Project Research — Development of a Supply/Demand Infrastructure for Next-generation Electric Power

Advanced Utilization Technology of Biomass and Waste

Background and Objective

As an effort toward reducing CO_2 emissions, the use of biomass for power generation is expected. Due to the difficulty in collecting a large amount of biomass, it is important to plan a business model appropriate to the potential. Since the calorific value of biomass is generally low due to the high moisture content of biomass, the development of biomass utilization technologies including upgrading technologies is a critical issue. In this project, the evaluation technology of biomass potential and the utilization technology of biomass energy are developed. The evaluation technology of biomass potential is meant to assist planning of the biomass energy project. The utilization technology of biomass energy consists of upgrading technology based on coal combustion and gasification technologies that have been developed by CRIEPI. The aim of the development is to increase the use of biomass energy. The targets cover the various sorts of biomass, from woody biomass such as that from forest thinning to waste-derived biomass such as sewage sludge.

Main results

1 Evaluation Technology of Biomass Potential: Potential of Biomass Power Generation in the Tohoku Region

The potential of waste power generation in Japan and the LCA-CO_2 of the coal-fired power plants in Japan and abroad were evaluated (Y10010). The amount of biomass waste (combustible rubble, agricultural, and forestry waste) generated from the earthquake disaster reconstruction process of the Tohoku region was estimated using the evaluation method. The power generation potential of the biomass waste was evaluated considering the progress of rubble treatment and the recovery of agriculture and forestry. In the case where the reconstruction plan proceeded smoothly and where the biomass was used as fuel for power generation in the Tohoku area, the electric energy reached 418 GWh/y. This value is equivalent to one-half of the new energy output (851 GWh/y in FY2010) of Tohoku Electric Power Co. (Fig. 1) (Y11019).

2 Upgrading and Utilization Technology of Biomass

2-1. Co-combustion and Gasification Characterization of Carbonized Sewage Sludge*

The co-combustion test of carbonized sewage sludge and coal was carried out using the coal combustion test facility. The co-combustion characteristics of carbonized sewage sludge and coal was approximately equivalent to the mono-combustion characteristics of coal (Fig. 2). The gasification test of carbonized sewage sludge was carried out using the carbonized gasification test facility. It was difficult to discharge the ash as molten slag, and it was difficult to keep the calorific value of synthesis gas at 3.3 MJ/Nm^3 or more. The co-gasification test of the mixture of carbonized sewage sludge and low-ash woody biomass showed stable discharge of molten slag and kept the calorific value of synthesis gas at 4.7 MJ/m^3_N or more (Fig. 3).

2-2. Development of a Test Apparatus for the Carbonizing Characterization of Biomass

To estimate the carbonization characteristics of biomass, a small-size carbonization test apparatus (fuel feed rate of 1 kg/h) was developed. The carbonizing test of pine pellets (carbonizing temperature range of 300–600°C) showed that the char yield was in good agreement with that of the batch-type carbonizer (fuel feed rate of 50 kg/h). Since this apparatus enables the quantitative analysis of the non-condensable components and sampling of all the condensable components in pyrolysis gas, it can be used predict the carbonizing characteristics of biomass in a commercial carbonizer (M11014).

*Collaborative research with Bio Fuel Co.

Other reports: (Y11033)

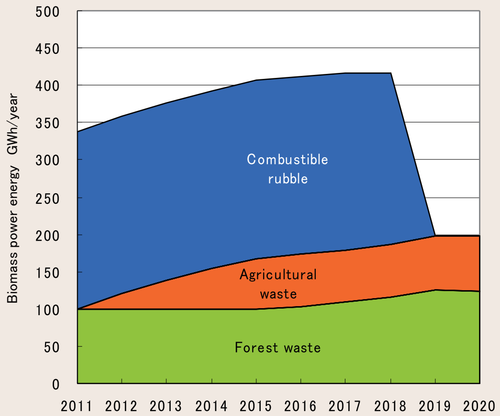

Fig. 1: Evaluation result of biomass power generation potential

Figure 1 shows the biomass power generation potential when the estimated amount of biomass generation is treated with the general waste treatment facility with the power generation system in the Tohoku region (completing the treatment in about eight years). Agricultural waste refers to agricultural residue from when the recovery of agricultural land goes smoothly. Forest waste refers to that derived from wood residue and forest thinning when the recovery from the forest industry proceeds smoothly, and the use of domestic lumber is increased. The combustible rubble and agricultural waste are produced in Iwate, Miyagi, and Fukushima prefectures, and the forest waste is produced in the six Tohoku prefectures and in Ibaraki Prefecture.

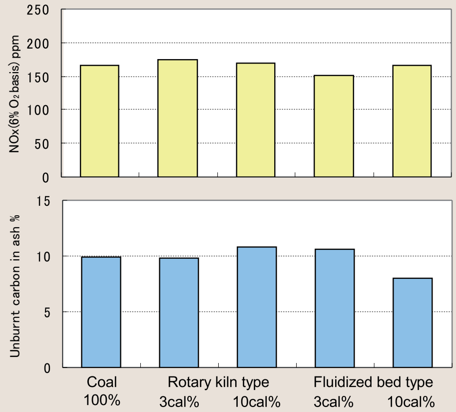

Fig. 2: Co-combustion test result of carbonized sewage sludge and coal

Figure 2 shows the NO_x levels in incinerator flue gas and the concentration of unburnt carbon in ash in a co-combustion test of the two types of carbonized sewage sludge and coal. This carbonized sewage sludge was produced by different production methods of carbonization. The NO_x levels and concentrations of unburnt carbon in ash were almost equivalent to that of the mono-combustion test of coal. The key words "kiln" and "fluidized bed" in the figure refer to the types of carbonizers used for the production of carbonized sewage sludge.

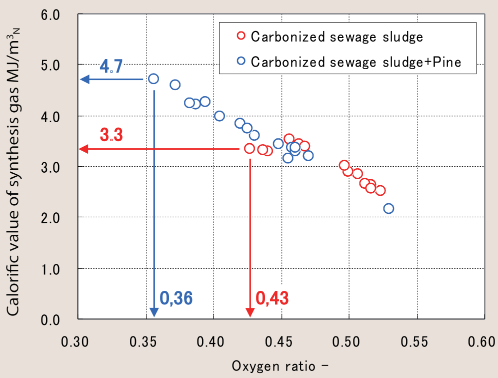

Fig. 3: Gasification test result of carbonized sewage sludge and pine

Figure 3 shows a relationship between the oxygen ratio and the calorific value of synthesis gas in the gasification test of the carbonized sewage sludge and the mixture of carbonized sewage sludge and pine. In case of the carbonized sewage sludge gasification, it was difficult to reduce the oxygen ratio to less than 0.43. When the oxygen ratio was reduced, the temperature of the gasifier went down. In case of the mixture gasification, the gasifier kept its temperature high at the oxygen ratio 0.36, and the calorific value of synthesis gas reached about 4.7 $MJ/m^3{}_N$.

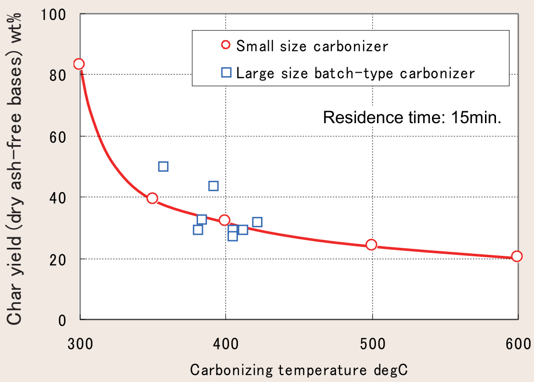

Fig. 4: Comparison of the char yield

As the carbonizing condition of the small-size carbonizing test apparatus, the carbonizing temperature is set at the range of 300-600°C, the residence time in the carbonizer at 15 minutes, and the fuel feed rate at 1.0 kg/h. As to the large-size batch-type carbonizer, the carbonizing temperature is about 350-425°C, the residence time is 15 minutes, and the fuel feed rate is 50 kg/h. Both results showed good agreement in char yield.