Priority Subjects — **Development of a Supply/Demand Infrastructure for Next-Generation Electric Power**

Sophisticated Technology for Low-Grade Energy Resources

Background and Objective

Co-firing of biomass has been promoted as a measure to reduce CO_2 emissions in coal-fired power plants. However the co-firing rate requires improvement, due to the difficulty of pulverizing biomass compared to coal and the co-firing rate still remains too low at a mere few percent. At the same time, the use of low rank coal such as lignite has been proposed as an expansion strategy of fuel species for coal-fired power plants. Lignite reserves are reasonably high in Asia, and it is a good target for coal-fired power plants, however poises the problem of being difficult to use due to its high moisture content, low heating value and high spontaneous ignitability. In this project, we aim to develop a carbonization technology for low-grade resources such as biomass and lignite to use in coal-fired power plants, and to establish an evaluation technology for low-grade resources.

Main results

1 Development of carbonization technology for woody biomass

1) Heat balance analysis for the carbonization process

Carbonization tests of cedar chips were carried out using CRIEPI's demonstration scale carbonization test facility, which had a throughput and maximum carbonization temperature of 4t/day and 650 degrees Celsius. The feed rate of cedar chips (40% moisture) was from 130 to 145kg/h, and the carbonization temperature was between 340 and 400 degree Celsius. The fuel ratio*1 of the carbonized cedar was between 0.19 and 0.91 (Table 1). Under all test conditions, auxiliary fuel accounts for around 20% of total heat input of the carbonization process. The heat loss of the carbonization process was as low as approximately 10% of total heat input, which is equivalent to a commercial plant, therefore, it will be possible to evaluate large-scale commercial carbonization process using this test facility (Fig. 1).

2) Characterization of carbonized cedar and the carbonization process

In the carbonization process, the heat value ratio of carbonized cedar to raw cedar and the carbonization efficiency decreased with the increase in carbonization temperature, and these reduction rates increased as the carbonization temperature increased from 380 to 400 degree Celsius. Since the fuel ratio of carbonized cedar rapidly increased between 380 and 400 degree Celsius, it is believed that carbonization was accelerated in that temperature range (Fig. 2). By storing similar data for other biomass feedstock, it will be possible to predict the product properties of a commercial process by analyzing biomass feedstock.

2 Grindability estimation of coal used in coal-fired power plants containing a high percentage of carbonized wood

Assuming the use of carbonized wood at a high co-firing rate in coal-fired power plants, the grindability of coal containing a high percentage of carbonized wood was evaluated using a roller mill test facility. A raw cedar chip and three different carbonized cedar chips of 0.19, 0.25 and 0.58 in fuel ratio, were mixed with a coal, for grindability tests. These carbonized cedar chips were produced by the carbonization test facility described above. The mixing ratio of carbonized/raw cedar with coal was set at 3-30% on a calorie basis. The grinding power increased as the mixing rate rose, but the increase in grinding power was significantly suppressed by carbonizing the cedar chips. The grinding power reduced with the increase in fuel ratio of the carbonized cedar chip. The carbonized cedar chip with a 0.58 fuel ratio and the coal demonstrated almost equal grindability (Fig. 3).

*1 The ratio of volatile matter and fixed carbon in the fuel increases with the progression of carbonization.
*2 One of the quality indicators of carbonized biomass, expressed as the product of heat value and production of carbonized biomass divided by the product of heat value and the feed rate of raw biomass.
*3 One of the performance indices of the carbonization process, expressed as the product of heat value and production of carbonized biomass divided by the sum of the product of heat value and feed rate of raw biomass and the product of heat value and feed rate of auxiliary fuel.

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Table 1: Carbonization test conditions and fuel properties of raw / carbonized cedar

The conditions of the carbonization test and the industrial analysis data of raw cedar and carbonized cedar.

Low — Fuel Ratio — High

Run No.	Unit	Cedar	Run1	Run2	Run3	Run4	Run5
Carbonization Temperature	℃	-	340	360	380	400	400
Feed Rate of Cedar	kg/h	-	146	128	134	146	129
Ash	% db	0.2	0.3	0.3	0.3	0.5	0.7
Volatile Matter	% db	85.7	83.8	82.1	81.3	63.1	52.1
Fixed Carbon	% db	14.1	15.9	17.6	18.4	36.4	47.2
Fuel Ratio	-	0.16	0.19	0.21	0.23	0.58	0.91
HHV	MJ/kg	20.6	20.7	21.2	21.6	25.7	28.6

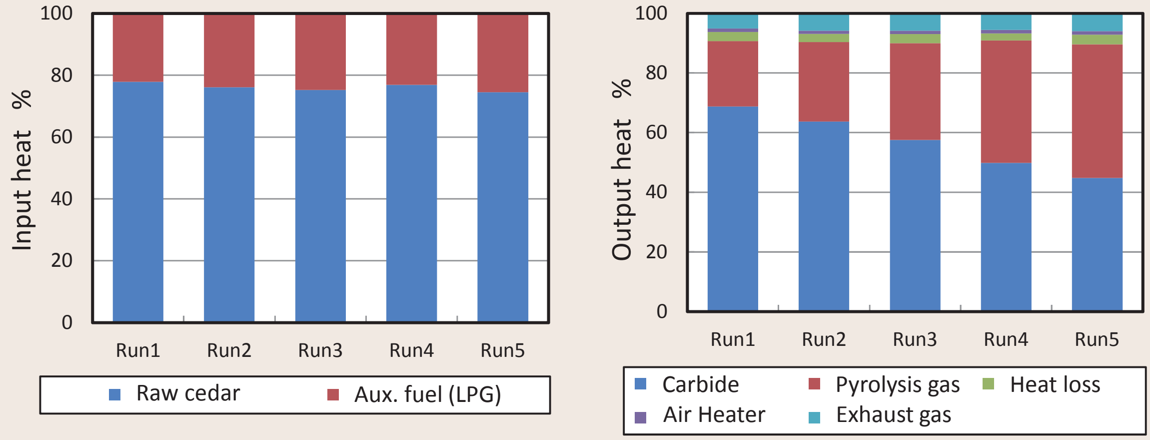

Fig. 1: Heat balance of the carbonization process (Left: Input heat, Right: Output heat)

The graphs show the input and output heats of the carbonization process obtained from a heat balance analysis of the carbonization test facility. The input heat is composed of heat generated by raw cedar and auxiliary fuel (LPG), while the output heat is composed of heat generated by carbonized cedar, pyrolysis gas, exhaust gas and loss from equipment. The information is used for optimization of carbonization conditions and design/operation of commercial carbonization plant.

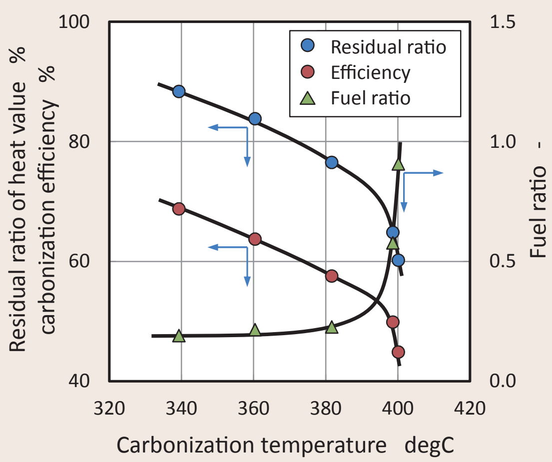

Fig. 2: Effect of carbonization temperature on the residual ratio of heat values in carbonized cedar and carbonization efficiency

The graph shows the relation of the carbonization temperature to the residual ratio of heat value*2 and the carbonization efficiency*3. This data can be utilized for setting carbonization test conditions, optimizing test conditions and developing tools to predict the fuel properties of carbonized biomass.

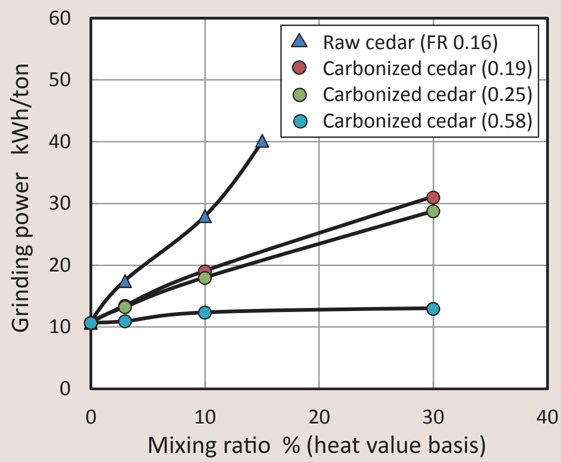

Fig. 3: Effect of mixing rate on grinding power

A grinding test of a coal and raw/carbonized cedar chips mixture was carried out using the roller mill test facility. It was difficult to grind the coal with 30% raw cedar chips. The grindability of carbonized cedar chips was greatly improved.