BIOMASS GASIFICATION OF SUGAR CANE SINGLE GAS OUTLET UPDRAFT SYSTEM BY STRAW FILTER CLEANING

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Abstract. Research gasificatin to produce syngas made from sugar cane that brings so much impurity particles used in the form of wet scrubber filter and straw filter function produces syngas which is more environmentally friendly. temperature data collection at four points gasification reactor to determine the temperature distribution in the reactor to obtain the zone drying, pyrolysis, reduction, and oxidation. The energy content of LHV syngas best reviewed when the reactor temperature 850^0C achievement of stability and reactor temperature in the range of 700-800^0C for 70 minutes. The higher the value LHV syngas then is inversely proportional to the fuel consumption / the specific fuel consumed which will be less, because the better the value LHV carbon conversion into syngas (CH_4, CO, and H_2) higher and reduce unburned carbon. At optimal conditions, namely the achievement of 850^0C temperature produces the energy conversion efficiency of 37%.

Keywords : Gasification, Biomass, Sugar Cane, Straw Filters

I. INTRODUCTION

Sugar Cane (Saccharum Officinarum) is a plant grown for sugar feedstock. After the extraction sugarcane producing sap and their byproducts is bagasse, with composition: 46-52% water, 43-52% fiber and 2-6% dissolved solids. Based on the reports from the Department of Agriculture, the national sugar cane production is 33 million tonnes / year [4]. Assuming that the percentage of pulp in approximately 30-34% of sugar cane, the sugar factories in Indonesia has the potential to generate bagasse with the average about 9.90 to 11.22 million tons/year. Currently, the most important use of the dregs is the boiler fuel in sugar mills, in addition as the raw materials of particle board, pulp, and chemicals such as furfural, xylitol and plastic.

The development of renewable energy is referring to a reference [6] about National Energy Policy. It mentioned that on 2025 the New Energy and Renewable Energy at least 23% and on 2050 at least 31%. The efforts to develop the renewable energy is using the biomass conversion. The development of biomass waste utilization agricultural and forestry industries as an energy source is integrated with the industry, integrating biomass development with economic activities, encourage the manufacturing biomass energy conversion technologies and supporting business, and improving research in the development of the utilization of waste including agricultural waste for renewable energy.

According to the definition of the International Energy Agency (IEA), renewable energy is an energy derived from the natural processes that replenished continuously. One of biomass conversion technologies that can utilize the rice husks into syngasis is gasification. According to reference [7], Gasification is a process of changing the thermochemical solid fuel into gas, where the air need is lower than the air used for combustion processes. Biomass gasification process is performed by incomplete combustion in a room that is able to hold the high temperatures called a reactor or gasifier.

Gasification technology itself has been developed by previous studies, like for example on research that conducted by [5], which uses coconut shells as raw materials. The results showed the combustion air flow rate of 122.4 lpm get efficiency by 55%. [1] using the raw materials of rice husk at the primary air flow rate from the blower at 2200 lpm (11,176 m/s) to get an efficiency furnace that is still low at 6.123%. [2] uses bagasse feedstock with a fixed bed-type downdraft gassifier and the results showed that the gas produced has an average methane content of 3.6%. Heat generated by 2237.9 kJ / kg-bagasse or level of energy conversion efficiency by 29.5%, to develop, the further research is going to makeby the gasification of such modification methods and the development and customization tools.

By the basis of the gasification technology, development was undertaken back in a design tool of updraft gasification single gas outlet system [3]. In this gasification tool, the form of a combustion reactor that integrated by the tank of raw materials so that the gasification process can take place continuously, and do preheat the combustion air for the combustion air temperature adjustment with temperature gasification reactor also utilize the combustion heat in the reactor.

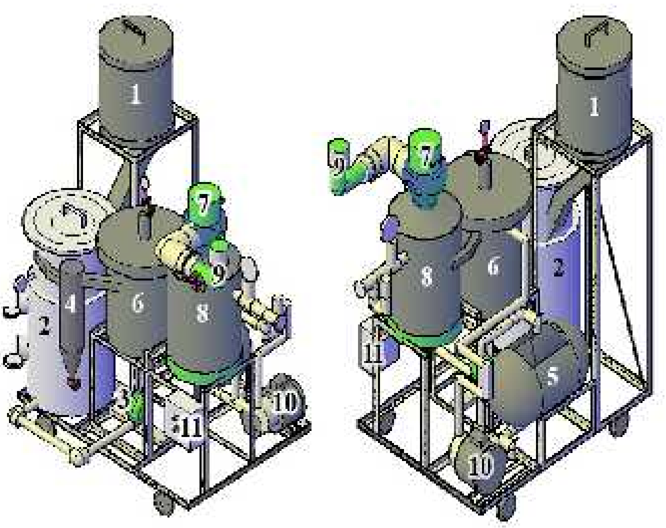
This is expected to reduce the moisture content of the air and produce the better syngas. The purposes of this research are to get a design tool that generates gasification syngas products that are environmentally friendly, to get the optimum conditions of temperature and the temperature distribution in the reactor gasification syngas results, to get the optimum conditions of updraft gasification system by continuously and the filter straw, to get a cleaner syngas and environmentally friendly.

The results of this study can be utilized for the development of gasification technology, in technical source of alternative energy for citizen and industry.

Human needs for energy is progressively increasing. It is not offset by the availability of existing energy sources. Remembering that the number of waste bagasse from the sugar industry which has not been utilized optimally, therefore it develop a method to obtain alternative energy by gasification of biomass raw material bagasse. In this design the entry of raw materials are made continuously, remembering that the time of ignition are quite long time and need the supporting fuels such as bagasse. To get a better gasification efficiency, the combustion air heating is done by utilizing the limited air supplied from the blower. From thebagasse gasification process,it reviewed an updraft gasification performance by the temperature distribution in the gasification reactor and the highest temperature reached by the gasification reactor.

II. RESEARCH METHOD

The updraft gasification system tools consist of main components that divided into two parts, the reactor gasification and gas cleaning system. A major component in the gasification reactor includes a combustion chamber, storage chamber ash and grate. Gas cleaning system consists of cyclone, wet scrubber and filter straw (figure 1).



1. Raw materials containers
2. Gasification reactor
3. Blower 1
4. Cyclone
5. Water reservoir tube
6. Water scrubber
7. Blower 2
8. Filter straw
9. Venturi burner
10. Pumps
11. The switch

Fig. 1 Gasification Updraft System Design

III. RESULTS AND DISCUSSION

The composition of the raw material determine the quality of the syngas produced in the gasification process with innovative use of filters in terms of several parameters, such as temperature distribution in the reactor which is an indicator of the 4 zones stages that occur in the gasification process, the composition of the gas produced, heat value of LHV syngas, the specific fuel consumed (SFC), specific energy consumed (SEC), and the energy conversion efficiency that can be seen in table 1.

Table 1.
The Results of Gas Heating Value, SFC, SEC, and Energy Conversion Efficiency.

Reactor Temperature Achievement (^{0}C)	**LHV Syngas (MJ)**	**SFC (kg/MW h)**	**SEC**
809	13,001	3889,94	0,39
821	12,978	3767,98	0,32
838	13,082	4009,19	0,44
840	13,007	3998,21	0,41
850	13,094	4028,23	0,45

Gasification by updraft single gas outlet with the aim to produce syngas in the form of CH_4, H_2 and CO is an environmentally friendly technology.
Oriented calculation overview to calculate the mass balance and energy balance in the gasification process, the heat value of burning the syngas, the specific fuel consumed (SFC) and the specific energy consumed (SEC).

The Effect of Temperature for the Composition of Syngas

In the gasification process, there are fourprocess to produce syngas, which is the stage of drying, pyrolysis, reduction, and oxidation. Each stage has a different temperature interval as the indicator.

On drying, the water content in the fuel bagasse removed through evaporation process, the drying zone requires temperatures around 100-500^{0}C interval. Furthermore, the raw material that is going through the second stage which is the pyrolysis temperature intervalaround 150-700^{0}C, in this zone the dry bagasse which is free of moisture, which is warming steadily and expected to eliminate the volatile content of biomass.

Biomass that warming at the high temperatures will cause the biomass split into charcoal (C), tar, oil, gas and other pyrolysis products. Pyrolysis products generally consist of three types, namely light gases (H_2, CO, CO_2, H_2O and CH_4), tar and charcoal.

In the third stage the temperature interval around 500-1000^{0}C entering a reduction zone where this process require to absorb the heat (endothermic reaction). In this stage some chemical reactions occurs such as the Water-Gas Reaction, Boudouard Reaction, Shift conversion, Methanation.

The formation of compounds that are useful to produce flammable gases such as H_2 and CO. The remaining 80% of the charcoal down to the bottom to form a layer of the reduction zone. In this section it will use almost all carbon and ash formed will be heading to the shelter ashes.

The next zone of oxidation/combustion temperature interval 700-1500^{0}C that this zone has the highest temperature in the reactor. This oxidation process produces heat (exothermic reactions) that heats the carbon layer underneath.

This process greatly influenced the distribution of oxygen, due to the presence of oxygen the exothermic reaction occurs to produces the heat needed in the overall gasification process. Approximately 20% of charcoal along with volatile will oxidize into CO_2 and H_2O by utilizing the limited oxygen supplied to the reactor (only 20% of the total air used in the combustion in the reactor).

In the figure 2 it showed the highest achievement reactor temperature, at 850^{0}C this temperature is needed the stage of pyrolysis, reduction, and oxidation that in this stage produce syngas H_2, CO and CH_4, the condition of the highest temperature reached by the temperature reactor produce H_2, CO and CH_4 % of the volume ofthelargest.

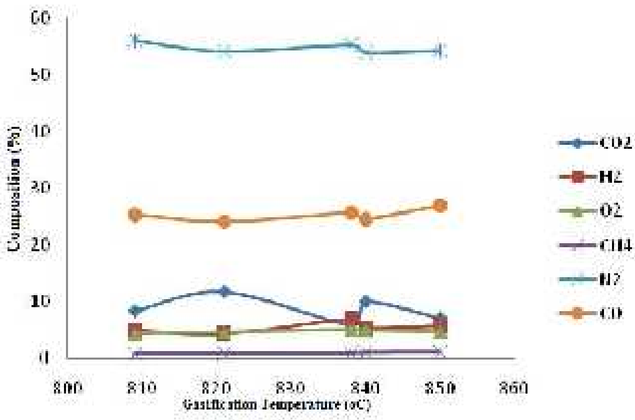


Fig. 2 Effect of gasification temperature on composition of syngas

The Effect of Temperature Reached by The Reactor on LHV Syngas

Value Combustion or Heating Value are the amount of heat released by 1 kg fuel when the fuel burned. In the gas combustion products there is H_2O in vapor or liquid form. The value of combustion when H_2O vapor formed be smaller if it compared with H_2O formed as a liquid. LHV of Heating Value is the value when the combustion in the combustion gases are not gaseous H_2O.

In figure 3 the gasification temperature graph of the value of LHV syngas, it can be seen an increase and decrease in the chart, but the maximum state is at a temperature of 850^{0}C reactor reached. Similarly, the composition of the syngas produced the results better when the temperature is set at the highest point of achievement that is 850^{0}C, so it just the same with the heat generated by the syngas that is at a temperature of 850^{0}C.

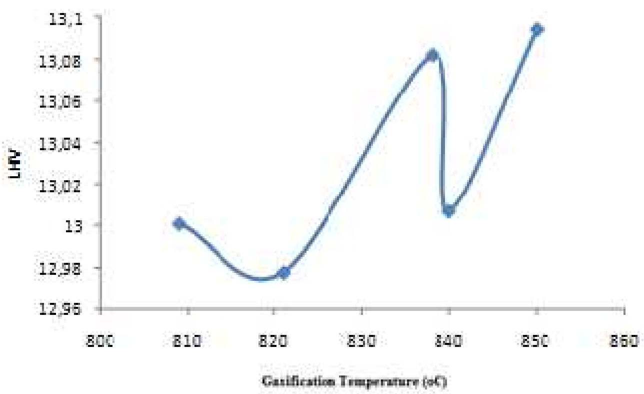


Fig. 3 Effect of gasification temperature on LHV Syngas

The decrease and increase in the graph is because it is not stayed a long time at a temperature of 800^{0}C, as described previously, at a temperature of approximately 800^{0}C it needed pyrolysis process, reduction, and oxidation, because the three processes produce syngas. It can be seen clearly in a trial state two thatthe attainment temperature of the reactor was 821^{0}C and the trial four which the reactor temperature reached 840^{0}C, where the two states was gaining high enough reactor temperature but did not get the heat value of burning syngas is not too high, this decreasement was happened because the temperature of the reactor was unstable by temperature araound 800^{0}C in a long time. When the pyrolysis process, reduction, and requires a high temperature of oxidation reactor that is directly proportional to stability for a long time, so that the process of pyrolysis, reduction, and oxidation can be proceed perfectly to produce syngas.

The Effect Reactor Temperature Reached Towards SFC and SEC

To determine the quality of the performance tool gasification to produce syngas, the parameters that need to be analyzed are Specific Fuel Consumed (SFC) and Specific Energy Consumed (SEC). Specific Fuel Consumed (SFC) is an engineering term used to describe the fuel efficiency of a tool with respect to the products, and Specific Energy Consumed (SEC) is the energy per unit mass.

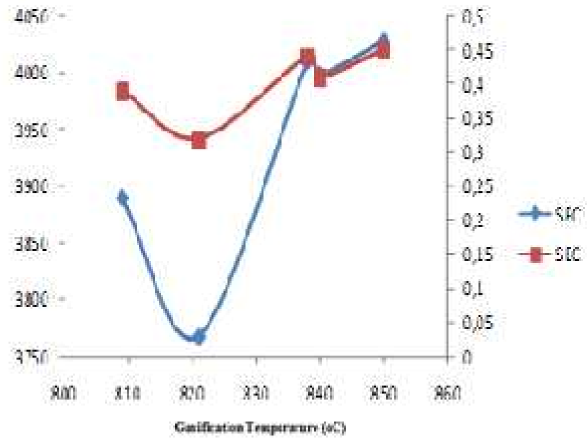


Fig. 4 Effect gasification temperature on SFC and SEC

In fig. 4 it can be seen the line on the graph shows the similarity in the results of the SFC and the SEC, it can be analyzed because of the use of fuel will be directly proportional to the energy required to obtain syngas produced. Furthermore, the specific temperature gasification of the fuel consumed (SFC) and Specific Energy Consumed (SEC) were generated graphics inversely proportional to the value of LHV syngas produced. This can be explained because when higher LHV value of a product, the combustion of carbon contained in the fuel to produce the syngas was perfect, so that the resulting SFC is lowered.

Conversely when the value is low, it because of the LHV of incomplete burning of carbon in fuel was increase in the SFC. Similar to the case in figure 3 that the raising of the consumption of fuel and energy in the trial of the second and the fourth to a temperature of the reactor reached 821^0C and 840^0C on the first trial and the third in which the achievement of lower temperature than trial to two and to four can be found in appendix data on the state of the achievement of the second experiment that the reactor temperature was 821^0C with the survival time temperature of the reactor around 700^0C only for 30 minutes and at the temperature of 800^0C it only lasted for 20 minutes.The fuel and energy consumption increasementcan be analyzed that whenthe reactor temperature reached a temperature at 800^0C but the stabilization of the temperature does not take a long time, it will cause a defective converting carbon into syngas (H_2, CH_4, and CO) then it requiredthe fuel supply more energy to produce syngas which has a value of combustion.

IV. CONCLUSION

The reach of the reactor temperature to pyrolysis process, reduction, and oxidation temperature greatly affect the results obtained syngas, and also the survival of the temperature for the process. In research. It reached the temperature at 850^0C.

There are so many benefits of the Innovation straw filter, the price is cheap, available, and able to reduce agricultural waste, which only burned by farmers and disrupt the air cleanliness. The optimal condition of straw filter when it used are 400 kg, after the gasification process, the eventual weight was 968.97 grams, which can absorb 568.97 gramsliquid smoke.

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