y., Luo, S., Liu, S., Xiao, B., Cai, L. 2009. Steam catalytic gasification of municipal solid waste for producing tar-free fuel gas. International Journal of Hydrogen Energy. 34(23): 9341–9346.

Maindra, M., Harmen, H., Susila, M. 2014. Studi Komparasi Dari Zat Aditif Sintetik Dengan Zat Aditif Alami Terhadap Pemakaian Bahan Bakar Dan Emisi Gas Buang Pada Mesin Genset Motor Bensin 4-Langkah. Jurnal Ilmiah Teknik Mesin FEMA (1): 98490.

Nindita, V. 2015. Studi Berbagai Metode Pembuatan BBM Dari Sampah Plastik Jenis LDPE Dan PVC Dengan Metode Thermal & Catalytic Cracking (Ni-Cr/ZEOLIT). 10(3): 137-144.

Sarker, M., Rashid, M. M., Rahman, M. S., Molla, M. 2012. Conversion of Low Density Polyethylene (LDPE) and Polypropylene (PP) Waste Plastics into Liquid Fuel Using Thermal Cracking Process. British Journal of Environment & Climate Change. 2(1): 1-11.

Surono, U. B. 2013. Berbagai Metode Konversi Sampah Plastik Menjadi Bahan Bakar Minyak. Jurnal Teknik. 3(1): 32-40.

Syamsiro, M. 2015. Kajian Pengaruh Penggunaan Katalis Terhadap Kualitas Produk Minyak Hasil Pirolisis Sampah Plastik. 5(1): 47-56

Syamsiro, M., Saptoadi, H., Norsujianto, T., Noviasri, P., Cheng, S., Alimuddin, Z., Yoshikawa, K. 2014. Fuel oil production from municipal plastic wastes in sequential pyrolysis and catalytic reforming reactors. Energy Procedia. 47: 180–188.

Wijayanti, W., Sasongko, M. N., Meidiana, C., Yuliati, L. 2013. Metode Pirolisis Untuk Penanganan Sampah Perkotaan Sebagai Penghasil Bahan Bakar Alternatif. Jurnal Rekayasa Mesin. 4(2): 85-92. .

The Production of Liquid Fuel from Plastic Wastes by Using Waste Garbage Power Plant: Study on the Effect of Electric Load and Fuel/Gasoline to Solar Ratio

ORIGINALITY REPORT

17%	7%	12%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Tahdid, Aida Syarif, Lety Trisnaliani, Sahrul Effendy. "Study of Plastic Waste Power Plants Capacity Unit 1 KWh Using Plastic Bags Based on Effectiveness Produced in Optimum Load", Journal of Physics: Conference Series, 2020 Publication	7%
2	T Eben Haezar, W Samdan, A Yudha, S Taufik Roni. "Design of Mobile and Integrated Tyre Repair Tools for Motorcycle", IOP Conference Series: Materials Science and Engineering, 2020 Publication	2%
3	en.trafomajujaya.com Internet Source	2%
4	www.iatekunsri.com Internet Source	1%
5	Jatmiko Wahyudi, Hermain Teguh Prayitno, Arieyanti Dwi Astuti. "PEMANFAATAN LIMBAH	1%

PLASTIK SEBAGAI BAHAN BAKU PEMBUATAN BAHAN BAKAR ALTERNATIF", Jurnal Litbang: Media Informasi Penelitian, Pengembangan dan IPTEK, 2018
Publication

6	en.indotrading.com Internet Source	1%
7	Submitted to Higher Education Commission Pakistan Student Paper	<1%
8	mafiadoc.com Internet Source	<1%
9	J. Štěpek, H. Daoust. "Additives for Plastics", Springer Science and Business Media LLC, 1983 Publication	<1%
10	Submitted to Academic Library Consortium Student Paper	<1%
11	www.aidic.it Internet Source	<1%
12	journal.portalgaruda.org Internet Source	<1%
13	www-us5.semiconductors.com Internet Source	<1%
14	marine.man-es.com	

	Internet Source	<1%
15	Submitted to Universitas Negeri Semarang Student Paper	<1%
16	www.ccsenet.org Internet Source	<1%
17	Wahyu Arini, Endang Lovisia. "PENGEMBANGAN ALAT PIROLISIS SAMPAH PLASTIK SEBAGAI MEDIA BELAJAR BERBASIS LINGKUNGAN PADA MATERI SUHU DAN KALOR DI SMP KABUPATEN MUSI RAWAS", Jurnal Perspektif Pendidikan, 2020 Publication	<1%
18	docobook.com Internet Source	<1%
19	Submitted to Universitas Negeri Jakarta Student Paper	<1%
20	Arif Setyo Nugroho, Rahmad, Moch. Chamim, Fatimah N. Hidayah. "Plastic waste as an alternative energy", AIP Publishing, 2018 Publication	<1%
21	www.scribd.com Internet Source	<1%
22	Rohit Kumar Singh, Biswajit Ruj, Anup Kumar	

	Sadhukhan, Parthapratim Gupta. "Thermal degradation of waste plastics under non-sweeping atmosphere: Part 2: Effect of process temperature on product characteristics and their future applications", Journal of Environmental Management, 2020 Publication	<1%
23	Harvard Deusto Business Research. "Full Issue Vol 9 No 1 (2020)", Harvard Deusto Business Research, 2020 Publication	<1%
24	sciencetechindonesia.com Internet Source	<1%
25	digilib.unimed.ac.id Internet Source	<1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	Off		