Development of a Supporting System for Optimal Gasifier Operation

Background

For highly efficient and stable operation of a coal gasifier in practical use of IGCC, it is important to establish methods for operating plant in appropriate conditions. In CRIEPI, a system which oversees online data and slag flow and optimizes the operating conditions automatically has been examined *[1].

Objectives

The purpose of this study is to develop technique which analyzes online data involving instantaneous fluctuations and builds gasifier performance evaluation functions (PEFs) simultaneously during the operation. In addition, it is intended to confirm the utility of the technique being applied to data based on the test results of the FRONTIA (3 t/d coal gasifier) of CRIEPI *[2].

Principal Results

1. Development of technique for real-time analysis of online data and building of gasifier performance evaluation functions

In the Supporting System for Optimal Gasifier Operation" (Fig.1) which was proposed in the previous work *[1], technique for real-time analysis of online data and generation of gasifier performance evaluation functions (PEF) is examined.

(1) As a result of statistical analysis of online data, it is found that the trend of combustor temperature can be expressed by the function of air ratio and coal feeding ratio *[3], and that of calorific value of syngas and char production rate can be expressed by the function of air ratio. Time averaging of the data in a certain interval which depends on the individual gasifier is effective to generate such functions accurately.

(2) It is also found that the fluctuations of the combustor temperature, calorific value of syngas and char production rate obtained by the experiment can be expressed accurately by the normal distribution. This proves that, for example, the probability (risk ratio) that the calorific value decreases below the lower limitation due to the stable combustion in the gas turbine combustor can be defined mathematically. Therefore the gasifier can be operated in the condition which suppresses the risk of exceeding the constraint of the gasifier's operation (Fig.2).

(3) The gasifier PEF and risk ratio obtained from the experiment of RUN1 *[4] (Fig.2) can be applied to the prediction of the gasification performance and fluctuations of online data in the experiment of RUN2 *[4] (Fig.3). In the range of air ratio in RUN1 and RUN2, the gasifier PEFs generated once can be utilized for the optimization calculation in other operating conditions.

2. Optimization calculation for actual gasifier test conditions

The technique for real-time generation of the gasifier PEF mentioned earlier is introduced into the optimization code *[1] and the optimization calculation is performed to investigate the optimal operating condition for FRONTIA with Coal DT (Table 1). In addition, for the actual experiment condition *[2], the two calculations are performed in conditions of constant combustor temperature and air ratio to investigate the high performance and stable operation conditions respectively.

Therefore, it was confirmed that the presented technique was effective for the optimization of the gasifier operating condition.

Future Developments

The presented technique will be applied to actual gasifier operation and validity will be explicitly demonstrated. In addition, online video processing for molten slag flows will be investigated to develop technique of evaluation of slag fluidity.

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Reference

H. Watanabe, et al., 2006, "Development of optimal gasifier operation supporting system", CRIEPI Report M05002 (in Japanese)

＊1：H. Watanabe et al., 2005, "Development of optimal gasifier operation supporting system", CRIEPI Report M04001 (in Japanese).
＊2：S. Hara et al., 2006, "Development of 3 T/D research gasifier for practical use of coal gasification technology", CRIEPI Report M05009 (in Japanese).
＊3：Ratio of coal fed into the reductor with coal fed into the combustor.
＊4：RUN1: high air ratio condition, RUN2: low air ratio condition.

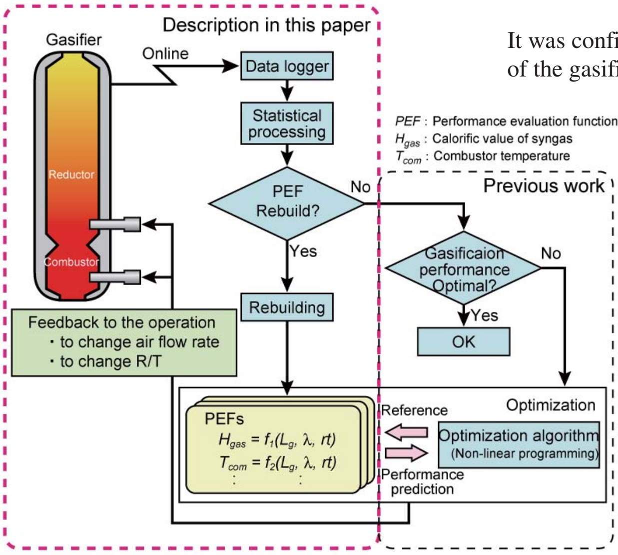

Fig.1 Flow chart of the supporting system for optimum coal gasifier operation

It was confirmed that the presented technique was effective for the optimization of the gasifier operating condition.

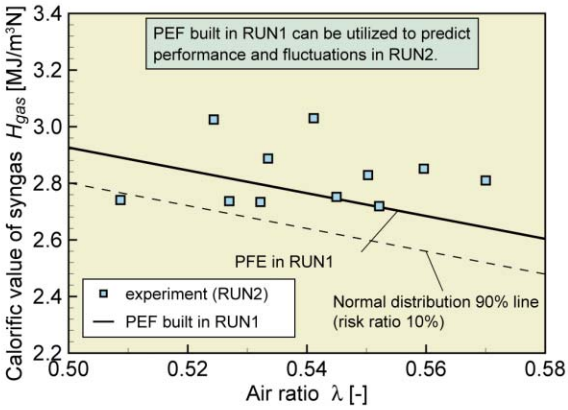

Fig.3 Comparison between PEF built in RUN1 and experimental result in RUN2

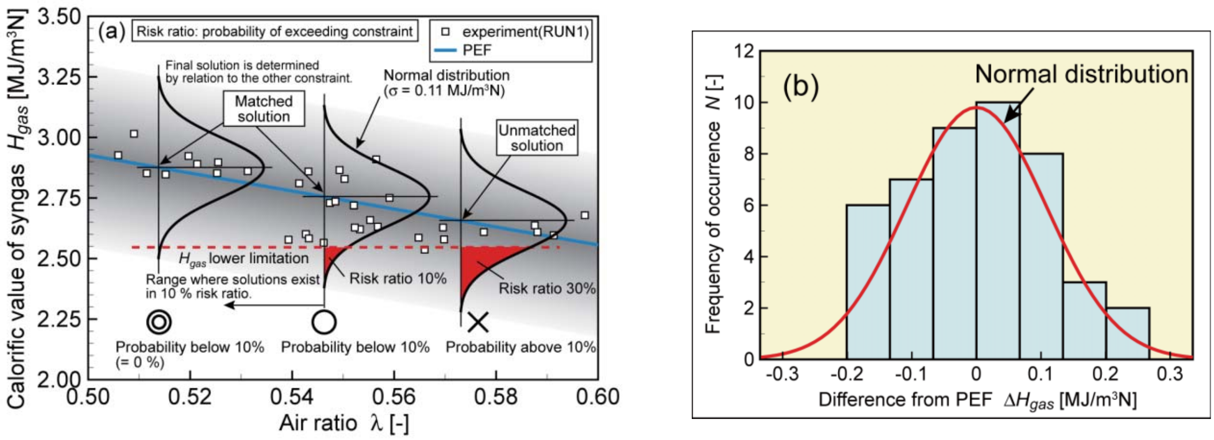

Fig.2 (a) Experimental data and PEF of calorific value of syngas in RUN1 and relation between risk ratio and optimization, (b) Relation between frequency of occurrence and difference from PEF

Fluctuations (difference from PEF) can be expressed accurately by the normal distribution. Therefore the risk ratio which is defined as the probability of exceeding the constraint rules of operating the gasifier can be defined mathematically and the solution which suppresses the risk ratio in a certain range is calculated by the optimization calculation.

Table 1 Optimization calculation results

Items		Const. rule	Solution	Base	Const. com. temp.	Const. air ratio	Remarks
Air ratio	-	-	0.467	0.505	0.467	(0.505)	- 0.038
Combustor temperature	K	> 1570	1625	1630	(1630)	1645	+ 15 K
Calorific value of syngas	MJ/m^{3}N	-	3.05	2.92	3.05	(2.92)	+ 0.13 MJ/m^{3}N
char production rate	kg/h	< 30	25.8	12.9	25.8	21.3	-
coal feeding ratio	-	0.5 to 0.6	0.56	0.59	0.54	0.53	-

Solution on the left hand side in Table 1 shows the maximum performance using the FRONTIA with Coal DT. Solutions on the right hand side shows that air ratio of 0.038 can be reduced in the same combustor temperature condition and combustor temperature of 15 K can be increased in the same air ratio condition from the base which is the actual experimental condition.

Note : constraint rules of optimization calculation in this paper
Combustor temperature : Temperature at slag viscosity of 15 Pa*s of Coal DT.
Char production rate : The value is based on the experience of the FRONTIA of CRIEPI.