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

Expansion of Fuel Types and the Improvement of Efficiency in IGCC

Background and Objective

Coal gasification combined cycle (IGCC) power generation, which is a highly efficient system and which has an advantage regarding environmental protection, is an important technology for electric power companies as an option for next-generation coal-based thermal power plants. CRIEPI has been involved in the research since the initial stage of IGCC development, and has been supporting the design and operation of the Nakoso IGCC demonstration plant.

Aiming at the development of a commercial IGCC plant and also to support the operation of the demonstration IGCC plant, we have developed gasification technology for many types of coal and a hot-gas cleanup system to improve fuel flexibility, thermal efficiency, and plant reliability etc.

Main results

1 Supporting Activities of the IGCC Demonstration Project

The gasification reactivity of sample coal was clarified in high-temperature and elevated-pressure conditions that are similar to the actual conditions of a gasifier. The gasification performance of the IGCC demonstration plant was predicted for sample coal based on the analytic results of the gasification reaction rates and on our one-dimensional numerical simulation technique, in order to discuss the operating conditions of the demonstration plant (Fig. 1). Furthermore, the results of the demonstration tests were expressed well by our three-dimensional numerical simulation technique, which could solve complicated phenomena in a gasifier. This supporting tool to evaluate the gasification performances of large-scale and commercial-scale gasifiers by the numerical simulation was verified for various operating conditions, such as for coal with remarkably high reactivity, as well as for coal blending.

2 Evaluation of the Availability of Biomass as a Blended Fuel for a Coal Gasifier

To expand the fuel types of the IGCC, the ash-melting characteristics and gasification characteristics of blended fuels, which consist of a mixture of coal and wooden biomass or sewage sludge carbonized fuel, were evaluated. It became clear that mixing the coal, which has a high ash melting point, and the sewage sludge carbonized fuel would cause a big drop in the ash melting point* relatively, while also promoting the gasification reaction (Fig. 2), as the sewage sludge carbonized fuel has high alkali content and a low ash melting point. The findings from this study indicated possibilities for the further expansion of the available types of coal for the IGCC.

3 Evaluation of Thermal Efficiency and Proper System Configuration for a Hot-gas Cleanup System

The process design of the hot-gas cleanup system, which removes halides and mercury, was conducted to achieve a higher thermal efficiency of the IGCC and simple system configuration. The new system was derived by improved design to decrease power consumption in the sulfur removal process and to minimize the instruments for the halide removal process (Fig. 3). The efficiency of the system was analyzed for the commercial-scale plant equipped with a gas turbine of 1500°C TIT. The net thermal efficiency of the IGCC plant is expected to increase by 1.6 % (HHV) in absolute value due to the decreased the thermal loss and the lower auxiliary power.

*The lower ash melting point generally causes stable operation, as molten ash is discharged from the gasifier.

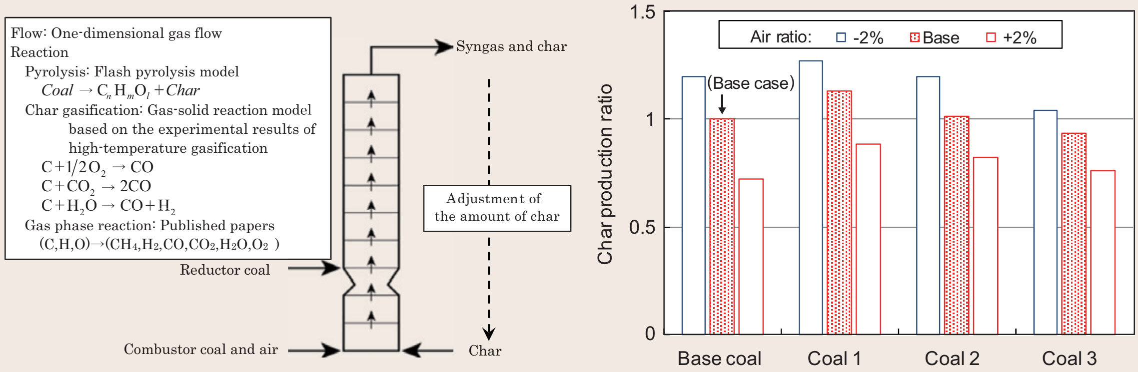

Fig. 1: Outline of the 1D numerical simulation of a gasifier and the prediction of gasification performance

The gasification performance at full load was predicted with the one-dimensional numerical simulation technique using the coal properties and the experimental results of the gasification reaction rate analysis. The prediction of the char production ratio, which is one of the gasification performance indicators to evaluate the operation of the gasifier, is shown in the right figure.

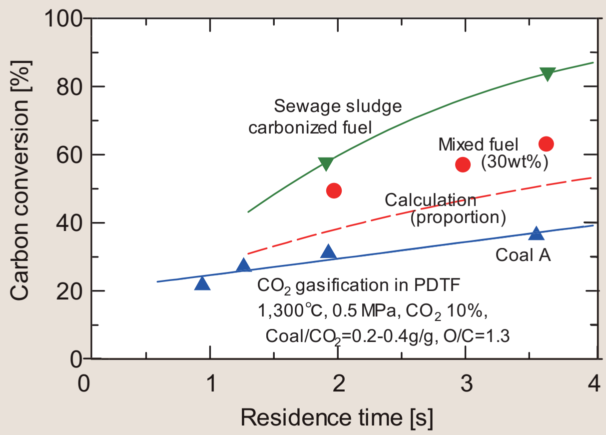

Fig. 2: Promotion of carbon conversion by mixing sewage sludge carbonized fuel

When 30% sewage sludge carbonized fuel was mixed with coal, the carbon conversion† in the gasification experiments was higher than that estimated from the coal and carbonized fuel. The inherent alkali content of the sewage sludge carbonized fuel should have promoted the gasification reactivity of the coal char.

$$^{\dagger}\text{Carbon conversion (\%)} = \frac{\text{Carbon in product gas (kg/h)}}{\text{Carbon in fed fuel (kg/h)}} \times 100$$

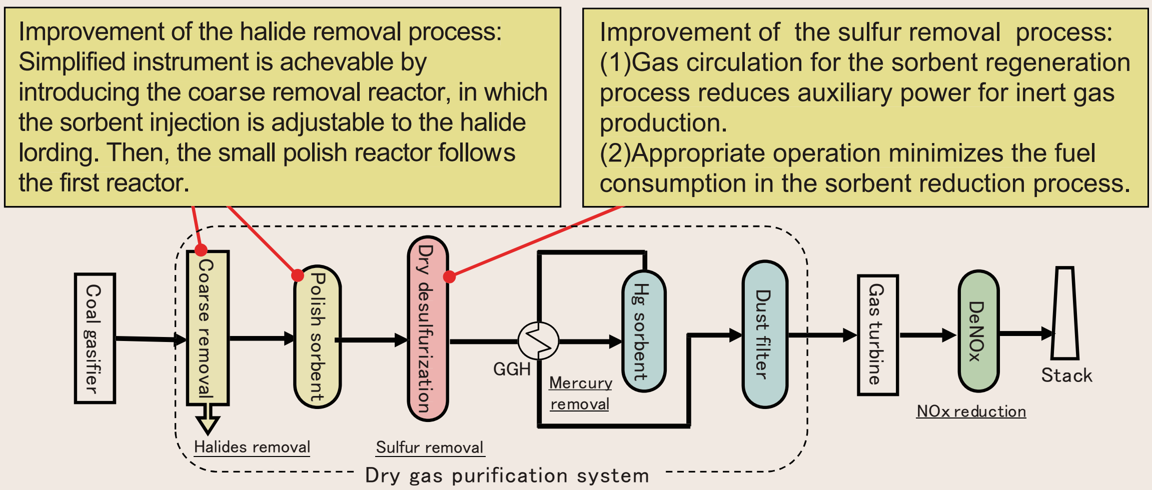

Fig. 3: System configuration of the proposed dry gas purification system

This gas purification system consists of dry gas removal processes for halide, sulfur, and mercury, followed by the filtration of remaining dust. The system was improved by reducing auxiliary power for the sulfur removal process and through simplified instruments for halide removal.