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

Development of Enhanced IGCC and Low Carbon Technologies

Background and Objective

Integrated coal gasification combined cycle (IGCC) power generation, which is a highly efficient and environmentally friendly system, is an important technology for the electric power industry as an option for coal-based thermal power plants. CRIEPI has been involved in the IGCC project research since the initial stage of development to support the design and operation of the Nakoso IGCC demonstration plant, and has also been developing a hot-gas cleanup system to improve the thermal efficiency of a next-generation IGCC system. Moreover, CRIEPI has proposed a highly efficient IGCC system with CO_2 capture (Oxy-fuel IGCC system) to solve the problems of carbon capture and storage (CCS) technologies that cause a significant drop in power generation efficiency and an increase in cost.

In this research, to promote introduction of a commercial IGCC plant, we support the operation of a demonstration IGCC plant, and build the technique to assess the design and operation of a commercial IGCC plant. We also evaluate the impact of a hot-gas cleanup system on the thermal efficiency and the cost of an IGCC system, and build up the technological basis for an oxy-fuel IGCC system.

Main results

1 Supporting Activities for the IGCC Demonstration Project and Evaluation of Coal Adaptability

The gasification performance of the IGCC demonstration plant was predicted for several test coals, using our one-dimensional numerical simulation technique and a gasification reaction rate analysis under high temperature and elevated pressure. A sensitivity analysis was conducted to predict the influence of operating conditions, such as air ratio, on gasification performance (Fig. 1), and the results were reflected in the demonstration tests. Another analytic method was also built to evaluate the molten slag behavior related to the stable operation of the gasifier, and a technique to evaluate coal adaptability based on the numerical simulation techniques was established (Fig. 2). Moreover, the mechanisms of a blockage in the syngas cooler of the demonstration plant were clarified. These activities have contributed toward the success of the IGCC demonstration project.

2 Evaluation of the Economic Impact of Hot-Gas Cleanup System

The introduction of a hot-gas cleanup system was estimated to reduce investment cost by 35% compared to the conventional wet gas cleaning system due to dry processes reducing the number of reactors, heat exchangers and pumps. On the other hand, the operational cost of the hot-gas cleanup system increased due to the costs of impurity sorbents and detergents. The cost of electricity from IGCC with the hot-gas cleanup system was evaluated to ultimately be lower than that with the wet gas cleaning system, due to the fact that the higher efficiency contributed to reducing fuel costs.

3 Development of Fundamental Technologies for Oxy-Fuel IGCC System*

In an oxygen-CO_2 blown coal gasifier in the oxy-fuel IGCC system, a gasification reaction is expected to promote by supplying CO_2 as a gasifying agent, but the temperature in the gasifier falls due to the higher molar specific heat of CO_2. In order to examine the influence of supplied CO_2, gasification experiments were conducted using the 3t/d coal research gasifier installed in CRIEPI. The CO_2 and oxygen concentrations in gasifying agents, and the coal feeding ratio of reductor to total were changed. As a result, reaction behavior in the gasifier was clarified experimentally (Fig. 3) and useful data to predict the gasification performance were obtained. (M12005)

In a hot-gas desulfurization process in the oxy-fuel IGCC system, carbon deposition reaction possibly deteriorates the performance of desulfurization sorbents. We proposed a recirculation of gas turbine exhaust to the upstream of desulfurization process. Carbon dioxide and steam in the exhaust significantly prevented the carbon deposition in the experiments using simulated gas. (M12001)

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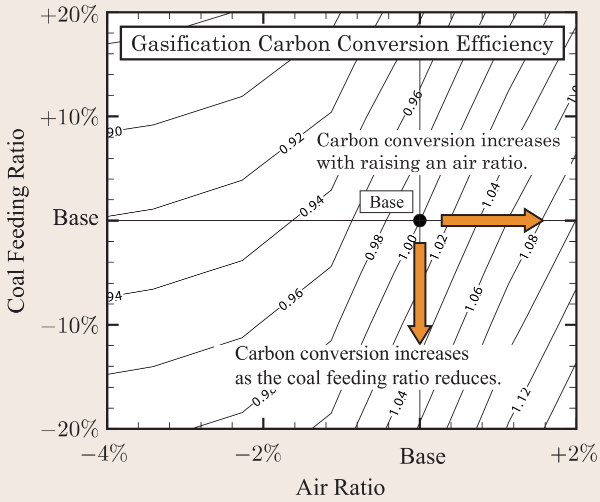


Fig. 1: Example of the prediction of gasification performance

Our one-dimensional numerical simulation technique enabled prediction of gasification performance of the IGCC demonstration plant. This figure is a two-dimensional map of the gasification performance by two operating parameters*1. The gasifier carbon conversion efficiency*2, which is an index of the gasification performance, is shown here.

*1 The air ratio is the ratio of the amount of supplied air to that of stoichiometric air. The coal feeding ratio indicates the ratio of the amount of reductor coal to total coal.
*2 The gasification carbon conversion efficiency is the ratio of the amount of carbon in syngas to that of carbon in coal and char.

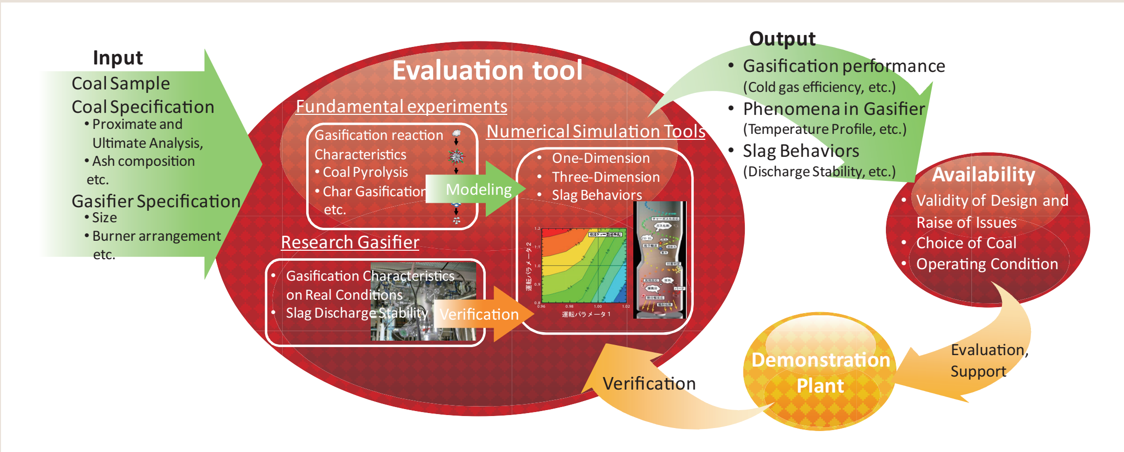
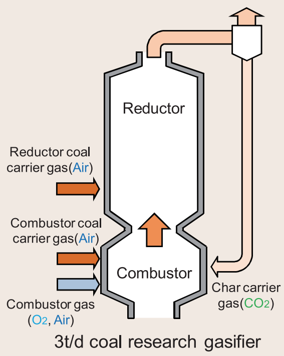


Fig. 2: Outline of the evaluation method of coal adaptability to the IGCC system

The technique to evaluate coal adaptability to a commercial IGCC plant has been established on the basis of fundamental experiments with a sample of candidate coal and numerical simulation tools verified in the demonstration plant tests. The one-dimensional numerical simulation tool is used for the sensitivity analysis of gasification performance, and the three-dimensional numerical simulation tool and the slag-behavior analysis tool are used for extensive prediction of phenomena in the gasifier.



*3 Cold gas efficiency is the ratio of energy content in syngas to the energy content in coal.

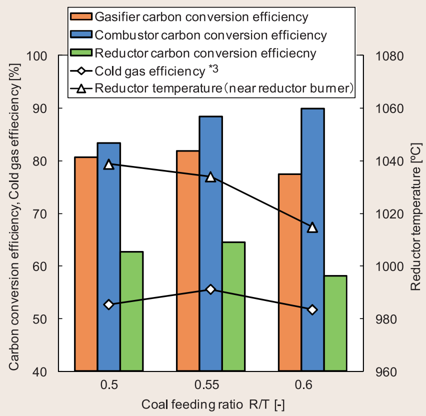


Fig. 3: Influence of coal feeding ratio in the gasification experiments using CO_2 as carrier gas

The gasification experiments, in which CO_2 was used as the char carrier gas, were conducted at various coal feeding ratios (R/T = feeding rate to reductor / total feeding rate), while the air ratio and combustor temperature were set at constant. As the value of R/T reduced, the combustor carbon conversion efficiency fell, whereas the gasification reaction in the reductor was promoted. It was found that the impacts of R/T on the combustor and reductor were different.