Advanced Utilization Technology of Biomass and Waste

Background and Objective

As an effort for the reduction of carbon dioxide emissions, the electric power companies are working on the co-combustion of carbon neutral biomass in coal-fired power plants. The aim of this project is the creation of a recycling society by expanding the use of biomass in electric power companies. So, we developed the evaluation technology of biomass potential and the highly effective utilization technology of the biomass and waste. The first technology supports a new business model for biomass, and the second one is applied to small-scale distributed power sources and the large-scale co-combustion of biomass in the coal fired power plants.

Main results

1. Evaluation of life cycle CO_2 emissions of biomass fuel

Based on a field survey, the evaluation of the life cycle CO_2 (LC-CO_2) emissions from domestic and foreign biomass fuels (woody pellet, Bagas pellet and EFB pellet) was carried out (Fig. 1). These biomasses are supplied to domestic coal-fired power plants as a fuel for co-combustion. Among the LC-CO_2 emissions, the influences of the land transportation of the raw material and product are small, and the influences of the drying process and pelletizing process of the raw material and the marine transportation of the product are large. LC-CO_2 emissions can be reduced by the utilization of waste heat in the drying process, green electricity in pelletizing process and the large-scale production of biomass pellet. Compared with the domestic biomass fuel, CO_2 emissions due to marine transport are added to the LC-CO_2 emissions of the foreign biomass fuel. However, both LC-CO_2 emissions become same level by the expansion of production scale and the improvement of production process [Y10010].

2. Basic design data of commercial carbonizing gasification power generation plant

The gasification performance of biomass was studied experimentally in the fuel moisture range of 5% to 30% using the carbonizing gasification test facility (Fig. 2). The result shows that the cold gas efficiency is maximized when the moisture-carbon ratio of biomass is about 0.4, and the concentration of tar is decreased by increasing the ratio. Based on this result, the heat and mass balance analysis of the 5t/d carbonizing gasification power generation system with biomass of 50% moisture was carried out. The analysis shows that the generating efficiency is maximized when the biomass is dewatered to 20% moisture (Fig. 3) [M10022]. Also, the phosphorus behavior in the carbonizing gasification process of the fermentation sludge was studied experimentally using the test facility [M10023]. As a result, the basic data to design the commercial plant of the carbonizing gasification power generation system was obtained.

3. Advanced co-gasification of biomass and coal in IGCC

The coal reactivity in low temperature gasification was enhanced by mixing coal and pyroligneous acid, which is unused resource derived from biomass [M08011]. By adding $CaCO_3$, as a melting point depressant, to the coal with a high ash melting point, and also mixing it with the crude vinegar, the coal reactivity in high temperature gasification was strongly enhanced due to the catalytic effect of calcium (Fig. 4) [M10015]. Therefore, the possibility that the gasification performance would be upgraded by the pre-treatment of coal using the crude vinegar derived from biomass was suggested.

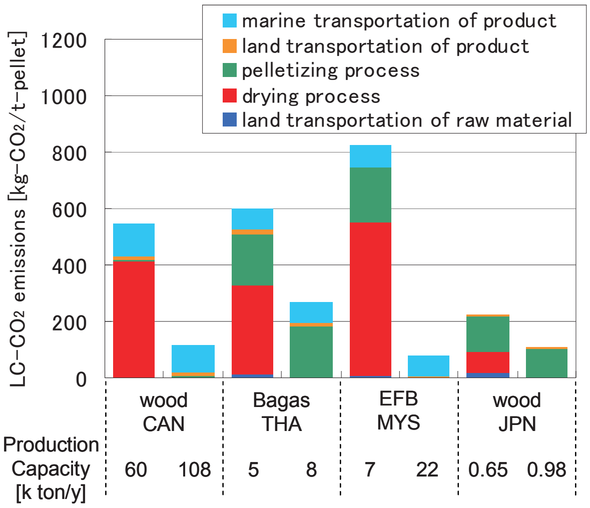

Fig. 1 LC-CO_2 emissions of biomass fuel

The left side bar chart of each country is the case of using the fossil fuel for drying process. The right side bar chart is the case of using the waste heat and the biomass fuel for drying process. In the right side bar chart of Malaysia, the proportion of pelletizing process in LC-CO_2 emissions is small because the biomass power is used to pelletize. In case of Canada, owing to the large-scale production and a low-carbon power source, the proportion of pelletizing process in LC-CO_2 emissions is small.

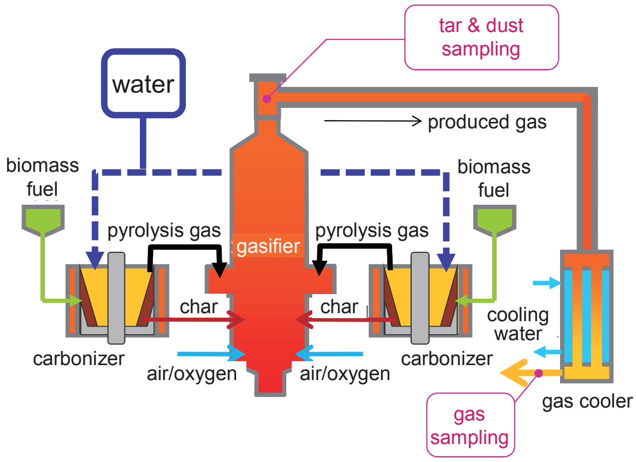

Fig. 2 Flow diagram of biomass carbonizing gasification test facility

In the moisture addition test, the pine pellet with 5% moisture was used as a fuel. The fuel moisture has been adjusted in the range of 5% to 30% by adding water to the carbonizer. The tar and dust in the product gas were measured at the top of gasifier and the gas composition of the product gas was measured at the gas cooler exit.

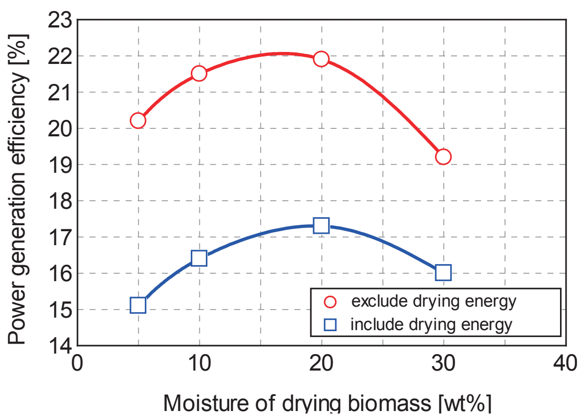

Fig. 3 Effect of fuel moisture on power generation efficiency

The biomass of 50% moisture is dried and fed to the carbonizing gasification power generation system. About 20% moisture of the drying biomass is an optimum value (maximum efficiency of power generation). If the fuel is dried to less than 20% moisture, the power generation efficiency decreases because of the decrease of the cold gas efficiency and the increase of drying heat source.

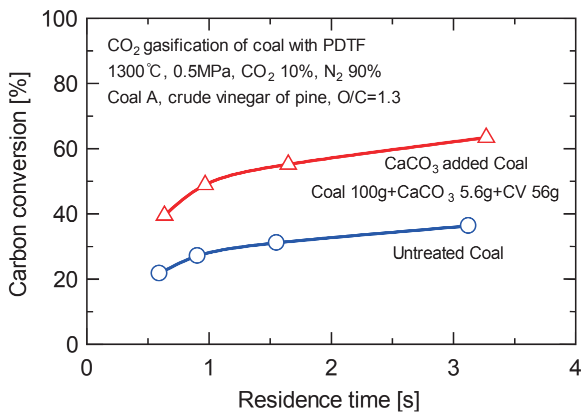

Fig. 4 Gasification of coal, $CaCO_3$ andcrude vinegar (CV)

Coal A (13.8% ash, 1.8% CaO in ash) has relatively low reactivity. The coal gasification reactivity was enhanced due to the catalytic effect of calcium, by means of adding the melting point depressant ($CaCO_3$) to the coal and also mixing it with the crude vinegar. The carbon conversion means the ratio from which the carbon contained in coal is converted into the gas.