Benefits of the self-heat two stage biomass gasification facility

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Introduction

This study presents the original carbonization furnace systems driven by the self-heat of combustion. This has the same principle as the Japanese traditional flat kettle for "*Bincho* charcoal" or "*Binchotan*", which is produced by refining process under 1,100 ºC (e.g., Kishimoto 1971, 1998). It is higher temperature treatment than many other furnace systems (e.g., Sikarwar et al., 2016). Its structure of heat storage and air insulation achieves fully spontaneous combustion. In this self-heat two stage biomass gasification facility system, waste wood biomass resources, such as scrap wood cut below 35 mm size, wood shavings, woody roots, wood debris, dieback and wood chips, could be inputted into a carbonization furnace automatically and continuously in the first stage (**Fig. 1**). The purified charcoal is transported to the gasification react furnace by conveyer, and stable supply of the aqueous gas, H_2 and CO are performed using liquid water and waste heat form the carbonization furnace in the second stage (**Fig. 2**).

Material and methods

We developed the automatic control system of the two-stage gasification facility that makes it possible to constant the gasification conditions by keeping the temperature of each stage. One-week continuous trial using coniferous tree chip of every 200 kg per hour is carried out. Safety and stability of the automatic control system, and the homogenization of the quality has been demonstrated.

Results

a. Demonstration of one week continuous operation
Before installing an automatic control system, the temperature of the carbonization furnace had been varied due to variations in moisture content and shape of the raw materials to be introduced. The automatic control system monitors both the temperature and the suppling air amount in each unit, and keeps the quality of carbonization furnace constant. Stable supply of uniform gas composition and uniform water gas amount was demonstrated. Conditions under which coal dust explosion does not occur is satisfied, and there is no tar adhesion in the plant system.

b. Composition analysis during water gas production process
Carbon content of each produced from carbonizing furnace and unreacted charcoal from gasification react furnace during operation, was 91.5% and 92.1%, respectively. From the sample piece provided within the equipment, to investigate the tar content in water gas and the exhaust gas, tar component was not detected. The total produced gas amount is 110 m^3/h, and the hydrogen and CO content of water gas are about 60 vol% and 15 vol%, respectively. Other components are CO_2 20 vol% and N_2 5 vol%. Both endothermic reaction and water gas shift reaction occurred under 700 ºC.

c. Other characteristics
i) Condition test to ensure the 20% mass carbonization yield under 1,072 ºC combustion.
ii) Condition to ensure the 76.2% of pyrolysis furnace reaction efficiency. It was not enough slightly to 80% of the target, however 16% improvement were achieved before the project commissioned that was about 60%.

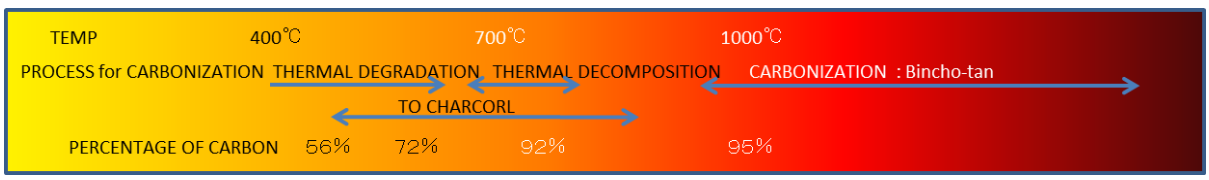

Fig. 1. Process for carbonization and temperature of "*Bincho* charcoal".

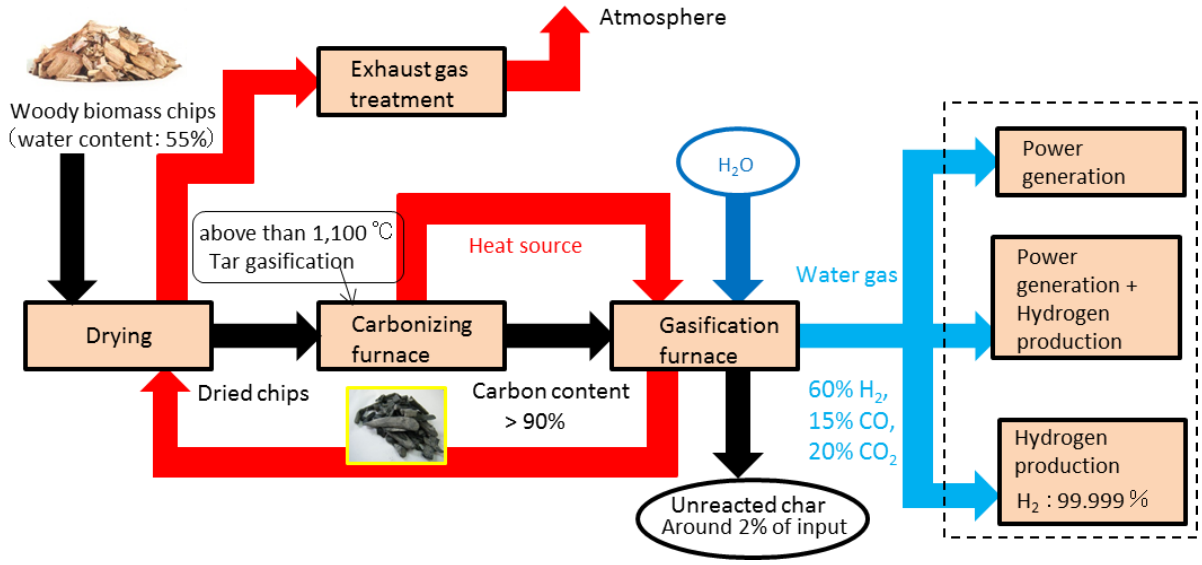

Fig. 2. System configuration and material flow of the self-heat two stage biomass gasification facility.

d. Future evolution of system

Released CO_2 gas can be used for activation of the charcoal, and the surface area of charcoal will be greatly increased. The present surface area around 300 m^2/g will be expected around 1,000 m^2/g. Unreacted char will be reduced and the produced gas amount can be increased. Alternatively, the self-heat two stage biomass gasification facility can be utilized as soil remediation equipment (e.g., Lehmann et al., 2003).

Conclusions

Benefits of the presented system are listed below.

- Tar-free: Complete decomposition of tar component in carbonizing furnace, which remains above 1,100 ℃.
- Carbon offset: No necessary auxiliary fuel other than for the ignition at start-up. Only the energy of wood chip combustion is released.
- High-quality Gas: No raw material remaining in gasification furnace after carbonization of chips due to char refining process. The hydrogen content of water gas reached about 60 vol% which is equal to theoretical value.
- Wet chips, water content 55%, can be used: A drying process using the waste heat of the carbonizing furnace is available for materials with high water content.
- Power generator or hydrogen production: The final stage of the facility, generator or hydrogen separation device, can easily be selected on depending on the use.

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