Energy saving and CO₂ reduction by boiler control optimization system "ULTY-V plus"

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Presentation Outline

1. Introduction
2. Current problems in boiler master control
3. Control mechanism of ULTY-V plus
4. Effect of ULTY-V plus
5. Specification and connection method
6. Delivery record
7. Efficiency and cost performance calculation
8. Summary
1-1. Introduction

CO₂ Reduction Measures for Existing Power Plants

- Improvement of Efficiency
- Post Combustion Capture

- Combustion Adjustment
- Upgrading O&M
- Boiler Control Optimization
  ...
“ULTY-V plus” is the boiler control optimization system which can reduce coal consumption and CO2 emission by connecting with existing boiler control system!

Reduction of coal consumption: Approx. 1%

- “ULTY-V plus” stabilizes plant control by self-learning function incorporated with AI (Artificial Intelligence).

Before Installation

- Main steam pressure
- Coal consumption

After Installation

- Main steam pressure
- Coal consumption
Boiler master control is one of the main system in Automatic Plant Control (APC).

Main Steam Pressure is basically stabilized by PID (Proportional-Integral-Derivative) control method.
In coal fired boiler, a combustion state always changes due to following factors.

- Change of Coal Moisture
- Soot Blow
- Load Change
- Switch of Coal Brand
- Air & Water Temperature
- Ash Deposition
2-3. Basics and problems of PID control (1)

P(Proportional) Control

In case of ideal condition

Fuel Function

Coal Flow, t/h

Boiler Master, %

Setting = Actual

P(Proportional) control is a fundamental element in PID control.

If there is no deference in setting and actual fuel function, PV(Process Valuable) becomes same with SV(Set Value) in a short time.
In practical, there is a gap between actual and setting value of coal flow.

PV(Process Valuable) becomes different from SV(Set Value).

In order to eliminate the deviation and stabilize Main Steam Pressure, I(Integral) control is additionally applied.
2-5. Basics and problems of PID control (3)

**P(Proportional) Control**

- In PI control, corrective action continues until the deviation between PV and SV becomes zero by I(Integral) function.
- Time to eliminate the deviation depends on the setting of plant control parameters.
- When the plant control parameters are not suited to the current boiler characteristics, it will take time to stabilize Main Steam Pressure.

**PI(Proportional-Integral) Control**
A lagged time that change of coal feed rate respond to main steam pressure is rather long in coal fired boilers.

Pressure correction itself triggers fluctuations in main steam pressure, because the gap in fuel function causes control deviations.
Since boiler is easy to cool and difficult to warm in general, coal feed tend to be larger during the recovery of pressure compared to its control even if in the case of same fluctuation range. \( A < B \)

Therefore, the time to increase coal feed for recovering pressure \((T_2)\) is longer than the time to decrease coal feed \((T_1)\). \( T_1 < T_2 \)

Coal feed always tend to be surplus!
3-1. Parameter to monitor boiler condition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Boiler Condition</th>
</tr>
</thead>
</table>
| $\frac{BM}{MWD} = 1$ | - Ideal state: Control gain and heat absorption are balanced.  
- When disturbance happened to boiler, process can be stabilized quickly. |
| $\frac{BM}{MWD} > 1$ | - Due to less heat absorption, larger coal feed is needed to get same output.  
- Weak control gain makes a time to stabilize MSP longer. |
| $\frac{BM}{MWD} < 1$ | - Due to good heat absorption, coal feed becomes smaller.  
- Small disturbance induces big fluctuation with strong control gain. |
ULTY-V plus monitors the change of boiler condition by calculating $\frac{BM}{MWD}$. 

ULTY-V plus outputs correction coefficient that $\frac{BM}{MWD}$ always becomes 1.

ULTY-V plus gradually changes the correction coefficient to avoid fluctuation.

- ULTY-V plus will realize the ideal condition where the boiler master is controlled only by P(Proportional) method.
ULTY-V plus optimizes fuel function through a process, where the gap between set and actual value in the fuel function at each boiler load is corrected. It is always stored and continuously rewritten in the boiler control system.

Fuel function

Correction coefficient

- Fuel input is controlled based on the correction coefficient stored in ULTY-V plus.
3-4. Installation of ULTY-V plus

PID Controller for MSP

Set Value (SV) of MSP

Process Variable (PV) of MSP: Main Steam Pressure

Deviation Variable (DV)

MW Demand (MWD)

Manipulated Variable (MV)

Coal flow

ULTY-V plus

÷

Moving Average

Fuel Function

Calculation

After ULTY Correction

Learning

Setting

Storage, Rewrite

Boiler Master, %

Coal Flow, t/h
3-5. Control display of ULTY-V plus

- ULTY-V plus displays current and cumulative reduction of coal and CO$_2$ emission.
Main steam pressure gradually became stable after ULTY-ON.

**Coal consumption**

**ULTY OFF (9:00~10:00)**

- **Ave:** 34.889 t/h
- **SD:** 0.279 t/h

**ULTY ON (11:00~12:00)**

- **Ave:** 34.652 t/h
- **SD:** 0.134 t/h

**Coal consumption**

- **Ave:** $\Delta 0.68\%$

**Main steam pressure**

**ULTY OFF (9:00~10:00)**

- **Ave:** 16.558 MPa
- **SD:** 0.0291 MPa

**ULTY ON (11:00~12:00)**

- **Ave:** 16.555 MPa
- **SD:** 0.0155 MPa

**Standard deviation**

- **Ave:** $\Delta 47\%$
A test was conducted under a severe condition where the boiler load was changed from minimum to maximum in around an hour. → Steam temperature was stabilized.

**ULTY OFF**

- **Main steam temp.**
  - Maximum: 573.2°C
  - Setup: 569°C
  - Difference: +4.2°C

- **Reheat steam temp.**
  - Maximum: 546.0°C
  - Setup: 541°C
  - Difference: +5.0°C

**ULTY ON**

- **Main steam temp.**
  - Maximum: 571.0°C
  - Setup: 569°C
  - Difference: +2.0°C

- **Reheat steam temp.**
  - Maximum: 546.0°C
  - Setup: 541°C
  - Difference: +5.0°C

Main steam temperature is stabilized.
4-3. Effect of ULTY (3)

Reduction in flue gas temperature

- Flue gas temperature is decreased because stable combustion and a good heat absorption state can be maintained.
- Both boiler efficiency and turbine efficiency are also enhanced because power generation, turbine rated pressure, and turbine rated temperature can be stably maintained.
Reduction of unburnt carbon in fly ash

- Continuous stable combustion leads to improve combustion propagation, as a result, unburnt carbon in fly ash is reduced.
- Because of this, boiler efficiency is enhanced.

**A coal**

<table>
<thead>
<tr>
<th>Unburnt carbon in fly ash, %</th>
<th>ULTY OFF</th>
<th>ULTY ON</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.6</td>
<td>2.6</td>
</tr>
</tbody>
</table>

1.0% decrease

**B coal**

<table>
<thead>
<tr>
<th>Unburnt carbon in fly ash, %</th>
<th>ULTY OFF</th>
<th>ULTY ON</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.4</td>
<td>2.5</td>
</tr>
</tbody>
</table>

0.9% decrease
## 5-1. Standard specification of ULTY-V plus

### Items

<table>
<thead>
<tr>
<th>Items</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumed power</td>
<td>0.3kVA</td>
</tr>
<tr>
<td>Ambient temperature</td>
<td>0 - 55°C</td>
</tr>
<tr>
<td>Humidity</td>
<td>5 - 95%</td>
</tr>
<tr>
<td>Control device</td>
<td>Yokogawa STARDOM</td>
</tr>
<tr>
<td></td>
<td>Duplex configuration</td>
</tr>
<tr>
<td>I/O card</td>
<td>Non-redundant configuration</td>
</tr>
<tr>
<td>Power supply</td>
<td>Duplex configuration</td>
</tr>
<tr>
<td>Man-machine function</td>
<td>LCD operation</td>
</tr>
<tr>
<td>OS</td>
<td>Windows 7 Professional</td>
</tr>
<tr>
<td>HDD</td>
<td>1TB</td>
</tr>
<tr>
<td>DVD</td>
<td>Multi</td>
</tr>
</tbody>
</table>

※ The construction work to connect ULTY to existing DCS will fall under your scope of work. Construction specifications will be submitted.
5-2. Connection method to existing system

- Control signal is separated from data collection. Therefore, the operation of existing boiler control system is guaranteed when the PC stop in the worst case.

- Standard analog connection includes 5 input (Main steam pressure, Main steam flow or Power generation, Coal feed, Boiler master, MW demand) and 1 output (ULTY correction coefficient).
### 6. Delivery record

<table>
<thead>
<tr>
<th>Business type</th>
<th>Once-through boiler</th>
<th>Circulation boiler</th>
<th>Fluidized bed boiler</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric power</td>
<td>1</td>
<td>9</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>Steel</td>
<td>-</td>
<td>15</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Paper</td>
<td>-</td>
<td>9</td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td>Petroleum, Chemical</td>
<td>-</td>
<td>11</td>
<td>-</td>
<td>11</td>
</tr>
<tr>
<td>Cement</td>
<td>-</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1</strong></td>
<td><strong>47</strong></td>
<td><strong>11</strong></td>
<td><strong>59</strong></td>
</tr>
</tbody>
</table>

- Regardless of the type of boilers and their operating systems, ULTY-V plus can be installed in a wide variety of plants.
- It is applicable to a variety of fuels, such as coal, petroleum coke, heavy oil, by-produced gas, and biomass. However, natural gas fired boilers are not included because their main steam is stable.
7-1. Optional function of ULTY-V plus

- ULTY-V plus includes a software that calculates the efficiency and cost performance of each coal brand in addition to the energy saving function.
- Additional technical services are provided to customers as option using IoT technology.

* Optional technical services will be expanded in the future.
7-2. Efficiency and cost calculation system

- Efficiency, environmental impact and cost performance of each coal brand is analyzed based on the boiler data accumulated in ULTY-V plus.
8. Summary

- The Paris Agreement, an international framework for global warming measures, was formally adopted in 2015.
- We cannot avoid considering global environmental issues as one of the companies related to coal business.
- Idemitsu has developed highly-efficient clean coal technologies through research on improving energy efficiency and reducing environmental impacts.
- “ULTY-V plus” is a system that can optimize the combustion control of boilers by being connected to the boiler control system, and can reduce coal consumption through the realization of stable plant operation.
- We hope to contribute to the prevention of global warming and the realization of a sustainable society, by reducing CO2 emissions through the spread of “ULTY-V plus”, both inside and outside the country.
Thank you very much for your kind attention.

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