Development of a Supporting System for an Optimum Coal Gasifier Operation

Background

The construction of 250 MW coal gasification combined cycle (IGCC) demonstration plant is being advanced in Japan. Achieving the highly efficient and stable operation of the plant are key matters for the practical use of IGCC needing to both produce high calorie gas and maintain slag discharge under stable temperature. An empirical standard has been applied in the pilot plant etc. and it has not been necessarily operated in the optimal condition. A commercial plant requires more reasonable conditions and operations.

Objectives

To develop an optimization technique of a gasifier operating condition that uses an online image and data processing. In addition, to confirm the utility of the technique being applied to data based on the test results of the 2 t/d coal gasifier of CRIEPI *[1].

Principal Results

1. Development of a supporting system for an optimum coal gasifier operation

“A Supporting System for an Optimum Coal Gasifier Operation”(Fig.1) was proposed that monitors slag flow and gasification performance online to learn the relationship between operating conditions and gasification performance and to build a database, and has the function to set optimal operating condition automatically in cooperation with the performance evaluation functions. The following items of this system were focused on in this report.

(1) Gasifier performance evaluation functions concerning combustor temperature, calorific value of product gas and amount of recycling char that have gasifier load, air ratio and coal feeding ratio *[2] as a parameter

(2) Optimization algorithm for non-linear system to aim to produce the maximum calorific value of syngas in which combustor temperature for slag discharge, calorific value of product gas for quality of product gas and quantity of recycling char for limitation of plant capacity are imposed as constraint rules

(3) An index for stable operation to set reasonable operating tolerance by statistically processing online data of plant input fluctuation, such as air flow rate, which have the potential to influence slag flow and gasification performance

2. Optimization calculation for actual gasifier test conditions

The optimization calculation was carried out on the 2 t/d coal gasifier in 100% and 80% gasifier load of base conditions (Table 1). As results of the calculation, air ratio could be reduced 0.047 (Fig.2) and calorific value of syngas could be increased 0.28 MJ/m^{3}N (Fig.3) in 100% gasifier load. In addition, air ratio could be reduced 0.073 (Fig.2) and calorific value of syngas could be increased 0.43 MJ/m^{3}N and it exceeded the minimum calorific value in 80% gasifier load. However, below 70% gasifier load it was clarified that the solution that fills the constraint rules in Table 1 did not exist.

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

Future Developments

The relation between the operating conditions and the molten slag discharge will be clarified by using the FRONTIA, a new coal gasifier for research. And an autonomous improvement function by online data processing, database building and a learning algorithm will be studied.

Main Researcher: Hiroaki Watanabe,
Research Scientist, Thermal Engineering Sector, Energy Engineering Research Laboratory

Reference

H. Watanabe, et al., 2005, “Development of a Supporting System for an Optimum Coal Gasifier Operation”, Technical Report M04001 (in Japanese)

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*1 : S. Hara, et al., 1990, “Characteristics of a 2 T/D Pressurized Two Stage Entrained Bed Coal Gasifier”, Technical Report W89042 (in Japanese)

*2 : Ratio of coal fed into the reductor with coal fed into the combustor

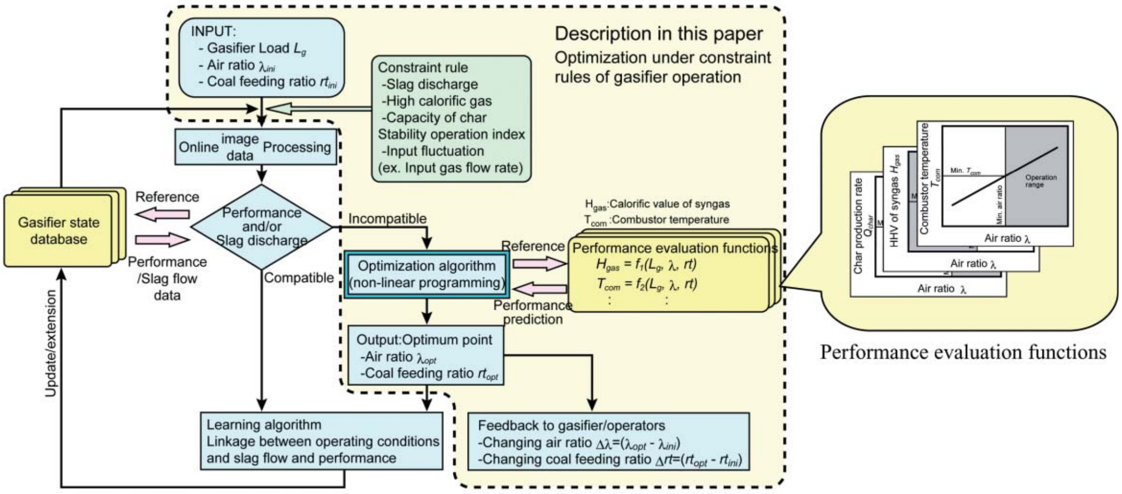

Fig.1 Flow chart of the supporting system for optimum coal gasifier operation

The system monitors the slag flow and the gasification performance online to learn the relationship between operating conditions and gasification performance and to build a database, and has the function to set optimal operating condition automatically in cooperation with the performance evaluation functions.

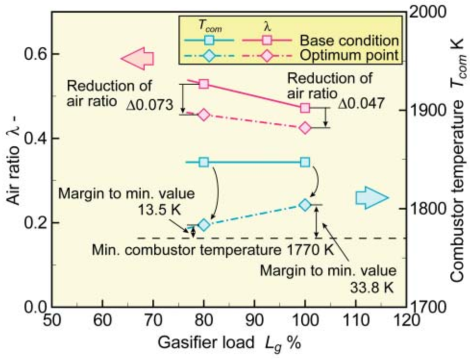

Fig.2 Solutions for air ratio and combustor temperature

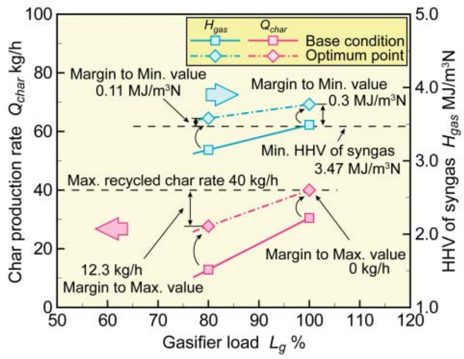

Fig.3 Solutions for char production rate and HHV of syngas

Air ratio can be reduced 0.047 and calorific value of syngas can be increased 0.28 MJ/m³N in 100% gasifier load. In addition, air ratio can be reduced 0.073 and calorific value of syngas can be increased 0.43 MJ/m³N and it exceeds the minimum calorific value in 80% gasifier load.

Table 1 Optimization calculation results

Load	Items		Base	Const. rule	Solution	Remarks
100%	Air ratio	-	0.472	-	0.425	Reduction 0.047
	Combustor temperature	K	1847.3	> 1770	1803.8	keeping slag discharge
	Calorific value of syngas	MJ/m^{3}N	3.49	> 3.47	3.77	Increasing 0.28MJ/m^{3}N
	Char production rate	kg/h	30.5	< 40	40.0	Rate-determining step
	Coal feeding ratio	-	0.6	0.6～0.8	0.74	-
80%	Air ratio	-	0.529	-	0.456	Reduction 0.073
	Combustor temperature	K	1847.3	> 1770	1783.5	Rate-determining step
	Calorific value of syngas	MJ/m^{3}N	3.15	> 3.47	3.58	Exceeding lower limitation
	Char production rate	kg/h	12.9	< 40	27.7	-
	Coal feeding ratio	-	0.6	0.6～0.8	0.72	-

Note : constraint rules of optimization calculation in this paper

Combustor temperature : 1,770 K (It takes 50 K margin from the critical temperature 1,720 K of the tested coal ash.)

Calorific value of syngas : 3.47 MJ/m^{3}N (The value is based on the experience of the pilot plant operation.)

Char production rate : 40.0 kg/h (The value is based on the experience of the 2 t/d coal gasifier operation of CRIEPI.)

Fluctuation of air flow rate : Fluctuation characteristics are assumed as a normal distribution. The solution satisfies the constraint rules in 90% of the operating time.