Energy saving and CO_2 reduction by boiler control optimization system "ULTY-V plus"

Toru YAMASHITA
Coal & Environment Research Laboratory
Coal Business Department
Idemitsu Kosan Co.,Ltd.

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

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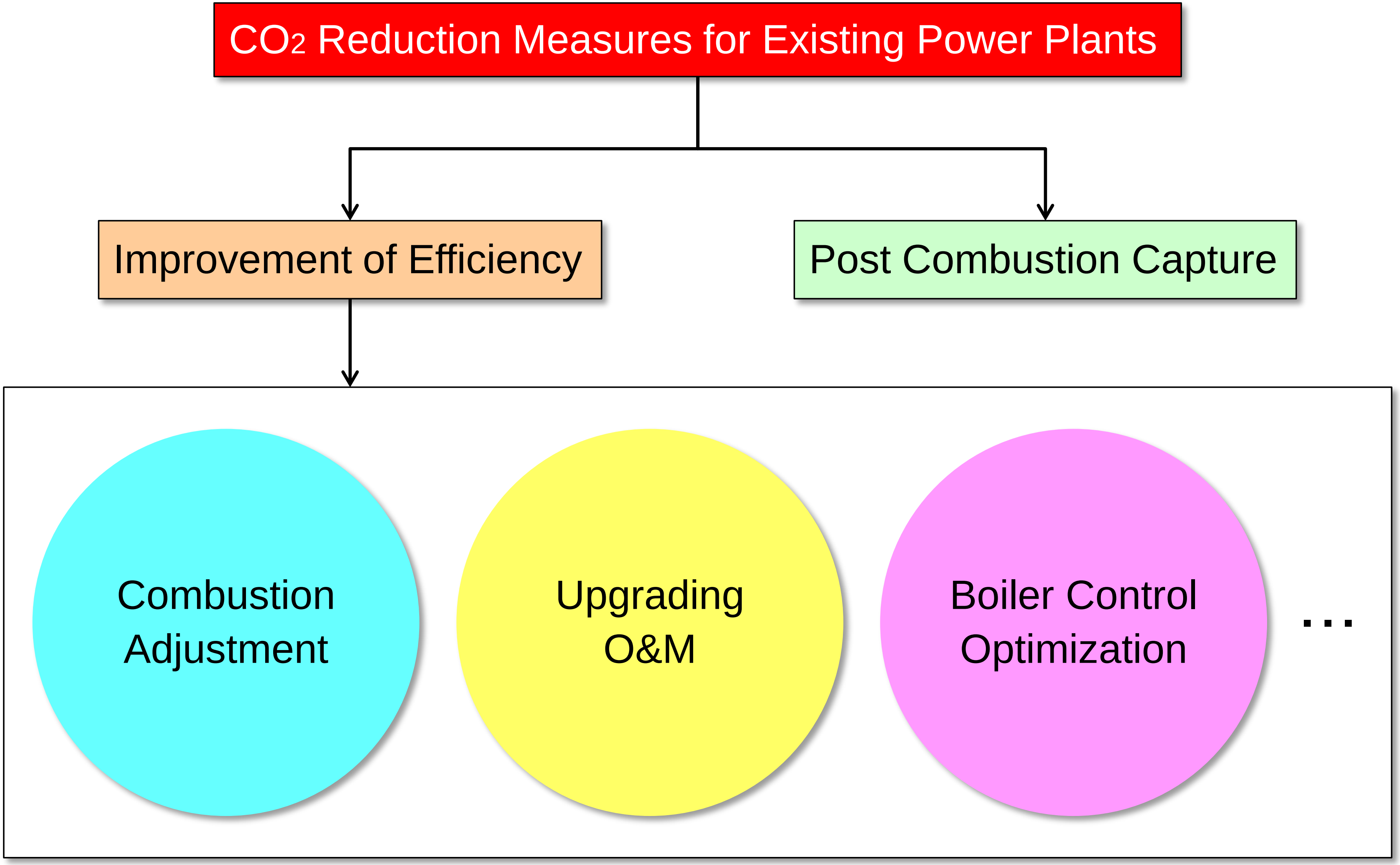
1-1. Introduction



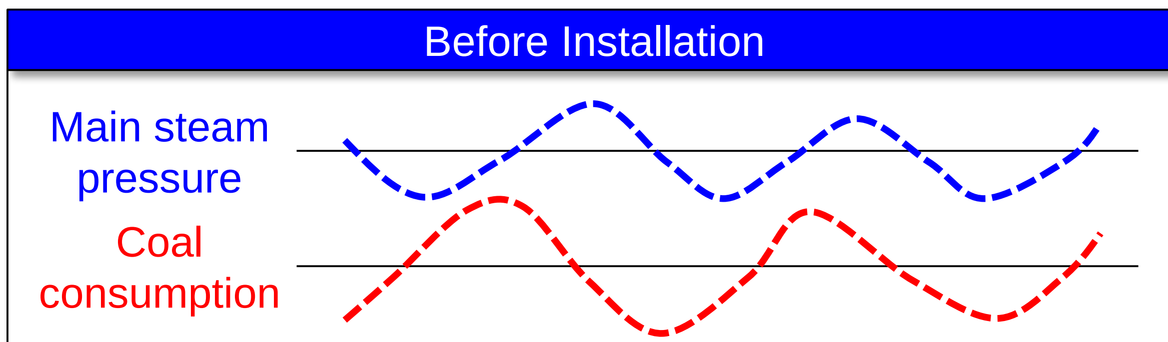
1-2. Boiler control optimization system

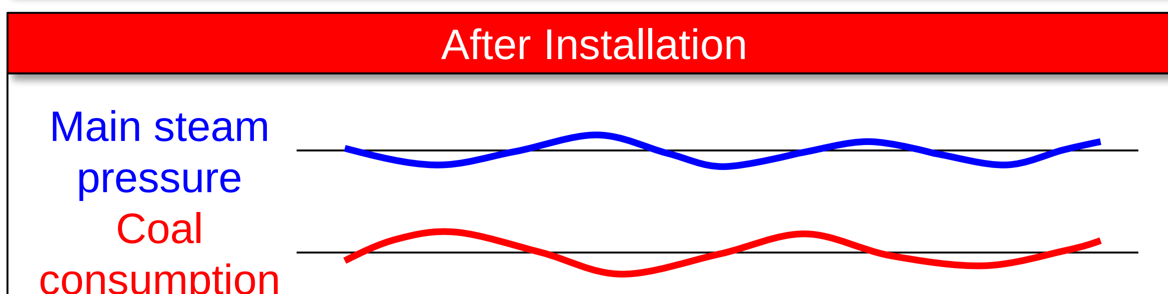
"ULTY-V plus" is the boiler control optimization system which can reduce coal consumption and CO_2 emission by connecting with existing boiler control system !

ULTY-V plus

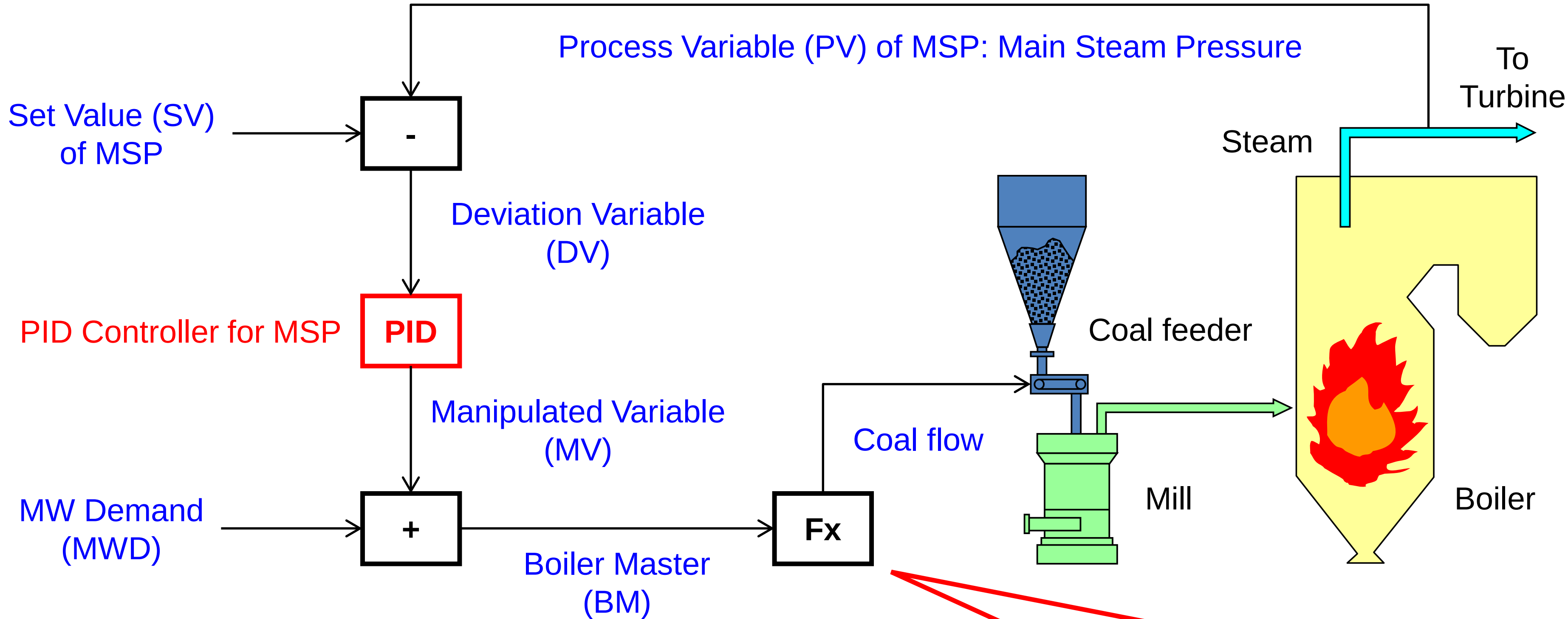
Reduction of coal consumption: Approx.1%

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

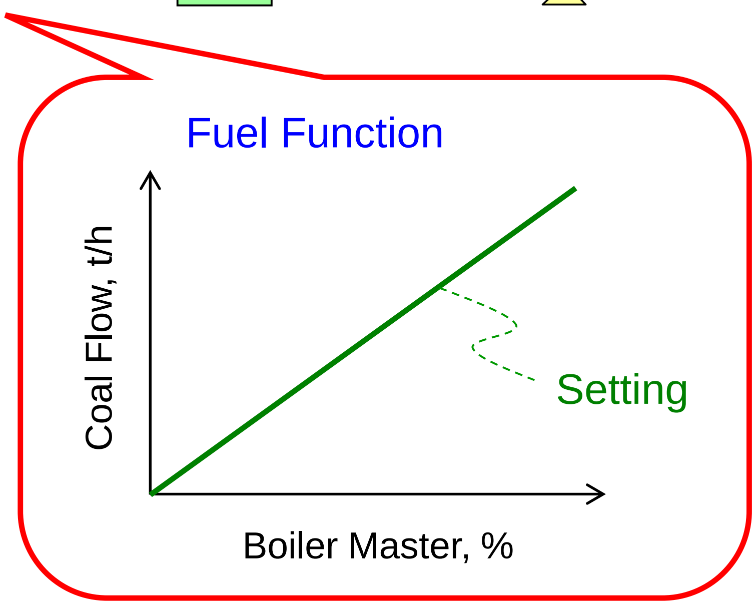




2-1. Basics of boiler master control

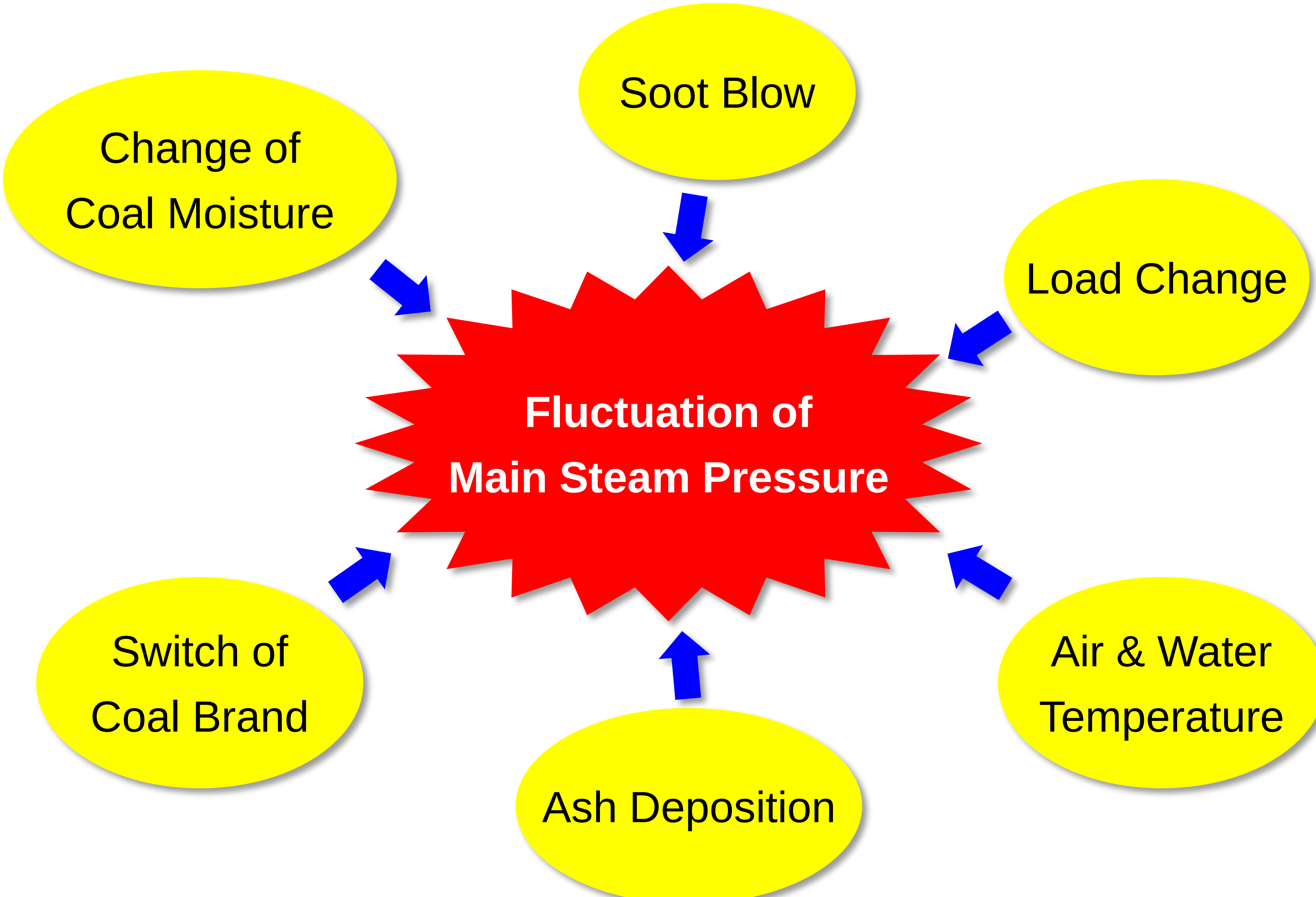


- Boiler master control is one of the main system in Automatic Plant Control (APC).
- Main Steam Pressure is basically stabilized by PID (Proportional-Integral-Derivative) control method.



2-2. Fluctuation factors of coal fired boiler

In coal fired boiler, a combustion state always changes due to following factors.



2-3. Basics and problems of PID control（1）

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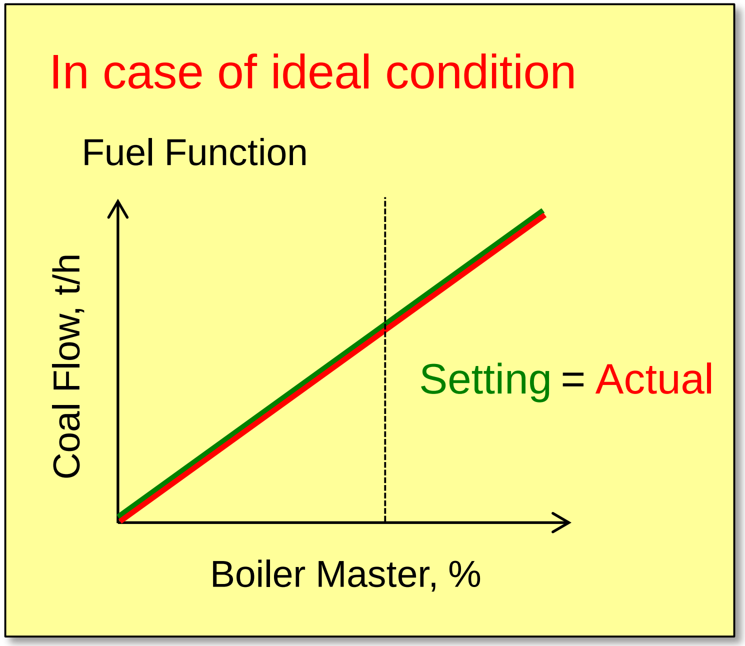
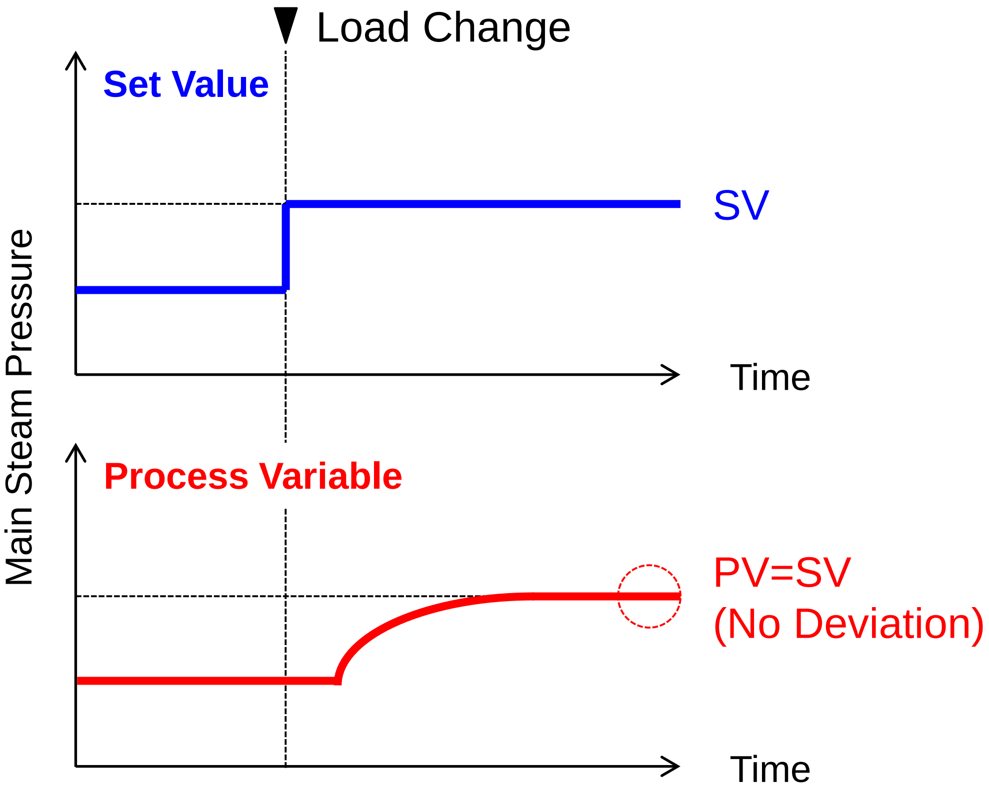
P(Proportional) Control

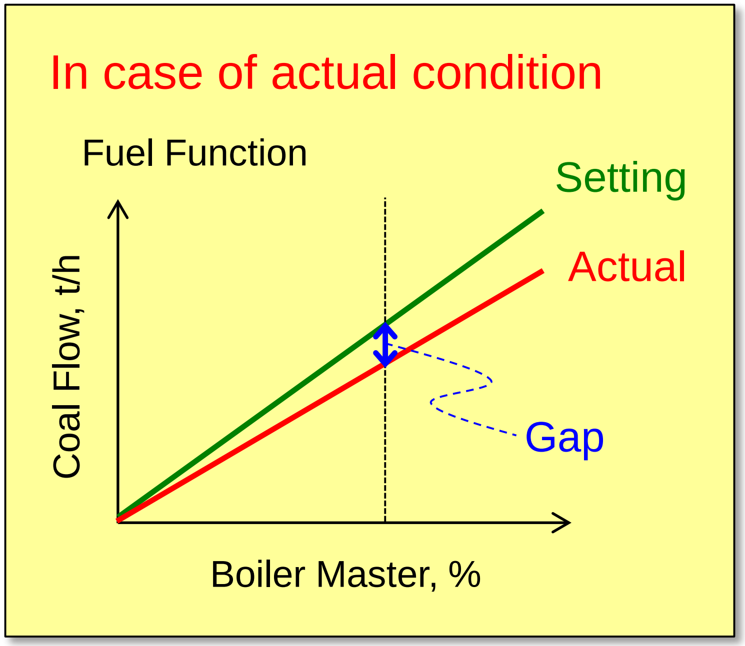


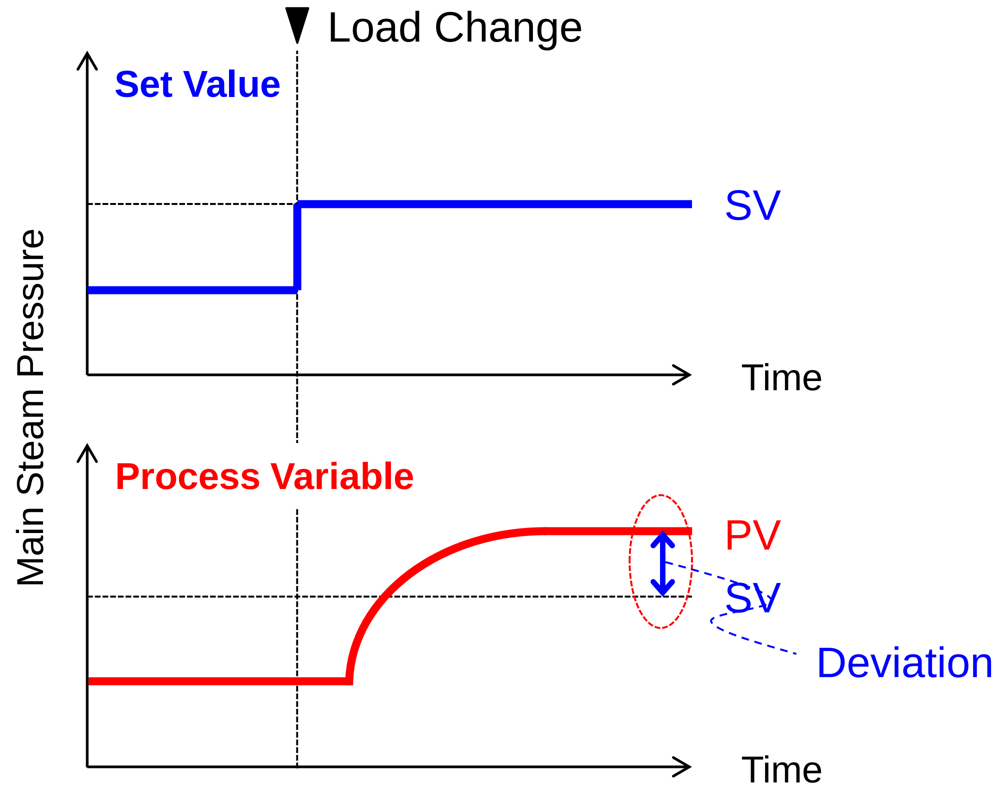


- P(Proportional) control is a fundamental element in PID control.
- If there is no deference in setting and actual fuel function, PV(Process Valuable) becomes same with SV(Set Value) in a short time.

2-4. Basics and problems of PID control（2）

P(Proportional) Control





- 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）

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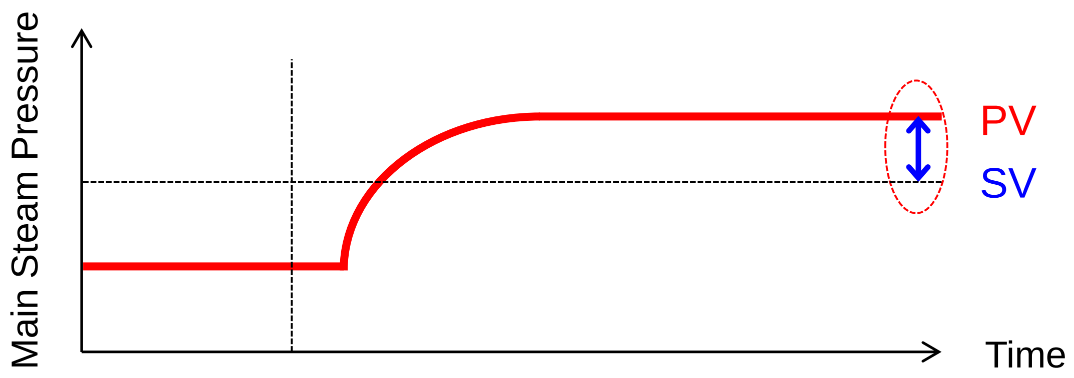
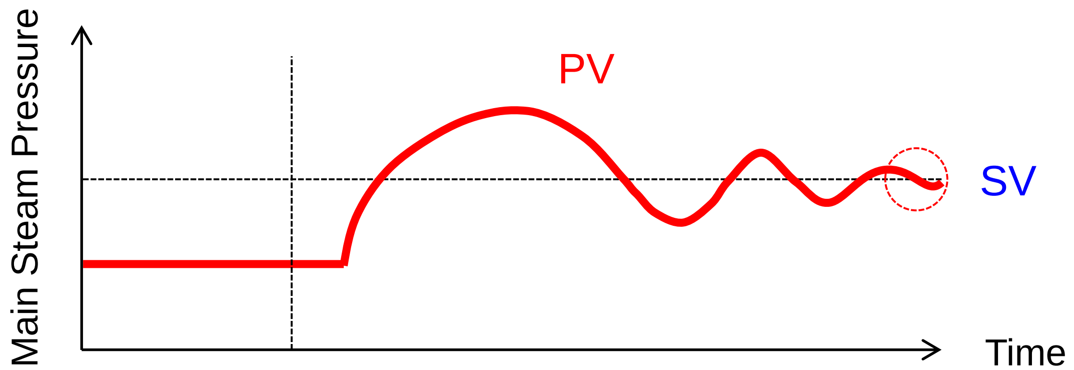
P(Proportional) Control

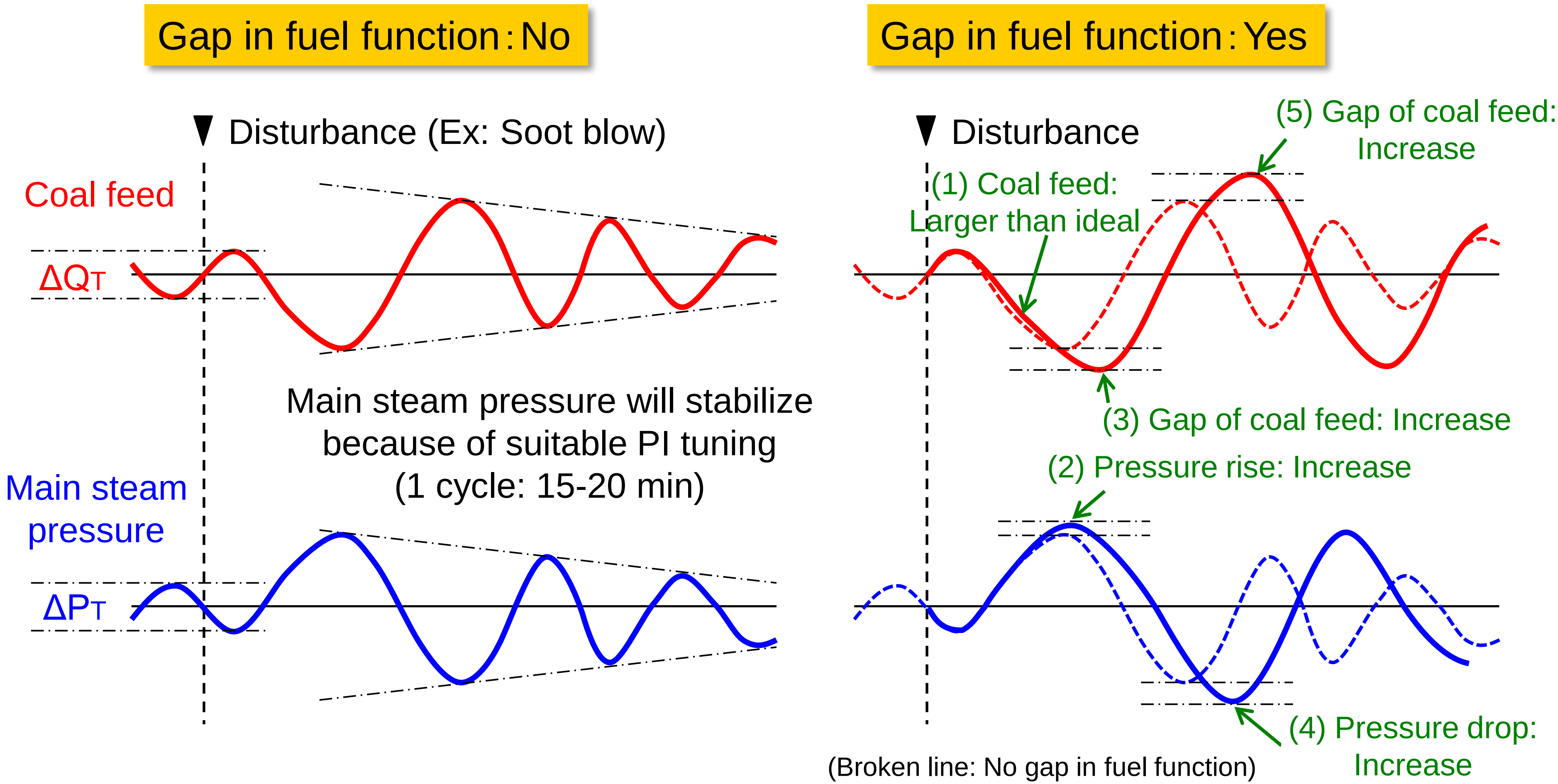


PI(Proportional-Integral) Control



- In PI control, corrective action continue 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.

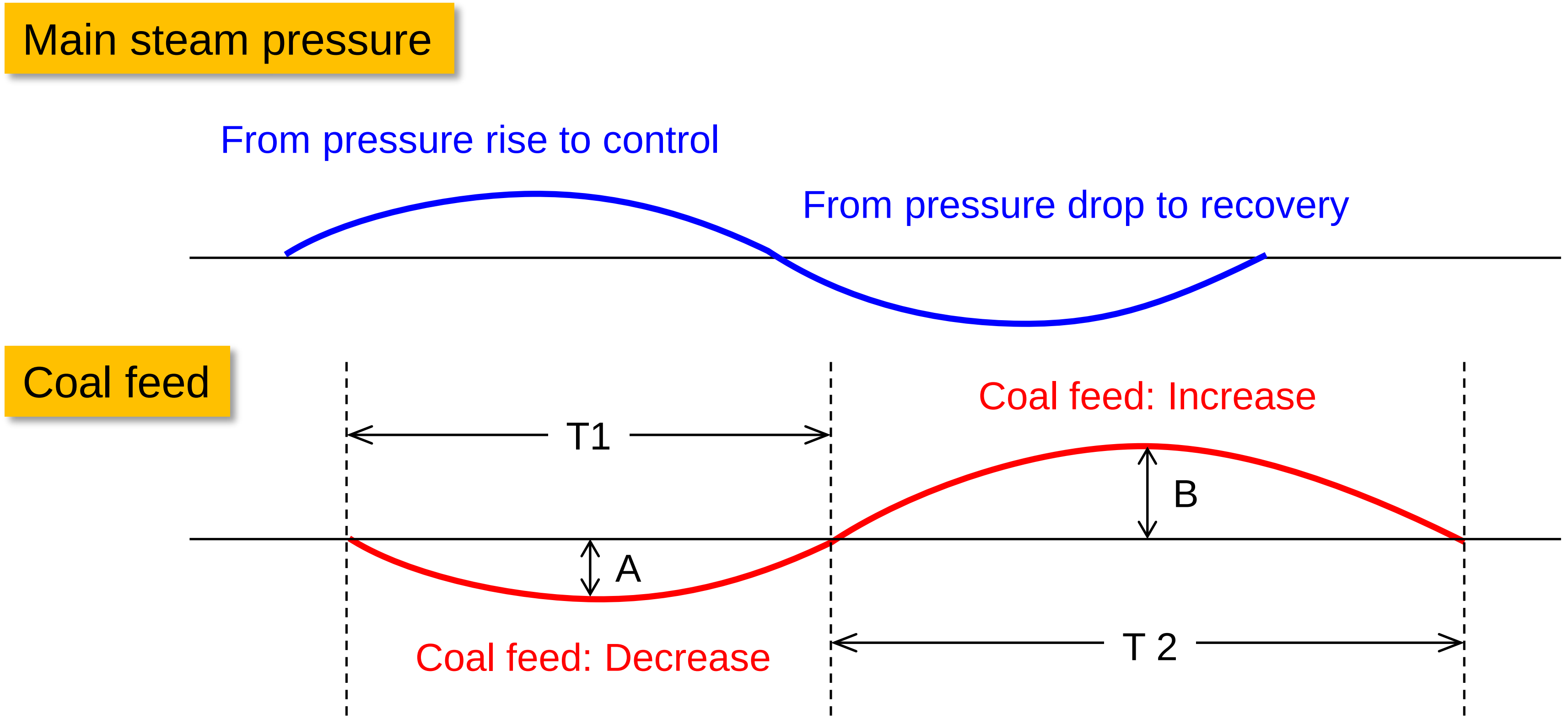
2-6. Actual situation at coal fired boiler (1)



- 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.

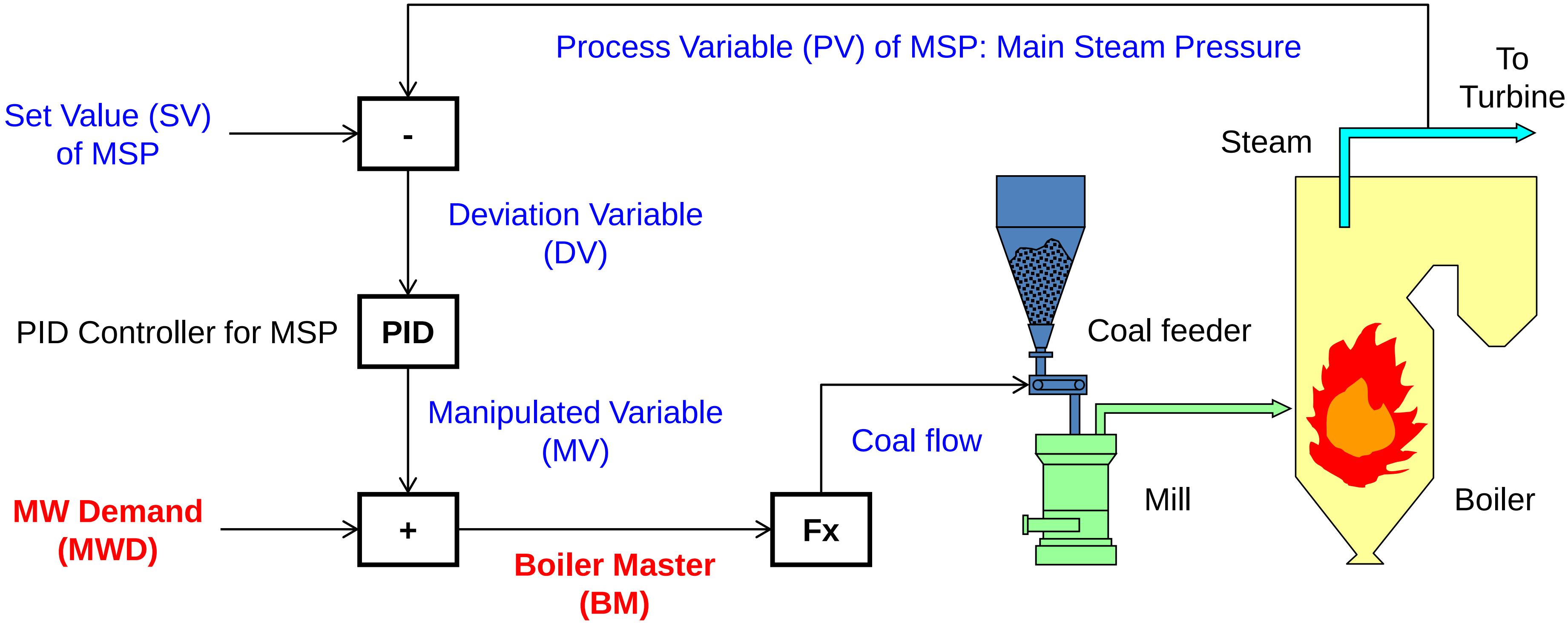
2-7. Actual situation at coal fired boiler（2）

- 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 (T2) is longer than the time to decrease coal feed (T1).【T1<T2】



Coal feed always tend to be surplus!

3-1. Parameter to monitor boiler condition



Parameter	Boiler Condition
$\frac{BM}{MWD} = 1$	● 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.

3-2. Optimization procedure by ULTY-V plus

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.

3-3. Optimization of fuel function

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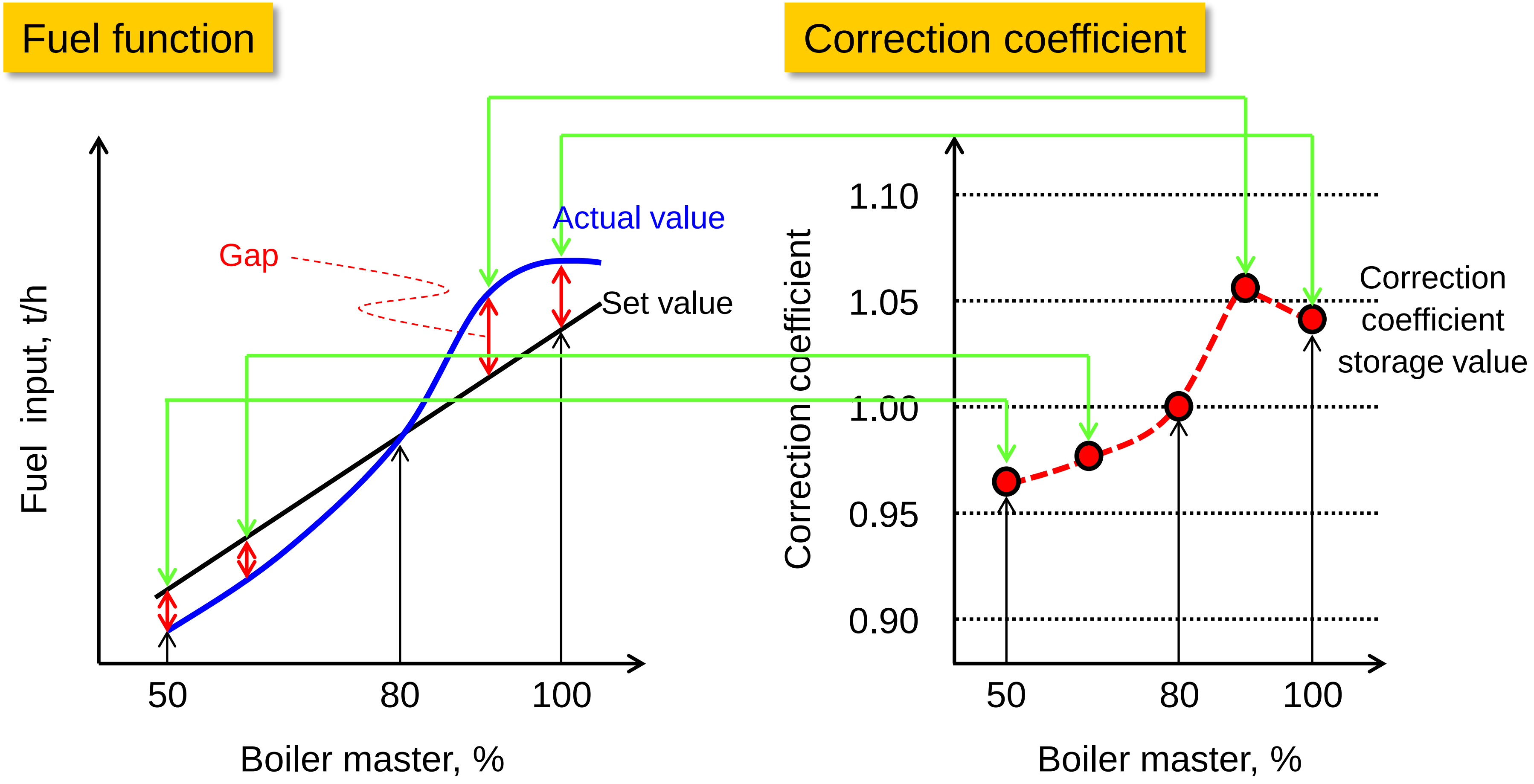
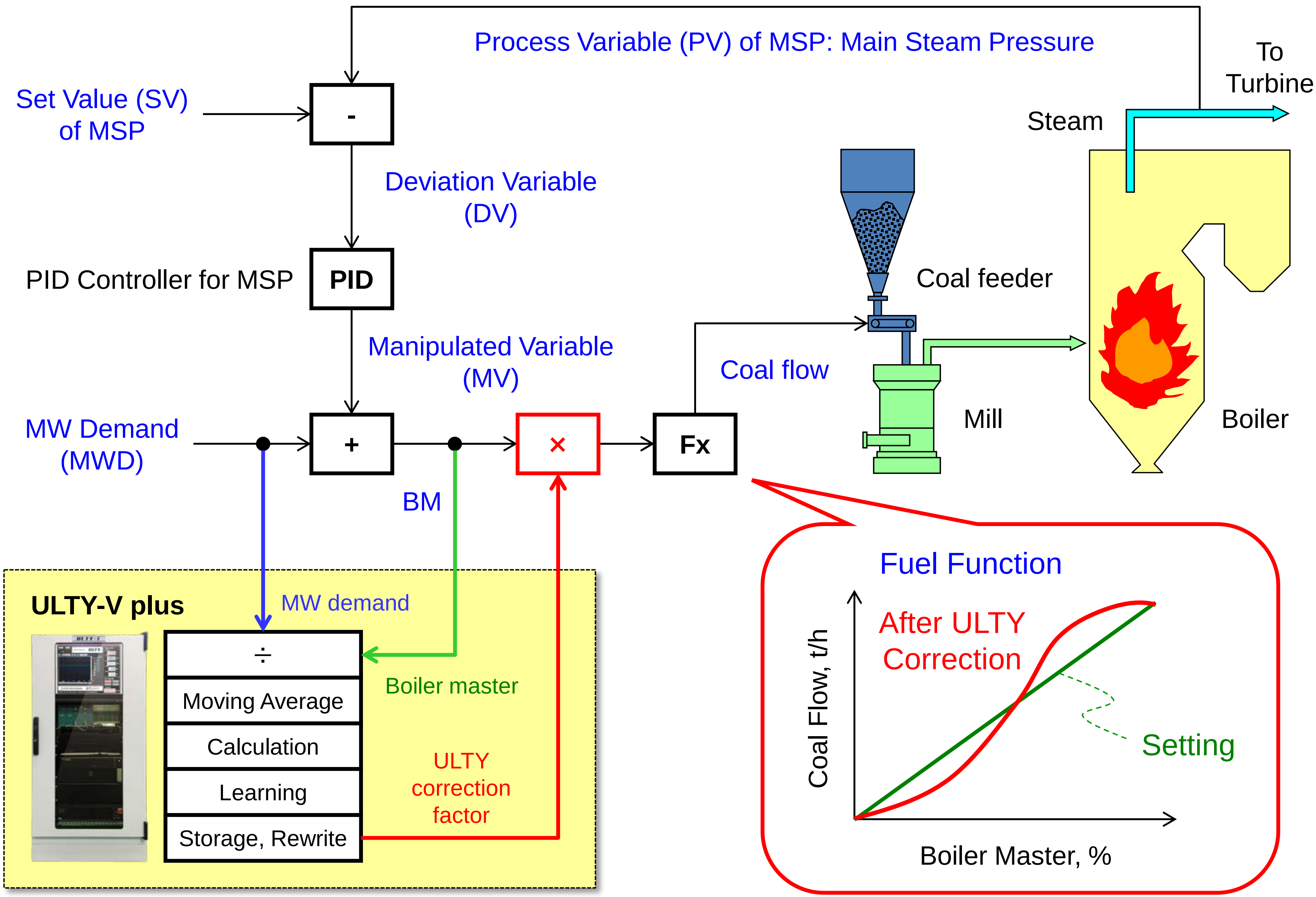
ULTY-V plus optimizes fuel function through a process, where the gap between set and actual value in the fuel function at each boiler load is corrected. It is always stored and continuously rewritten in the boiler control system.



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

3-4. Installation of ULTY-V plus



3-5. Control display of ULTY-V plus

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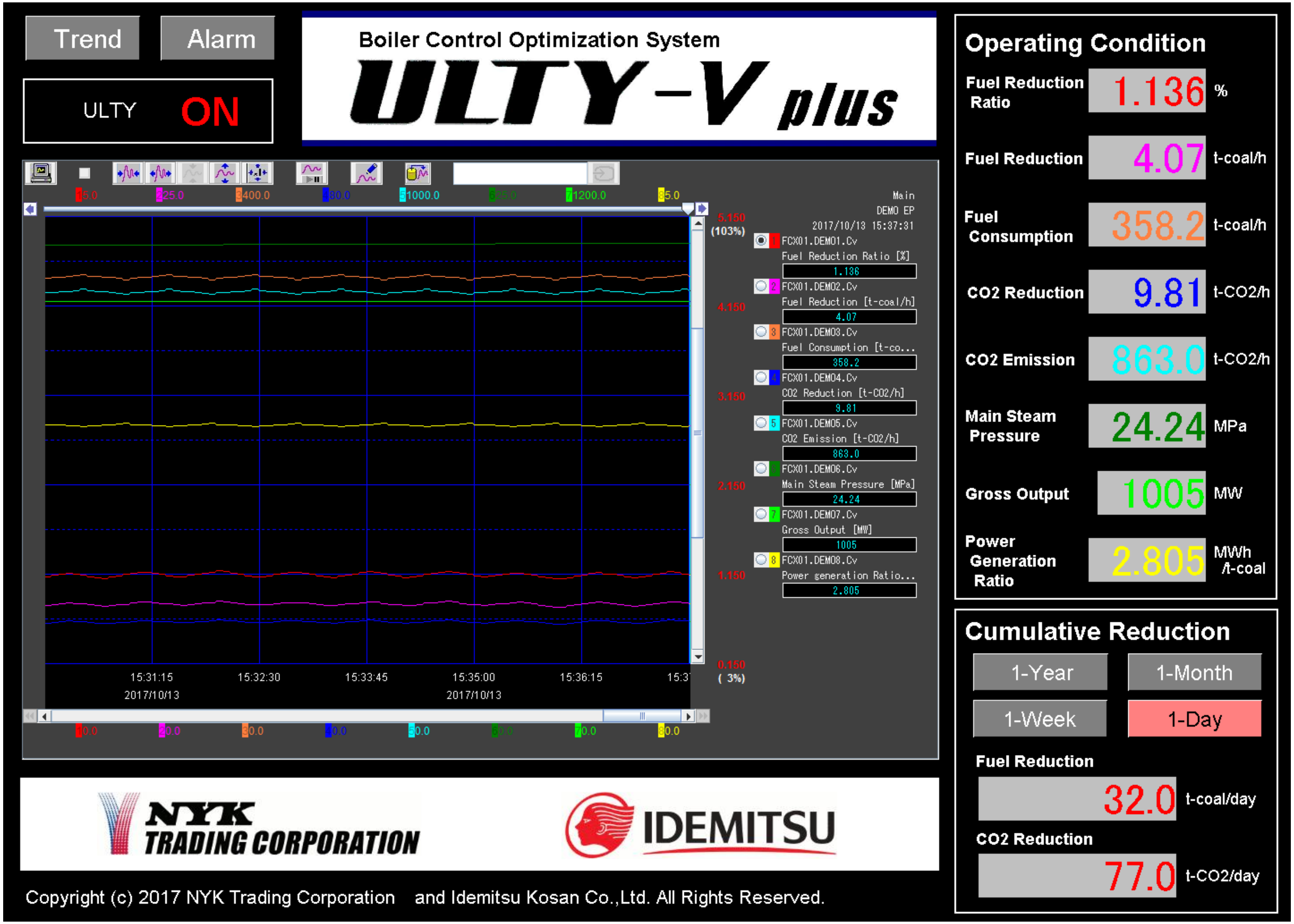
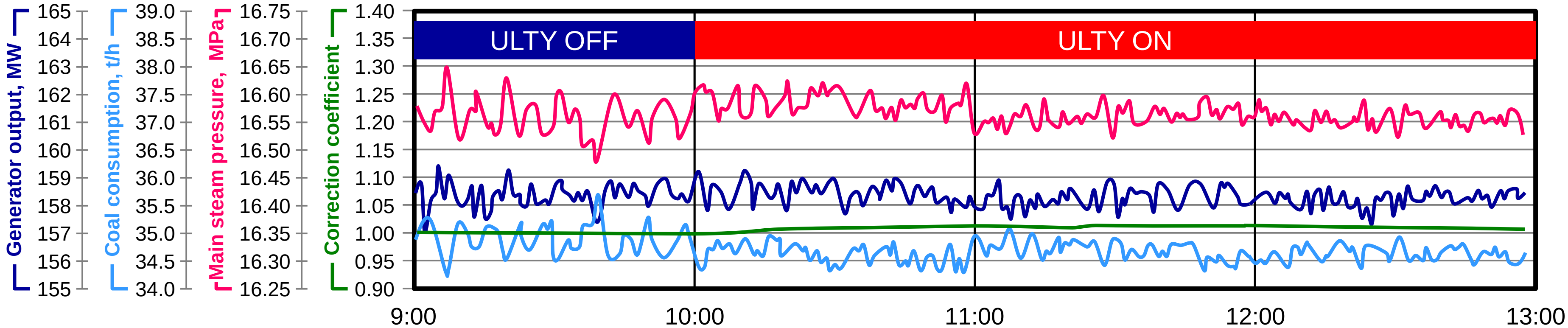
- ULTY-V plus displays current and cumulative reduction of coal and CO_2 emission.

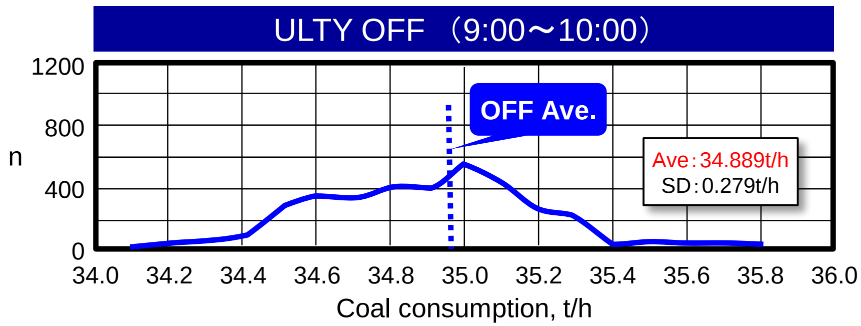


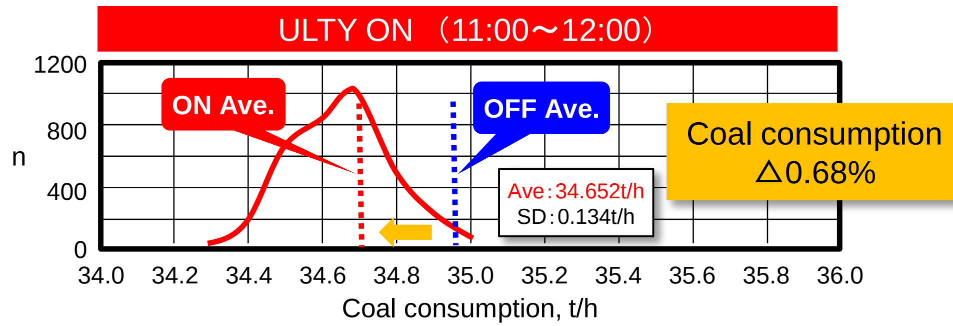
4-1. Effect of ULTY（1）

Main steam pressure gradually became stable after ULTY-ON.

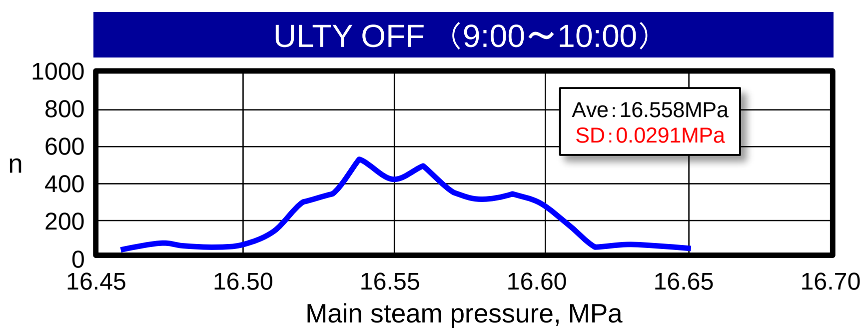


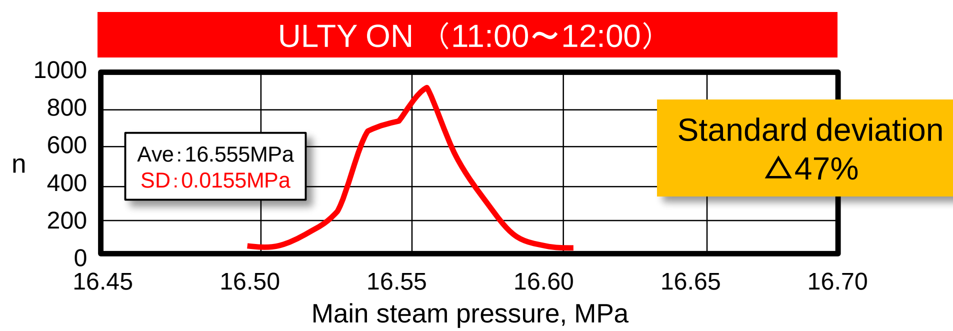
- Coal consumption





- Main steam pressure





4-2. Effect of ULTY（2）

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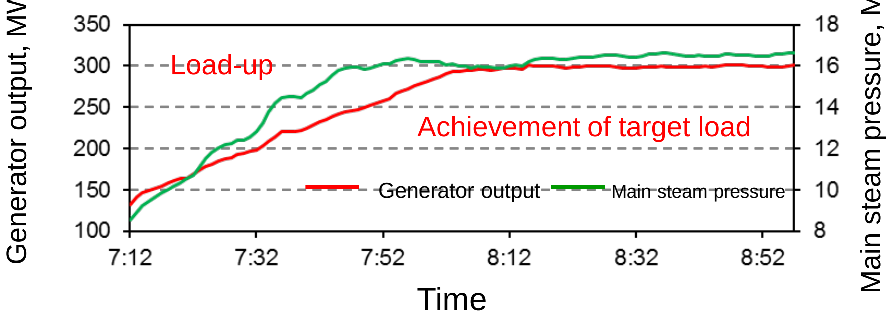
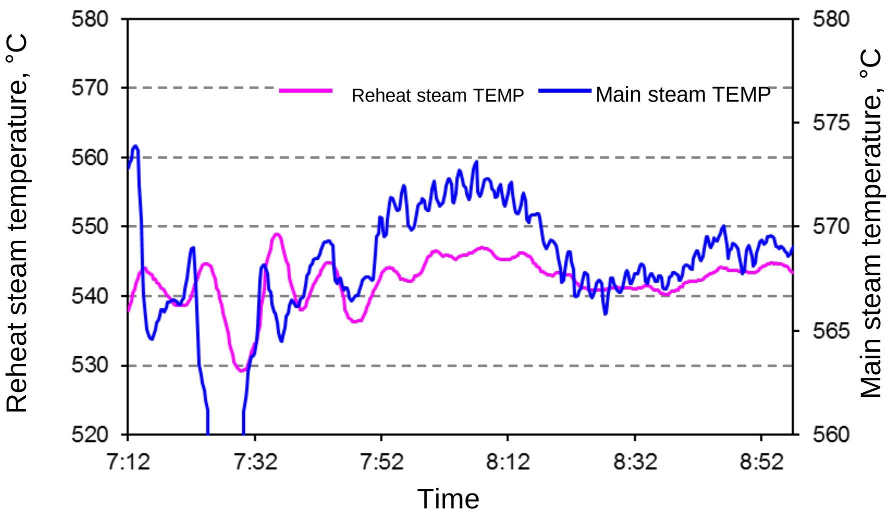
A test was conducted under a severe condition where the boiler load was changed from minimum to maximum in around an hour. → Steam temperature was stabilized.

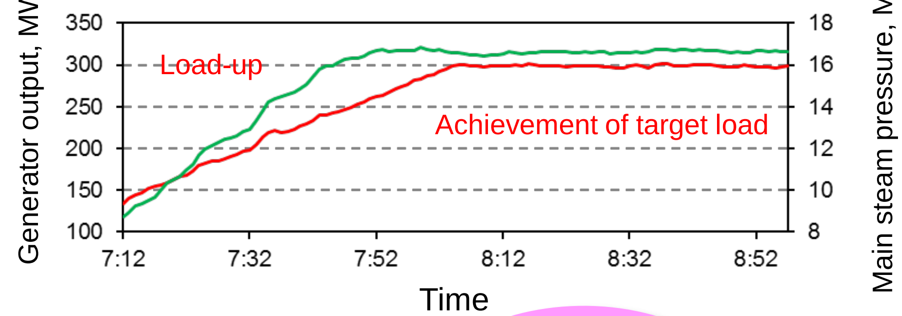
ULTY OFF

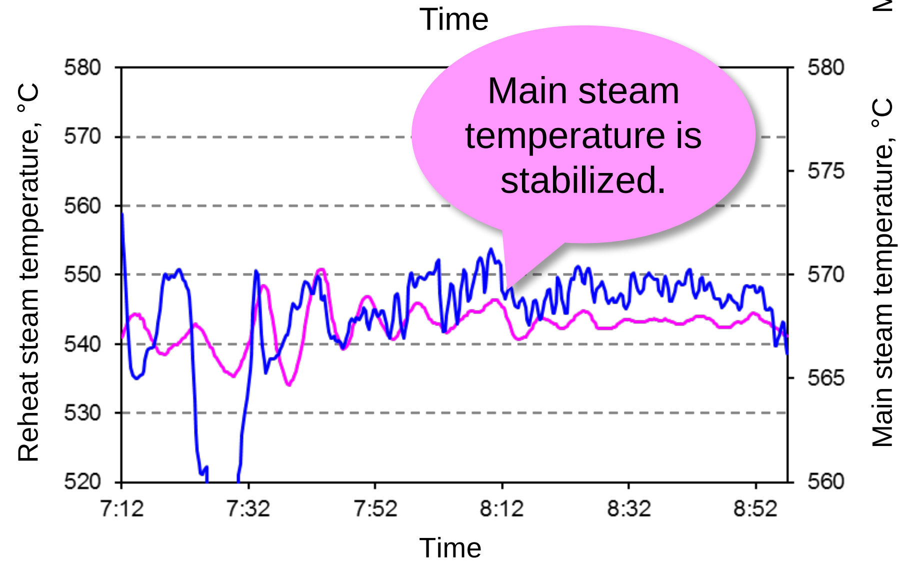




	Maximum	Setup	Difference
Main steam temp.	573.2°C	569°C	+ 4.2°C
Reheat steam temp.	546.0°C	541°C	+ 5.0°C

ULTY ON



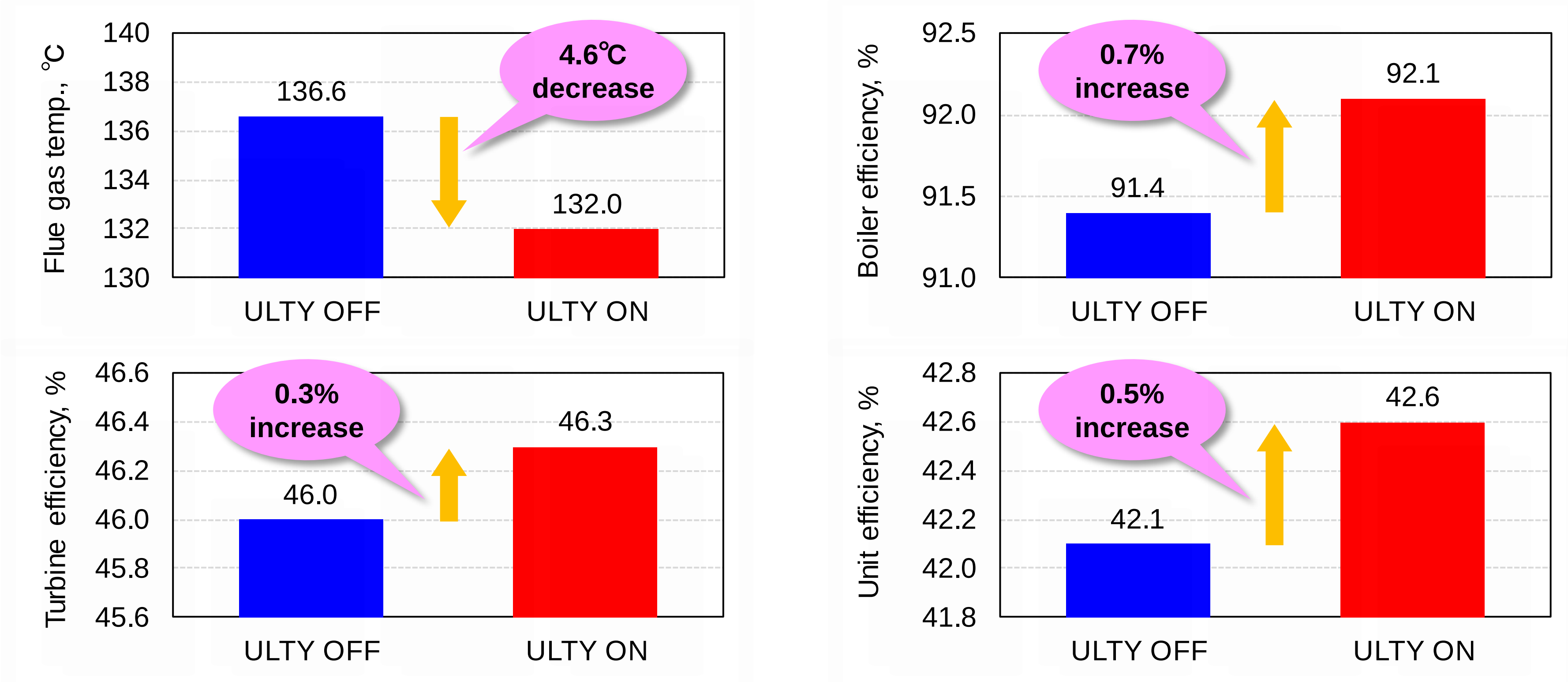


	Maximum	Setup	Difference
Main steam temp.	571.0°C	569°C	+ 2.0°C
Reheat steam temp.	546.0°C	541°C	+ 5.0°C

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.



4-4. Effect of ULTY（4）

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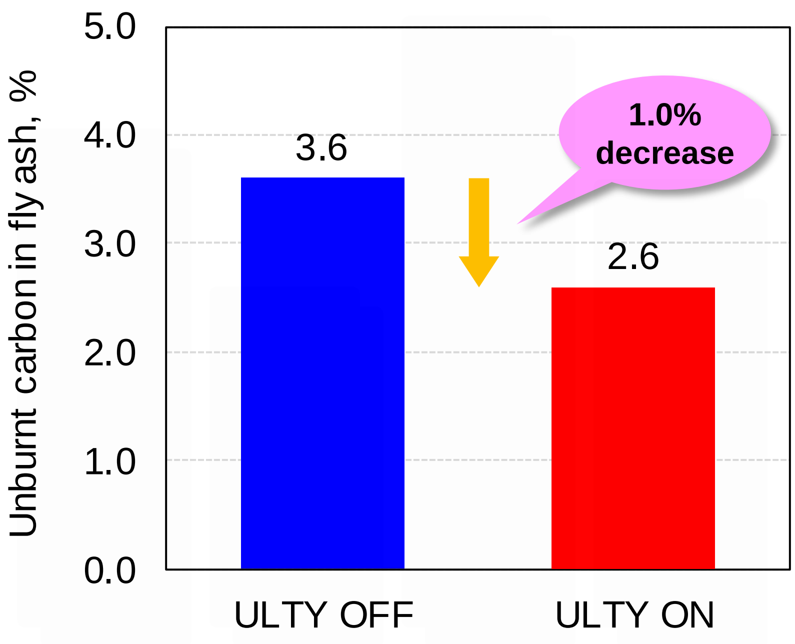
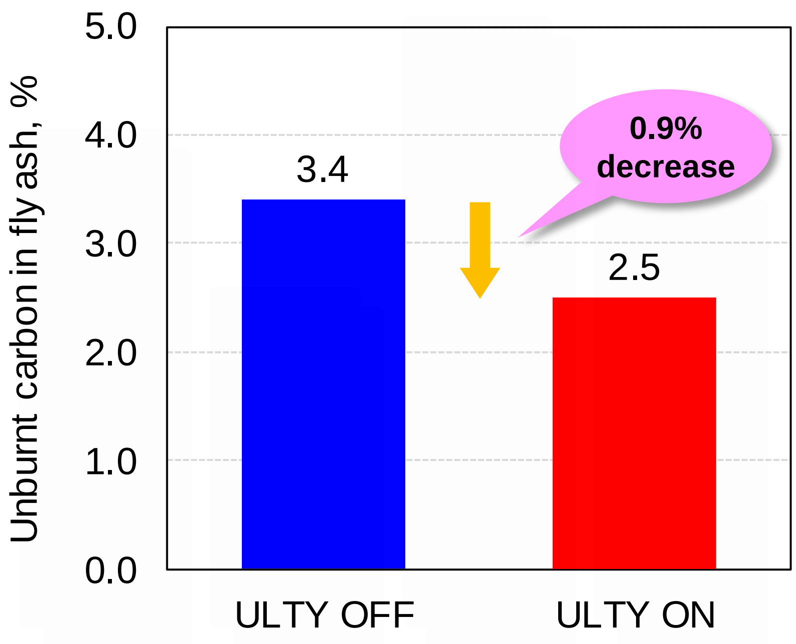
Reduction of unburnt carbon in fly ash

- 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



B coal



5-1. Standard specification of ULTY-V plus

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Width:　700mm

Depth:　720mm

Height: 1,350mm

Weight:　180kg

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

※ 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

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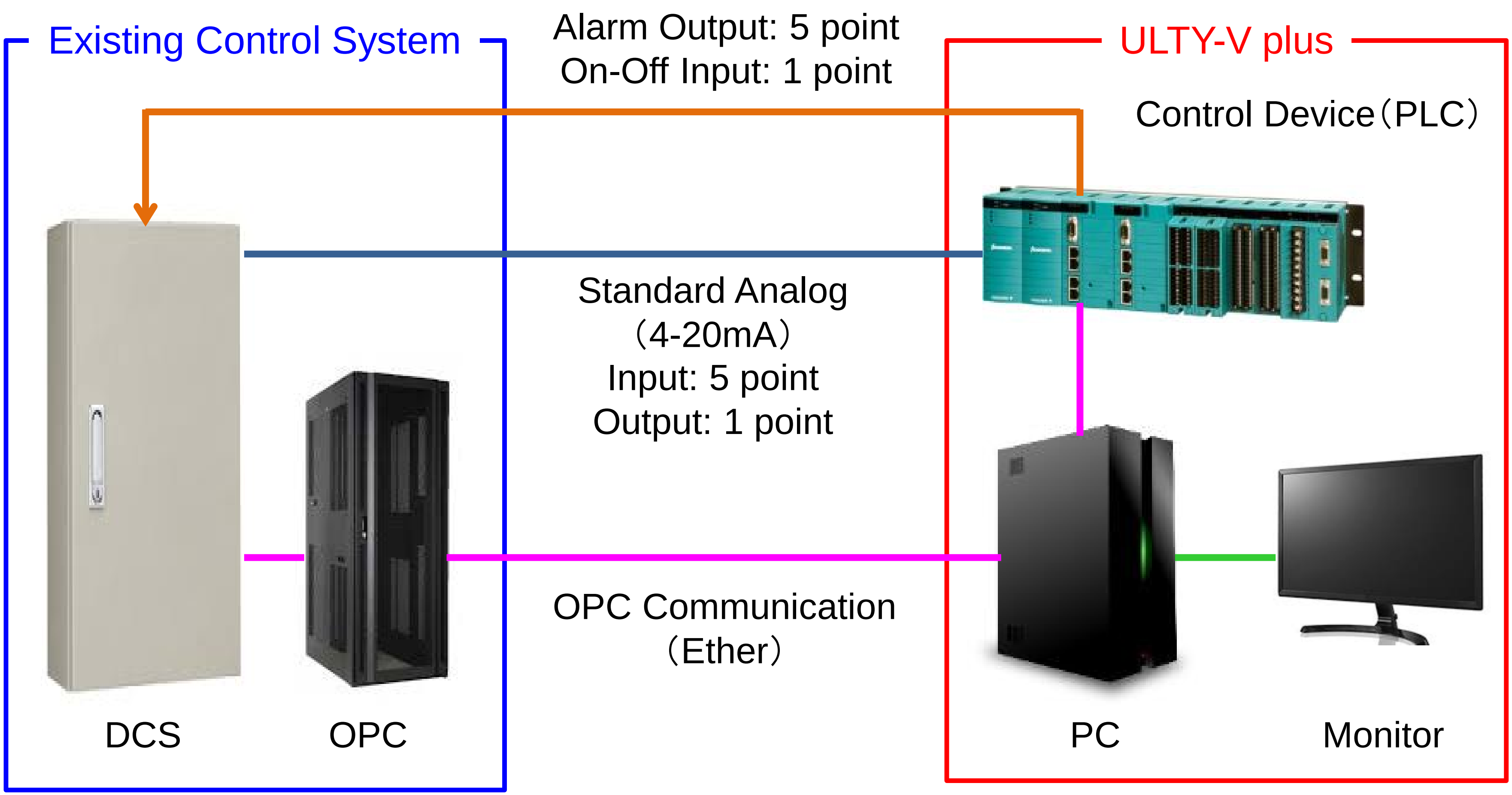


- Control signal is separated from data collection. Therefore, the operation of existing boiler control system is guaranteed when the PC stop in the worst case.
- Standard analog connection includes 5 input (Main steam pressure, Main steam flow or Power generation, Coal feed, Boiler master, MW demand) and 1 output (ULTY correction coefficient).

6. Delivery record

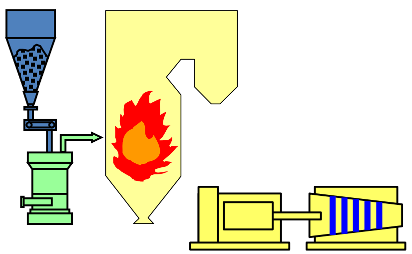
Business type	Once-through boiler	Circulation boiler	Fluidized bed boiler	Total
Electric power	1	9	1	11
Steel	-	15	1	16
Paper	-	9	6	15
Petroleum, Chemical	-	11	-	11
Cement	-	3	3	6
Total	**1**	**47**	**11**	**59**

- 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.

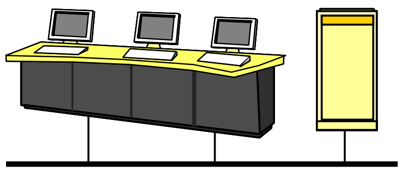
7-1. Optional function of ULTY-V plus

- 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.

Power plant



Existing control system



ULTY-V plus

Energy saving control with AI

Display of energy saving effect

Collection of operation data

Efficiency and cost calculation

Option

Periodic reporting

Remote monitoring

etc.

* Optional technical services will be expanded in the future.

7-2. Efficiency and cost calculation system

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

ULTY-V plus Efficiency & Cost Performance Calculation System

Efficiency and Cost Performance Report

Report of Excel Format

Close

Calculation results of power generation efficiency, environmental impact and cost performance are summarized. A graph which compare with standard coal are displayed by clicking radio button.

Report Period

Start Date : 2017/5/18 8:00 End Date : 2017/5/21 10:00 74 hours average is shown as follows.

Coal Properties

Items	Standard-Coal	Coal-A	Coal-B
Total Moisture [wt%, AR]	10.5	11.9	11.2
HGI	50	50	45
Gross Heating Value [kcal/kg, AR]	6,373	6,440	6,290
Gross Heating Value [kcal/kg, AD]	6,800	6,700	6,670
Net Heating Value [kcal/kg, AR]	6,100	6,120	6,000
Net Heating Value [kcal/kg, AD]	6,200	6,250	6,100
Moisture [wt%, AD]	4.5	8.4	3.0
Ash [wt%, AD]	12.0	2.4	14.0
Volatile Matter [wt%, AD]	33.0	41.2	33.0
Fixed Carbon [wt%, AD]	50.5	48.0	50.0
Fuel Ratio	1.53	1.17	1.52
Carbon [wt%, DAF]	80.00	77.18	76.50
Hydrogen [wt%, DAF]	4.45	5.45	4.80
Nitrogen [wt%, DAF]	1.80	2.10	1.90
Sulphur [wt%, DAF]	0.34	0.36	0.60
Oxygen [wt%, DAF]	13.41	14.91	16.20
Total Sulphur [wt%, DB]	0.37	0.45	0.55
IDT (Oxi.) [Deg.]	1,240	1,265	1,300
HT (Oxi.) [Deg.]	1,315	1,290	1,370
FT (Oxi.) [Deg.]	1,450	1,450	1,490
IDT (Red.) [Deg.]	1,300	1,250	1,290
HT (Red.) [Deg.]	1,330	1,275	1,350
FT (Red.) [Deg.]	1,430	1,465	1,480
SiO2 [wt%]	45.63	36.82	48.55
Al2O3 [wt%]	31.67	33.98	32.15
TiO2 [wt%]	0.63	0.99	0.70
Fe2O3 [wt%]	8.18	7.90	5.50
CaO [wt%]	3.77	5.02	3.27
MgO [wt%]	2.23	3.10	2.50
Na2O [wt%]	3.79	7.02	1.20
K2O [wt%]	1.03	0.82	1.00
P2O5 [wt%]	0.62	0.10	0.50
MnO [wt%]	0.04	0.05	0.04
V2O5 [wt%]	0.04	0.08	0.04
SO3 [wt%]	2.19	3.16	4.55

Efficiency

Gross Output : 1,000.8 MW

Power Generation per 1t-Coal (Raw Coal)
- Gross : 2.78 MWh/t-coal
- Net : 2.67 MWh/t-coal

Coal Consumption per 1kWh (Raw Coal)
- Gross : 391.9 g/kWh
- Net : 401.1 g/kWh

Coal Consumption per 1kWh (25.7MJ/kg Conversion)
- Gross : 296.9 g/kWh
- Net : 303.9 g/kWh

Boiler Efficiency
- Input and Heat Method : 95.6 %, HHV
- Heat Loss Method : 94.8 %, HHV

Unit Efficiency (Input and Heat Method)
- Gross : 40.73 %, HHV
- Net : 39.80 %, HHV

Caution is needed for comparing different coal brands, because the seasonal modulation of turbine efficiency are not corrected when the coal consumption rate and unit efficiency values are calculated.

Environmental Performance

CO2 Emission Rate per 1kWh
- Gross : 1.018 kg-CO2/kWh
- Net : 1.042 kg-CO2/kWh

Average Emissions
- NOx at De-NOx Inlet : 15.0 ppm, O2 6% Conv.
- SOx at De-SOx Inlet : 25.0 ppm
- Dust at Stack Inlet : 10.0 mg/Nm3

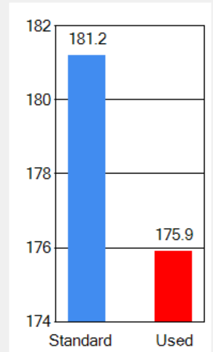
Cost Performance

Fuel Consumption, Fuel Cost
- Fuel Consumption : 175.9 t/h
- Fuel Cost : 11,924.66 USD/h

Fuel Cost per 1kWh
- Gross : 0.02657 USD/kWh
- Net : 0.02719 USD/kWh

Comparison between Standard Coal and Used Coal

Consumption of Fuel [t/h]



(Used Coal) - (Standard Coal) : -5.3 t/h

Fuel Saveing by ULTY-V plus (Estimated Value)

- Fuel Reduction Ratio : 1.54 % (Compared based on the estimation of fuel consumption at the time of ULTY-OFF)
- Fuel Cost Reduction : 183.63 USD/h
- CO2 Reduction : 7.06 t-CO2/h Calculated with CO2 coefficient 2.33 t-CO2/t-coal

Fuel saving efficiency by ULTY-V plus is the value estimated based on boiler operation data.

Coal Consumption Record

Date	Main-Coal	Main-Coal Ratio[%]	Sub1-Coal	Sub1-Coal Ratio[%]
2017/5/12 AM	Coal-A	70	Coal-B	30
2017/5/12 PM	Coal-A	70	Coal-B	30
2017/5/13 AM	Coal-A	70	Coal-B	30
2017/5/13 PM	Coal-A	70	Coal-B	30
2017/5/14 AM	Coal-A	70	Coal-B	30
2017/5/14 PM	Coal-A	70	Coal-B	30
2017/5/15 AM	Coal-A	70	Coal-B	30

Remarks

Unit Efficiency (Input and Heat Method)
Used-Coal: 39.80%, Standard-Coal:39.65%
(Comparison:+0.15%)
Fuel Cost per 1kWh
Used-Coal: 0.02719USD, Standard-Coal:0.002760USD
(Comparison:-0.00042USD)

The part of this data is NOT an actual measured value BUT an estimated value.

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8. Summary

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- 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 CO_2 emissions through the spread of “ULTY-V plus”, both inside and outside the country.

Thank you very much for your kind attention.

   

IDEMITSU

Coal & Environment Research Laboratory
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