Development of Downdraft Biomass Gasification System for Multi Biomass Feedstock

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Abstract—Various efforts have been done to overcome the limitations of fossil fuel source. Biomass gasification, one of many renewable energy conversion systems, has a potential to apply in Indonesia. Gasification process takes place in a reactor called a gasifier. Producer gas for gasification can be used as a heat source or sources of energy for electricity generation. However, it is only particular gasifier models suitable for the particular type of biomass. Biomass with different characteristics requires a different gasifier designs that ensures the performance of gasifier. This study aims to design and develop a downdraft biomass gasifier that compatible for multi biomass feedstock. It is expected that gasifier has similar performance for different type of biomass. The main components of gasifier system are reactor, cyclone, cooler, filter and blower. The gasifier is tested with saw dust. The test conducted in order to obtain compatibility of gasifier for very fine particle size of biomass. The result shows gasifier can be manufactured with simple manufacturing method, however the design have to be optimize to obtain the optimum temperature in reactor zone for gasification occurs.

Keywords—gasification; producer gas; biomass; compatibility; continuity

I. INTRODUCTION

The depletion of fossil fuels became a serious problem for last several years. Efforts have been done for solving the problem. Many researchers have investigated various sources of renewable energy and developed the energy conversion system for those sources. One of feasible energy conversion system is biomass gasification. Biomass gasification is a thermo-chemical process of converting solid biomass into combustible gas called producer gas by means of partial oxidation carried out in reactor called gasifier[1] (Khisore, 2008). Biomass gasification occurs through a sequence of complex thermo-chemical reactions. In first stage, partial combustion of biomass producing gases and char occurs along with generation of heat. This heat is utilized in the drying of biomass to evaporate its moisture as well as for pyrolysis to bring out the volatile matter and for further reduction to generate producer gas. This gas consists of a mixture of combustible gases such as Carbon monoxide (CO), Hydrogen (H₂), and traces of Methane (CH₄) and other hydrocarbons. Normally, air is used as gasifying agent; however, the used of oxygen can produces higher caloric value gas but is not usually done due to the cost implication. Compared than solid biomass, producer gas has advantages: gases are easy to clean, to transport and to burn efficiently with a low excess of air and little resulting pollution. Further, gases can be burned in an internal combustion engine and can be easily applied in combined cycles[2] (Swaaij, 1981).

Under high temperature, the biomass loses its moisture and is then subjected to pyrolysis resulting in its decomposition into char and volatile. The volatile products are a mixture of a large number of short chain hydrocarbons which may crack further to yield compounds such as Carbon monoxide, Hydrogen, Carbon dioxide, water vapor and tar. These pyrolytic yields react with oxygen in high temperature combustion zone where oxidation and reduction reactions yield producer gas[3] (Kumar A, 2006).

Operating parameter on producer gas has been investigated by many researchers. An effect of biomass sources and particles size on producer gas has been reported by Kumar. A[4] hard wood typically gives a higher caloric value of producer gas than softwood. Hardwood and ordinary wood shows marginally better gasifier power output as compared to softwood. The percentages of Carbon monoxide, Hydrogen, and calorific value of the gas decrease with initial increasing in particle size. Dogru et al. [4] investigated hazelnut shells gasification in downdraft gasifier. The quality of product gas is to be dependent on smooth flow of the biomass in the reactor. Flow characteristics of biomass in the gasifier reactor play an important rule for optimum operation of gasifier. Composition of combustible gas CO, H₂, and H₄ was found to be dependent on gas flow rate. Increase in gas flow rate results in increasing CO, H₂, and CH₄ composition, hence higher calorific value of producer gas at higher gas flow rate[5] (Singh, et al., 2006).

Many types of biomass feedstock have been tested for in gasification system. Vyarawalla et. al.[6] utilizing wood and rice husk as fuel type downdraft gasifier small scale with 9 kW power output is used to drive the water pump. Various fruits shell have also been explored as a possible fuel biomass gasifier. Dried shell of Jatropha[7]
Typically, particular gasifier is only suitable for particular biomass. The performance of gasifier reduces when for different type of biomass. Biomass with different characteristics requires a different gasifier designs to ensure the performance of gasifier. Hence, this work aims to design and develop a downdraft biomass gasifier that compatible for multi biomass feedstock. The gasifier is expected has a similar performance for different type of biomass.

II. METHODOLOGY

The work is started with designing and manufacturing downdraft gasifier system. The reactor is made from stainless steel. Other main components are cyclone, cooler, filter, and blower. Typically in downdraft gasifier, biomass is fed from top of the reactor. Air enters the gasifier in the oxidation zone through air nozzles (tuyer) by means of suction blower. Remains gasified biomass flow through the grate region at the bottom of gasifier. Producer gas flows in the recirculation duct from the bottom of reactor and exits at the top of reactor. Producer gas is cooled by heat exchanger cooling unit. Further, gas is cleaned in the filter from dust and particle present in producer gas.

Biomass is balanced and loaded into the reactor from the top up to ¾ reactor height. To generate the flame inside a reactor, biomass in the reactor was initiated by holding the flame in a form of a blowtorch or wick near to an air nozzle. After 10-15 minutes generated producer gas in the burner was flared. Time required to produce combustible gas and duration of gas combustion flame is measured. After gasification process, the height of reactor is measured to get the amount of biomass is been gasified.

III. RESULTS AND DISCUSSION

From experimental work of sawdust gasification, it is observed that producer gas from gasification of sawdust cannot be ignited well till 30 minutes gasification. Only a few second of flame produced from producer gas as show on Figure 2.

Figure 2. Flame produced.

The problem is probably due to temperature in reaction zone is not high enough for gasfication occurs and also air supply into the reactor is not appropriate. Only pyrolisis occurs instead of gasification when temperature in the reaction zone is low. This is shown by white color of producer gas from gasification. Another possibility is the porosity in reactor is very low. This is because of very fine particle of sawdust.

IV. CONCLUSION

The gasifier is tested with saw dust. The test conducted in order to obtain compatibility of gasifier for very fine particle size of biomass. The result shows gasifier can be manufactured with simple manufacturing method, however the design have to be optimize to obtain the optimum temperature in reactor zone for gasification occurs. For very fine particle, sawdust can be briquetted prior to gasification process to obtain good quality of gas.

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