*Proceedings of*
*The 5th Sriwijaya International Seminar on Energy and Environmental Science & Technology*
*Palembang, Indonesia*
*September 10-11, 2014*

# $NO_x$ and CO Emissions Of Rice Straw, Coconut Shell and Biobriket Combustion As Alternative Fuel

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## ABSTRACT

Biobriquette can be used to anticipate the high fossil fuel needed as alternative fuel, cheap and easily obtained. Biobriquette is solid fuel and derived from organic residues. Generally, coal biobriquette making process used biomass waste such as straws, sawdust or various shell biomasses (coffee, cocoa, hazelnut, corn, cassava and jatropha waste). In this research used biomass waste from rice straw with adding the various coconut shell compositions. The compositions of rice straw: coconut shell are 50% : 50 %, 60%: 40%, 70% : 30%, 80% : 20%, 90% : 10% with 10 % tapioca adhesive addition. One of variables determined the biobriquette quality was pollution level generated in the combustion process which was Nox and CO gas. In this research obtained best quality composition of rice straw : coconut shell was 50% : 50% and had emission level for Nox gas at 3.17 mg/m$^3$ and CO gas at 0.5 mg/m$^3$. The biobriquette product was feasible due to the emission value were below the emission standards set for Nox ≤ 1000 mg/m$^3$ and CO ≤ 500 mg/m$^3$.

Keywords: biobriquette., Gas emissions, rice straw, coconut shell.

## INTRODUCTION

Agricultural lands in Indonesia partly are tidal area used as agricultural land and plantations. As agricultural land, generally farmers grow rice and cultivate plantation of coconut trees. In the rice harvest will leave a stack of straw that was not widely used by farmers. Some farmers use straw into compost and animal feed. However, some of farmers burned rick (solid waste), arguing (1) after the burning land, a pile of hay colored black and provided granules fungus that can be used, (2) did not require the cost to process them, (3) simple and practical. But burning straw will create a new problem which are pollutant gases such as CO, $NO_x$ and $CO_2$ (Silman,1999;Lee,2000;Conen,2010) and more gases (Crutzen,1979; Panoutsou ,2011), so it will contribute to air pollution and global warming (Duffey, 2010). Besides smoke, straw was quickly burned, went up flames, combustion fly easily and generated low energy (heat) belowed 1500-4000 cal / g. Utilization of rice straw into fuel has been done by Subroto (2006) by using bagasse mixing coal into biobriquette with ratio 90%: 10%. His research results indicated that flammable substances pollutants will be reduced until 20%. Budiman, *et.,al* (2006) utilized Jatropha seeds and husks into fuel biobriket without carbonization with ratio 70%: 30%, which gave results that biobriquette produces highly flammable and provided a large CO levels. Subroto (2007) made biobriquette of straw and wood charcoal with ratio 40%: 60%. Their research suggested that CO levels diminished and high fuel value of 5.4 x$10^{-3}$ kw. Supriyadi, *et,.al* (2008) produced biobriquette by utilizing agricultural waste mixed with coal with ratio 60%: 40%, where the results of their study showed at temperature 300$^o$C and 90 minutes gave the minimum CO levels.

Mahendra (2010) mixed straw-coal to get fuel (biobriquette), with variation of raw materials. From the results of his research showed that 30% coal and 70% straw with a firing rate 3.5 g / min obtained at 890 ppm CO levels. Coconut shell is also a solid waste plantation, most farmers utilized a coconut shell as charcoal. Ndraha (2009)

conducted a study biobriquette making process from coconut shell and wood dust. From the research obtained water content 4.74%, ash content of 5.61% and calorific value 7192.15 cal / g. Straw and shell are agricultural waste wich have calor (heat) when processed through the carbonization can be used as a source of energy for domestic heat as coal called biobriquette. Coal briquettes are less popular in the public because the heat generated was too high impacted damaging cookware and impractical as well as having a high content of sulpur (Mandasini, *et.al*, 2010). Instead, briquettes from straw have enough heat so it will not damage the cookware (Hall. DO, 1987). The heat that resulted by coal briquettes reached 6000 - 7000 kilocalories (kcal), kerosene 10,000 kcal (Aladdin, 2011), the fuel value of rice straw below 6000 kcal and shell have greater fuel value than coal subituminus class (5990-7540) kcal / kg (Kirk. et al, 1979). From the description above, the researchers conducted a study to utilize rice straw and coconut shell. The expectation of this case was to utilize rice straw and coconut shell as waste to become charcoal biobriquette with variation of raw material compositions of 90% -50% rice straw and 10% -50% coconut shell by using tapioca as an adhesive and press constancy 12600 Psi (kg/m.s$^2$ 14000), which is expected to become an alternative fuel quality later. Variables that determined the biobriquette quality was pollutant level in the combustion process (Grover, 1996). Pollutants analysis focused on the levels of NOx and CO combustion. Rice straw has lower level of pollutant than the coconut shell (Yerizam, 2013). It expected low level of NOx and CO emissions. Researchers wanted to know the levels of NOx and CO exhaust gas in the biobriquette combustion produced by using comparative composition.

## METHODOLOGY

Rice straw and coconut shell carbonization process is carried out at a temperature of 500$^o$C for the carbonization of rice straw within 7 minutes and 700 ° C for coconut shell within 2 hours. Carbonization results for size 60 mesh sieve. Then they processed to be biobriquette by comparison (RS: CS) that were 50%: 50%, 60%: 40%, 70%: 30%, 80%: 20% and 90%: 10% and mixed with 10% starch adhesive. Then they molded by using mold briquette with the cylinder size were 7.9 cm high, 2.54 cm ID, OD 4.5-in. Biobriquette dried in the oven at 110$^o$C for a day, and then baked in a kiln to determine the pollutants resulting from the combustion. Combustion gases were measured by using IGG (impinger Gas). Straw and coconut shells were also conducted burning before in the same furnace and measured the gases in the same way. NOx and CO gas were analyzed. NOx gas, tested with Disulphonic Acid Phenol method, based on SNI 19-7117.5-2005, where NOx levels were determined by using UV-Vis Spectrophotometer, while the CO concentration were determined by using the analysis instrument, the UV-Vis spectrophotometer.

## RESULTS AND DISCUSSION.

Biobriquette calorific value with composition and pressure variations can be seen in the Table 1.

**Table 1. Effect of the composition and pressure to the biobriquette calorific value**

| Compotition Jp:Tk (%) | Calorific Value (cal/gr) | | |
|---|---|---|---|
| | P = 3000 psi | P = 6000 psi | P = 12000 psi |
| 90 : 10 | 1023.34 | 1394.32 | 1527.64 |
| 80 : 20 | 3254.79 | 3348.76 | 3593.05 |
| 70 : 30 | 3901.77 | 4158.42 | 4321.45 |
| 60 : 40 | 3643.04 | 3771.45 | 3860.74 |
| 50 : 50 | 4833.40 | 4952.58 | 5145.63 |

From Table 1. calorific value composition (Jp : Tk) fullfill the SNI 01-6235-2000 was 50:50 at 5145.65 cal/gr

NOx is a poisonous gas, brown-red, smelling like nitric acid and very influential in the environment. Nox produced from burning rice straw, coconut shell and biobriquette on 100 mesh particle size can be seen Figure 1

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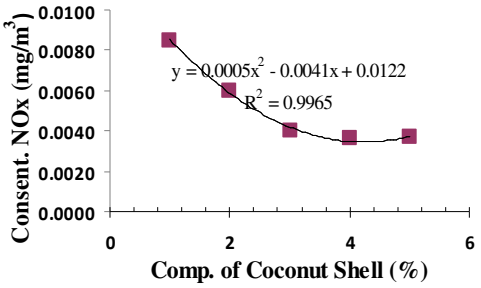


**Figure 1. Influence of Composition Ratio of Straw Rice Straw And Coconut Shell To NOx emissions**

From Figure 1 can be seen that the more composition of rice straw in the mixed biobriquette made the NOx emissions formed more. This was happened because at the time of firing, solid particle size became smaller made total surface area of the solids touch smaller, so the reaction

chances became greater and the reaction also took place more quickly. Reaction rate became greater due to faster air diffusion that inserted to fuel molecules caused of combustion activation energy. It effected to differences in temperature and concentration of biobriquette molecules and air molecules. Because of rapid combustion reaction rate, O and N molecules reacted faster so that the levels of NOx generated greater.

Burning of rice straw, coconut shell and biobriquette made in the furnace by analyzing the NOx and CO levels obtained the following results.

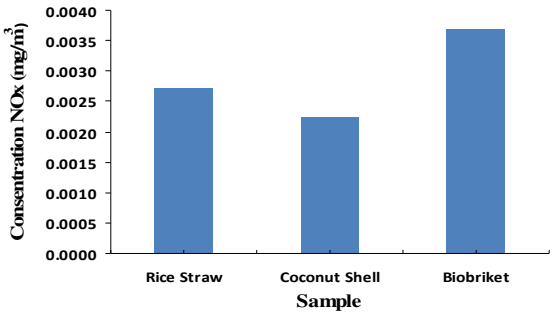


**Figure 2 NOx gas Emission Level To Rice straw, coconut shell and Biobriquette**

In Figure 2 shown the greatest concentration of NOx was biobriquette compared to rice straw and coconut shell, due to the addition of alum adhesive (starch) which gave the potential nitrogen to form NOx compounds. Nitrogen was removed from adhesive due to the combustion process will increase the concentration of NOx biobriquette combustion products. While the rice straw was main raw material of manufacture biobriquette showed concentration NOx after combustion was greater than the coconut shell 0.002713 mg / $m^3$. This indicates that when the rice straw burned after harvest by farmers, certainly contributed greater NOx compounds increasingly.

Nox compound formed by nitrogen elements in combustion of bio-fuels reacted to oxygen. The reaction produced nitrogen oxide (NO) and nitrous oxide ($N_2O$). NO oxidized by oxygen or ozone, sooner or later will form NOx compounds. NO and NOx will damage people and the environment. For human NO has the ability to restrict the oxygen levels in the blood. While NOx contacts to water vapor or inhaled by humans will be formed $HNO_3$ (nitric acid) which is very harmful to the body and environment. Because NOx will sting when contact the eyes, nose and respiratory and heart. $HNO_3$ in high concentration can cause death.

In the natural environment, NOx compounds can damage metals by oxidizing metal so causing rust. Flora and fauna will not enjoy the atmosphere that filled NOx pollutants, because it greatly affects the oxygen exchange needed by flora and fauna. NOx can also absorb ultraviolet rays from the sun where the NOx-energy molecules will react in a row with hydrocarbons in the air, because NOx is a catalyst that can lead to new substances. This process is called as photochemical smog. In this process, NOx turns into NO and active oxygen. Active oxygen atoms react easily with other substances such as oxygen and produce ozone or react with hydrocarbons will produce secondary pollutants that can harm the environment.

CO gas is colorless and odorless. In testing the CO gas emission by using solution absorbent of KI and $I_2O_5$, it can be stated that biobriquette which has the greatest CO emissions compared to gas emissions from rice straw and coconut shell. CO gas production from the rice straw and coconut shell combustion and biobriquette can be seen in Figure 3 . The best composition biobriquette with ratio 70:30 of raw material composition was 4.3479 mg / $m^3$.

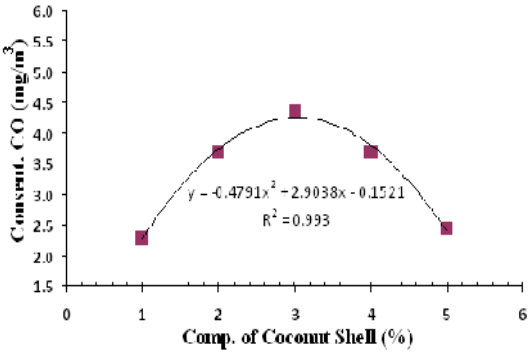


**Figure 3.Influence of Composition Ratio Straw Rice And Coconut Shell To CO Emissions**

This was occurred because of the larger the grain size in a material when the combustion process was difficult to achieve, so as the result,
The potential to form CO became greater, presence a long time to reach high temperature so CO is formed more and more, because of the complex carbon compound existed in materials was not oxidized to carbon dioxide.

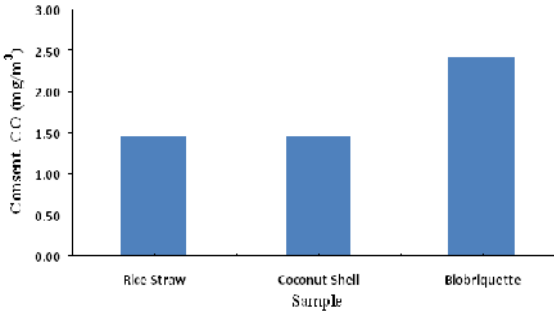


**Figure 4. Levels Of CO Gas Emissions To Rice straw, coconut shell and biobriquette**

In Figure 4, biobriquette had CO emission value greater than rice and coconut shell. This was occurred due to unburned carbon (slake), black smoke that burned in the combustion biobriquette early, together with the carbon from the fuel will reduced and formed CO at the same time.

The formation of CO gas from the various activities of human life will increase pollutants in the air. According to Sastrawijaya (2009), CO level of 10 ppm (15 mg / $m^3$) in the air will cause human illness and within a half hour 1300 ppm (1950 mg / $m^3$) can lead to death. When we sit under the air environment containing CO gas levels by 60 ppm (90 mg / $m^3$) for 8 hours, then the ability of the blood to bind oxygen fell as much as 15%, same as blood loss of 0.5 liters.

CO gas in the air will be oxidized to form $CO_2$ compounds. $CO_2$ gas in the air will be used by organisms and the other half will dissolve in seawater. $CO_2$ from sea surface will drop due to differences of acidity, temperature and salt content in the sea. In tropical regions such as Indonesia, which has temperature of 20°C-40°C will cause the water temperature rises, so the $CO_2$ evaporates into the air. Mechanism towards equilibrium was slow, so $CO_2$ will be more in the Air. These conditions will rise earth temperature, because the $CO_2$ can absorb thermal energy from the earth's surface and causing global warming. Rising temperature at the earth's surface will melt the ice at the poles, sea levels rising, and many coastal drowning. This is known as the greenhouse effect.

## CONCLUSIONS

Based on the research that has been done can be concluded that:

1. biobriquette has the best quality obtained from data and graphs was sample with a ratio of 50: 50 (Jp : Tk) pressure of 12600 Psi. (14000 kg/m.$s^2$).
2. biobriquette NOx emission level value was 0.00370 mg/$m^3$ and CO emission level was 2.4163 mg/$m^3$ from straw-coconut shell.
3. Biobriquette produced decent to be used, caused the values were still below the emission standards <1000 mg/$m^3$ for NOx (SNI 19-7117.5-2005) and CO ≤ 500 mg / $m^3$ (SNI 19-7117.9-2005).

## ACKNOWLEDGEMENTS

The authors thank to promoters and co-promoters who have given advices and guidances on the completion of this paper. The authors also thanks to director of POLSRI, has provided both moral and material support in the completion of this paper.

## REFERENCES

Aladin, Hadi and Mahfud. 2011. Natural Resources Coal. I. mold Publisher Supreme Lubuk Bandung. ISBN: 978-979-505-230-2..

Budiman S, Sukrido, and Arli Hariana. 2006. Making Biobriket of Mixed Seeds (Jatropha caucas L.) with husks As Alternative Fuels. Chemical and Process Engineering Seminar. Department of Chemical Engineering Faculty of Engineering, Diponegoro University. Semarang.

Conen F and Albrecht Neftel. 2010. Nitrous Oxide Emissions from Land-Use and Land-Management Change. Nitrous Oxide and Climte Change. Edited by Keith Smith. Page 145-161.Earthscan Ltd. ISBN: 978-1-84407-757-1

Crutzen,P.J., L.E.Heidt., J.P.Krasnec, W.H.Pollock and W.Seiler. 1979. Biomass Burning as a source of Atmospheric Gases CO, $H_2$, $N_2O$, NO,$CH_3Cl$, COS, Nature. P. 282, 253-256

Dufey, R.B. and Ibrahim. D. 2010. Global Warming – What is The Cure. Global Warming. Edited by Ibrahim Dincer. Adnan Midili. Arip Hepbasli and T. Hikmet Maggie Momba and F.Karakoe. Page 1-45. Springer Science+Business Media. e-ISBN: 978-1-4419-1017-2

Grover, P.D., and S.K.Mishra. 1996. Biomass Briquette: Technology and Practices. Food and Agriculture Organization of the United Nations. Regional Wood Energy Development Programme In Asia GCP/RAS /154/NET

Hall, D.O and R.P Overend.1987. Biomass Regenerable Energy. John Wiley and Sons Ltd: Great Britain

Kirk, R.E and D.F.Othmer. 1979. Encyclopedia of Chemical Technology. Third Edition. Vol. 6. John Wiley & Sons. Inc. New York. p.224-285. 307-323.

Lee, D.S and Robert Sausen. 2000. New Directions: Assessing the Real Impact of CO2 Emissions Trading By The Aviation Industry. Atmospheric Environment 13, p.5337-5338

Mahendra.H.S. 2010. Biomass Briquette Combustion Characteristics Test straw-Coal with variation Composition. Final Report of the Department of Mechanical Engineering Faculty of Engineering, University of Muhammadiyah Surakarta. Solo

Mandasini., Andi Aladin dan Andi Artingsih. 2010. Making Mixed Coal, Rice Husk As Alternative Fuels. Chemical and Process Engineering Seminar 2010 ISSN: 1411-4216. Department of Chemical Engineering Faculty of Engineering, Diponegoro University. Semarang.

Ndraha, Nodali. 2009. Test Material Composition Bioarang Coconut Shell Briquette Maker And The Quality Of Wood Powder Produced. University of North Sumatra. Faculty of Agriculture. Department of Agricultural Technology.

Panoutsou, Calliope. 2011. Supply of Solid Biofuels: Potensial Feedstocks, cost and sustainability IssuesbinEU27. Solid Biofuels for Energ a Lower Greenhouse Gas Alternatif. Springer Vertaq London Limited2011

Silman, S. 1999. The Relation Ozone, NOx and Hydrocarbons in Urban and Polluted Rural Environments. Atmospheric Environment 33, p.1821-1845.

Subroto. 2006. Mixed Coal Combustion Characteristics Biobriket, Cane and Straw Pulp. Media Engineering, Vol 7, No. 2, July 2006, p. 47-56

Subroto. 2007. Combustion Characteristics of Coal Briquettes Mixed Wood and Straw. Media Engineering, Vol 8, No. 1, January 2007, p. 10-16

Yerizam.M., M.Faisal, Marsi., Novia. 2013. Characteristics of Composite Rice Straw and Coconut Shell as Biomass Energy Resources (Briquette)(Case Study: Muara Telang Vilage, Banyuasin of South Sumatra. International Journal on Advanced Science Engineering Information Technology Vol.3(2013) N0.3 ISSN: 2088-5334. p.42-48.