Expansion of fuel types and improvement of efficiency in IGCC

Background and Objective

Highly efficient coal gasification combined cycle power generation (IGCC) is an important technology for electric power companies as a next generation coal-based thermal power plant. CRIEPI has been involved in the research since the process development at the initial stage of IGCC development. We have supported examination of the design and operating condition of the demonstration plant.

Aiming at the development of commercial IGCC, we developed the gasification technology for many types of coal, dry gas cleaning system for IGCC, and gasifier operating condition diagnosis and trouble prediction system for flexible fuel operation and improvement of efficiency and reliability in the future.

Main results

1. Supporting activities to IGCC demonstration project

The gasification performance of the IGCC demonstration plant was predicted for several coals, including sub-bituminous coals, based on the analysis of the gasification reaction rates in TGA and the one-dimensional (1D) numerical simulation technique (Fig. 1). The supporting tool to evaluate the operating conditions of the IGCC demonstration plant from the operating data was also developed using CRIEPI's thermal efficiency analysis program named "EnergyWin". It became easy to grasp the condition of each process in the IGCC plant and the performance of each equipment and evaluate the mass heat balance of the total plant with this tool.

2. Clarification of gasification reactivity of brown coal for expansion technology of fuel types

Though Victorian brown coal in Australia is low-rank coal, it has advantages in terms of reserves, cost and reactivity. It has been known that free radicals, especially H radicals, formed by the thermal cracking and/or reforming of volatiles have inhibitory effects on gasification reactivity of brown coal[*1]. The mechanisms and elementary reactions of the char gasification including volatile-char interactions were proposed in this study. Volatile-char interactions consist of the adsorption of H radicals from volatiles and the volatilization of catalyst elements displaced by H radicals. The proposed kinetics model has described the experimental results very well (Fig. 2). This kinetics model would be useful in designing a gasifier for Victorian brown coal. [M10014]

3. Calculation tools for optimization of the dry gas purification system

Calculation tools for determining the appropriate design data of each process in the dry gas purification system (Fig. 3) were developed. It is expected to derive high efficiency and superior cost reduction of IGCC power plant. These tools provide the design data of reactors and utility consumption for proper operation of constituent processes of the system.

*1: In the gasifier, the volatile matter is instantaneously discharged by the pyrolysis of coal, and the char that consists of carbon and ash is generated. Then, C in the char reacts with CO_2 and H_2O ($C+CO_2 \rightarrow 2CO$, $C+H_2O \rightarrow CO+H_2$).

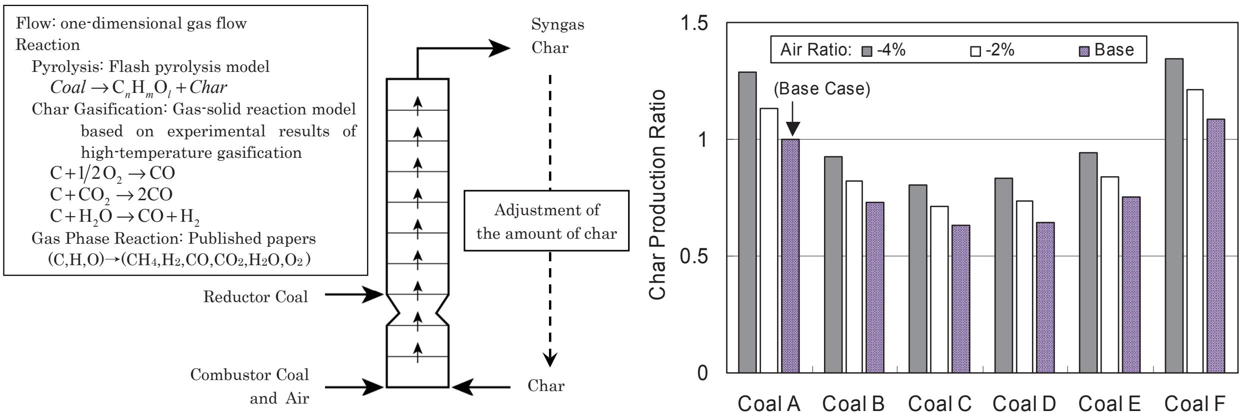

Fig. 1　Outline of 1D numerical simulation of gasifier and prediction of gasification performance

The gasification performance at full load was predicted with the one-dimension numerical simulation technique (left figure). The right figure shows char production ratio, which is one of the gasification performance indicators and important for stable operation of the gasifier.

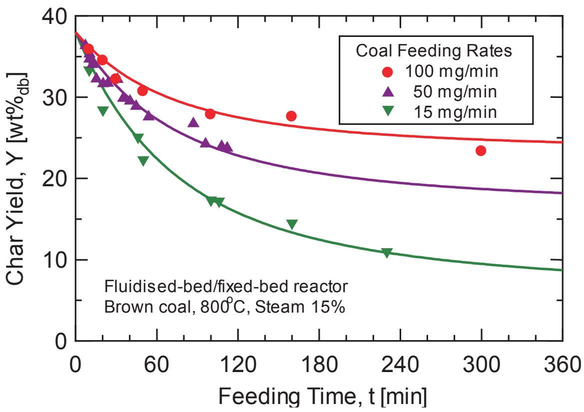

Fig. 2　Verification of the proposed model

Dots show the experimental results*2 and lines show the prediction. The char yield increased with the coal feeding rate at the same feeding time. This means the observed gasification rate dropped with the coal feeding rate because of the inhibitory effects of volatile-char interactions. The proposed kinetics model described the effects quantitatively.

*2: S. Zhang, J. Hayashi, C. Z. Li, "Volatilisation and catalytic effects of alkali and alkaline earth metallic species during the pyrolysis and gasification of Victorian brown coal. Part IX", Fuel **90** (2011) 1655-1661

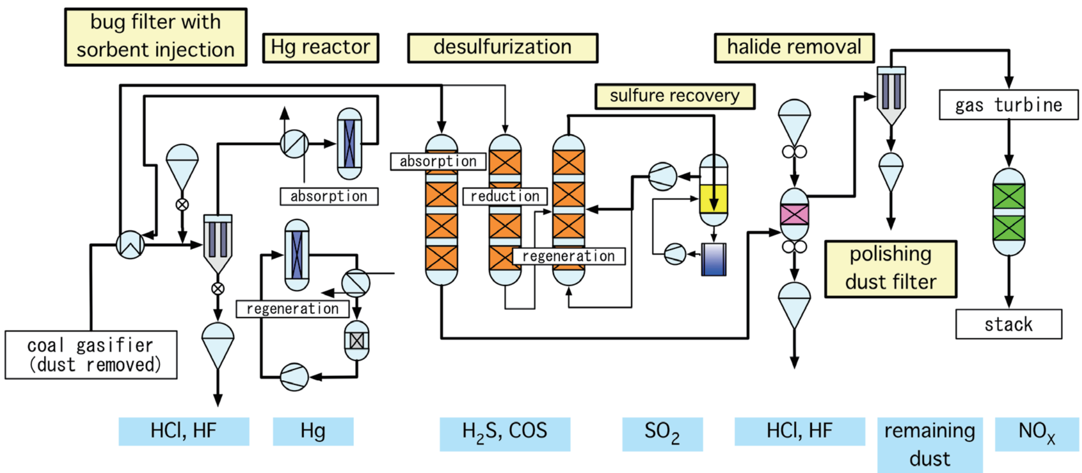

Fig. 3　Typical system configuration of the dry gas purification system for IGCC power plant

The basic design data derives the heat-mass balances, utility consumption, and proper operating condition of each process. The data is combined to optimize the system by evaluating the thermal efficiency and system configuration. The results will clarify the quantitative advantage of the utilization of the dry gas purification system.