Examination for Optimization of Oxygen Enriched Air Blown Coal Gasifier – Influence of Oxygen Concentration in Gasifying Agent on Gasification Performance –

Background

In the air blown IGCC (Integrated coal Gasification Combined Cycle) demonstration plant, a small scale air separation unit (ASU) is set up. Nitrogen from ASU is used for the transportation of coal and the char＊1 etc., and oxygen is mixed with air as a gasifying agent. From the viewpoint of the highly effective and stable operation of the gasifier, and improvement of plant efficiency in a commercial plant, in order to optimize the oxygen concentration in the gasifying agent, it is necessary to clarify the influence of the oxygen concentration in the gasifying agent on the gasification performance quantitatively.

Objectives

The purpose of this study is to clarify the influence of the oxygen concentration in the gasifying agent on the gasification performance such as per pass carbon conversion efficiency, char product rate, combustor temperature by our “3 t/d coal gasifier for basic research (3 t/d gasifier)”.

Principal Results

To exclude the influence of the change of the char recycle efficiency from the gasification test result of coal CV (USA) and coal MN (Indonesian) in 3t/d gasifier, the gasifier per pass performance＊2 was evaluated. In addition, based on that result, the gasification performance in stable state of char recycle efficiency (constant carbon conversion efficiency) was calculated. As a result, the following findings were obtained.

1. Influence of oxygen concentration in gasifying agent on gasifier per pass performance

Shown in Fig. 1, it was clarified that the per pass carbon conversion efficiency (index that evaluates reactivity in gasifier) improved by 1.5-3 points in coal CV and 3-4.5 points in coal MN by the rise of the oxygen concentration (coal CV: from 22.5 to 25%, coal MN: from 21 to 25%). Moreover, the heat absorption rate to the combustor wall necessary to predict the combustor temperature was clarified. This combustor temperature greatly influences the discharge of the liquid slag from the gasifier.

2. Influence of oxygen concentration in gasifying agent on gasification performance in stable state of char recycle efficiency

The gasification performance at carbon conversion efficiency 90% and air ratio 0.52 was calculated based on the test results of the gasifier per pass performance, and the influence of the rise of the oxygen concentration (coal CV: from 22.5 to 25%, coal MN: from 21 to 25%) was clarified (Fig. 2).

(1) The cold gas efficiency is almost constant in both coal CV and coal MN. The influence of the oxygen concentration on the cold gas efficiency is small.

(2) The char product rate decreases by about 10 points in coal CV and about 16 points in coal MN. There is a possibility that the char recycle facility can be made compact by increasing the oxygen concentration.

(3) The combustor temperature rises at 100℃ or more in both coal CV and coal MN. An increase in the oxygen concentration becomes an effective method to obtain an excellent slag discharge.

Future Developments

For fuel expansion in a commercial IGCC plant, the gasification characteristic of the sub-bituminous coal, the blending coal and the mixture of coal and biomass will be examined.

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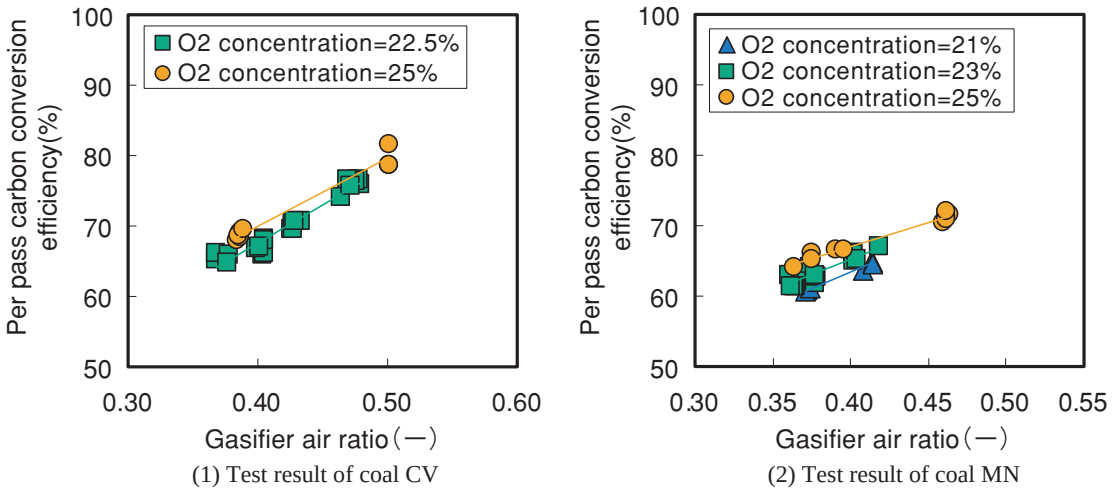
Reference

S. Hara, et al., 2009, “Examination of Gasification Characteristics of Pressurized Two-stage Entrained Flow Coal Gasifier – Influence of Oxygen Concentration in Gasifying Agent –”, CRIEPI Report M08019 (in Japanese)

＊1：The char is a fine particle contained in product gas and consists of unburnt carbon and ash. To raise the efficiency of the gasifier, the char is recycled to the gasifier.

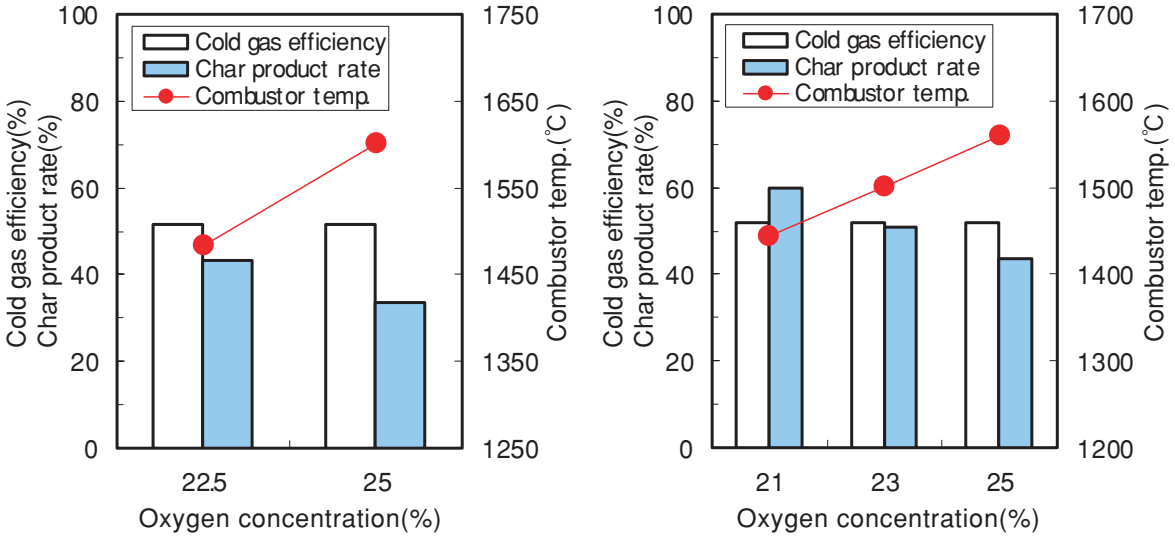
＊2：The gasifier per pass performance is a performance at the gasifier exit to input coal and recycle char, and is not influenced by change of the char recycle efficiency. On the other hand, the performance to input coal (overall performance: carbon conversion efficiency, cold gas eficiency etc.) is influenced by change of char recycle efficiency. In this gasification test, the carbon conversion efficiency is 86.4-96.4% in coal CV and 81.9-90.1% in coal MN by change of the char recycle efficiency.



(1) Test result of coal CV (2) Test result of coal MN

Fig.1 Influence of oxygen concentration on the per pass carbon conversion efficiency

The influence of the oxygen concentration on the gasifier per pass performance, such as improvement of per pass carbon conversion efficiency by rise of oxygen concentration etc., was quantitatively clarified.



(1) Calculation result of coal CV (2) Calculation result of coal MN

Fig.2 Gasification performance at carbon conversion efficiency 90% and air ratio 0.52

Because the char product rate decreases by rise of oxygen concentration, there is a possibility that the char recycle facility can be made compact. In addition, the combustor temperature rises, so increasing the oxygen concentration becomes an effective method to obtain an excellent slag discharge.

Definition of index

Air ratio(-)=(input air*)/(theoretical air for input coal)
Gasifier air ratio(-)=(input air*)/(theoretical air for input coal and recycle char)
Carbon conversion efficiency(%)=(gaseous carbon in product gas)/(solid carbon in input coal) × 100
Per pass carbon conversion efficiency(%)=(gaseous carbon in product gas)/(solid carbon in input coal and recycle char) × 100
Cold gas efficiency(%)=(chemical heat of product gas)/(chemical heat of input coal) × 100
Char product rate(%)=(carbon in product char)/(carbon in input coal) × 100

*When the oxygen concentration in the gasifying agent changed, the amount of air was converted from the amount of oxygen in the gasifying agent.