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ScienceDirect

Energy Procedia 142 (2017) 291–296

Energy Procedia

www.elsevier.com/locate/procedia

9th International Conference on Applied Energy, ICAE2017, 21-24 August 2017, Cardiff, UK

# Development of a Noval Ultra-small Biomass Gasification and Power Generation System

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**Abstract**

Small-scale, distributed and low cost biomass power generation technologies are highly required in the modern society. There are big needs for these technologies in the disaster areas of developed countries and un-electrified rural areas of developing countries. This work aims to demonstrate the technical feasibility of a portable ultra-small power generation system based on the gasification of carbonized wood pellet/briquette. A combined pretreatment process including carbonization and densification were adopted to deal with various biomass materials. Pelletization/Briquetting of carbonized fuel realized the stable operation of an updraft gasifier. After purification with several secondary clean devices, tar content in syngas was reduced to 0.49 $g \cdot m^{-3}$ and 1.4 $g \cdot m^{-3}$ for carbonized pellet and carbonized briquette, respectively. The cold gas efficiency during carbonized wood briquette gasification was about 64.4%, and the corresponding overall efficiency of the engine was 19.0%. Moreover, the steady output of 25 kW power was continuously realized. Therefore, the comprehensive system covering biomass carbonization, densification, gasification, syngas purification, and engine system is feasible for portable, ultra-small power generation


Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.

*Keywords:* small-scale power generation; densification; carbonized pellet; carbonized briquette; gasification.

## 1. Introduction

Although waste and biomass power generation plants are going to be bigger and more centralized, “Mobile” is still the trend of modern technologies. Small-scale, distributed and low cost biomass power generation technologies are highly required in the modern society. Many researchers have been focusing on the development of portable, small-scale and distributed power generation facility from waste and biomass gasification for more than 20 years.[1-

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1876-6102 
Peer-review under responsibility of the scientific committee of the 9th International Conference on Applied Energy.
10.1016/j.egypro.2017.12.046

4] There are big needs for these technologies in the disaster areas of developed countries and un-electrified rural areas of developing countries. If operated successfully, gasification process can therefore contribute to the renewable and sustainable providing of a bio-syngas, which can be directly applied for power generation by coupling with the biogas engine system. [5]

This paper is the first to use carbonized pellet/briquette for gasification power generation. The whole system from biomass carbonization, densification, gasification, syngas purification, and power generation were analyzed, respectively. The optimizations of carbonization and densification processes for making high quality pellet/briquette were discussed, and tar remove efficiency, the cold gas efficiency and overall efficiency of engine were explored for further verify the feasibility of this new technical route for small-scale power generation.

## 2. Descriptions of pilot unit for biomass gasification integrated with electricity generation

### *2.1. Pretreatment of Biomass Resources*

In this project, biomass initially experienced a carbonization process with almost no auxiliary fuel consumption. Then, carbonized pellet/briquette with high quality was produced with the biomass char for the corresponding gasification. The schematic diagram of the pretreatment process is shown in Fig.1.

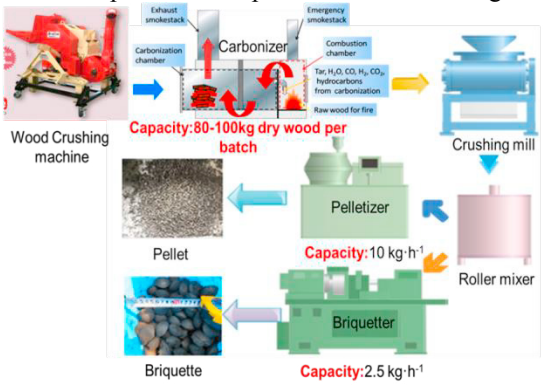


Fig. 1. The pretreatment system of biomass

The carbonizer is mainly composed of a combustion chamber and a carbonization chamber. Initially, 500 mL kerosene was used to ignition raw wood in the combustion chamber for firing. When the temperature of the carbonization chamber was lower than 200 $^{o}$C, that is, in the drying and degassing stage, the heating of the whole carbonizer was supported by adding raw wood in the combustion chamber with several batches. When biomass in the carbonization chamber started to significantly release combustible volatiles including bio-oil, $H_2$, CO, $CH_4$ etc., these gases would be transferred into the combustion chamber for burning and further releasing heat. No more wood was needed for heating the whole system from now on. After carbonization, the biomass char was crushed, and then mixed homogeneously with binder and water, and finally was made into carbonized pellet/briquette. After fully mixing, the moist powder was pressed in a pelletizer fixed with a pair of revolving rollers (F-5/11-175, Japan) or a ball press machine (240-type, China) for making pellets and briquettes, respectively. In this project, the poval solution (9.1 wt.%), corn starch solution (9.1 wt.%), syrup solution extracted from corn starch were tested as binder for making high quality carbonized pellet/briquette.

### *2.2. Gasification and syngas purification systems*

The schematic diagram of the gasification, syngas purification and power generation systems is shown in Fig.2. The updraft gasifier which was composed of a conveyer, a screw feeder, a fixed bed reactor and ash discharging parts was adopted. The outlet syngas went through the gas cleaning devices including cyclone separator, water