2006 Prize of the Chairman of ECCJ

Measures to Improve Steam Recovery Intensity of Waste Heat Boiler

Hokkai Iron & Coke Corporation
Coke Section, Manufacturing Department

◎ **Keywords: Waste heat recovery and usage**

◎ Outline of Theme

Our waste heat boiler uses red-hot cokes as heat source and recovers high-pressure steam for power generation.
We achieved 5% improvement in steam recover intensity by stabilizing temperature at the boiler inlet at high-level, implementing a measure to take some air into a red-hot coke cooling chamber to burn gas components.

◎ Implementation Period for the said Example

July 2004 – October 2005

● Project Planning Period	July 2004 – February 2005	Total 8 months
● Measures Implementation Period	January 2005 – June 2005	Total 6 months
● Measures Effect Verification Period	June 2005 – October 2005	Total 5 months

◎ Outline of Hokkai Iron & Coke Corporation

- Items Produced Hot metal, mold pig iron, coke
  Chemical products (refined COG, tar, ammonium sulfate, kerosene)
- No. of Employees 268
- Annual Energy Usage Amount Fuel (crude oil equivalent) 1,245,052 kl/year
  (Actual consumptions by Electricity 16,670 MWh/year Hokkai Iron & Coke in FY2005)

◎ Process Flow of Target Facility

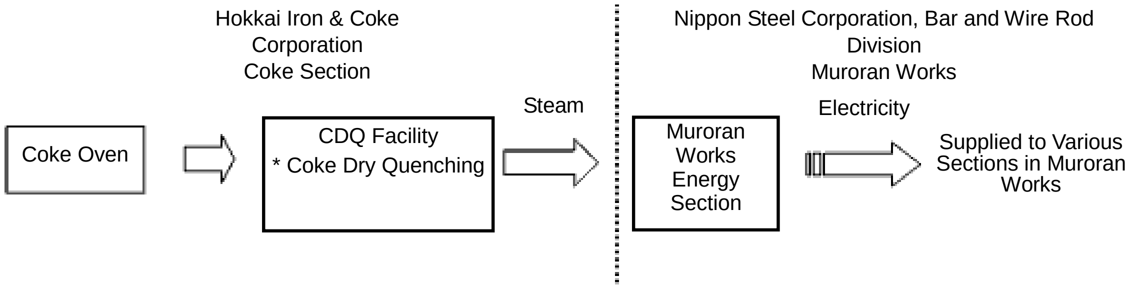


Fig. 1 Overview of Equipment Flows

1. Reasons for Theme Selection

Due to global energy price hike, rising energy cost has become one of major problems for entire iron works. Considering the above, we determined to work on the selected theme not only for cost reduction in the plant but also for contribution to energy conservation. We planned to complete the project by way of reducing consumption of heavy oil, which was an expensive energy source used by the power plant, through maximum utilization of valuable heat source in the CDQ facility and increase of steam recovery.

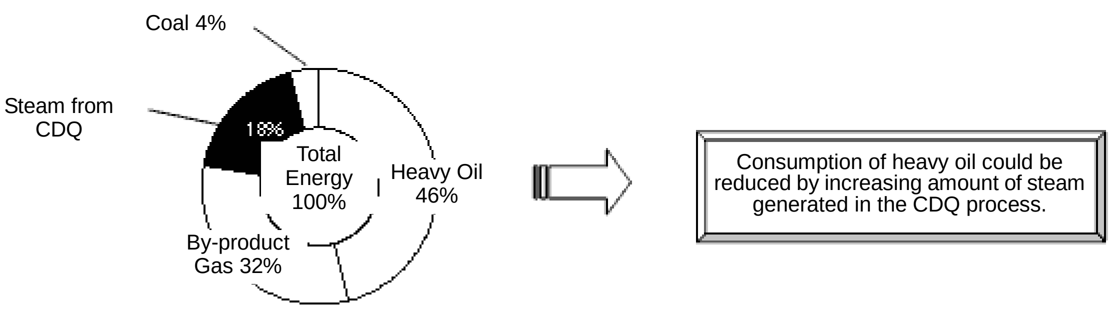


Fig. 2 Energy Consumed by Power Plant

2. Understanding and Analysis of Current Situation

(1) Understanding of Current Situation

1) CDQ Facility

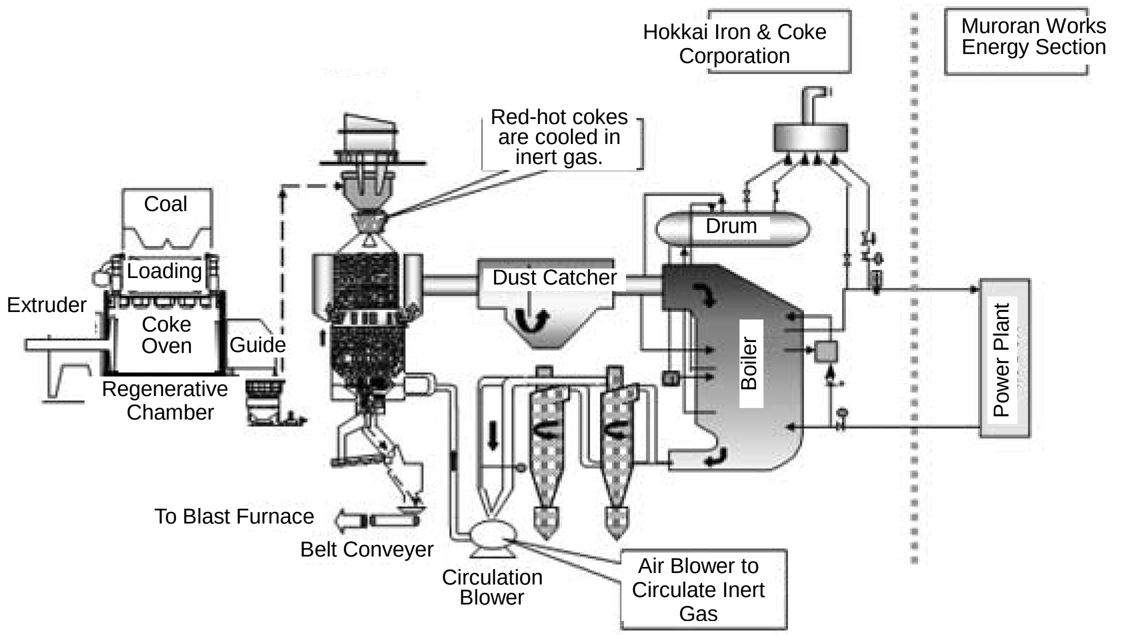


Fig. 3 Overview of CDQ Facility Operation

In the CDQ facility (Fig. 3), the red-hot cokes manufactured and heated to around 1,000℃ in the coke oven are loaded into the CDQ chamber, quenched in inert gas, and discharged at the temperature of 230℃ or below to be transferred to the blast furnace. Having gradually recovered the sensible heat while the cokes are cooled in the chamber, the inert gas is then heated to elevated temperature at around 890℃ when it comes near the dust catcher (temperature at the boiler inlet). The heat is exchanged in the boiler room to be sent to the power plant as high-pressure steam for power generation.

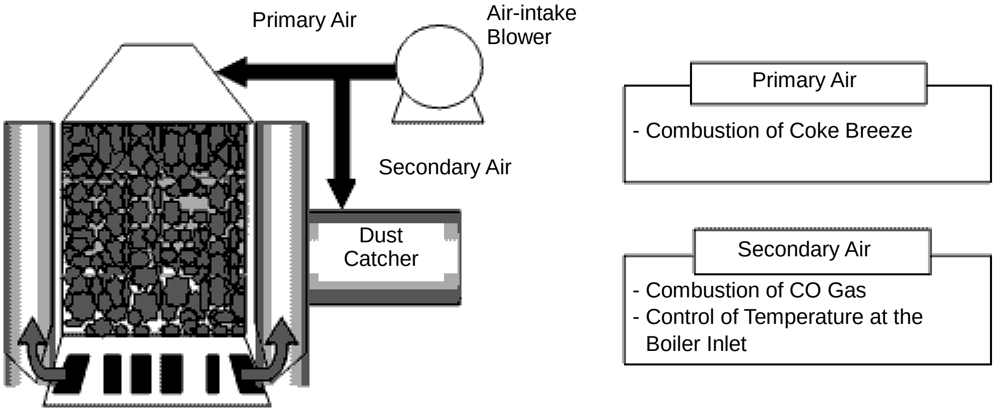


Fig. 4 Roles of Air Intake

In order to control temperature and concentration of the gas in the CDQ system, two air-intake systems are installed (Fig. 4). The primary air is blown into the chamber in order to burn the coke breeze and control generation of CO gas. The secondary air is blown into the outlet of the chamber in order to burn the CO gas and control the temperature at the boiler inlet.

(2) Analysis of Current Situation

1) Relationship between air volume and recovered steam volume

The temperature at the boiler inlet rises as the secondary air removes an appropriate amount of the gas in the system (Fig. 5). By efficiently controlling the removal, the temperature at the boiler inlet is stabilized at high-level, resulting in increased steam recovery volume (Fig. 6).

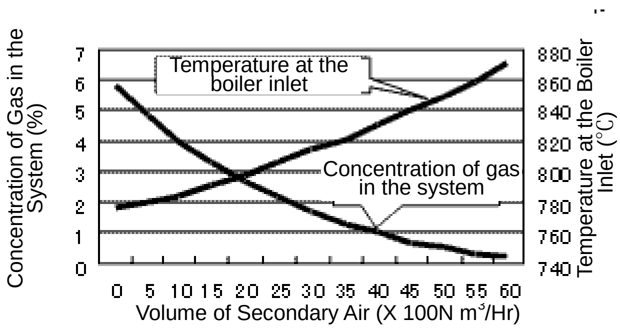


Fig. 5 Relationship among Secondary Air, Gas in the System, and Temperature at the Boiler Inlet

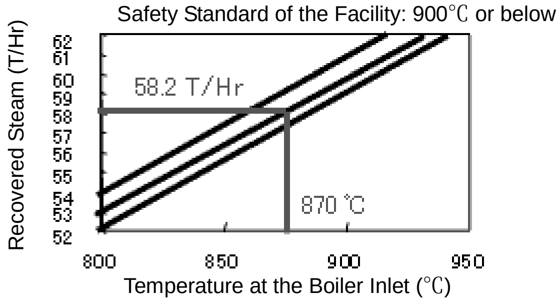


Fig. 6 Relationship between Recovered Steam and Temperature at the Boiler Inlet

2) Process to control air-intake volume

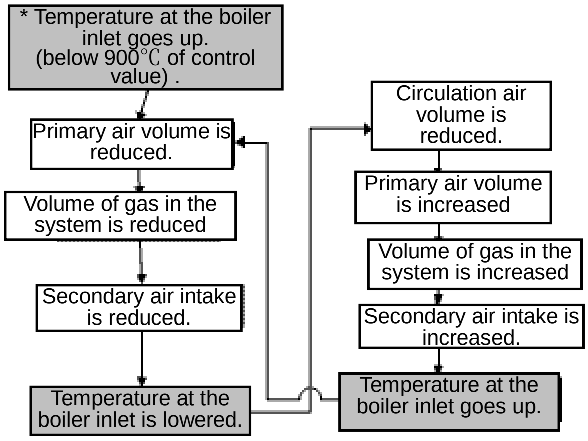


Fig. 7 Process to Control Amount of Air Intake

Actions required when the temperature at the boiler inlet goes up to the control value of 900℃ are reducing primary air volume; lowering CO concentration to around 1%; reducing secondary air volume; and reducing circulation air volume upon confirming the temperature at the boiler inlet is dropped. And when the temperature further goes down, primary air should be increased to burn the gas, so that temperature at the boiler inlet rises again.
To complete the above flow, operators make judgments depending on the situations and take appropriate actions to control the air-intake volume.

3) Operators' work

Our research on operators work hours per day found that a large part of their hours is spent in operation monitoring and other operational communications, and among others, in arrangements for transferring cokes to blast furnace. Therefore, the air-intake control, which is the most important job for steam recovery, accounted only for some 20%

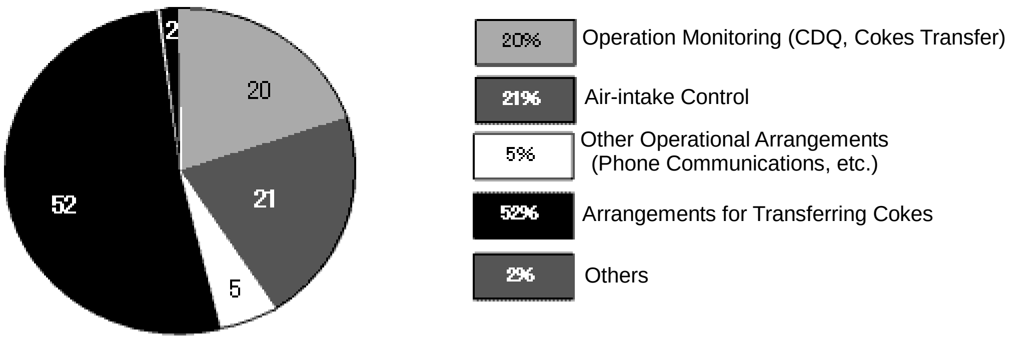


Fig. 8 Breakdown of Operators' Work

4) Comparison of operators work data

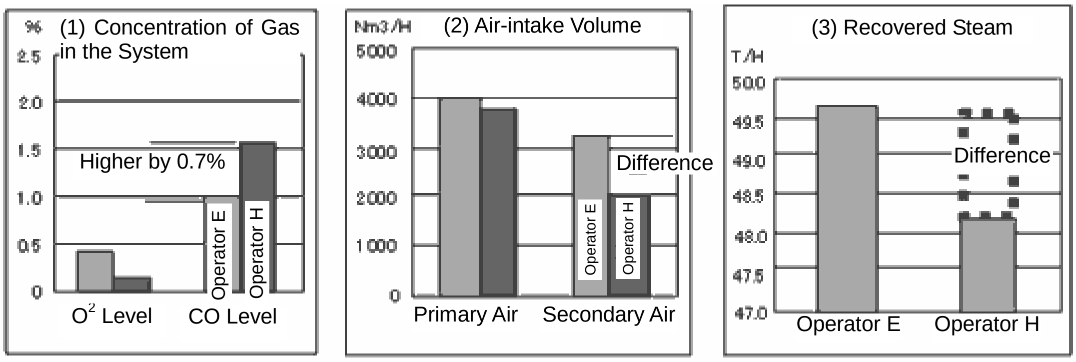


Fig. 9 Comparison of Operators Work Data

As shown in Fig. 9, volume of recovered steam varies among operators, depending on personal factors such as their work experience.

3. Progress of Activities

(1) Implementation Structure

Consist of three shifts four pairs and fix the division of roles, our program was driven forward in a planned manner.

····▶ As Planned ——▶ Actually Carried Out

	Steps to Be Covered	Groups to Be Engaged In	2004: 8 10 12 / 2005: 2 4 6 8 10 12
P	Selection of Theme	A・C	
P	Analysis of Current Situation	B・C	
D	Planning of Measures	D・C	
D	Implementation of Measures	D・C	
C	Confirmation of Effect	A・D・C・D	
A	Prevention of Setback/Summarizing	C	

Table 1 Activity Plans and Results

(2) Target Settings

Results of the activities carried out in 2004: Successful improvement by 3% in steam recovery intensity.

⇒

Making it more challenging, we decided to set a difficult target of 5% improvement and make necessary efforts toward it.

(3) Problem Points and Measures

1) Extraction of the problem points

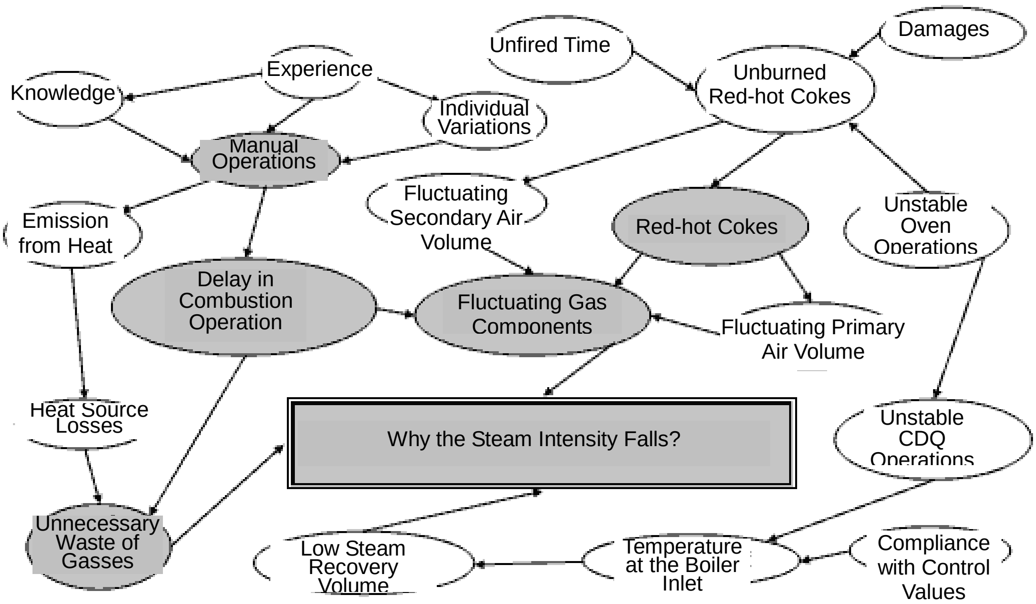
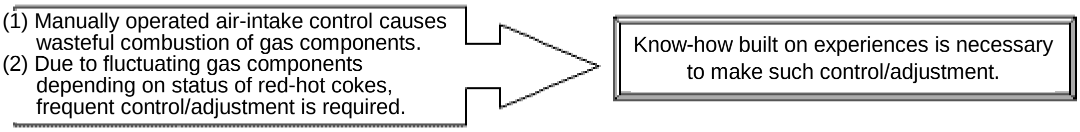


Fig. 10 Correlation Diagram

2) Clarification of the problem points



(4) Review and Discussions on Draft Measures

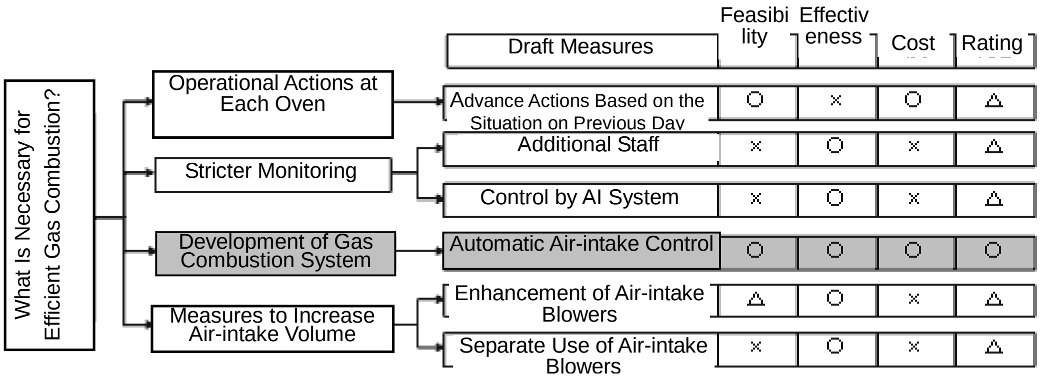


Fig. 11 Flow Chart

In order to develop more efficient gas combustion process, we came up with 13 draft measures and evaluated 6 important measures of the 13 in terms of feasibility, effectiveness, and cost factors. Based on the evaluation results showing the automatic air-intake control was the most appropriate measure to burn the gases more efficiently, we determined to drive it forward.

4. Details of Measures

(1) Measure to Develop Automatic Air-Intake Control System (Taking Knowhow and Expertise of Experienced Operators into the Control System)

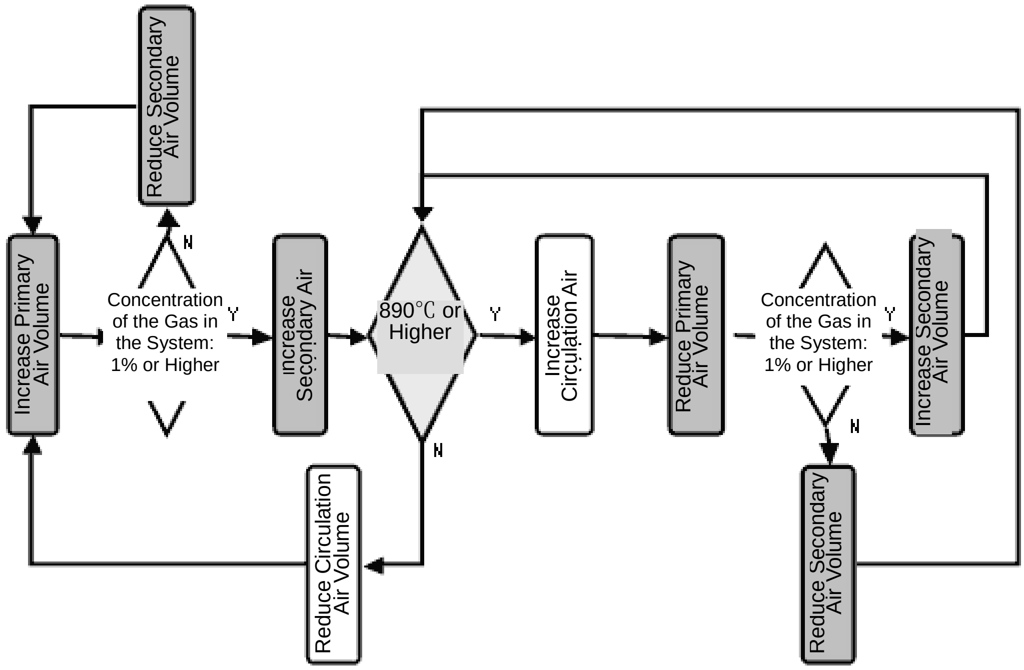


Fig. 12 Logic of the Automatic Air-Intake Control

【Description of the automatic control operations】(Fig. 12)

1) Setting the temperature at the boiler inlet as a base point, increase or reduction of primary air volume is selected depending on temperature.
2) Concentration of the gas in the system changes as the primary air volume is increased or reduced.
3) Secondary air volume is increased or reduced depending on the concentration of the gas in the system, leading to increase or decrease of the temperature at the boiler inlet.
   Repeating the above process properly, efficient heat recovery can be achieved. However, having an impact on other factors, the circulation air control is excluded from the cascade control.

5. Effects Achieved after Implementing Measures

(1) Comparison of Operators Work Data

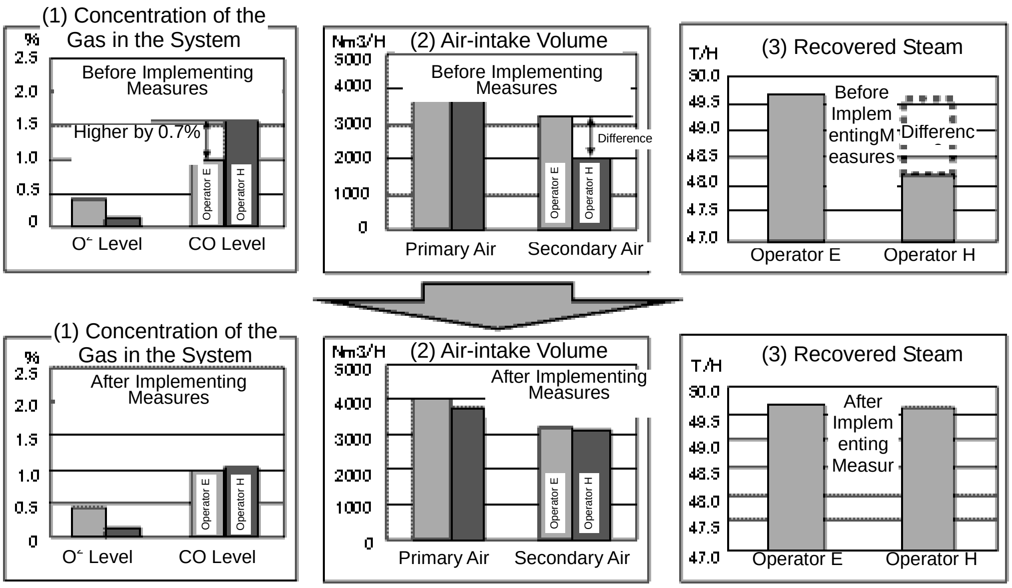


Fig. 13 Comparison of Operators Work Data

(Before and after implementing improvement measures)

(2) Comparison of Steam Recover Intensity

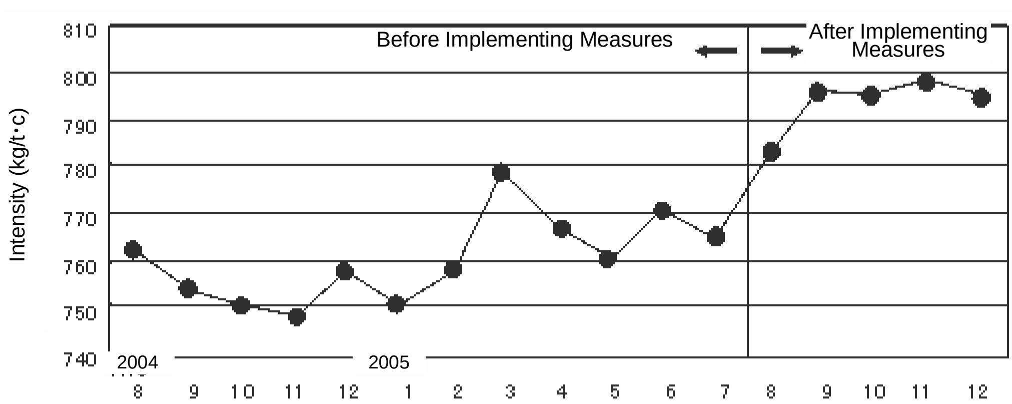


Fig. 14 Changes in Steam Recover Intensity

Improvement in Steam Recovery Volume

Before Implementing Measures		After Implementing Measures	
756.8kg/t·c	⇨	797.2kg/t·c	Improved by 5.1%

6. Summary

In this project, we focused on achieving improved steam recovery volume and steam recovery intensity through effective combustion of gas components in the CDQ system, setting it as our theme of the activities.

The results of the project brought us a great gain, since improvement in recovered steam in our workplace means contribution to energy conservation and cost reduction of relevant business partners.

7. Future Challenges

As a result of the improvement activities, a large impact on the steam recovery volume by capability of individual operator was successfully prevented through systemization of the operations. We are now determined to make further efforts to improve CDQ system facilities, aiming at further stabilization of the steam recovery at high-level and more stable operations.