2nd Oxyfuel Combustion Conference
(September 13,2011)

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Development of an Advanced Oxy-Fuel Combustion Technology with Flue Gas Re-circulation System, New Types of Burner and Characteristics of Mill Performance

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Contents

1.1 CCS Technology Development Trend and Hitachi Vision

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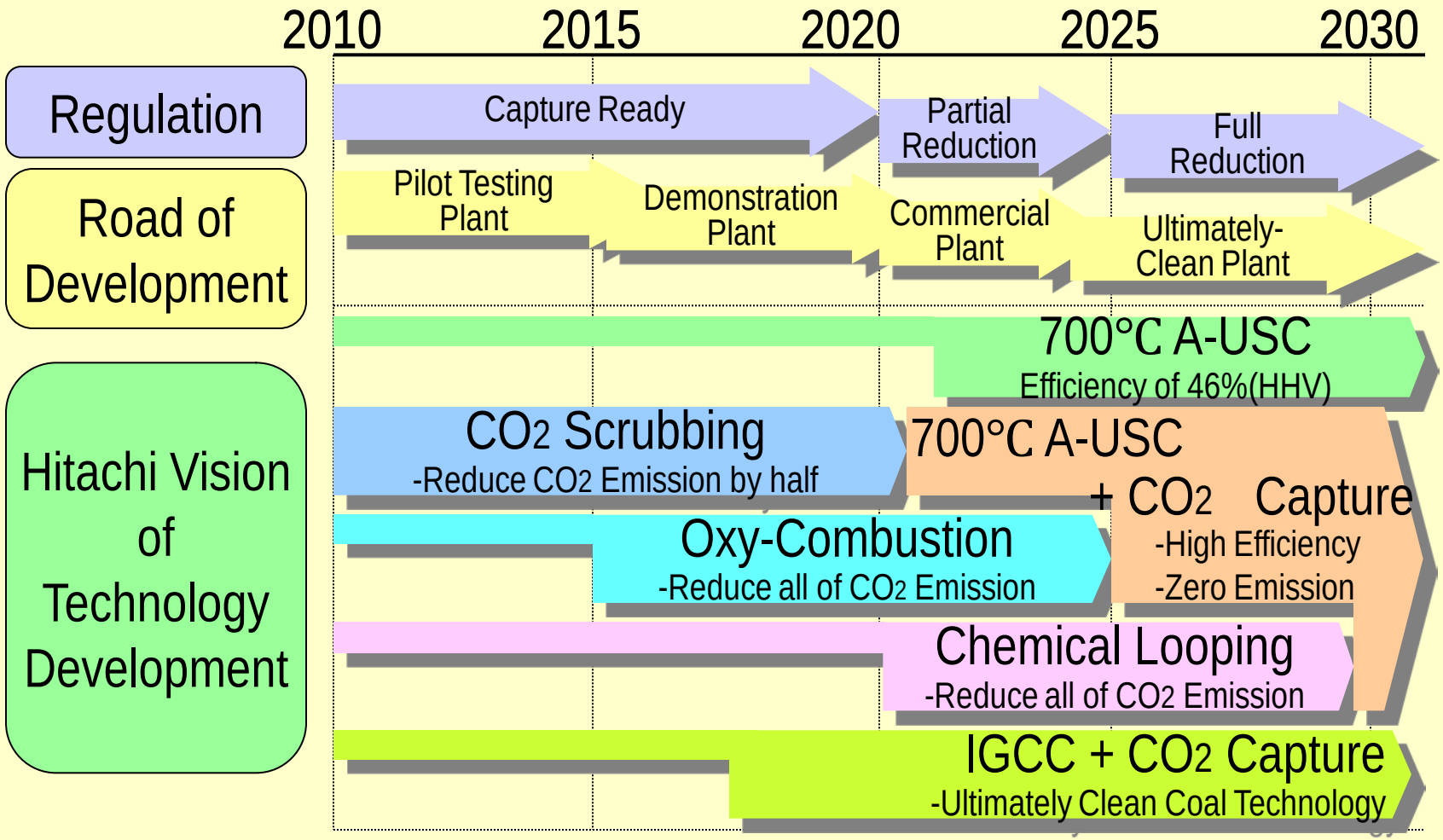
- Coal firing is currently the leading source of power generation
- Hitachi has been developing two key technologies of CO_2 capture from coal fired power plants; "CO_2 Scrubbing", "Oxy-Combustion" and high efficiency plants "700C A-USC", " IGCC"



1.2 Advantage of Oxy-Combustion

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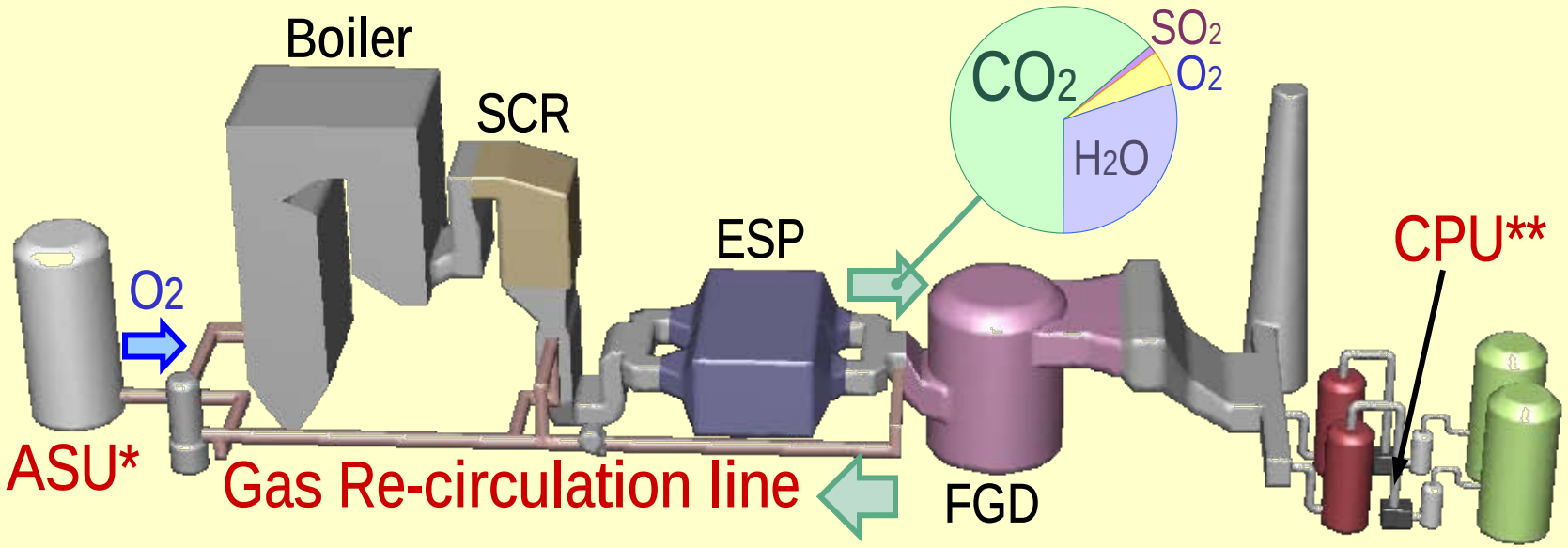
- The Oxy-combustion is an effective method in that it can remove CO_2 gas from combustion flue gas.
- The Oxy-combustion system can be retrofitted to existing power plants with no change to the plant water-steam cycle and only limited modifications to the boiler.
- Hitachi and FORTUM have jointly studied a conceptual Oxy-combustion power plant design that allows practical CO_2 capture for future CO_2 sequestration efforts.



* ASU : Air Separation Unit
** CPU : CO_2 Purification Unit

1.3 Development Subjects in Oxy-Combustion

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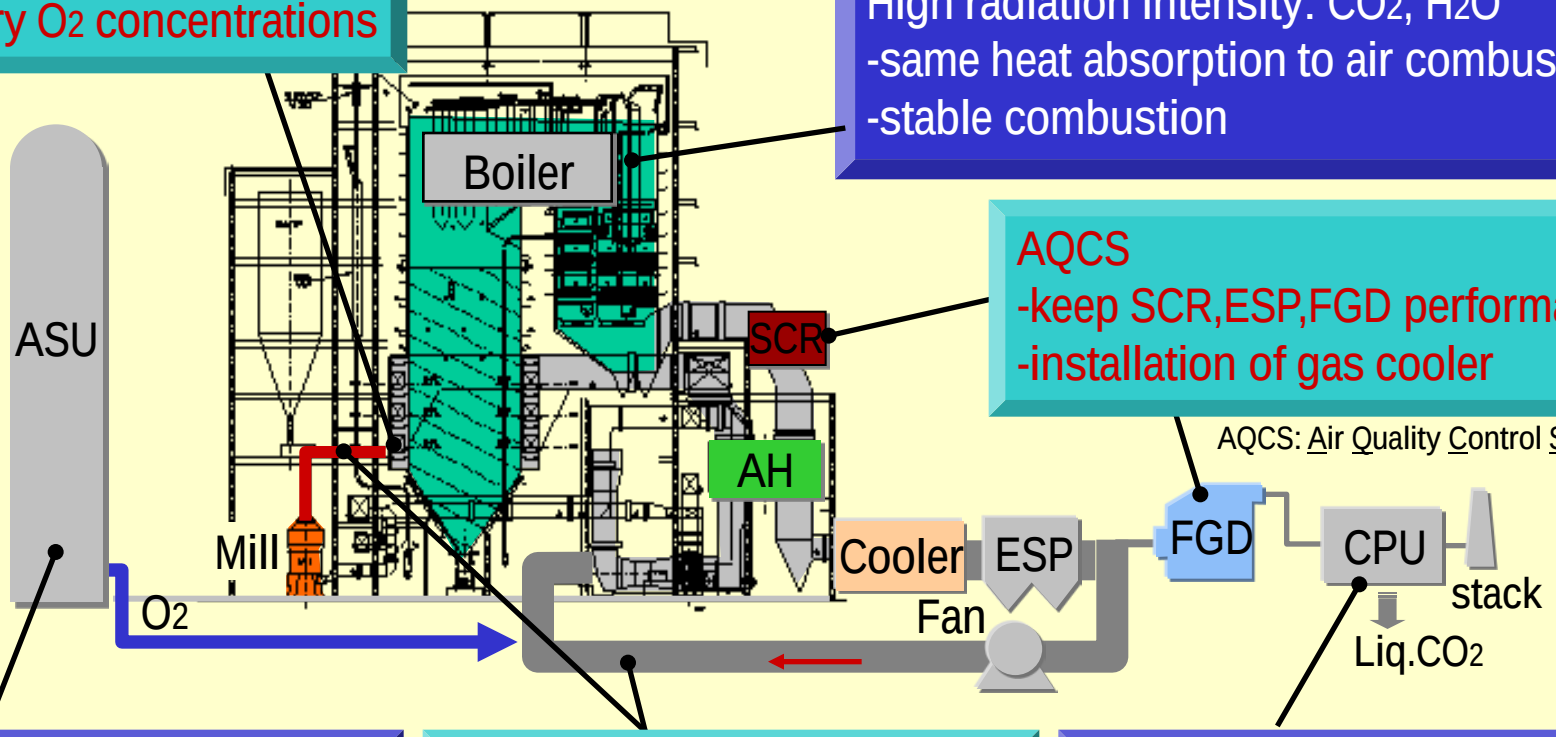
Burner
-operation stability
-low p'ry O_2 concentrations

Boiler
High radiation intensity: CO_2, H_2O
-same heat absorption to air combustion
-stable combustion



AQCS
-keep SCR,ESP,FGD performance
-installation of gas cooler

AQCS: Air Quality Control System

ASU
-reduce initial cost
-reduce power consumption
compact & low power

Mill outlet pipe
-keep temperature 70 – 90 C
Re-circulation line
-reduce corrosive gas: SO_3

CPU
-reduce corrosion potential
(SO_3, Hg, Cl etc)
-reduce power consumption
compact & low power

ASU: Air Separation Unit

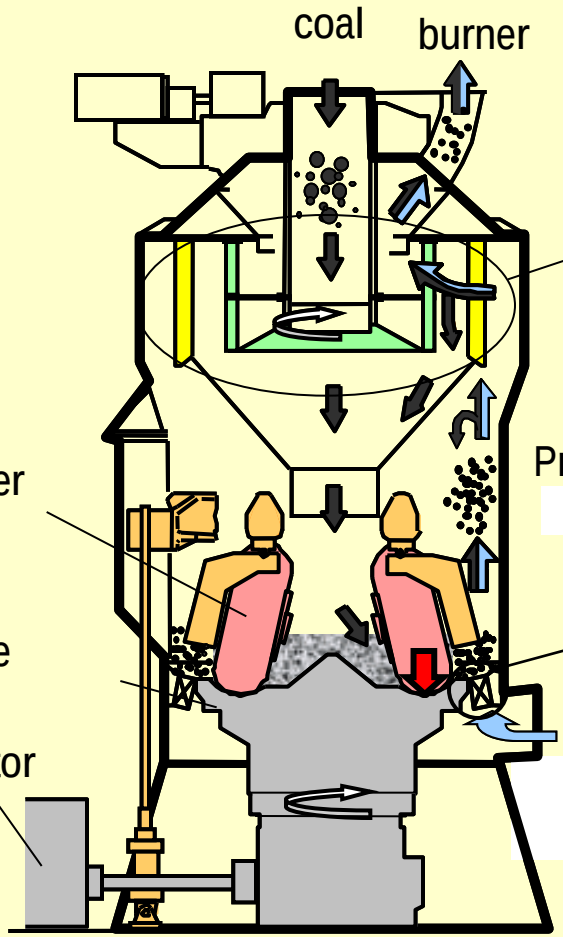
CPU: CO_2 Compression and Purification Unit

Development of an Advanced Oxy-Fuel Combustion Technology with Flue Gas Re-circulation System, New Types of Burner and Characteristics of Mill Performance

2. Study of mill performance in the oxy-fuel combustion conditions

2.1 Objective

- To evaluate the mill performance in CO2(modified recirculation flue gas) compared with in air.
- Items; mill power and pressure drop of mill



Keep fineness of product same as air with existing classifier

Keep pressure drop in mill under PAF capacity

Keep mill power lower than motor capacity

Bench scale mill

CO_2 supply system (Max.300kg/h CO_2 gas)

Schematic view of MPS mill and consideration items

2.2 Results

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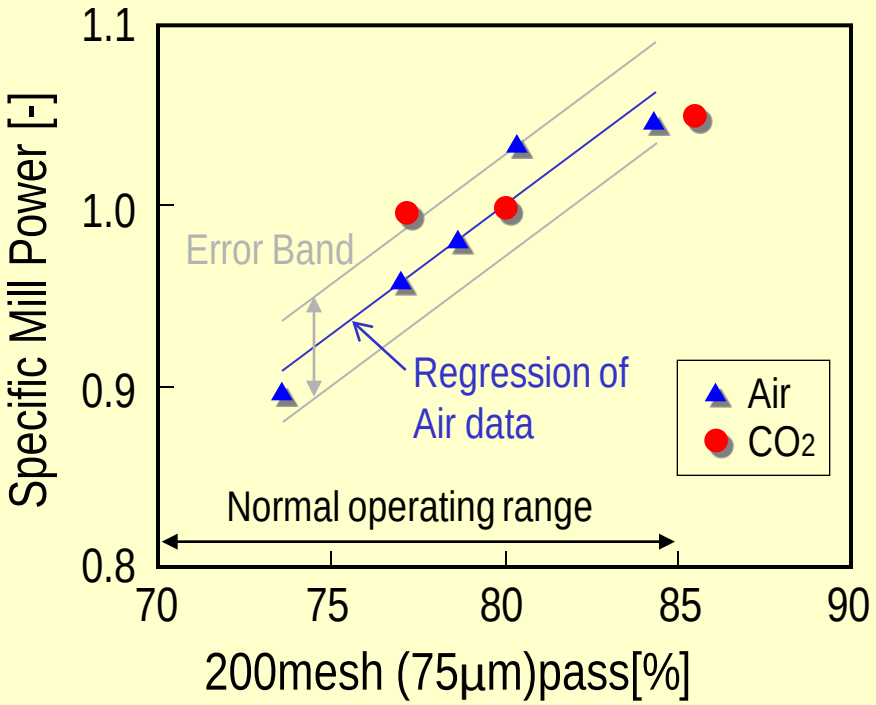
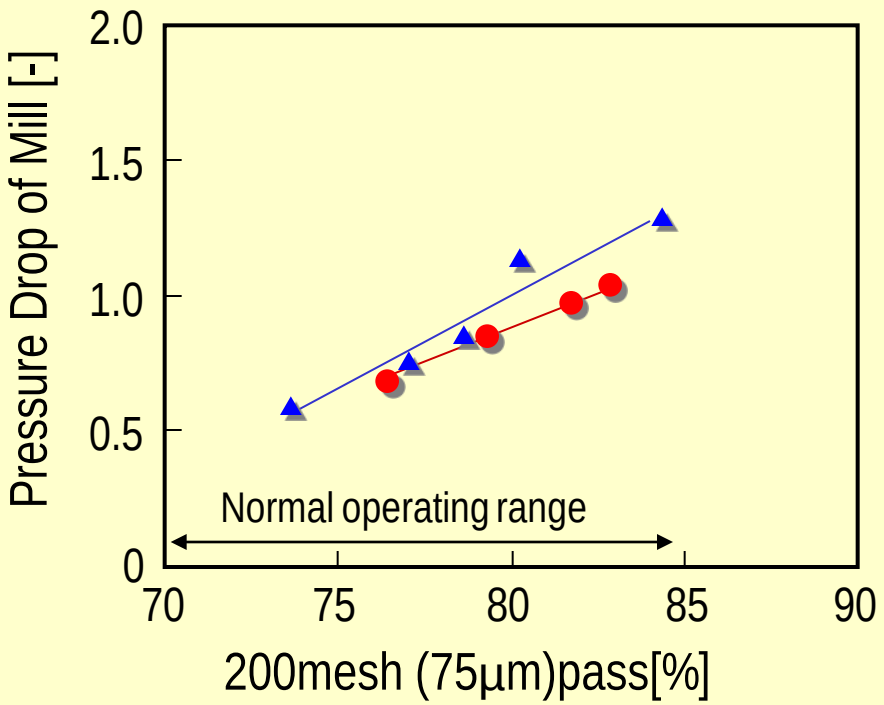
-The specific mill power in CO_2 is almost the same as that in the air.
-The pressure drop through the mill under CO_2 condition (simulating the oxy-fuel gas) is almost the same as that under air condition



Mill power in relation to fineness of product



Pressure drop of mill (throat+coal bed) in relation to fineness of product

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3. Features of New Burner

3.1 Subjects of Oxy-Combustion Burner

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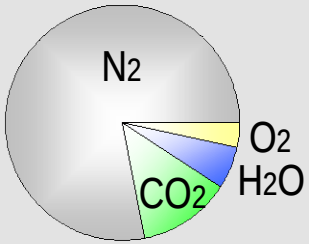
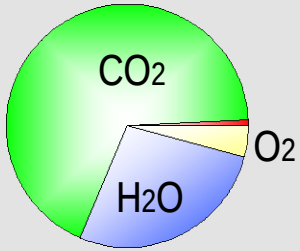
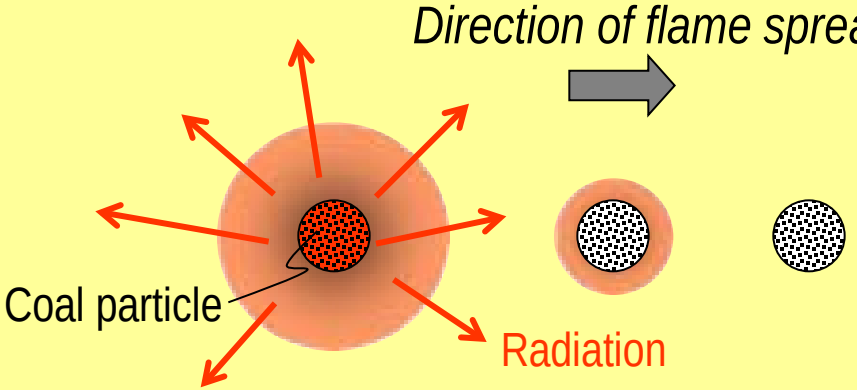
Burner flame becomes unstable with changing gas composition ($N_2 \Rightarrow CO_2$)

Item	Air Combustion	Oxy-Combustion
Flue gas composition		



Flame spread speed in Oxy-combustion is lower than that of air combustion because of gas heat capacity is increased.

Mechanism of Flame Spread

Air Combustion (Pry O_2=21%)

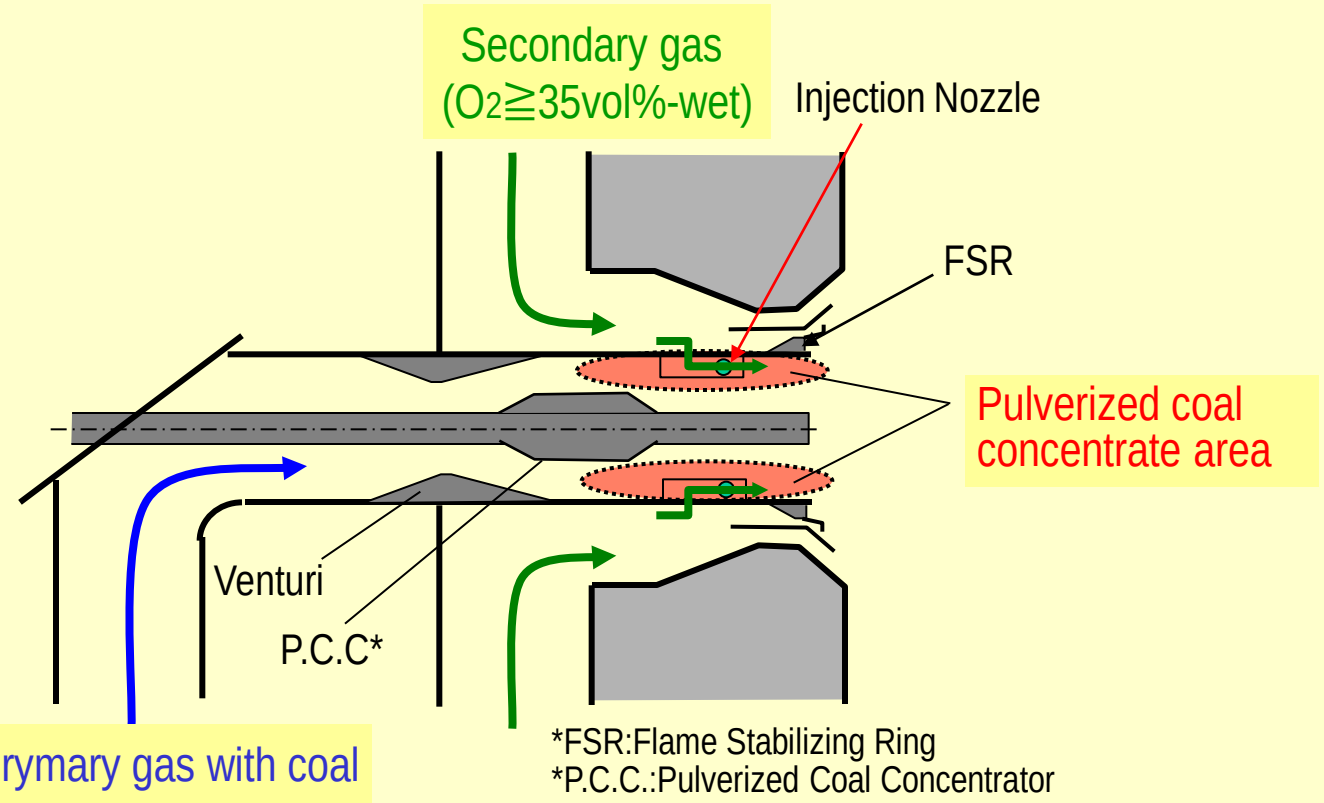
Oxy-Combustion (Pry O_2=21%)

Photographs of burner flame (4MWth test facility)

3.2 Concept of New Burner (NR-LE Burner)

(1) O_2 concentration of primary gas is maintained at 21vol%-wet or less for preventing the pulverized coal explosion at the primary gas line and mills.

(2) To promote the ignition of the pulverized coal, secondary gas of a higher O_2 concentration is supplied to the pulverized coal concentrate area of primary gas line.



NR-LE : NOx reduction and load extension burner
(Pat.EP-P01312859,US-P07213522)

3.3 Results of Numerical Analysis

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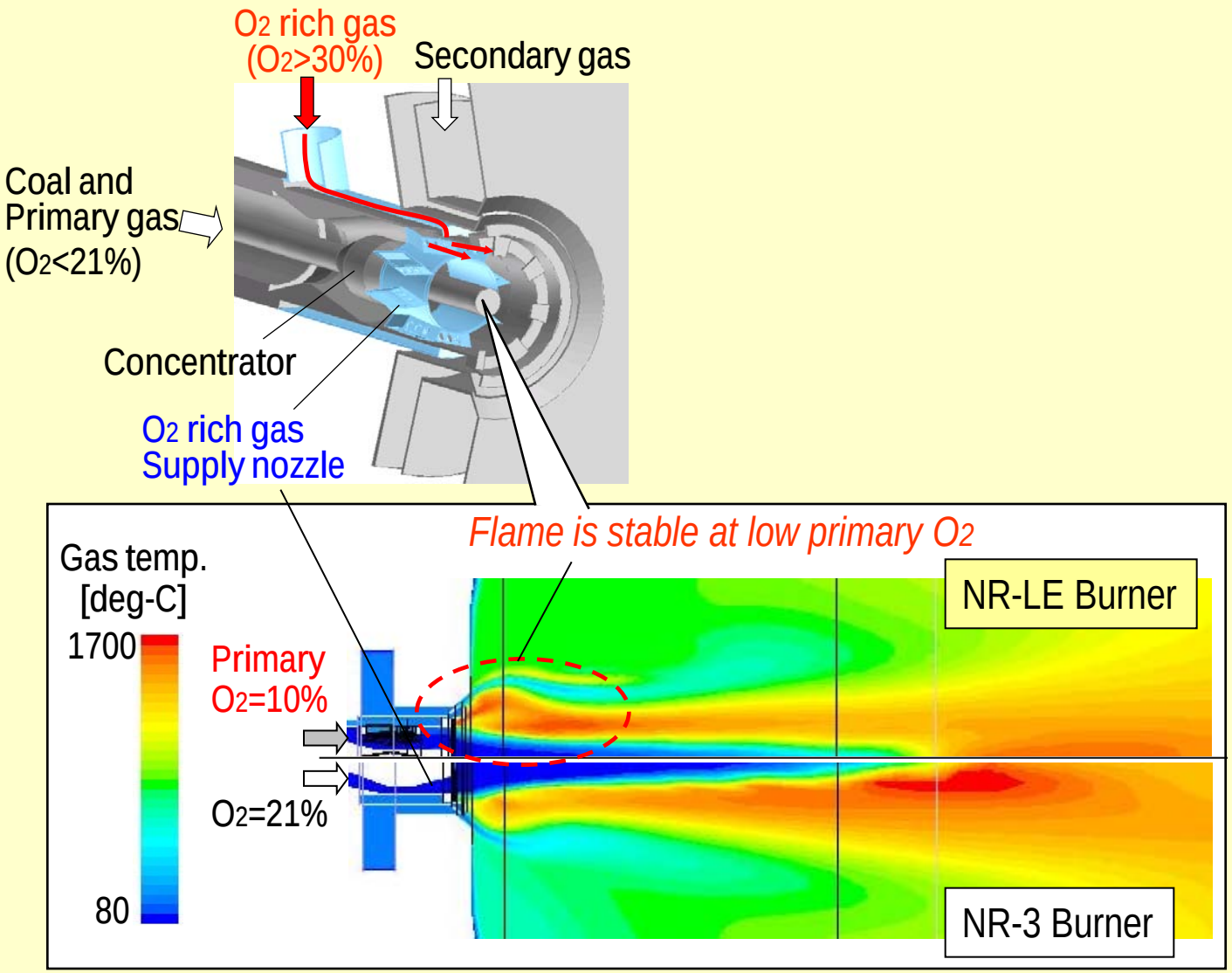
NR-LE burner can realize stable combustion under low Pry O_2 concentration



3.4 4MWth Test Facility (Verification of Flame Stability of Burner)

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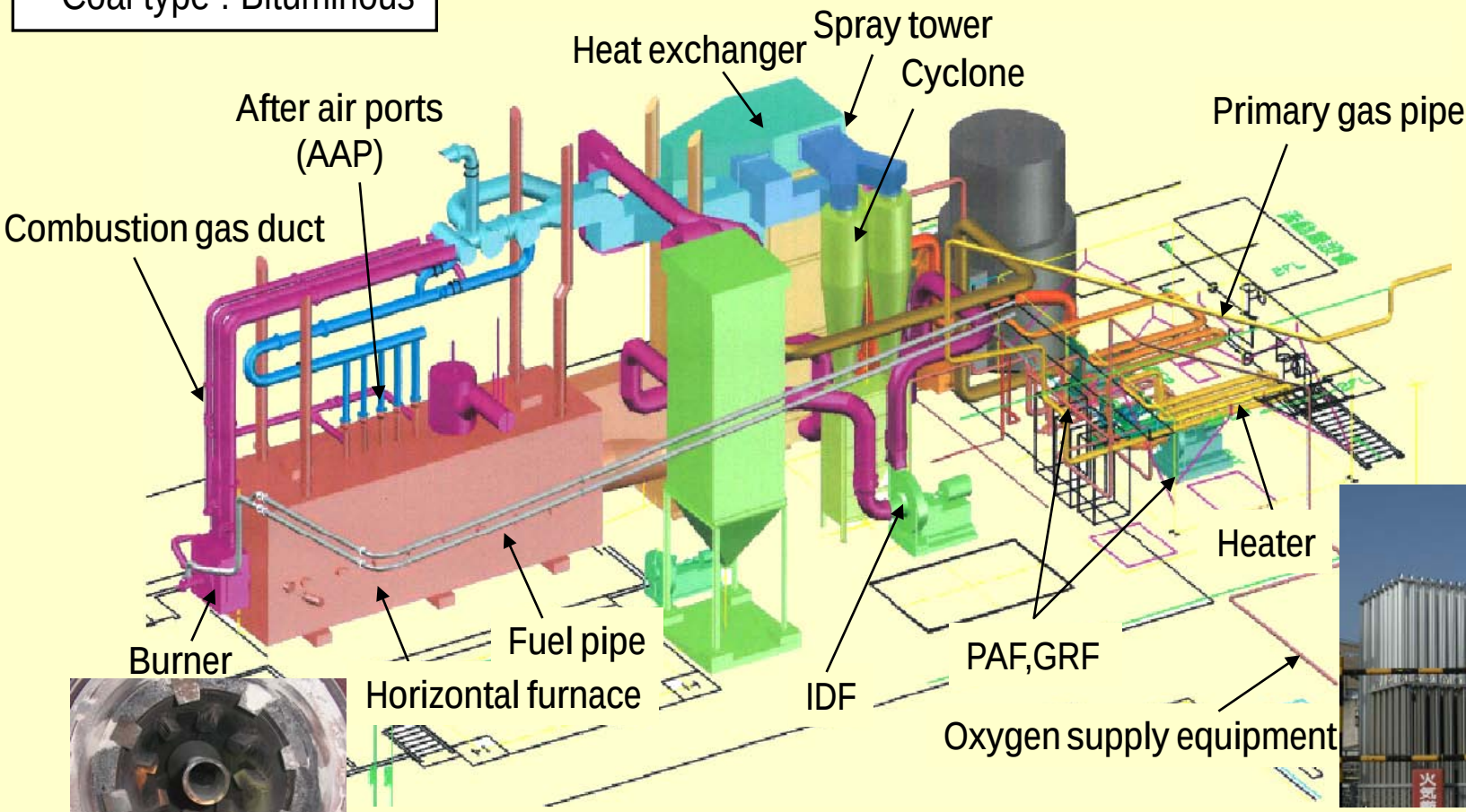
Typical test conditions
- Coal type : Bituminous



3.5 Result of 4MWth Test(1) ; Operation Stability

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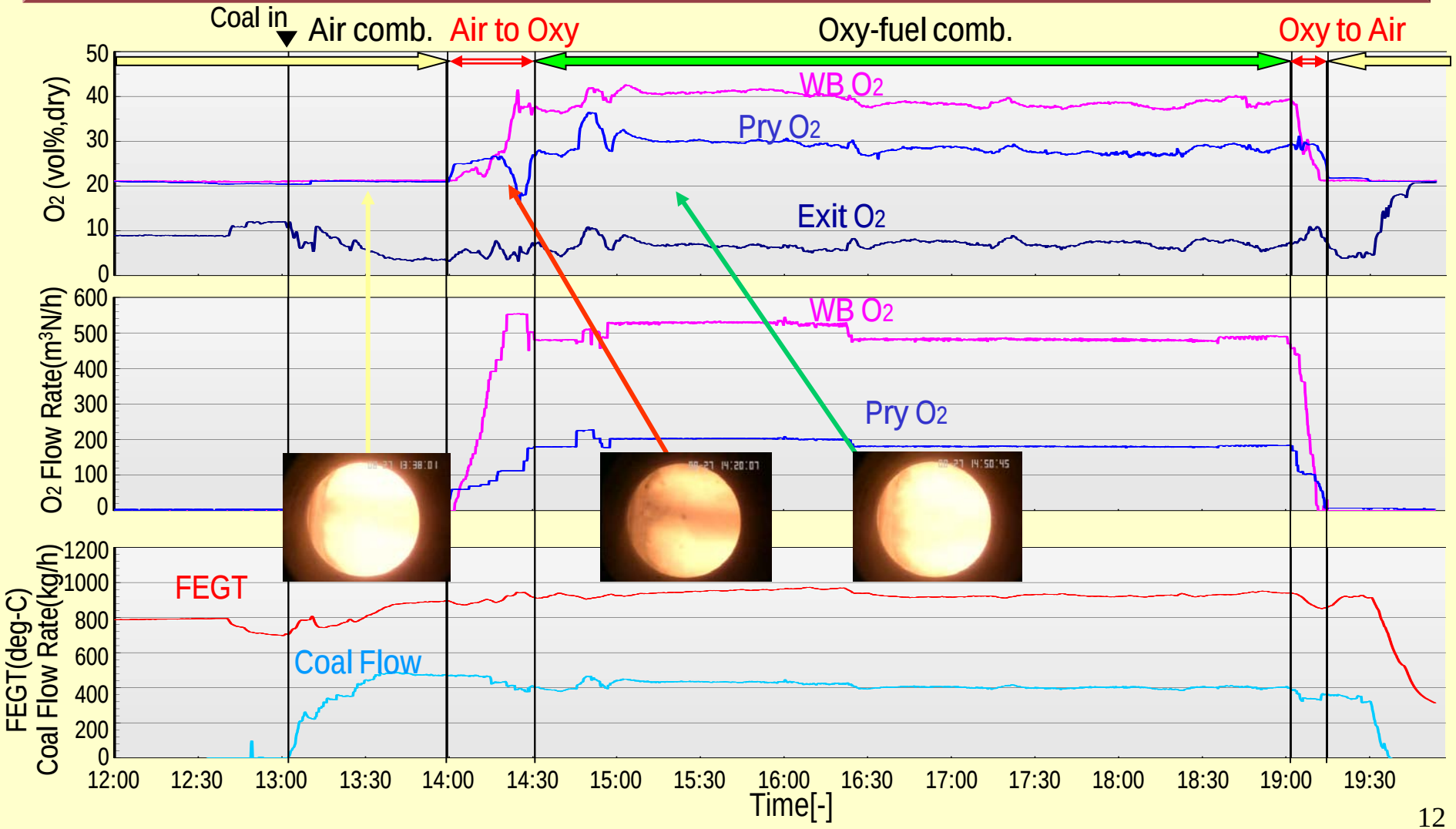
Switching time from air to oxy-fuel combustion ; 30min
Flame was stable during switching from air to oxy-combustion



3.6 Result of 4MWth Test(2) ; Flame Stability

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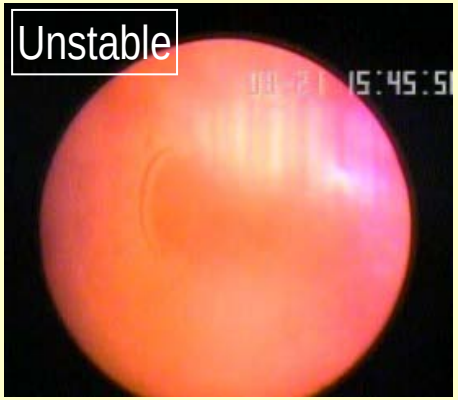
Pry O_2 content can be reduced to 10% for unexpected operating conditions with a new burner (NR-LE)

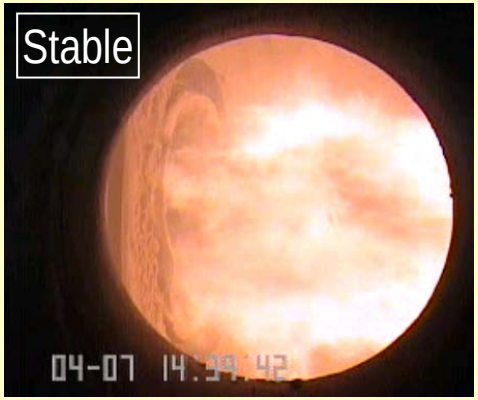
a. Pry O_2=21%(wet)

b. Pry O_2=10%(wet)



b. Pry O_2=5%(wet)

NR-LE Burner



a. Pry O_2=28%(wet)

b. Pry O_2=24%(wet)

c. Pry O_2=21%(wet)

NR-3 burner

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4. Features of Hitachi Oxy-Combustion System

4.1 Subjects of Gas Re-Circulation in Oxy-Combustion

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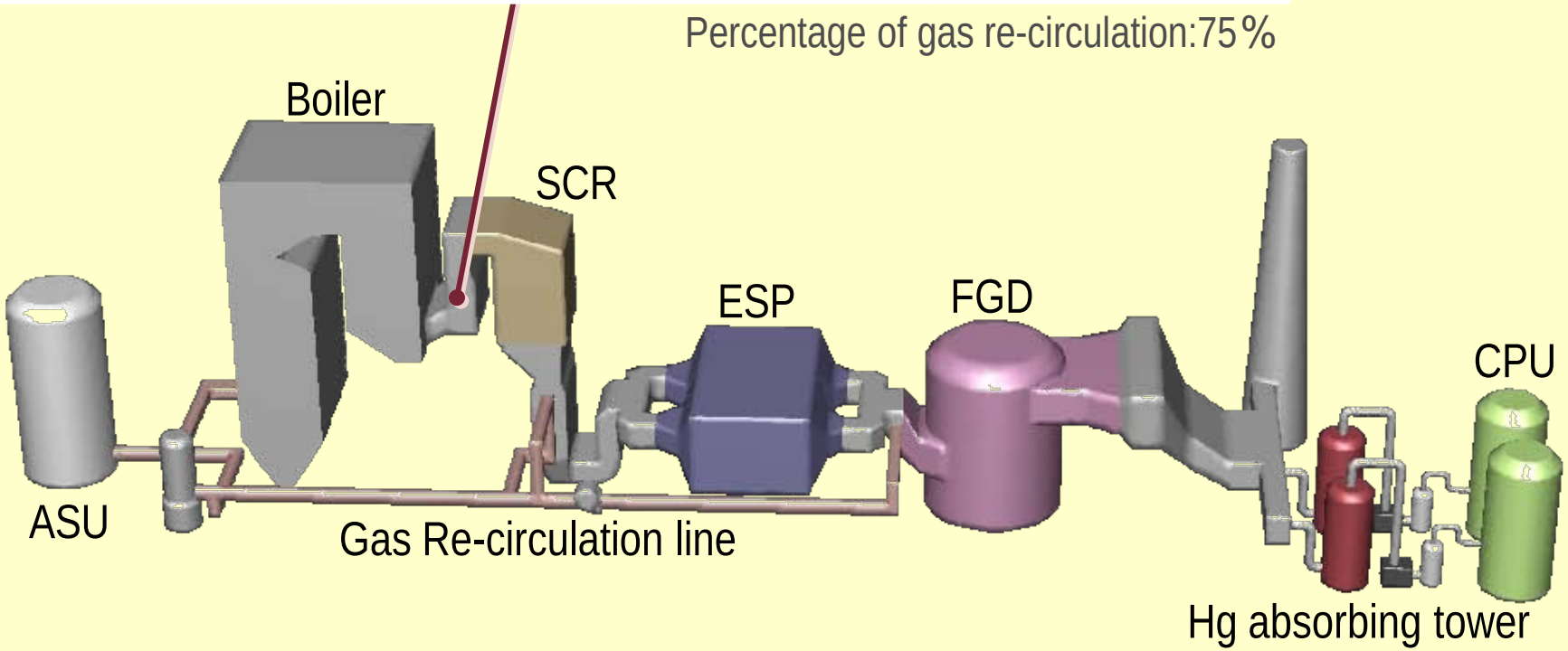
Corrosion potential is increased under condition of Oxy-combustion

Condition	SO_2 [ppm]	SO_3 [ppm]	Hg [μg/m^3N]
Air Combustion	2,000	30	10
Oxy-Combustion	10,000	180	40

Percentage of gas re-circulation:75％



4.2 Mechanism of SO_3 Removal

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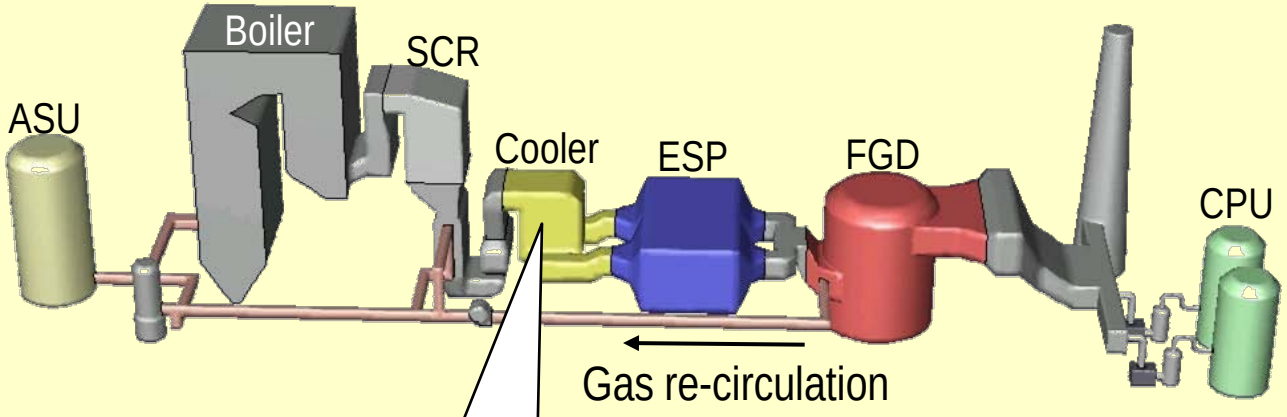
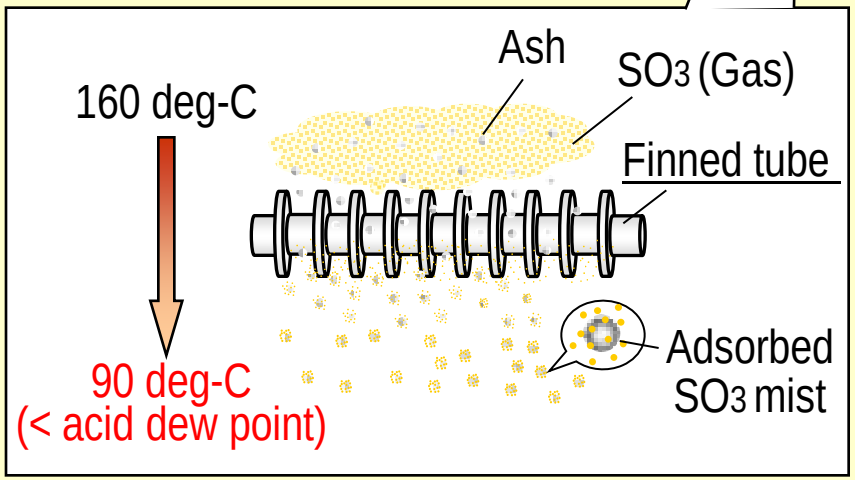
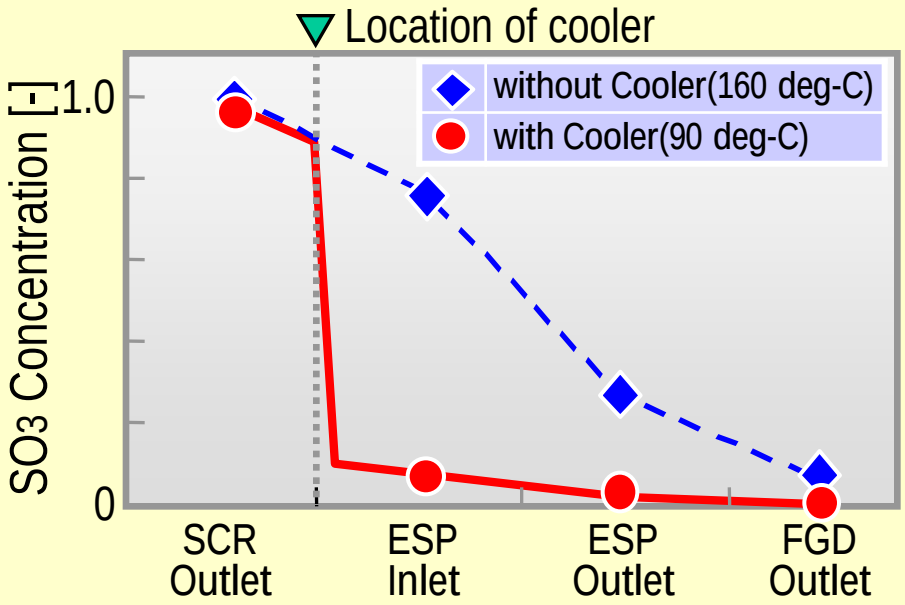
- Below acid dew point, SO_3 in flue gas change to mist
- Mist stick to ash and are neutralized by alkali contained in ash and caught with ESP







4.3 1.5MWth Test Facility (Verification of Flue Gas Treatment)

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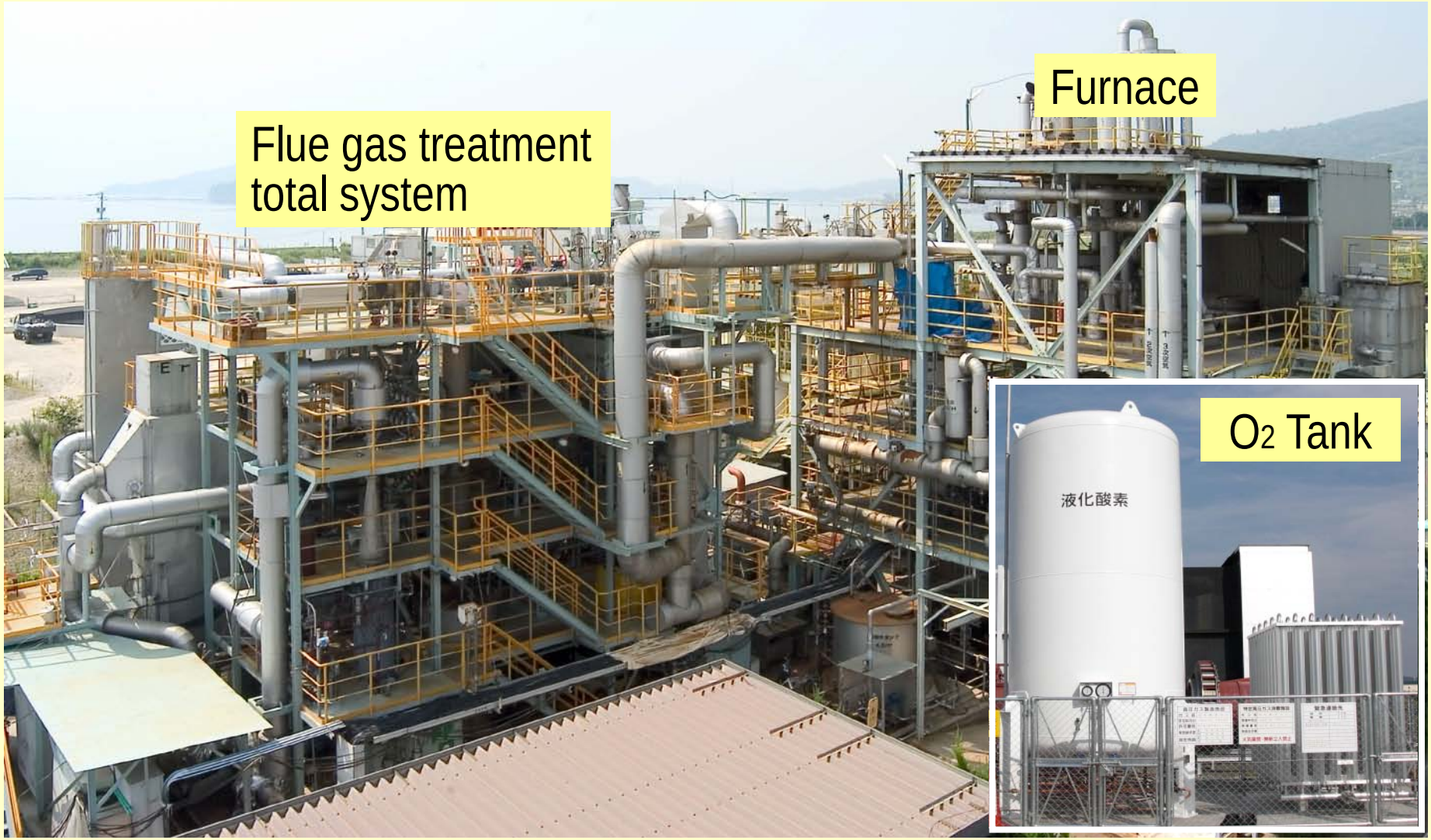

This study was partly carried out under contract with New Energy and Industrial Technology Development Organization(NEDO) of Japan.

4.4 Result of 1.5MWth Test(1) ; SO_3 Removal

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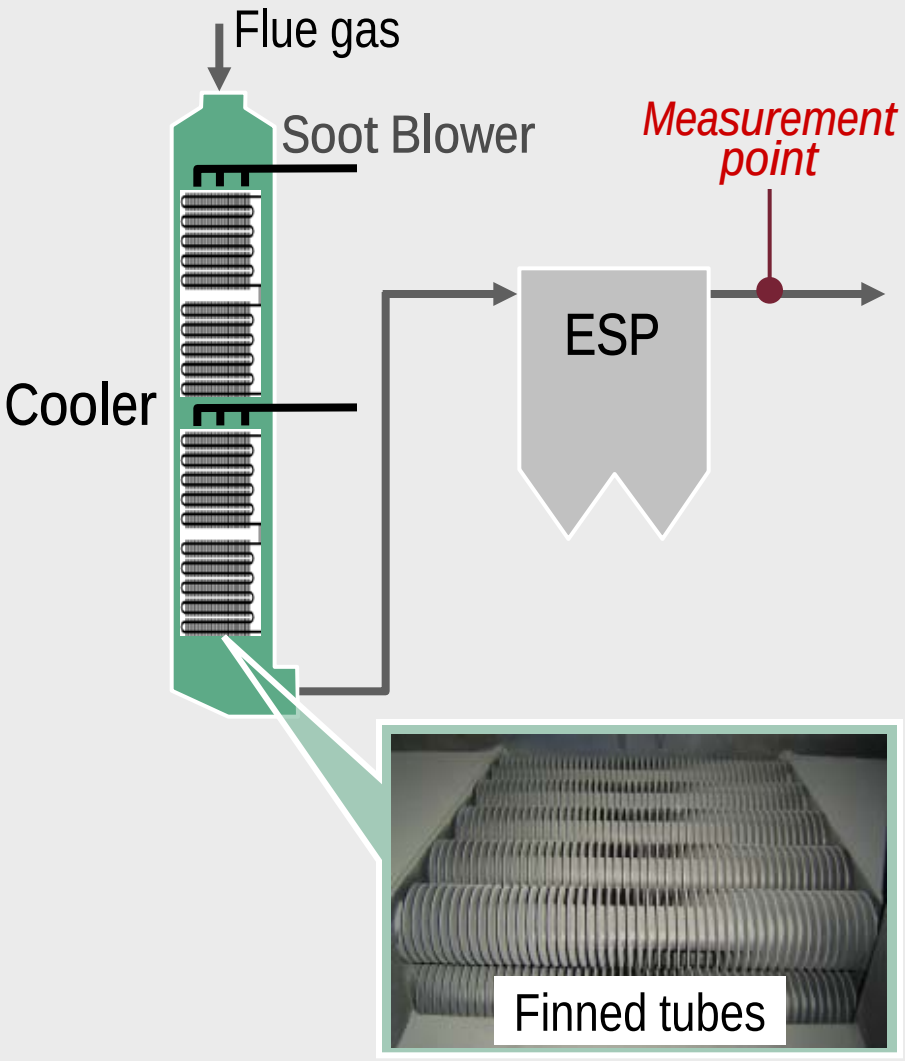
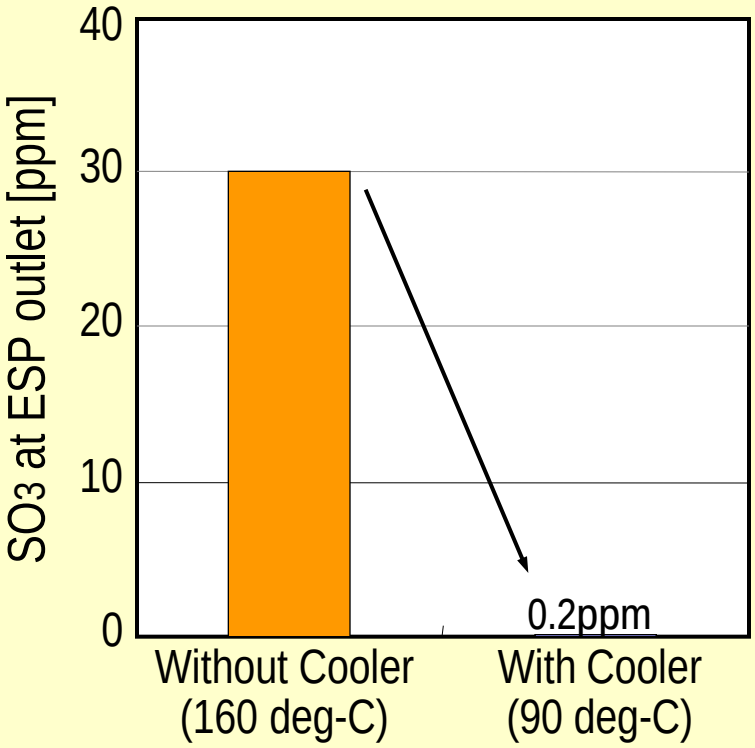
SO_3 can be reduced under 1ppm with 90 deg-C cooler system



Test condition
- Coal : High surfer coal (S=2.7%)
- Moisture content in flue gas :30-40%



4.4 Result of 1.5MWth Test(2) ; Acid Corrosion

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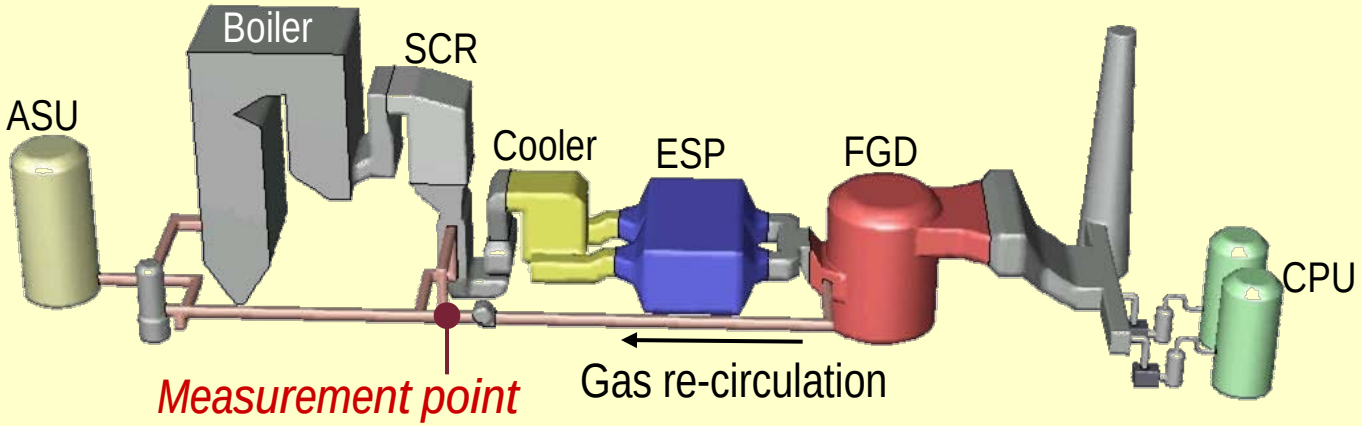
Acid corrosion did not appear at the re-circulation gas duct with 90 deg-C cooler system



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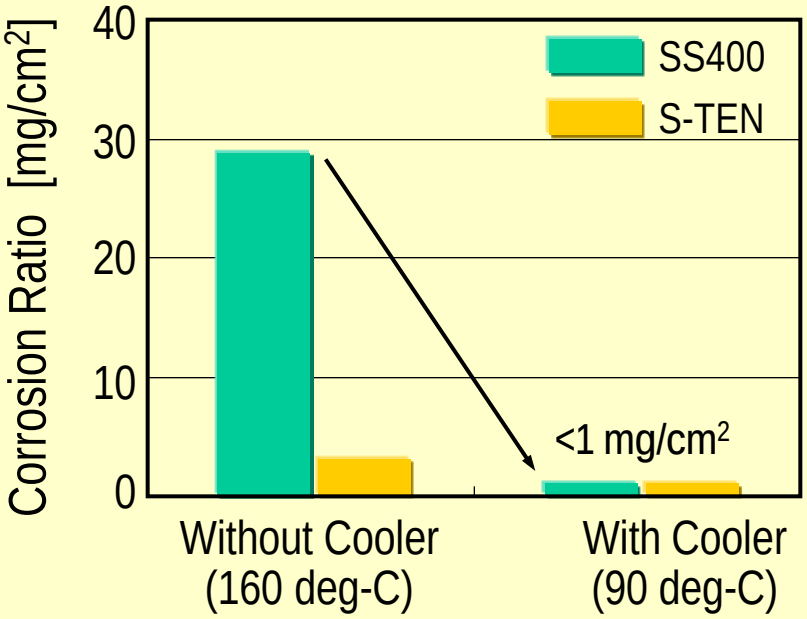

5. Summary

Hitachi has developed a new system for oxy-combustion.
Features of this system include:

(1) Mill performance at air combustion can be maintained at oxy-fuel combustion

(2) Stable combustion under low O_2 content of primary gas with NR-LE Burner

(3) SO_3 removal by decreasing flue gas temperature at the ESP inlet with the cooler system.

Future Work

- Large scale demonstration (Burner and Total system)

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