Co-firing with a high-ratio of wood biomass to make the most existing coal-fired power plant

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Introduction

Reduction of CO_2 emissions is essential regarding coal-fired power plants. IHI has developed the technology, a co-firing system for coal and a high-ratio of carbon-neutral wood biomass”(up to 50% in calorific value) to significantly cut CO_2 emissions from the pulverized coal fired power plant.

Conventional pulverizer for coal can handle only up to 2-3% wood biomass. To solve this problem, a coal pulverizer was modified for handling wood. The some test clarified that modified conventional pulverizer works well for biomass of pellet type.

In addition, several tests were conducted, combustion test, CFD analysis, tests regarding ash adhesion behavior and corrosion rate, and study of influence for flue gas treatment system.

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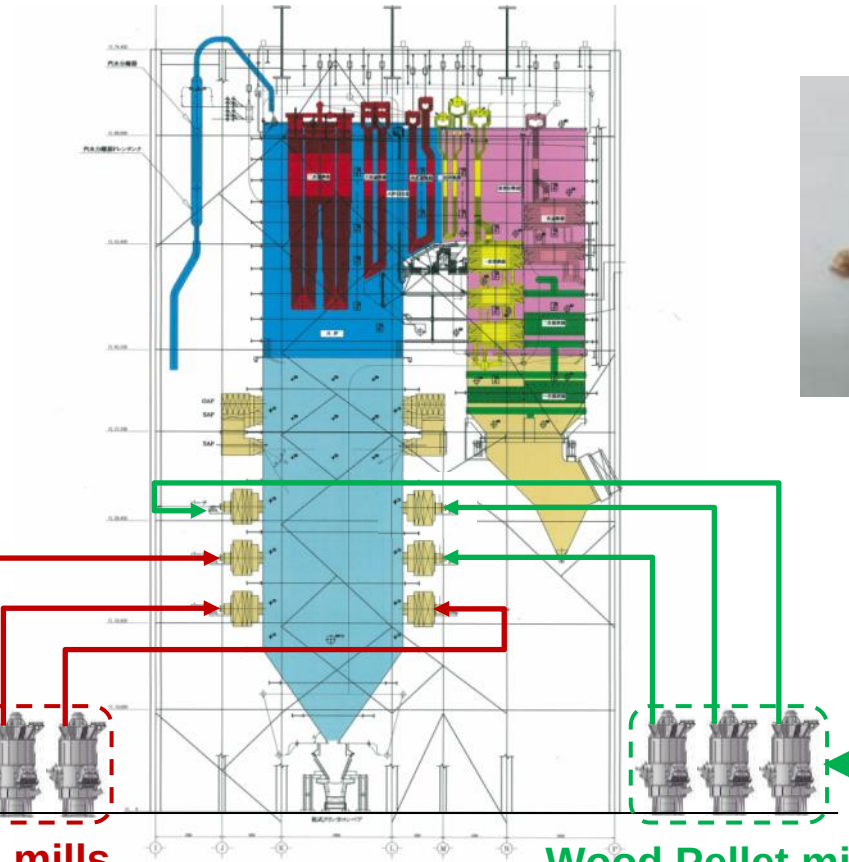
Table of Contents

1. Concept for co-firing system

Our concept is very simple, to realize co-firing with a high-ratio of wood biomass by retrofitting the coal pulverizers (mills) to the wood pellet ones.

Co-firing system of wood pellets 50% with coal 50%

Coal



Wood pellets

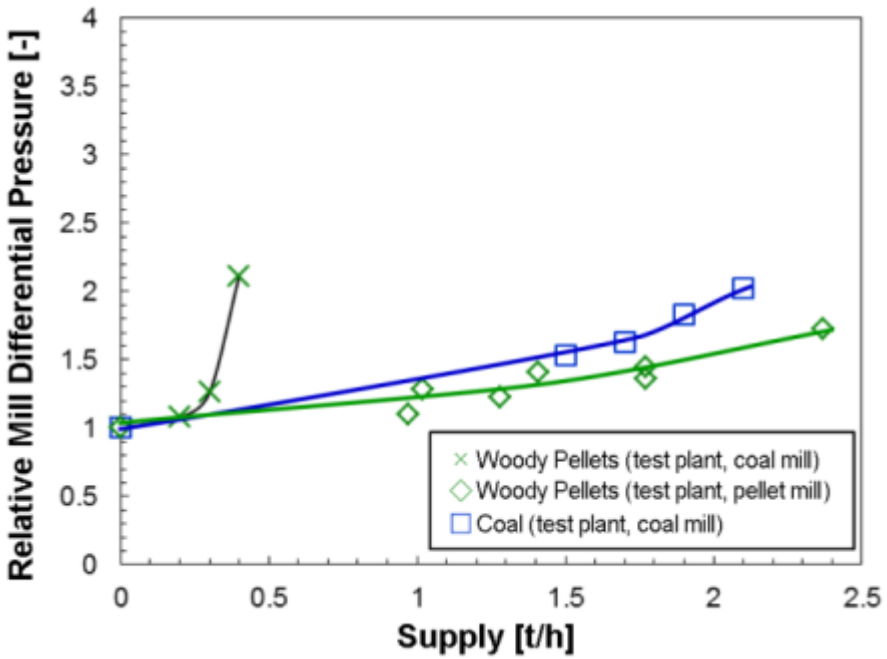
Coal mills

Wood Pellet mills

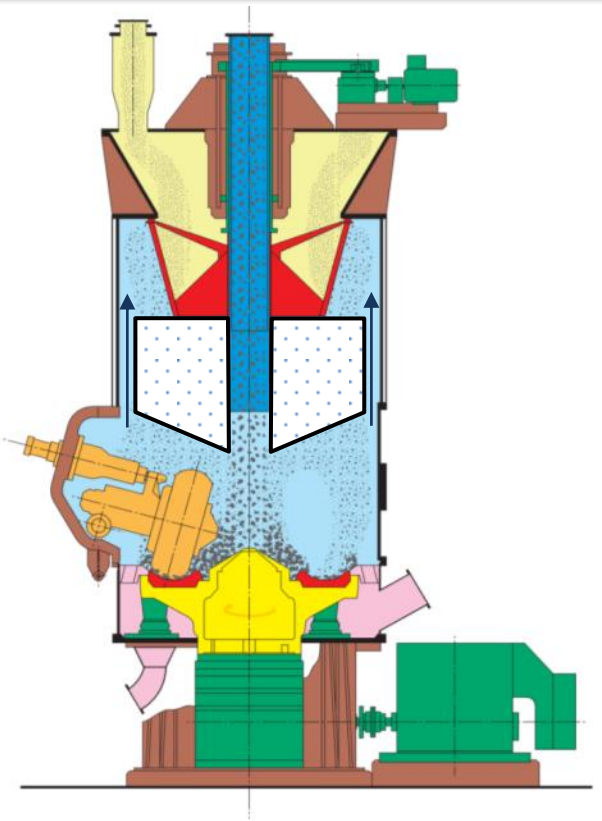
2. Research results to realize co-firing rate 50%
(1) Performance of pellet mill

Wood pellets for combustion do not need to be as fine as coal. Pulverized wood pellet was promoted to be exhausted by increasing flow velocity inside mill equipped "flow acceleration ring".

Processing capability (Test plant)



Pellet mill retrofitted from coal mill

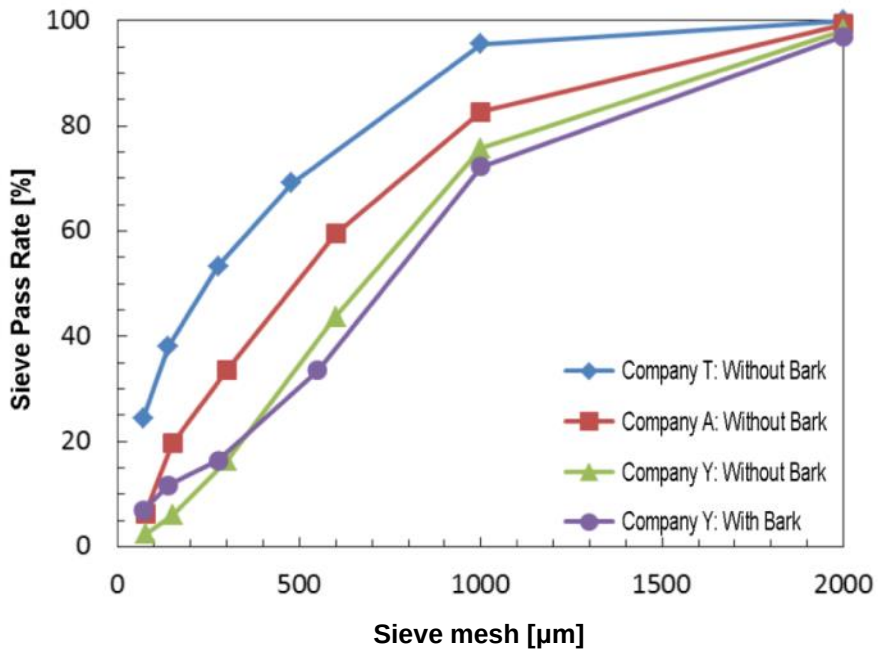


2. Research results to realize co-firing rate 50%
(2) Performance of burner

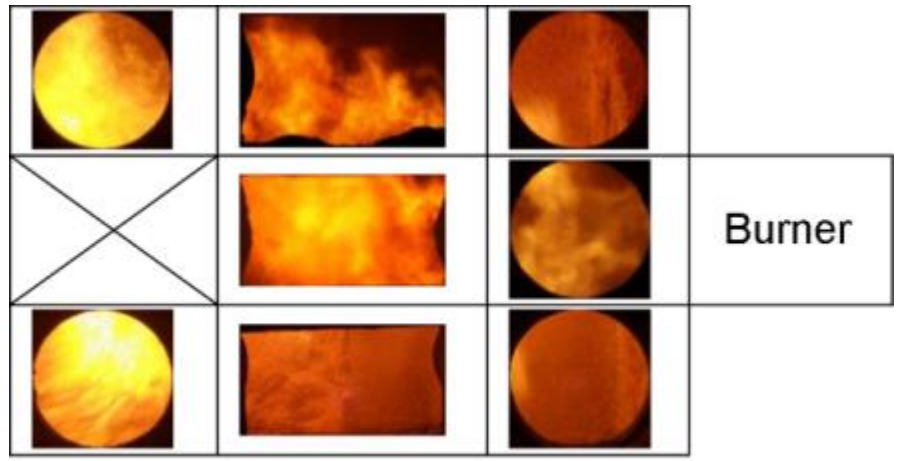
Fineness of pulverized wood pellet depends on the type of wood pellets.

Even if fineness is approx. 70% of 1mm sieve pass rate, it can be burn at a single coal burner which thermal input was approx. 2,000kg/h-coal.

Fineness (Test plant)



Burner Flames (Test plant)



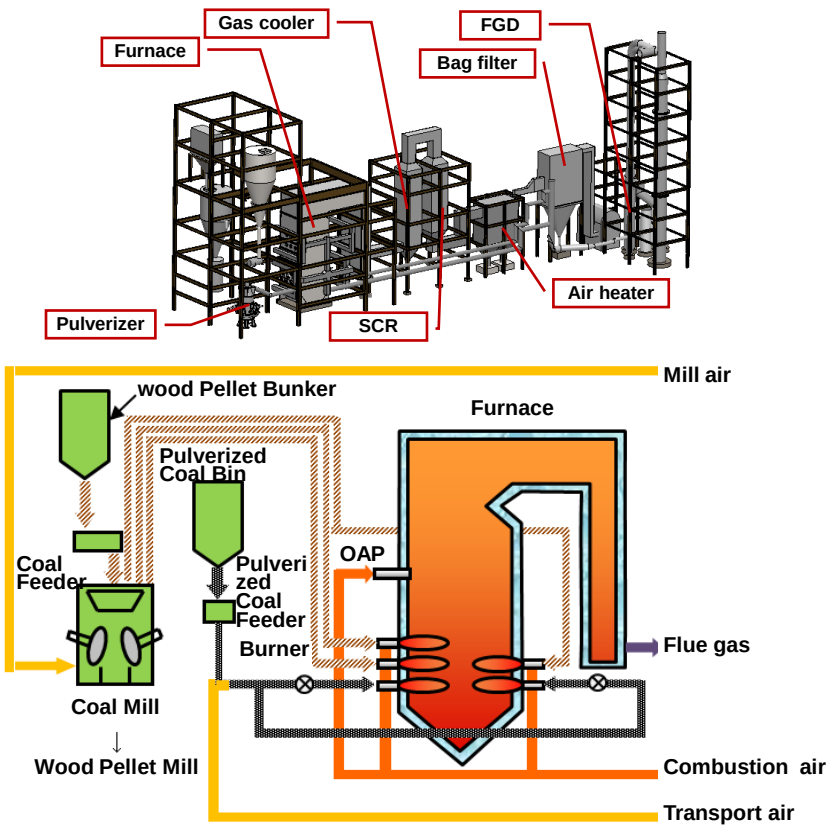
*Burner Flames of pulverized wood pellet made by company Y(with bark)

2. Research results to realize co-firing rate 50%
(3) Flue gas characteristics

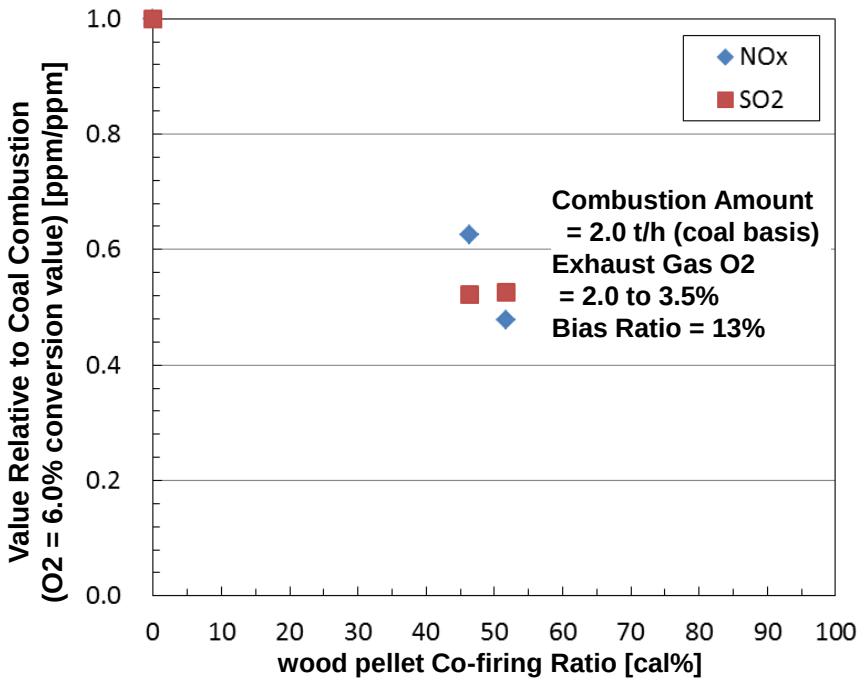
The test of co-firing rate 50% was conducted in a coal combustion test facility having with multi-burners and its thermal input was approx. 2,000kg/h-coal.

The co-firing with wood pellet lowers the resultant concentrations of SO2, NOx.

Coal combustion test facility (CCTF)

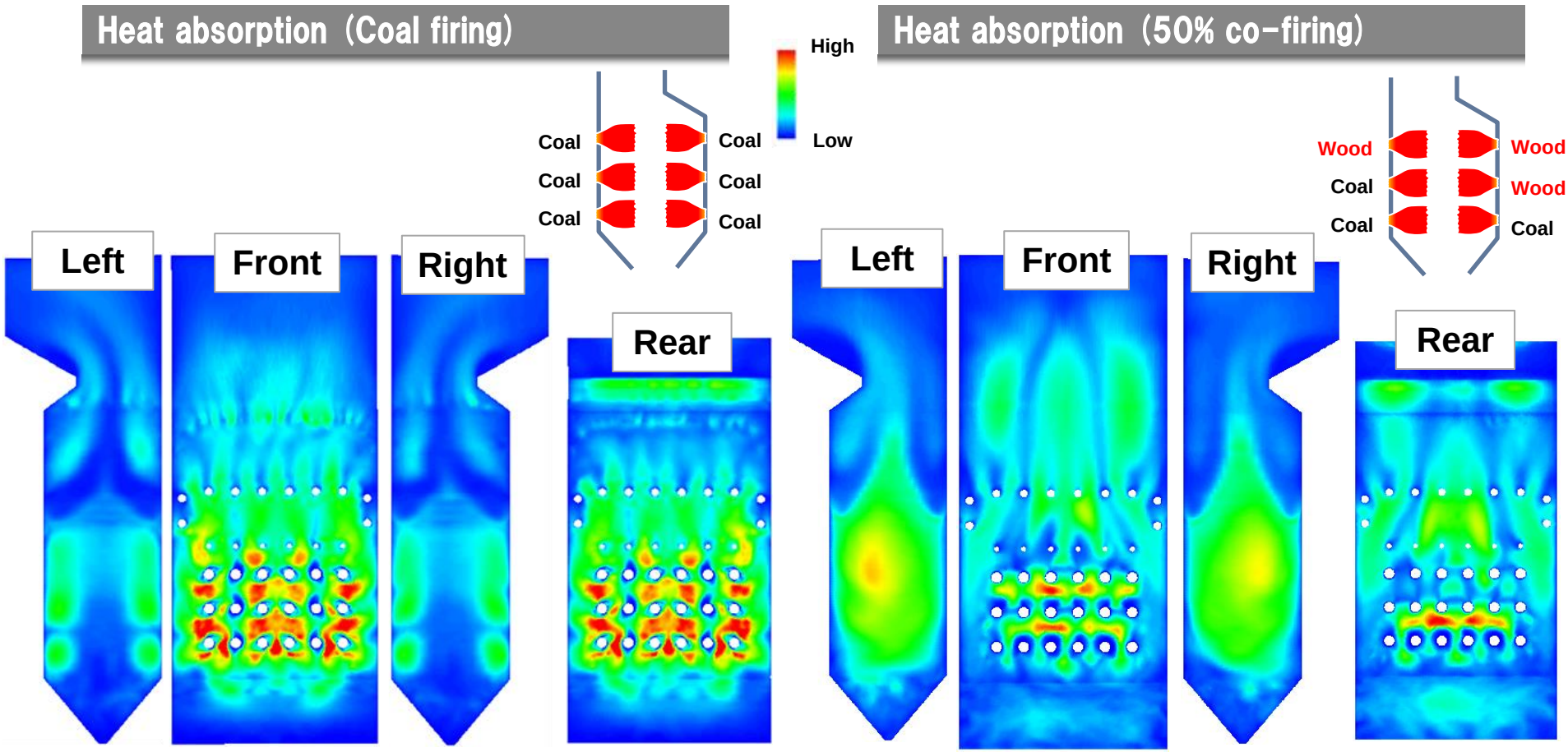


Flue gas characteristics (CCTF)



2. Research results to realize co-firing rate 50%
(4) Heat Absorption

There are some differences in heat absorption distribution between coal firing and 50% co-firing, but It is within the normal range of variation.



2. Research results to realize co-firing rate 50%
(5) Ash adhesion

A probe was inserted into the furnace. We found that the adhesion rate of ash during co-firing is almost same, and but the it's amount of ash was reduced comparing with the coal firing's.

Ash adhesion test at 1300 degree C

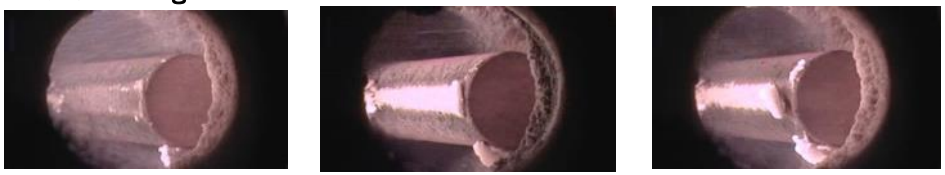
Coal

0min (after ash fall down) 30min 60min(before ash fall down)

30% co-firing

0min (after ash fall down) 20min 35min(before ash fall down)

60% co-firing



0min (after ash fall down) 30min 66min(before ash fall down)

Image of experimental apparatus

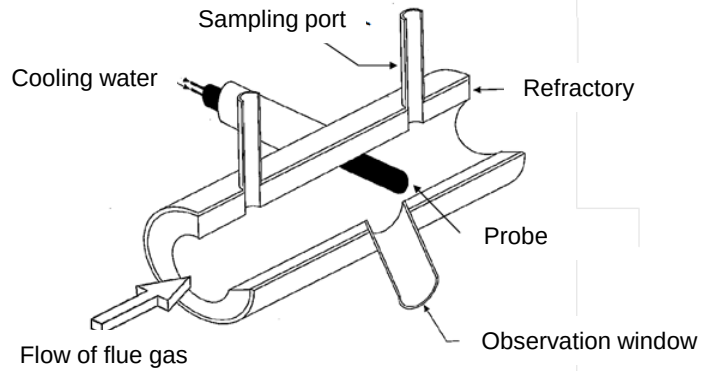


Photo of experimental apparatus

2. Research results to realize co-firing rate 50%

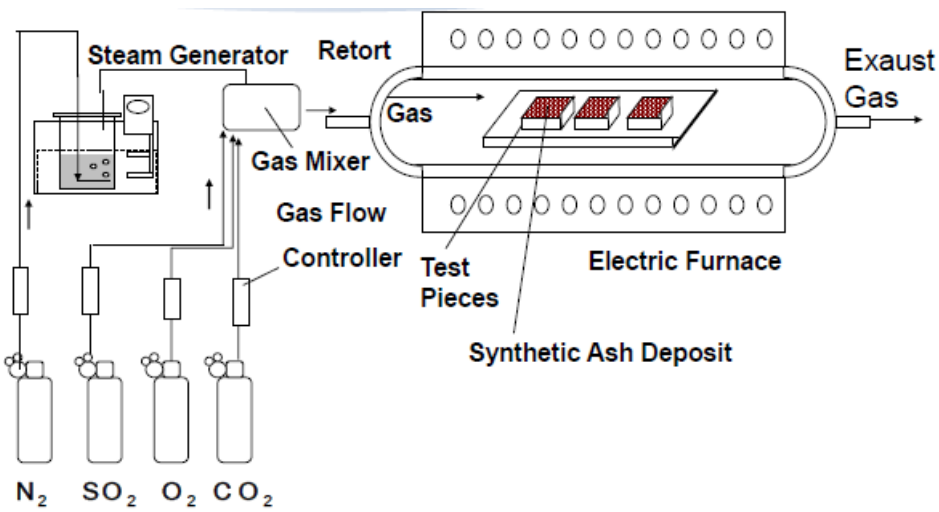
(6) Corrosion characteristics

The corrosion characteristics on boiler heat-transfer tubes under the wood pellets co-firing was evaluated. The amount of corrosion was increased at co-firing rate 100% in the superheater or reheater environment as below.

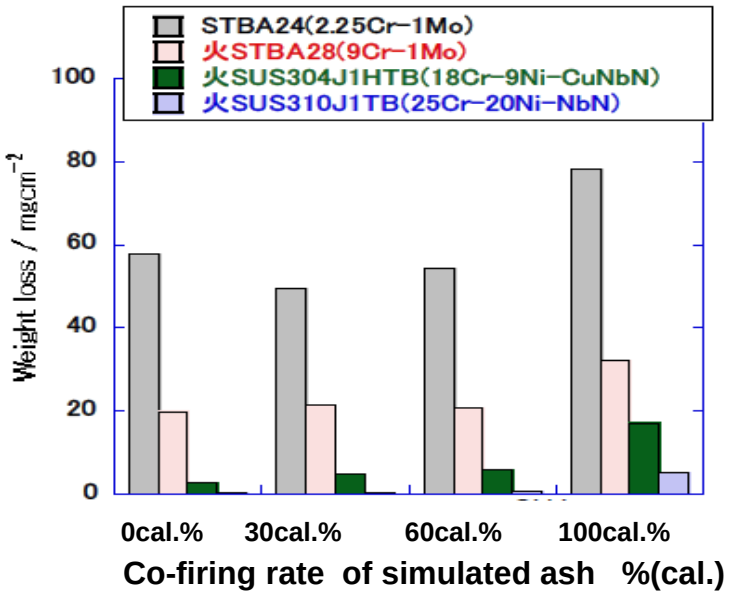
Test procedure

- **Simulated adhesion ash composition was determined from ash adhesion test**
- **Metal sample was suitably hold in a simulated combustion gas atmosphere**
- **Corrosion was evaluated from the weight loss of metal before and after the test**

Image of experimental apparatus



650 ℃, 500 hour (Superheter/Reheater)



2. Research results to realize co-firing rate 50%
(7) Influence on selective catalytic reduction

The deposited ash made ca. 20%-deterioration in the NOx removal efficiency compared with the fresh condition's because of some components in wood biomass. Therefore, it is absolutely necessary to consider/design the amount of catalyst in advance.

Selective catalytic reduction

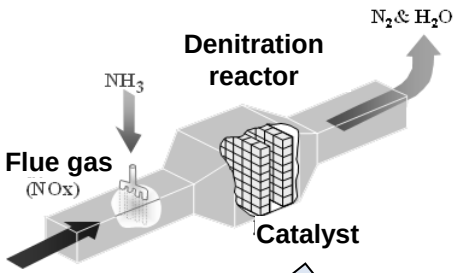
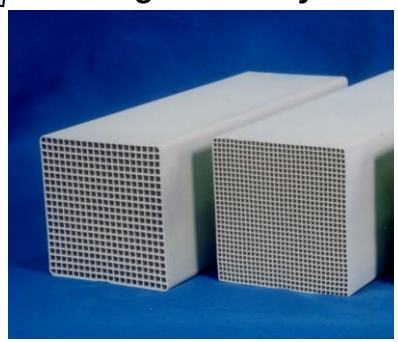
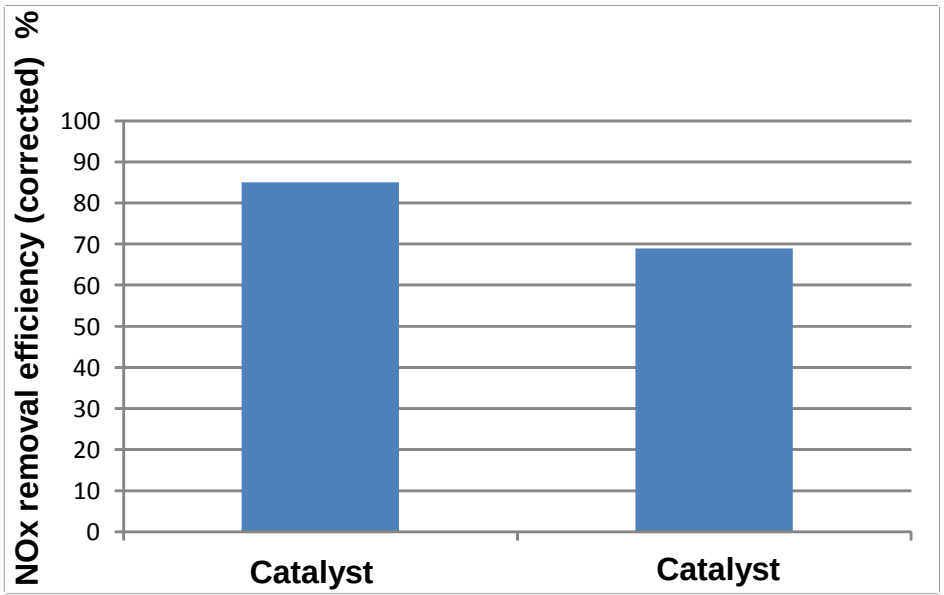


Image of Catalyst



NOx removal efficiency (Laboratory test)



+ wood biomass combustion ash

2. Research results to realize co-firing rate 50%
(8) Influence on wet desulfurization equipment

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Cl and F in the exhaust gas reduces the PH of the absorbing liquid, and lowers the desulfurization performance and corrodes the metal material of the equipment. Cl and F in some wood biomass are higher than that of coal.

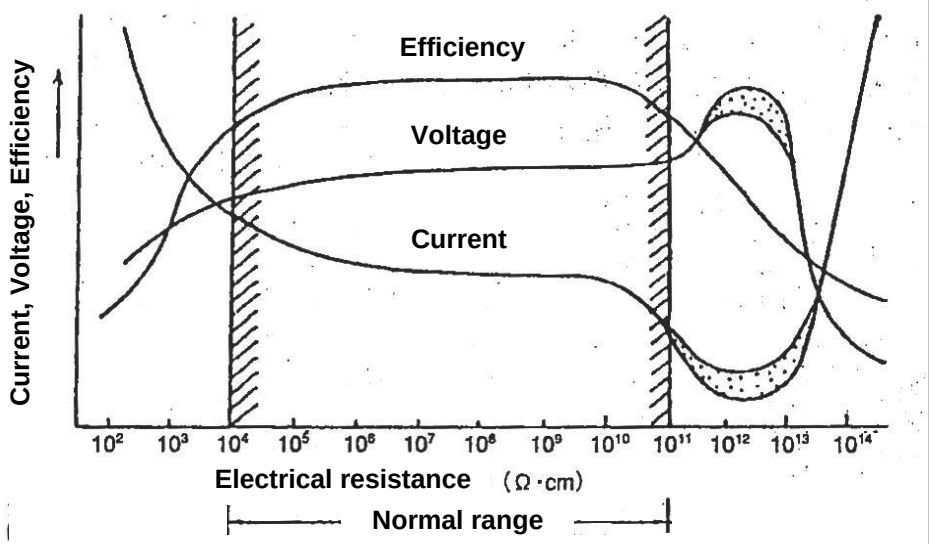
The content of chlorine and fluorine

Items	unit	Analysis value		Quote value from literature	
		wood powder	Coal	wood biomass	Coal for domestic
		Japan	Australia	Pine, cedar, bamboo, cypress, Broadleaf tree	Australia:4, US:5 China:3 South Africa:3, Japan:2
Cl	ppm	50	220	670(3400-160)	213 (610-30)
F	ppm	<50	-	-	104 (180-58)
Source		IHI	IHI	New Energy and Industrial Technology Development Organization	Central Research Institute of Electric Power Industry

2. Research results to realize co-firing rate 50%
(9) Influence on electrostatic precipitator

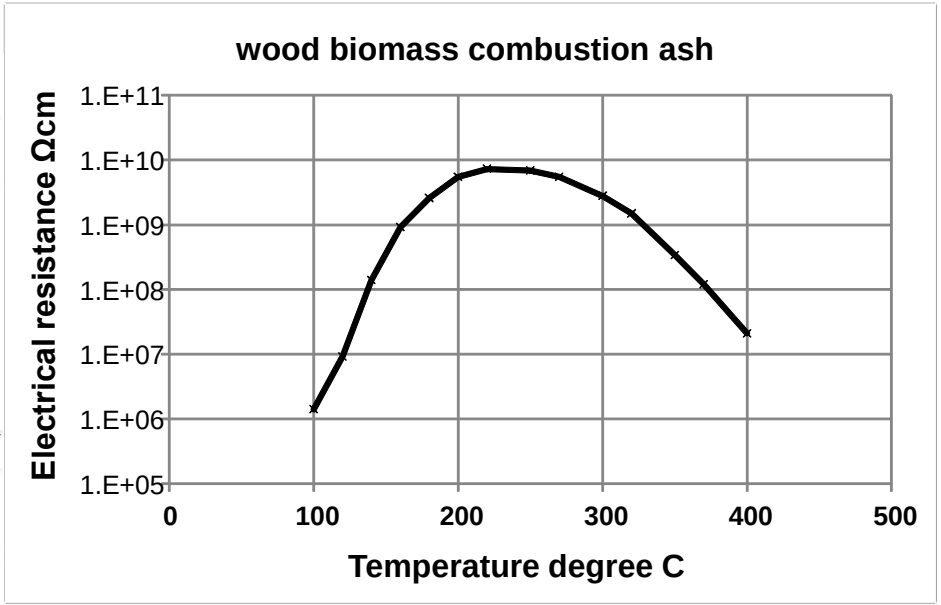
It is well known that the performance of Electrostatic precipitator is affected by the electrical resistance of the ash. Electrical resistance of wood biomass combustion ash from the test furnace is within the range of stable operation.

Dust collecting performance



Source: Thermal and Nuclear Power Engineering Society

Electrical resistance of ash from test plant



3. Application of co-firing with a high-ratio of wood biomass

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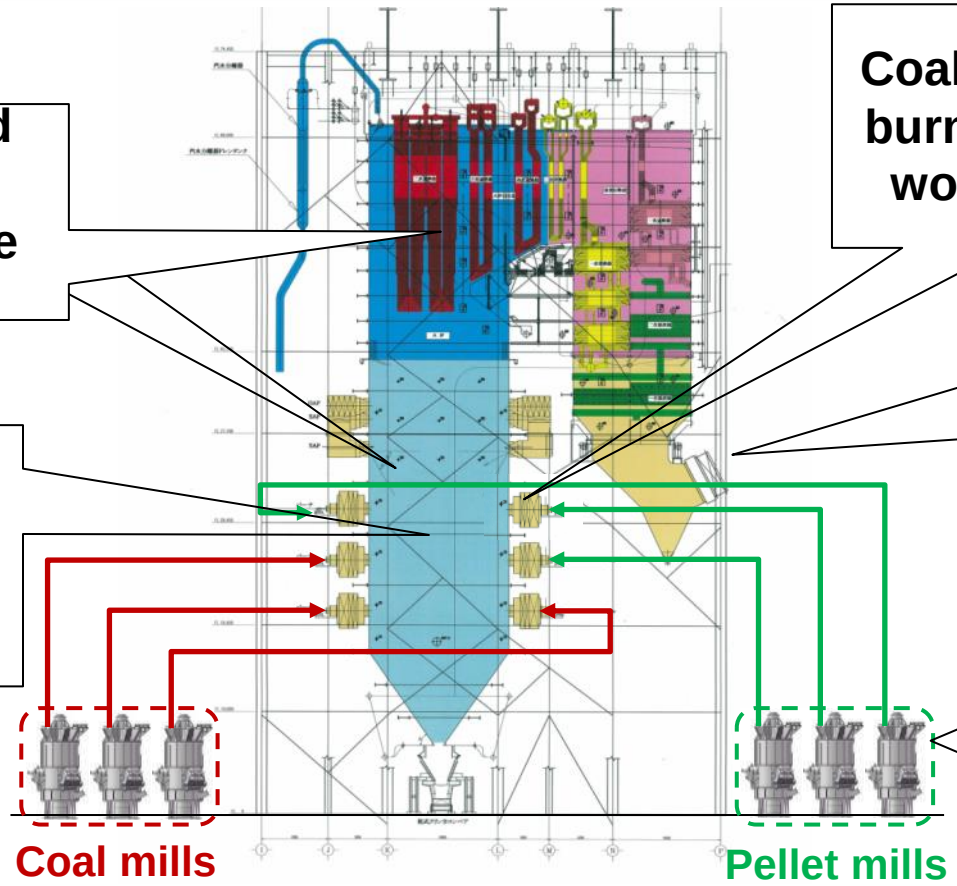
IHI firmly believes that we can realize the 50% co-firing according to the above mentioned test and research program.

Co-firing system of woody pellets 50% with coal 50%



Ash adhesion and corrosion characteristics are almost same.

Coal burner can burn pulverized woody pellet.

There is a little impact for flue gas treatment.

Heat absorption is enough to fit in the normal range of variation.

Pellet mill has a same capacity as coal mill.

Summary

IHI has a prospect of the technology for the co-firing with a high-ratio of wood biomass. We would like to thank Ministry of the Environment, Government of Japan who supported us through this research program, to all who helped us.

A new pulverized coal fired power plant (110MW) applying co-firing with a high-ratio of wood pellet just started operation in September 2017. One more new power plant (149MW) is under construction (It will start operation in 2018).

IHI will contribute to the reduction of CO_2 emissions along with everyone involved in coal fired power.

Terima kasih atas perhatian anda.
Thank you for your attention.

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Realize your dreams

Properties of coal and wood pellets (1/2)

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Wood pellets are intended as biomass in this presentation. Test coal is bituminous coal, example of their properties are described in the table below.

Properties for verification test

Items	unit	Base	Coal	Wood pellet
Higher heating value	J/g	dry	30520	20590
Total moisture	%	As received	10.1	9.1
Proximate analysis	—	—	—	—
Moisture	%	Air dry	2.7	7.2
Ash	%	Air dry	10.4	0.5
Volatile matter:VM	%	Air dry	34.3	77.1
Fixed carbon:FC	%	Air dry	52.6	15.2
Ultimate analysis	—	—	—	—
C	%	dry	73.56	52.41
H	%	dry	4.74	5.98
O	%	dry	9.28	41.1
N	%	dry	1.32	<0.01
Total S	%	dry	0.42	0.01

Properties of coal and wood pellets (2/2)

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Bituminous coal and wood powder were used for the adhesion test.

Properties of coal and wood for adhesion test

Items	unit	base	Coal	Wood
Proximate analysis	—	—	—	—
Moisture	%	Air dry	1.9	5.2
Ash	%	dry	12.7	0.4
Volatile matter:VM	%	dry	30.9	82.2
Fixed carbon:FC	%	dry	56.4	17.4
Ash component				
SiO2	%	Ash	64.2	13.6
Al2O3	%	Ash	21.4	5.5
TiO2	%	Ash	1.13	0.3
Fe2O3	%	Ash	4.45	6.3
CaO	%	Ash	1.02	44.2
MgO	%	Ash	0.88	14.5
Na2O	%	Ash	0.58	1.6
K2O	%	Ash	1.52	8.5

2. Research results to realize co-firing rate 50%
(10) CFD analysis

The characteristic inside of the furnace under 50% co-firing was analyzed using with CFD model. We found that the gas temperature is slightly lower than that of coal firing, and there is much CO derived from wood near the burners .

CFD model

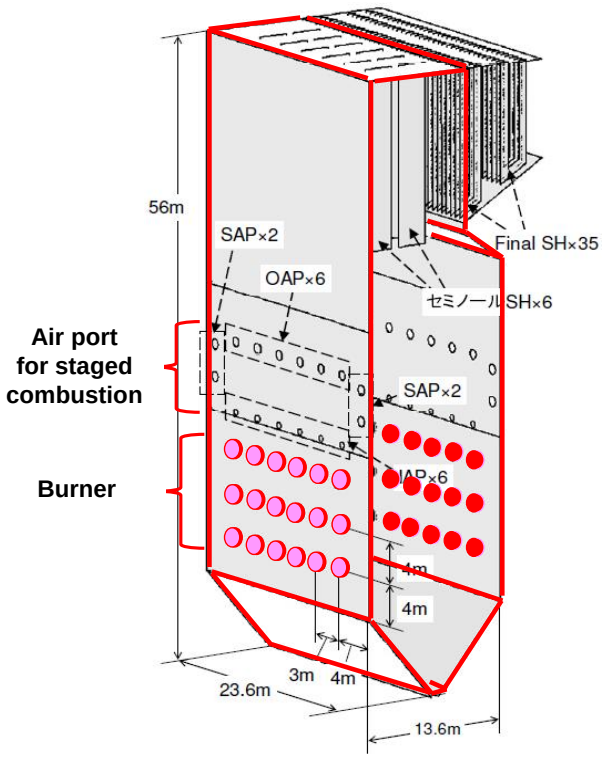

Image in the furnace (Central cross section)