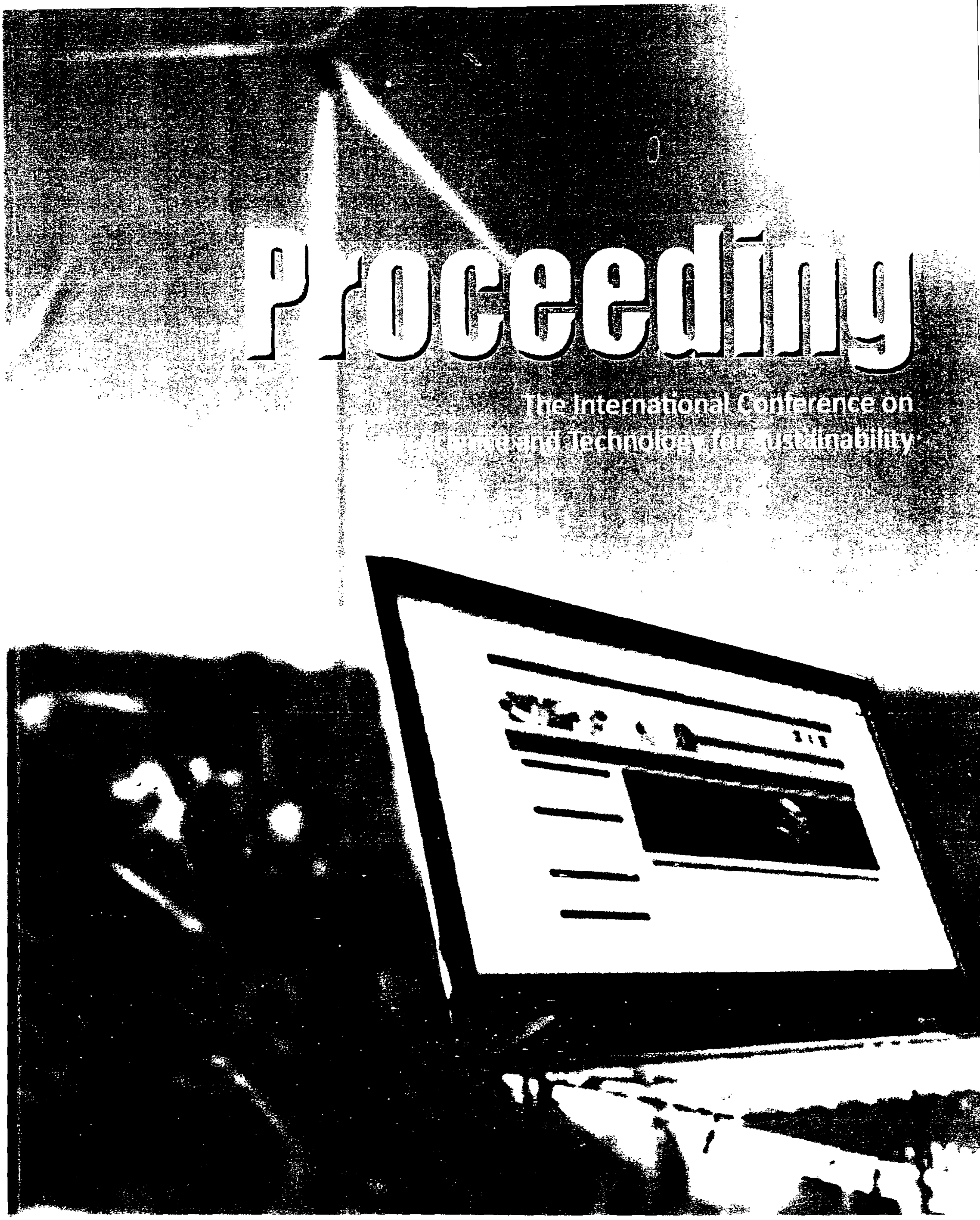
UIN Sultan Syarif Kasim Riau
Fakultas Sains dan Teknologi

ICoSTechS 2014

Proceeding

The International Conference on Science and Technology for Sustainability



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PREFACE

The 1st International Conference on Science and Technology for Sustainability 2104 (ICoSTechs2014) is an international event hosted by Faculty of Sciences and Technology, University of Islam Negeri Sultan Syarif Kasim Riau (UIN SUSKA Riau). The purpose of this conference is to provide a forum for researchers, scientists and engineers to exchange new ideas and interact in-depth through discussion with peers from all over the world in the fields of electrical and electronics engineering, informatics, mathematics and industrial engineering. The main goal of this event is to facilitate communications among researchers and practitioners, not only concerning the core areas but also involving multi –disciplinary and interdisciplinary work.

We are grateful to all those who have contributed to the success of ICoSTechs2014. There are a number of parties that have assisted us in organizing this conference become a reality. We would like to thank all authors, participants, faculty members for their participation and support, IEEE Indonesia sections, IIIT (The International Institute of Islamic Though) and BKS PTN Barat (State Universities Cooperation Agency of Western Region). Last but not least, we greatly appreciate the committees and external reviewer's precious and timely reviews. Their expertise is very vital in ensuring the success of this event.

We really hope that all participants benefit tremendously from the conference. Finally, we would like to wish the participants success in the presentations and social networking.

Dr. Alex Wenda
General Chair
The 1st International Conference on Science and
Technology for Sustainability 2104, (ICoSTechs2014)
Batam, Indonesia.

REMARK

First, blessing and mercies so we can be here together in this room to healthy condition. And we also convey our syallawat to Prophet Muhammad by saying Allahuma.....

Nowadays, sustainability has been an emerging major issue of the world in order to create a Better Life for the Current and Future Generations. Achieving a Sustainable Development will require changes in many fields, including Sciences and Technologies.

More than one hundred definitions of sustainable development exist, but the most widely used one is the definition from the Brundtland Report of the World Commission on Environment and Development, presented in 1987. It states that sustainable development is the "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development promotes the idea that social, environmental, and economic progresses are all attainable within the limits of our earth's natural resources. Sustainable development approaches everything in the world as being connected through space, time and quality of life.

Sustainable development constantly seeks to achieve the social and economic progresses in ways that will not exhaust the earth's finite natural resources. The needs of the world today are real and immediate, yet it is necessary to develop ways to meet these needs that do not disregard the future. The capacity of our ecosystem is not limitless, meaning that future generations may not be able to meet their needs the way we are able to now.

The world's resources are finite, and the growth that is not well-managed nor unsustained would lead to an increased poverty and declined condition of the environment. We owe it to the future generations to explore lifestyles and paths of the development that would effectively balance the progress with an awareness of its environmental impacts. In order to preserve the future, we must appreciate the interconnectedness between humans and nature at all levels. Sustainable Science and Technology practices may help us do this, and through education, research and building awareness, preserving the future is within everyone's reach.

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The 1st International Conference on Science and Technology for Sustainability (ICoSTechs2014) 2014 offers a place and opportunities for researchers and professionals from academic, business, industries, Governments, NGOs, and other sectors to exchange their scientific and technological information. ICoSTechs2014 is also provided for students to present their research papers.

All submissions will be peer reviewed. Accepted papers will be published in the conference proceedings. Selected Paper with a few corrections will be propose to published in **IEEE Xplore Digital Library, TELKOMNIKA Journal (Index by SCOPUS and ISI)**, and **IAES Journals (Institute of Advanced Engineering and Science Journals)**

On this occasion I wish to thank the Recor of UIN Suska Riau who had agreed to attend on this occasion and be apride for us on his presence, and we also appeal to the Rector in order to open a international seminar was officially. Thank you very much to **Prof Zehnder Alexander Jakob Boris** over a given time, hopefully on the other occasion we may invite you back.

Thanks to the invitations has the pleasure to present, thanks to the chairman and the entire committee which has prepared this activities, and also to the all of participants in this seminar, hopefully be beneficial to all of us. Congratulations and hope that with the implementation of this seminar makes our role in the world of science and technology more clearly visible, so our presence is felt by the community. So any remarks from me, finally I apologize if there are words that are not in place. Congratulations.

Dra. Hj. Yenita Morena, M.Si
Dean Faculty Sains and Technology
UIN Suska Riau, Pekanbaru
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ICOSTECHS 2014 SCHEDULE

Wed, October 22nd 2014

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CONFERENCE DAY

07.30 – 10.10	**Opening Ceremony**
	Coffee Break
10.10 – 12.20	**Session I Presentation from Keynote Speaker**
	Prof. Zehnder Alexander Jacob Boris
	Moderator : Kunaifi, S.T, M.Sc
13.30 – 15.30	**Session II Paralel Presentation**
	Moderator Room A : Ismu Kusumanto, M.T
	Moderator Room B : Rika Susanti, S.T, M.Sc
	Coffee Break
15.30 – 16.00	**Closing Ceremony**

PARALLEL SESSION SCHEDULE

Room A

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2	Muhammad Sufi, Jalil Ali, Saktioto	Paper06	13.50-14.10
3	Fahrul Agus, Rahmat Sholeh, Heliza Rahmania Hatta, Tarbiyatul Munawwarah	Paper07	14.10-14.25
4	Imam Tahyudin, Berlilana	Paper08	14.25-14.40
5	Andang Sunarto, J. Sulaiman, A. Saudi	Paper09	14.40-14.55
6	Rahmad Kurniawan, Okfalisa, Mohd Zakree Ahmad Nazri	Paper11	14.55-15.10
7	Abdul Rahman Hemdi, M. M. Mahadzir, Muhamad, Salwa Mahmood, Muhamad Zameri Mat Saman, Safian Sharif	Paper12	15.10-15.25
8	Azriyenni, M.W. Mustafa	Paper13	15.25-15.40
9	Haviluddin, Rayner Alfred	Paper14	15.40-15.55
10	Iwan Iskandar, Lestari Handayani, Weli Andrian	Paper10	15.55-16.10
11	Dian Mursyitah	Paper18	16.10-16.25
12	Zulfatri Aini	Paper19	16.25-16.40
13	Angraini, Yozita Dewi	Paper21	16.40-16.55
14	Nanda Putri Miefthawati, Mohammad Arif	Paper23	16.55-17.10
15	Rice Novita, Fadli Gunawan	Paper29	17.10-17.25
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17	Sutoyo, Liliana	Paper45	17.40-17.55

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3	Aji Prasetya Wibawa, Andrew Nafalski	Paper17	14.10-14.25
4	Dedi Irawan, Ismu Kusumanto, Saktioto, Jalil Ali	Paper20	14.25-14.40
5	Adhatus Solichah A., Dwi Sunaryono, Riyanarto Sarno, and Andre Victorio Allorerung	Paper24	14.40-14.55
6	Dewi Fitria, Miklas Scholz and Gareth Swift	Paper28	14.55-15.10
7	Fanny Camelia, T. L. J. Ferris, Merry Siska	Paper30	15.10-15.25
8	Difana Meilani, Merry Siska, Feli Elysa	Paper31	15.25-15.40
9	Wayan Firdaus Mahmudy	Paper38	15.40-15.55
10	Rado Yendra, Ari Pani Desvina, Rahmadeni and Abdul Aziz Jemain	Paper32	15.55-16.10
11	Megawati, Kridanto Surendro	Paper34	16.10-16.25
12	Idria Maita	Paper37	16.25-16.40
13	Teddie Darmizal, Benny Ranti	Paper35	16.40-16.55
14	Tengku Nurainun	Paper36	16.55-17.10
15	Rahmayanti Dina, Ferdira Oekma	Paper39	17.10-17.25
16	Febi Yanto, R. Joko Musridho	Paper41	17.25-17.40
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IcosTechS

Development of Gasification - Pyrolysis Technology using Residual Household Waste to Produce Alternative Energy

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Abstract— **This research aims to design a gasification technology by utilizing the residual household waste as biomass to produce gas. The residual waste consists of organic waste (waste products of composting) and non-organic waste (paper and plastic). The resulted gas is used to substitute the diesel engine for driving a crusher machine which is used to cut the household waste for pre-process composting. The gasification uses pyrolysis because the residual household waste also contains plastic that can be converted into oil, and so called as gasification-pyrolysis installation. The installation of gasification-pyrolysis can reduce the diesel fuel of crusher machine up to 80%. The burning of gasification is approximately done at 400°C. The quality of the produced gas consist of CO_2 = 3.34%, CO = 6745 mg/m^3 and NO_2 = 240 ppm, while the emissions of the crusher machine are: CO_2 = 2.01%, CO = 3975 mg/m^3, and NO_2= 111 ppm. Based on the test, we can conclude that gasification-pyrolysis technology using residual household waste can be involved in the integrated waste management of reduce, reuse and recycle program (IWS-3R) in order to solve the problem of the residual composting and reduce the operating costs of 3R program at the dump site. In addition, it also can make 3R program be more efficient so it can actualize a zero waste system.. Based on benefit-cost-ratio the gasification-pyrolysis has a positive cost effect.**

Keywords— residual household waste; gasifier-pyrolysis; 3R program; composting

I. INTRODUCTION

Waste management is an environmental issue in Indonesia. Based on data from JICA [1] the waste management capabilities in Java can only reach 59% of the total population. However, in the national scale the level of waste management is done by local governments is reached 23.4%, while by illegal burning is about 52.1%.

In Indonesia, the waste management has been regulated under the law of article No. 18/2008 concerning the 3R (reduce, reuse and recycle) program. In line with this regulation, the City and the County have developed a waste management in the region scale for organic and non-organic waste through the 3R and the composting programs currently. However, both programs (3R and composting) still leave about 30-4-% of the residual consisting of organic and non-organic residue. The organic residue is a material which is usually difficult to be destroyed but have dried up, while the non-organic residue is usually a material which can be burned easily, e.g. plastic, or other non-organic residue which can not be treated using 3R program . Usually, the residue dumped into a landfill or burned directly in the open area. This activity violated the law of article No. 18/2008 on waste incineration technical standards.

Before the composting process, the size of organic waste should be minimized to speed up the composting process. This process is done by a crusher machine using diesel fuel. However, the diesel fuel is a non-renewable fossil energy which its available is very limited. In another words, the composting process which aims to reduce the environmental issues, in the same time it also contributes another environmental issue, i.e., the fossil energy consumption, moreover when the capacity of waste management is done in the region scale.

In addition, the diesel fuel requirements is often an obstacle especially when the fuel prices is high, while the funding for Operation and Maintenance cost is limited. This leds to several community-based waste managements using 3R program can not continue their activities due to funding problem.

On the other hand, there is a biomass gasification technology which can produce gas to substitute natural gas [2], to cook or drive a motor i.e., spark plug engine, diesel engine or turbine [3], [4]. Biomass Gasification using plastic as a feedstock will generate 187-289 kJ/mol of activation energy [5], and using a mixed feedstock of plastic and paper give opportunities as an alternative energy which equivalent to LPG [6]. The optimum temperatures of gasification and pyrolysis of municipal waste occurs at 300°C and it will produce the fuel with calorific value of 150% of the optimal 1,980 kcal/kg [7]. The application of biomass gasification using a combination of urban waste and biomass in rural Greece showed a positive result by financial analysis

[8]. Based on the previous research, it can be seen that there is an opportunity to utilize the residual household waste consisting of both organic and non-organic residual wastes using gasification technology in which the resulted gas can be used to drive the crusher machine.

This research aims to design a gasification technology by utilizing the residual household waste as biomass, then the gas produced is used to drive the crusher machine at pre-composting process. This technology is expected to solve the problem of residues and the problem of fossil fuel simultaneously.

II. BIOMASS GASIFICATION – PYROLYSIS

Gasification is defined as the process of changing the solid materials - biomass, coal and coke - into gases. The resulted gas of the gasification process consists of CO, CO_2, H_2 and CH_4. The resulted gas which is a mixture of CO and H_2 called as a synthetic gas (syngas) and can be used to substitute the natural gas [2]. A biomass gasification is a chemical reaction between the biomass and air at a high temperatures. Basically, all organic residues have potential to be converted into biomass energy either by burning directly or by converting into solid material, liquid or gas [9]. It means that the municipal waste containing both organic and non-organic residues can be used as feedstock of biomass gasification.

Fig.1 shows the the diagram of gasification – pyrolysis process that involves pre-processing, pyrolysis, and syngas cleaning. The pyrolysis is a thermal degradation of waste in a vacuum to produce a gas (usually called syngas), liquid (pyrolysis oil), or solids (char, mainly ash and carbon). The pyrolysis occurs among 400°C - 1000°C, with a controlled oxygen [10] and results a mixture of ash, charcoal, water vapor, tar and gas which consist of CO_2, CO, H_2, CH_4, and H_2O. The pyrolysis is very attractive to reduce and avoid corrosion and emissions containing alkali and heavy metals [11]. There would be a net reduction in the emission of the sulphur di-oxide and particulates from the Pyrolysis/Gasification processes [12]. However, the emission of oxides of nitrogenVOCs and dioxins might be similar with the other thermal waste treatment technology [13]. A scrubber is required to clean up the gas before it feeds to the power generation [14] so that ash, charcoal, water vapor, and tar can be separated from the gas.

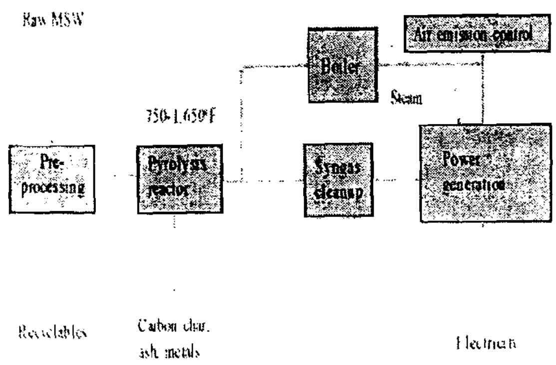

Fig. 1. Halton's installation of Gasification – Pyrolysis process for municipal waste
Source: [14]

III. METHODOLOGY

This research uses a quantitative method to determine the relationship between the amount of residual waste and the saving of the diesel fuel used by the crusher machine. The experiment is conducted using the artificial conditions. Finally, a financial analysis using benefit cost ratio is used to test its feasibility.

A. *The research steps*

Fig. 2 shows the flowchart of this research, which is begun by an initial survey, i.e., identification of locations that have implemented an integrated waste management of 3R program in a regional scale, identification of process that modify the crusher machine, identification of the physical and chemical characteristics of the residue. In the same time, literature review is done to select the gasification and gas cleaning technology in accordance with the conditions and characteristics of the residual waste. Based on the literatures and identification of the residual household waste characteristics, the gasification – pyrolysis technology is choosen, designed and installed at the selected location. The crusher machine is modified according to the energy produced of the gasification process.

B. *The installation of gasification-pyrolysis*

The installation of the gasification-pyrolysis in this research is designed by developing Halton Installation, and can be shown in Fig. 3.

The operational of gasification – pyrolysis installation is described as follows.

1. The residual household waste is dried in the dryer (C) using CO_2 which blows from the diesel engine (E).
2. The dried residual waste feed into the gasifier (A) up to 80% of full capacity and it is burned until smoldering.
3. Pyrolysis is occured in the gasifier (A) and it produces CO, CO_2, H_2, NO.

4. The gas produced from the gasification – pyrolysis installation is flowed through a rubber hose into the gas cleaner (B) to produce a clean gas which free from tar, ash, charcoal and water vapor by spraying water – which is circulated by a pump – to the dirty gas.
5. The cleaned gas is flowed into the diesel engine (E) which drives the crusher machine (D), and the volume of gas is regulated by a valve.
6. The addition of gas can reduce the consumption of the diesel fuel which regulated by closing the valve of diesel fuel.

In Fig. 3 we can see that the gasification – pyrolysis installation make a loop so that it can actualize Zero Waste System.

C. Research design

The installation is tested to monitor its function and performance so that it can be seen how much residue can be processed and the fossil fuel consumption can be saved. The experiment is conducted by burning certain amounts of the residual during a specified time, and then the requirement of the diesel fuel is measured. The saving of fuel consumption can be calculated by comparing the combustion using fossil fuel only and the mixture of fossil fuel and the resulted gas of gasification-pyrolysis installation.

The content of resulted gas is then being analyzed in a laboratory to determine the quality of the gas.

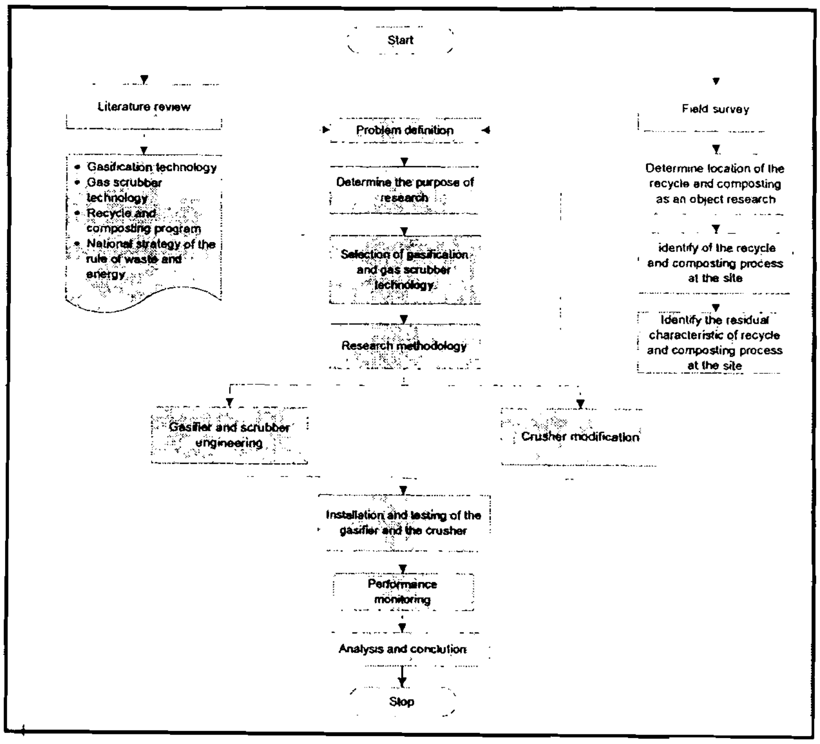

Fig. 2. Research steps

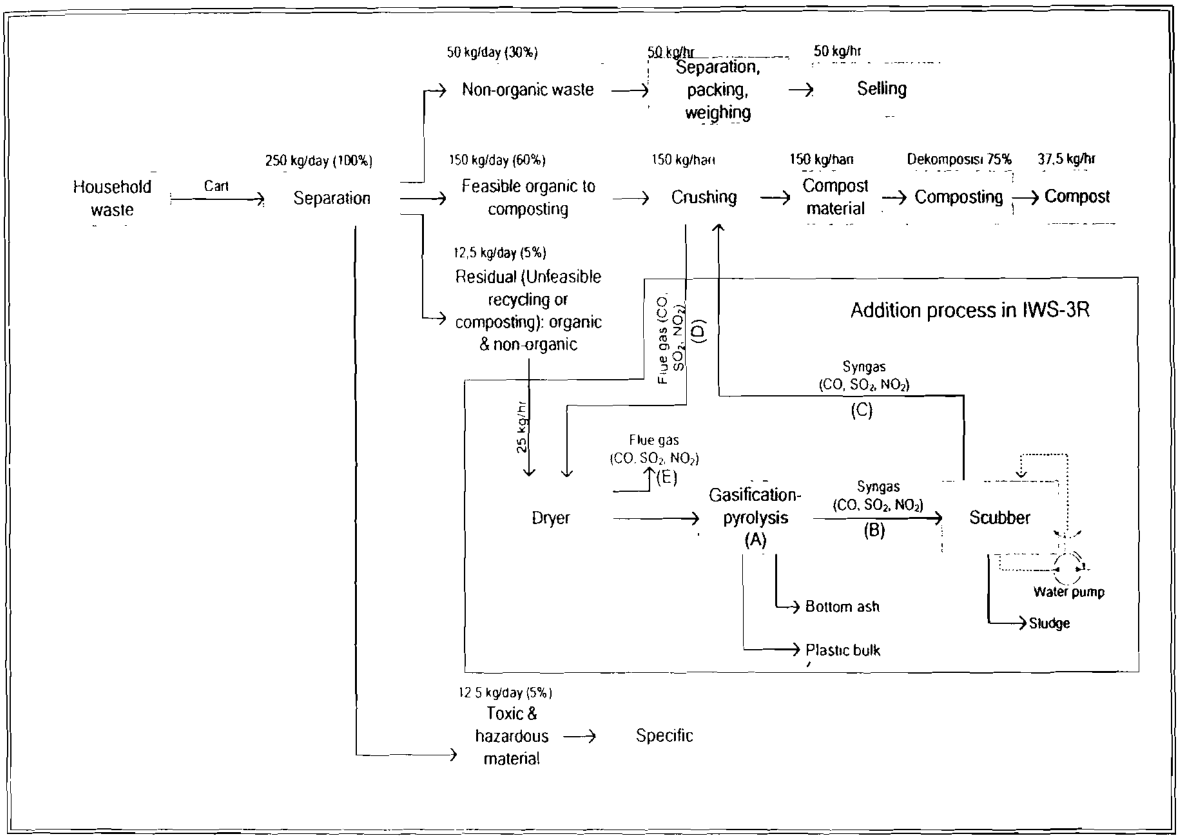

Fig. 4 : Input-outputof material flow, gas and waste in the IWS-3R inserted gasifikasi-pyrolysis

D. The Quality of the resulted gas

The measured of gas quality parameters are CO_2, CO and NO_2. Measurements were taken for two different sources of gas output, i.e., the output of gas from the gasifier and the exhaust gas of the driven motor of crusher machine. Sampling are taken 4 times for the gasifier and 3 times for the driven motor of crusher machine, and the results can be seen in Tables II and III.

TABLE I. THE SAVING OF DIESEL FUEL REQUIREMENT OF THE CRUSHER MACHINE

No	Duration (minutes)	Residual Input (Kg)	Diesel fuel consumption (ml)	Normal Diesel fuel consumption (ml)	Diesel fuel saving
1	60	1	200	1.000	80%
2	60	1	200	1.000	80%
3	150	2	500	2.500	80%
4	59	1	200	983	80%
5	85	1,1	230	1.417	84%

TABLE II. THE MEASURED GAS FROM THE GASIFIER (POINT B)

No	Parameter	The measured gas				Average
		[illegible]	[illegible]	[illegible]	[illegible]	
1	CO_2	3.52 %	4.57 %	3.51 %	1.76 %	3,34%
2	CO	6236 mg/m^3	10634 mg/m^3	7072 mg/m^3	3036 mg/m^3	6745 mg/m^3
3	NO_2	351 ppm	157 ppm	225 ppm	228 ppm	240 ppm

TABLE III. THE MEASURED GAS FROM THE DRIVEN MOTOR OF CRUSHER MACHINE (POINT A)

No	Parameters	The measured gas			Average
		1	2	3	
1	CO_2	1.80 %	1.98 %	2.26 %	2,01%
2	CO	3369 mg/m^3	3897 mg/m^3	4658 mg/m^3	3975 mg/m^3
3	NO_2	100 ppm	112 ppm	121 ppm	111 ppm

The laboratory analysis in Tables II and III show that the content of carbon monoxide (CO) and sulfur dioxide (SO_2) of produced syngas from both the gasifier (6745 mg/m^3) and the crusher machine (3975 mg/m^3) is very high, while the quality standards of CO according to the Minister of Environment Decree No. 21 in 2008 is 500 mg/Nm^3. It means that the gasifier must be modified to absorb CO.

E. Benefit – cost analysis

We use assumptions which are shown in Table IV to calculate benefit-cost analysis and benefit-cost ratio of gasification-pyrolcysis installation. We must calculte the investment and maintenance cost first, then we can calculate the benefit cost analysis.

Based on assumptions shown in Table IV and calculation in Table V, the net present value (NVP) of total cost is Rp 15,042,170, then the NPV of cost savings (benefits) is Rp. 25,686,083. Thus, the benefit – cost analysis of the gasification – pyrolysis is Rp. 25,686,083 - 15,042,170 = Rp. 10,643,913, which is greater than 0, so that the project is eligible. Moreover, the benefit – cost ratio is Rp. 25,686,083/Rp. 15,042,170 = 1.7, which is greater than 0. It can be concluded that the project is financially feasible or has a positive effect.

TABLE IV THE ASSUMPTIONS OF BENEFIT – COST ANALYSIS

No	Description	Quantitative
1	Tools maintenance	2% dari nilai investasi
2	Machine-hour	5 jam/hari
3	Diesel fuel consumption on normal condition	1 liter per jam
4	Diesel fuel price	Rp 5.500 per liter
5	The treated residual waste	1 kg/hour
6	Transportation cost to the IWS-3R	Rp 450,000 per 4 ton
7	The residual sanitary land fill cost	Rp 60,000 per ton
8	Interest rate	7.3% per year
9	Technical age of tool	5 years
10	Operator requirement	0 (to operate both gasifier and crusher machine)

Based on our quantitative research and the assumptions above, we calculate the benefits and costs during 5 years, and the result can be seen in Table V.

TABLE V BENEFIT AND COST

Year	Investment cost (Thousand)	Maintenance cost (Thousand)	Total Cost (Thousand)	Operational cost saving (Thousand)	Residual Transportation cost saving (Thousand)	Residual Landfill cost saving (Thousand)	Total saving (Benefit) (Thousand)
0	12,500		12,500				
1	-	625	625	5,280	675	360	6,315
2	-	625	625	5,280	675	360	6,315
3	-	625	625	5,280	675	360	6,315
4	-	625	625	5,280	675	360	6,315
5	-	625	625	5,280	675	360	6,315

There are 2 benefits of this research described below.

1. The environmental benefit; this research can be an alternative solution to reduce the residual waste which is resulted from the composting process. It also can reduced the requirement of diesel fuel which is used to drive the machine crusher. Fig. 5 is shown the scheme of environmental benefit. It can be seen that gasification-pyrolysis can be actualize a zero waste system.
2. The financial benefit; the operational of gasification-pyrolysis installation can give a positif benefit-cost ratio. It means that this installation has a greater benefit than its operating cost.

V. CONCLUSION

Based on the research that has been done, it can be concluded as follows

1. The household waste is dried in the dryer (C) using gas which blows from the diesel engine
2. The saving of diesel fuel in the crusher machine is equal to 80% of the normal requirements.
3. Based on the benefit - cost analysis and the benefit – cost ratio, the installation of gasification – pyrolysis has a positive effect and financially feasible.
4. The gasification – pyrolysis of residual household waste can be integrated in the Integrated Waste Management - 3R (IWS-3R) in order to solve the problem of residual recycling and reduce the operating cost at the dump site so that the 3R program of waste management is more efficient and can actualize a Zero Waste System.

The quality of CO in the resulted gas is higher than the quality standard regulated by the law. This gas must be reduced so that it will satisfy the quality standard of the law. It means that it is important to modify the gasifier – pyrolysis which can absorb CO. The CO absorber is installed between the diesel fuel and the dryer. It can theoretically reduced the CO resulted from the diesel fuel. The future research is to determine how much absorber is required to absorb CO.

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