한국남부발전㈜

The eighth international conference on Clean Coal Technologies

Optimization of Coal and Combustion Air Distribution for 500MW T – fired Plant

2017 / 5 / 9

KOREA SOUTHERN POWER,

HADONG THERMAL POWER PLANT

Combustion Technology Center

GOALS OF PRESENTATION

1. INTRODUCTION OF KOSPO
2. BACKGROUND
3. COMBUSTION SIMULATION
4. COMBUSTION TEST
5. DEMONSTRATION TEST
6. ECONOMIC EFFECT
7. CONCLUSTION

KOSPO
KOREA SOUTHERN POWER CO.,LTD.

Introduction of KOSPO

Introduction of KOSPO (Domestic Business)

KOSPO Leaps forward to A Global Top 10 Power Supplier

Total capacity **9,217MW**

Shinincheon CCPP

Capacity : 1,800MW
Start-up : '97.7
Fuel : LNG

Yeongwol CCPP

Capacity : 848MW
Start-up : '10.10
Fuel : LNG

Hadong TPP

Capacity : 4,000MW
Start-up : '09.5
Fuel : Coal

Samcheok CFB

Capacity : 2,044MW
Under Construction
Fuel : Coal

Andong CCPP

Capacity : 417MW
Start-up : '14.7
Fuel : LNG

Busan CCPP

Capacity : 1,800MW
Start-up : '04.3
Fuel : LNG

Hanrim CCPP

Capacity : 105MW
Start-up : '97.7
Fuel : Boil-off gas

Namjeju TPP

Capacity : 200MW
Start-up : '07.3
Fuel : Bio-Heavy Oil

Seongsan, Hankyung Wind Power

Capacity : 41MW

Introduction of Hadong TPP

INTRODUCTION

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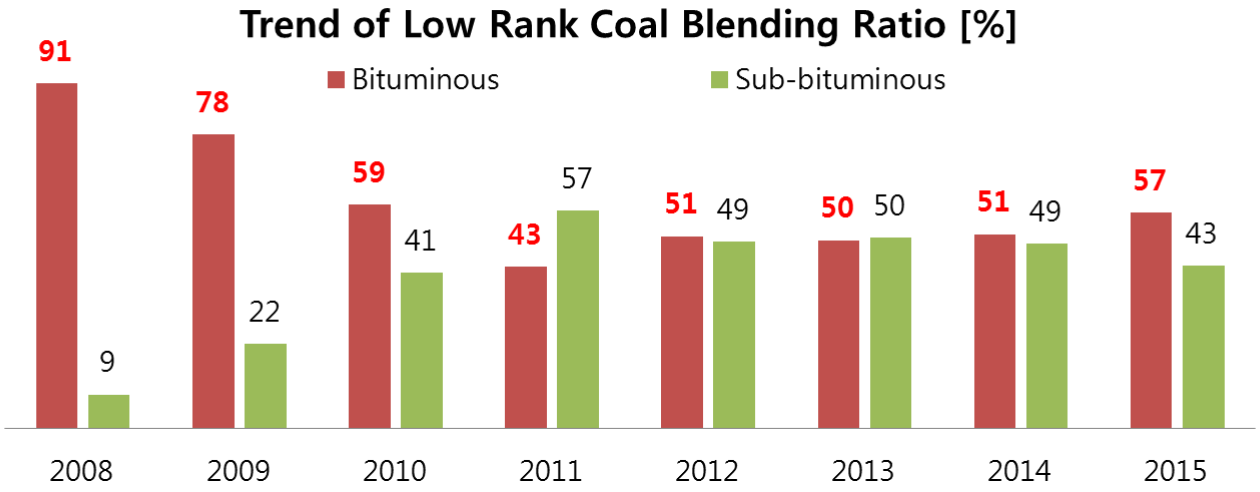
Background

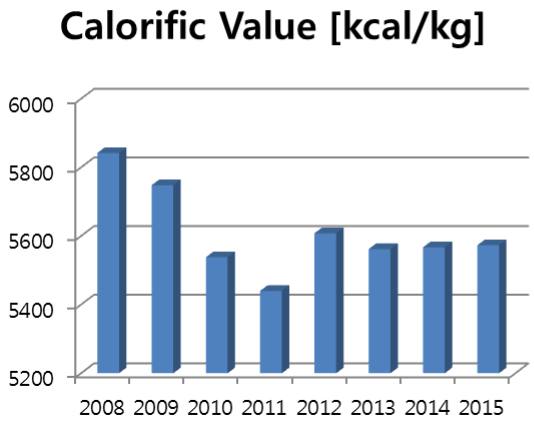
Fuel Change to Low Grade Coal and Diversity

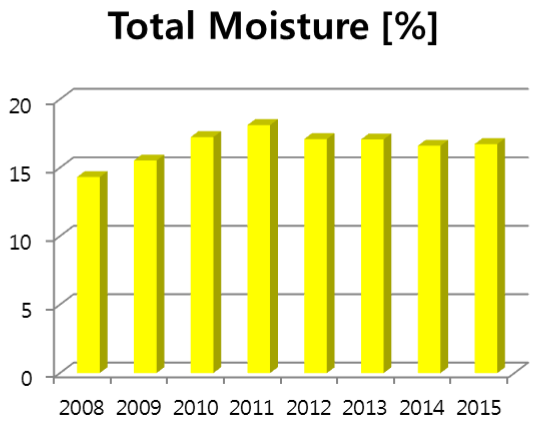
Increase imbalance of supply & demand in coal market and instability of coal price

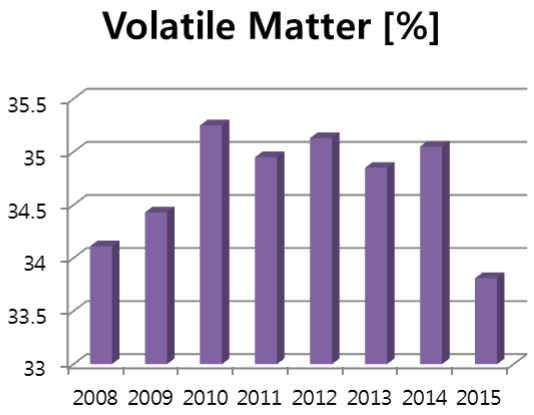
Type of coal is diversified to increase supply & demand of stability in coal

To reduce the cost of fuel





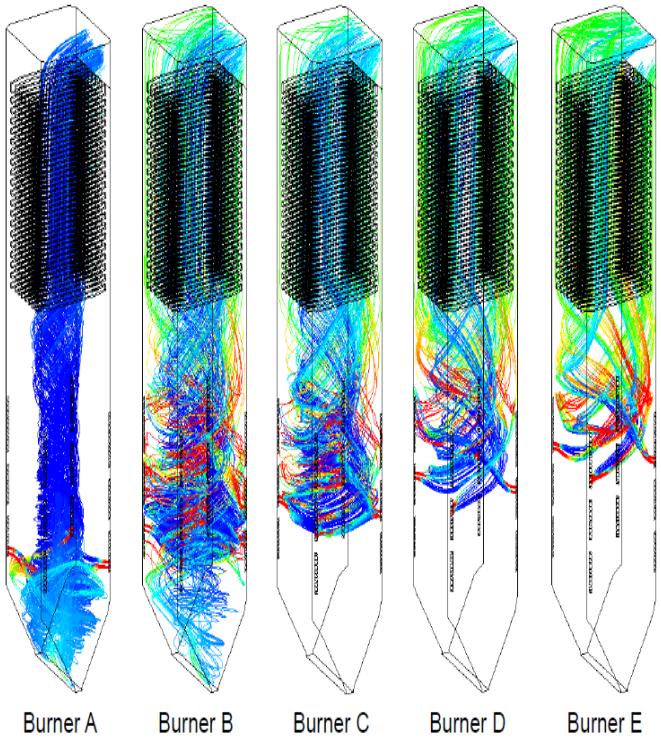




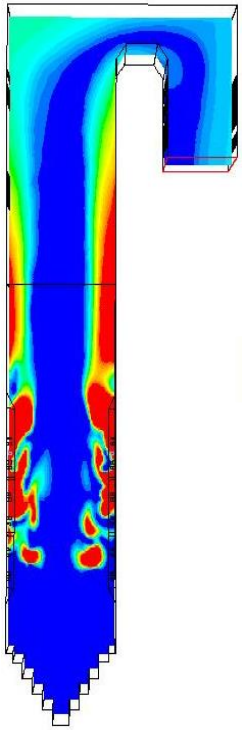
Introduction

- **Objectives** : Optimal distribution of oxygen and coal particle
  - Increase the efficiency of combustion
  - Increase the plant efficiency and Reduce CO2 emissions

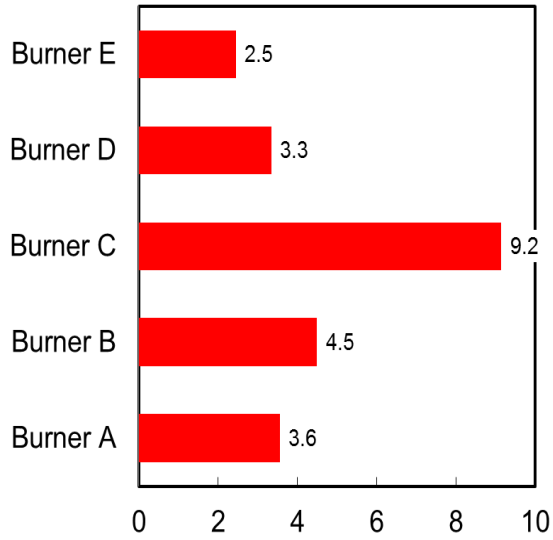
Pulverized coal particle



Oxygen distribution



Unburned Carbon [%]

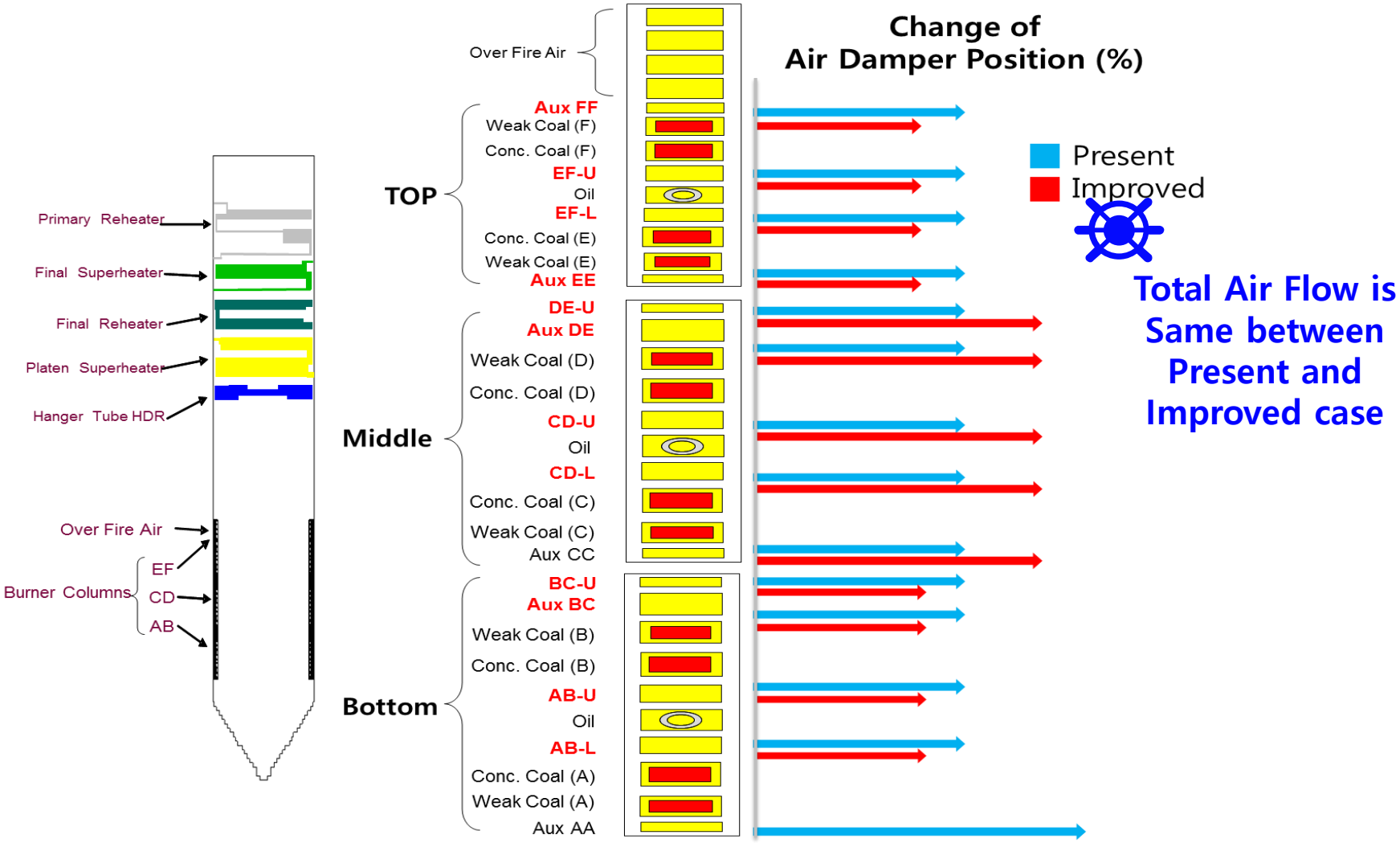


UBC is Different But, Air Flow each Burnrer is Same

Introduction

IDEA

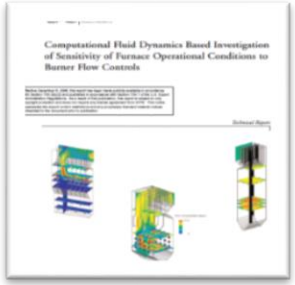
How about the change of distribution of Combustion Air according UBC

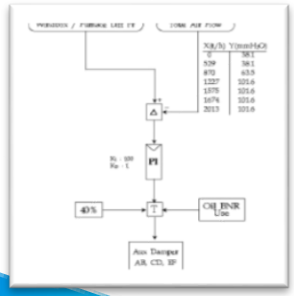


Introduction

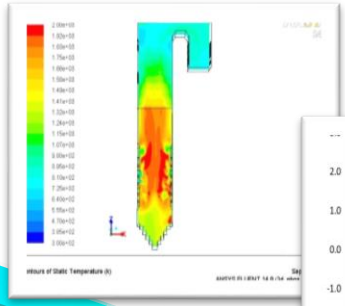
EPRI

Literature Review (13.5 ~15.4)

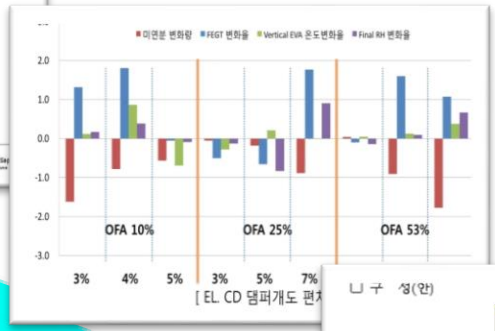




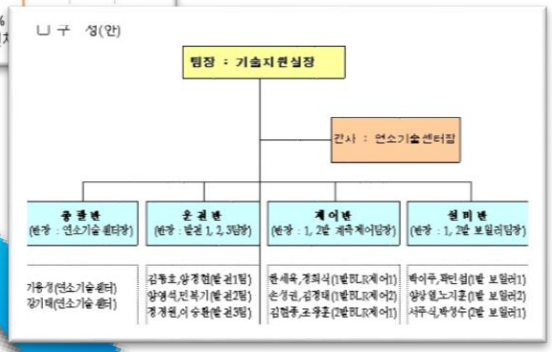
1-6 UNIT Logic change (13.5 ~15.4)



CFD (14. 4 ~ 15. 6)



Demonstration Test (15.7~16.6)



Make the Task Force Team for application (16. 3. 7 ~ 16. 4. 12)

Combustion Simulation

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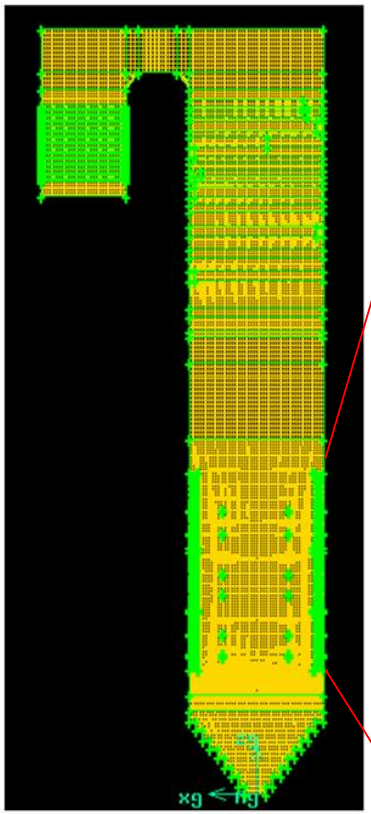
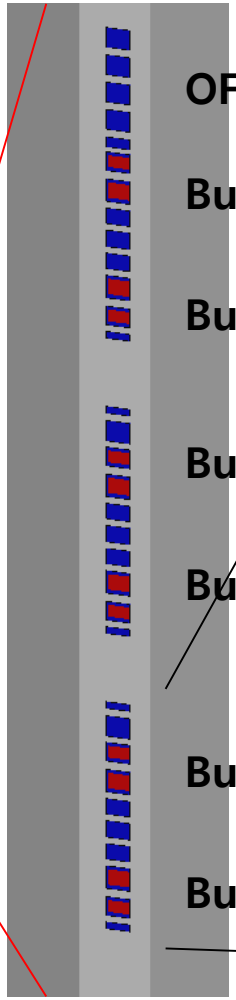
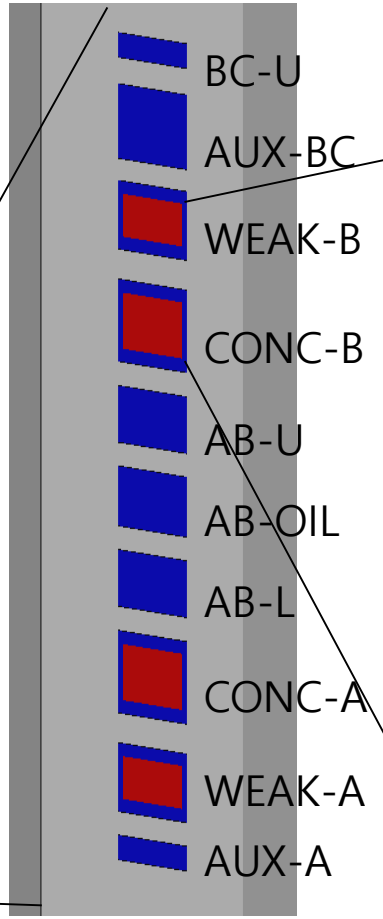
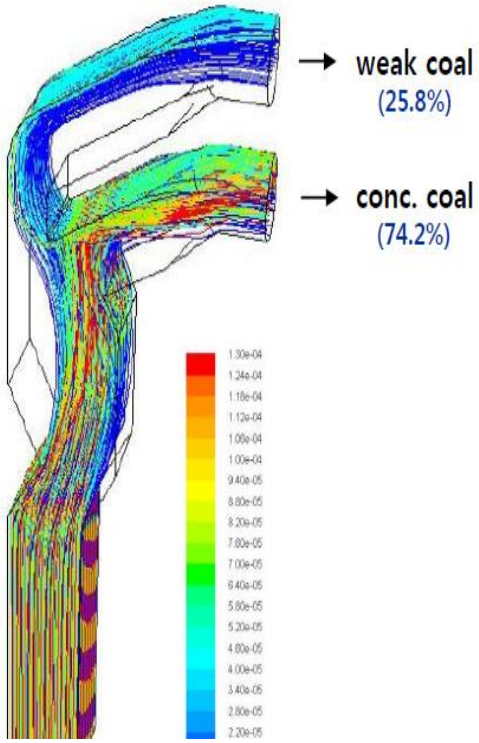
Modeling of Hadong 1-6 Unit





Burner arrangement





Calculation Condition

Base Conditions

Coal Flow (ton/hr)	Air flow (ton/hr)			Air Temperature (℃)		Number of mills	OFA Damper Position(%)
	Primary Air	Secondary Air	Total	Primary Air	Secondary Air		
209	397	1105	1502	60	305	5EA (#A~E)	10

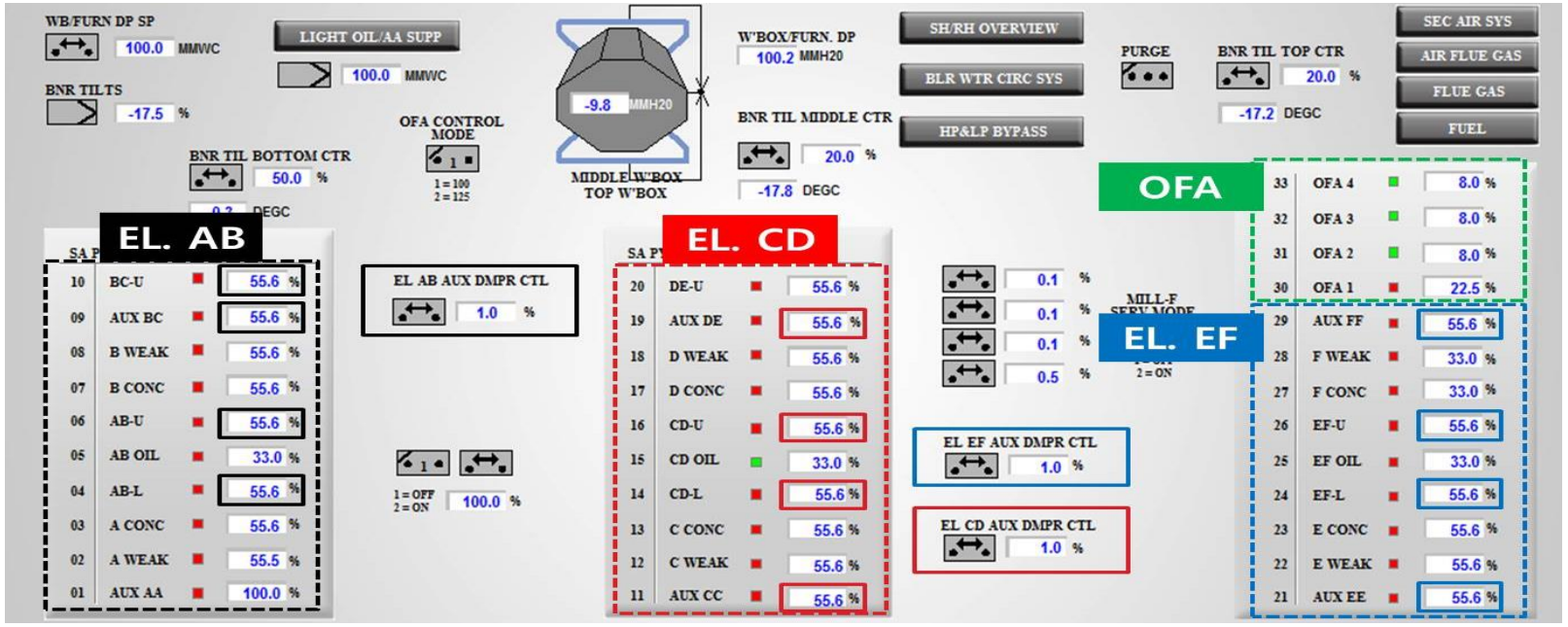
Coal Analysis used for simulation

Items		Test Coal
Coal Calorific value (As received base)		5621
Proximate Analysis	Fixed carbon	44.98
	V.M	33.31
	Ash	8.73
	Moisture	12.98
	Sum	100
Ultimate Analysis	C	68.24
	H	4.78
	O	12.85
	N	2.06
	S	0.93
	Ash	11.14
	Sum	100

Calculation Condition

Combustion Air Row Biasing

Items		Base	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
Secondary Air Damper Bias	EL.EF	1	1	1	1.1	1	1	1.2
	EL.CD	1	1	1.1	1	1	1.2	1
	EL.AB	1	1.1	1	1	1.2	1	1
Secondary Air Flow [kg/s]	EL.EF	74.13	73.77	73.71	74.96	73.64	73.57	75.25
	EL.CD	105.18	104.66	106.32	104.81	104.48	106.73	104.68
	EL.AB	106.02	107.01	105.42	105.65	107.48	105.21	105.51

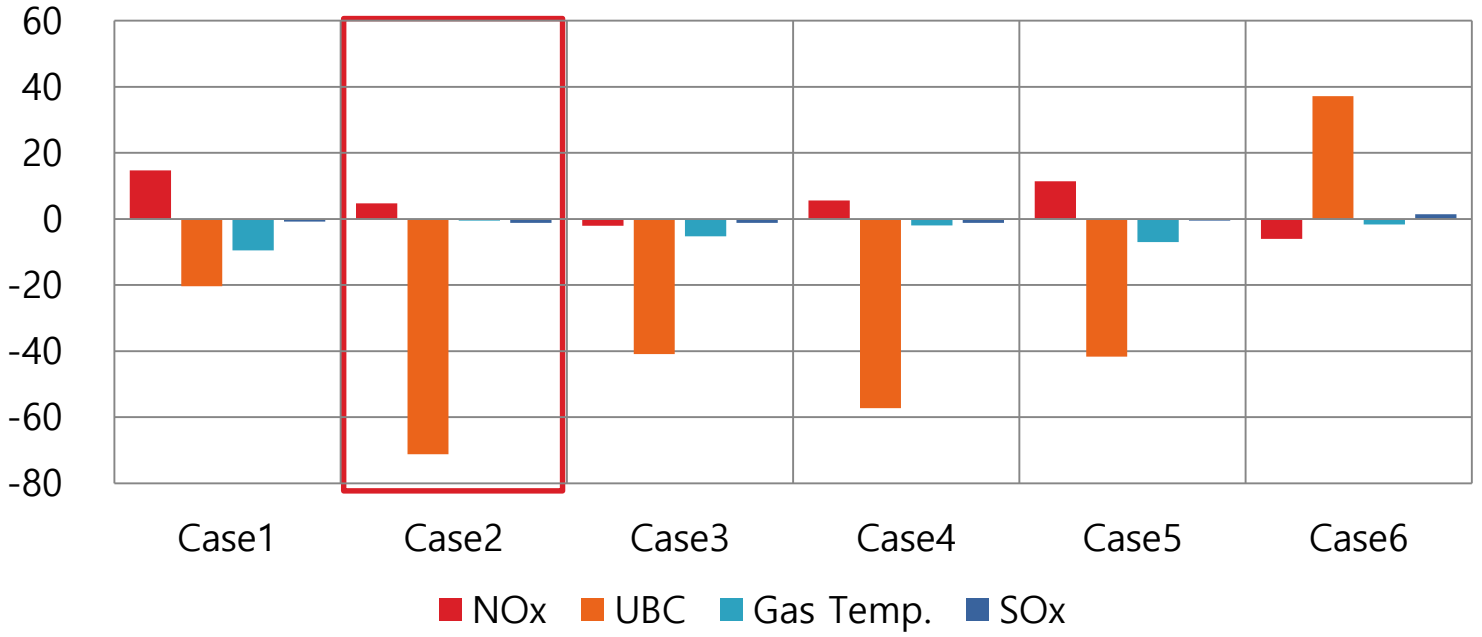


Results and Discussion

Combustion Air Row Biasing

Items		Base	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
UBC	%	14.75	12.18	5.59	6.66	6.29	9.19	20.41
NOx	ppm	129	148	135	126	136	144	121

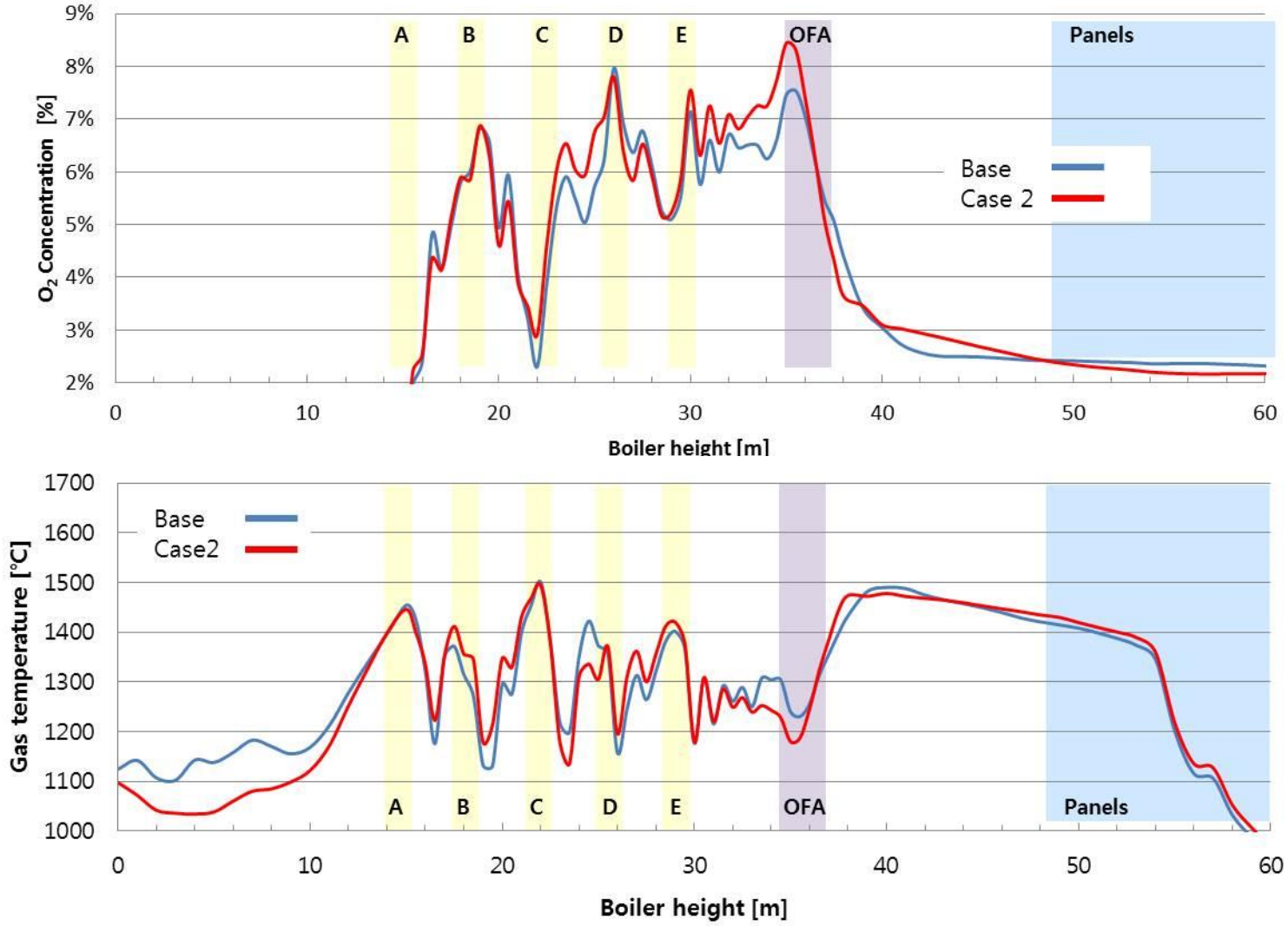
Relative Change(%) of NOx, UBC, Gas temp, SOx



Results and Discussion

Combustion Air Row Biasing

Average O2 concentration and gas temperature as function of furnace height



Calculation Condition

Coal Flow Row Biasing

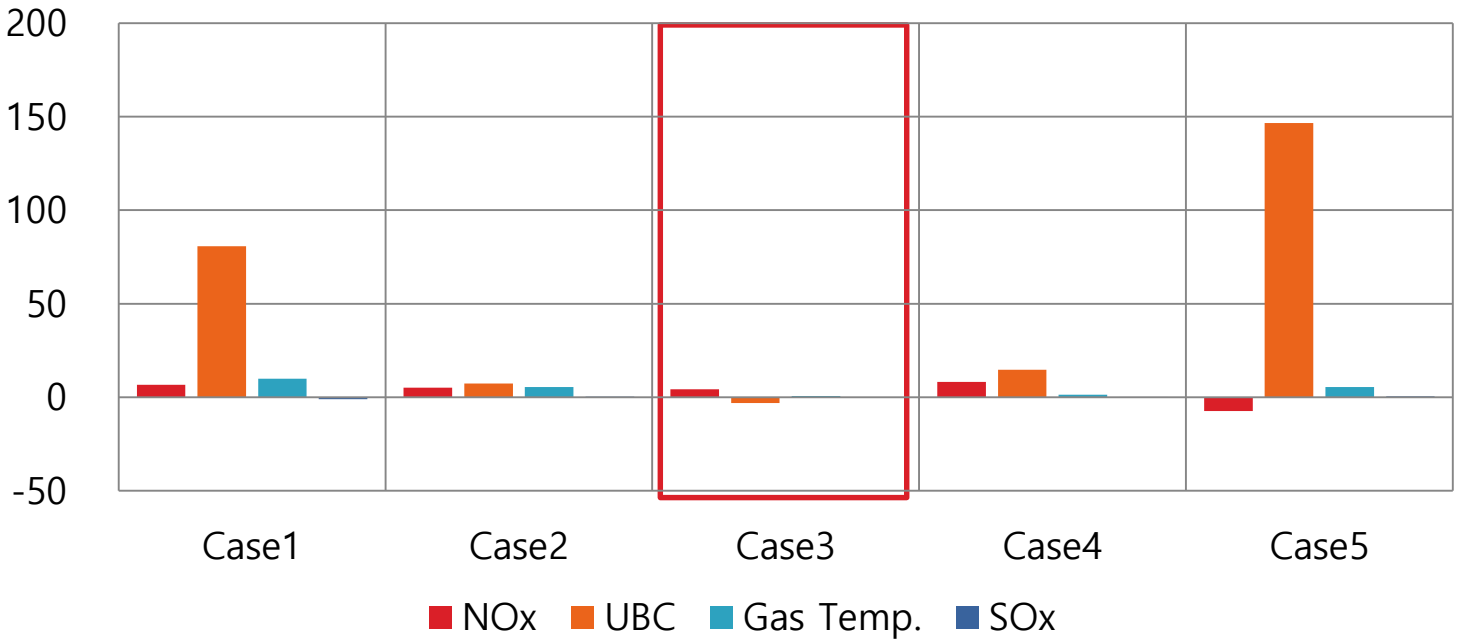
Items		Base		Case 1		Case 2		Case 3		Case 4		Case 5	
		Bias	Coal	Bias	Coal	Bias	Coal	Bias	Coal	Bias	Coal	Bias	Coal
Bias & Coal Flow (T/H)	E	1	41.84	1	43.41	1	43.41	1	43.41	1	43.41	0.85	35.57
	D	1	41.84	1	43.41	1	43.41	1	43.41	0.85	35.57	1	43.41
	C	1	41.84	1	43.41	1	43.41	0.85	35.57	1	43.41	1	43.41
	B	1	41.84	1	43.41	0.85	35.57	1	43.41	1	43.41	1	43.41
	A	1	41.84	0.85	35.57	1	43.41	1	43.41	1	43.41	1	43.41

Results and Discussion

Coal Flow Row Biasing

구 분		Base	Case 1	Case 2	Case 3	Case 4	Case 5
UBC	%	7.17	12.96	7.70	6.95	8.23	17.69
NOx	ppm	128	136	134	133	138	118

Relative Change(%) of NOx, UBC, Gas temp, SOx

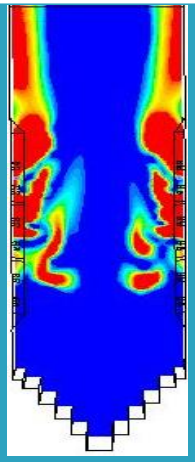
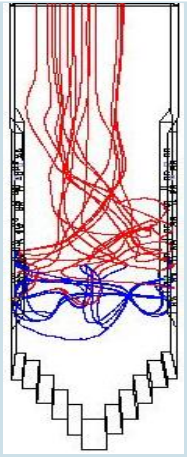
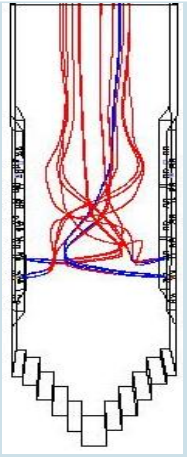
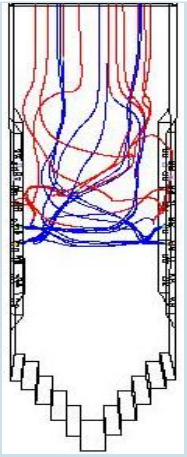
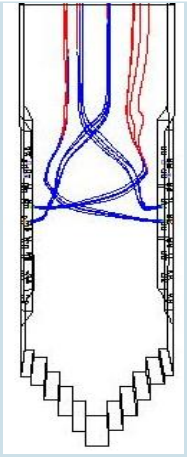
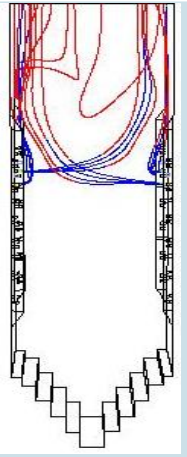


Results and Discussion

- **Pulverized Coal From Row C Burner Contribute most to UBC**
  - ✓ Combustion Air Row Biasing : UBC Change 14.75 → 5.59% (Case2, **EL.CD Air ↑**)
  - ✓ Coal Flow Row Biasing : UBC Change 7.17 → 6.95 % (Case 3, **Burner-C Coal ↓**)

- Why ?
  - ✓ Coal from Row Bottom experiences the most residence time for burnout
  - ✓ Coal from Row Top circulate at larger radius, in closer proximity to O2
  - ✓ Coal from Row Middle tends to pass through the central fuel rich core of fireball , seeing very low concentration of O2

➔ **Distribution O_2 in furnace and coal particle trajectory each burner**

O2 Distribution	A Burner	B Burner	C Burner	D Burner	E Burner
					

Combustion Test

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Combustion Test

- **Objective**

  ✓ **Test - 1**

  Verify about CFD Results

  (Combustion Air Row Biasing and Coal Flow Biasing)

  ✓ **Test - 2**

  Derive the Optimum Operating Conditions

  about Combustion Air Row Biasing

  ✓ **Test - 3**

  Demonstrate effect of Optimization of Combustion Air Distribution

Combustion Test 1

- **Test Objective** : Verify the Combustion Simulation Result
- **Test Schedule** : ‘15. 7. 2. 09:00 ~ 18:00
- **Test Conditions**
  - ✓ Power Output : Fixed output 505MW (at Sending End)
  - ✓ OFA Damper Position : Close (#1-4port 10%)
  - ✓ Pulverizer Operation : 5EA
  - ✓ Burner Tilt Position : Horizontal

Items	schedule	Test Condition
Baseline	10:00~12:00(2H)	Combustion Air and Coal Flow Row Bias : 1
Combustion Air Row Biasing	13:00~15:00(2H)	EL. CD Damper Bias : 1 → 1.1
Coal Flow Row Biasing	16:00~18:00(2H)	Pulverizer-C FDR Rate Bias : 1 → 0.85

Combustion Test 1

• Test Results of Combustion Air Row Bias

✓ UBC Reduce : 6.84 → 4.50%, 2.3%P ↓

Items	Combustion Air Bias			UBC [%]	SCR IN NOx [ppm]	FGD In SOx [ppm]	GAH In Gas Temp [℃]
	AB	CD	EF				
Baseline	1	1	1	6.84	128.8	399.8	335.5
Combustion Air Row Bias	1	1.1	1	4.50	127.1	420.1	336.5
Change				**-2.3**	**-1.7**	20.3	1.0
Relative Change(%)				**-33.8**	**-1.3**	5.1	0.3

• Test Results of Coal Flow Row Bias

✓ UBC Reduce : 6.84 → 6.48%, 0.36%P ↓

구 분	미분기별 석탄량[T/H]					미연분 [%]	SCR IN NOx [ppm]	FGD In SOx [ppm]	GAH In 가스온도 [℃]
	A	B	C	D	E				
변화 전	41	41	41	41	41	6.84	128.8	399.8	335.5
Pulv. C 석탄량 감소	42	42	36	42	42	6.48	124.3	422.7	337.5
Change						**-0.36**	**-4.50**	22.90	2.00
Relative Change(%)						**-5.3**	**-3.5**	5.7	0.6

Combustion Test 2

- **Test Objective** : Derive Optimum Operating Conditions of Combustion Air Bias
- **Test Schedule** : ‘15. 7. 22 ~ 11. 27. 09:00 ~ 18:00
- **Baseline Test Conditions**

Items	Contents
Gross Power Output	Automatic Generation Control, 510~515 MW
Test Coal	2~3 Blended coals, 5600kcal/kg
Coal Flow	200~220ton/hr
Air Flow	340Nm3/s
OFA Damper Position	10, 25, 53%

- **Parametric Matrix**

Items		Increase of EL.CD Secondary Air Damper (%P)			
		Base	Case 1	Case 2	Case 3
OFA Damper Position	10%	0	3 ↑	4 ↑	5 ↑ (Max)
	25%	0	3 ↑	5 ↑	7 ↑ (Max)
	53%	0	4 ↑	7 ↑	10 ↑ (Max)

Combustion Test 2

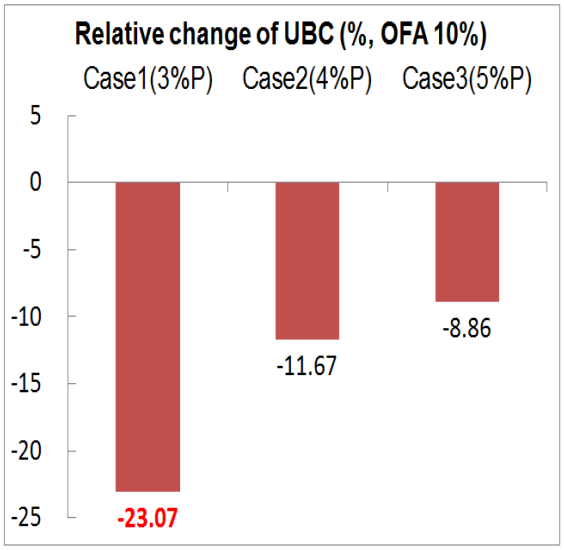
- **Test Results (UBC)**

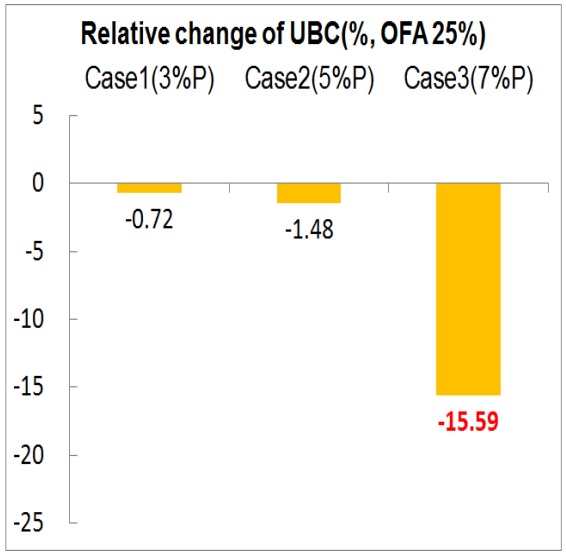
  - ✓ Relative change of UBC according to EL.CD Air Bias & OFA Damper Position
  - ✓ Optimum Condition of EL.CD Air Flow Increase

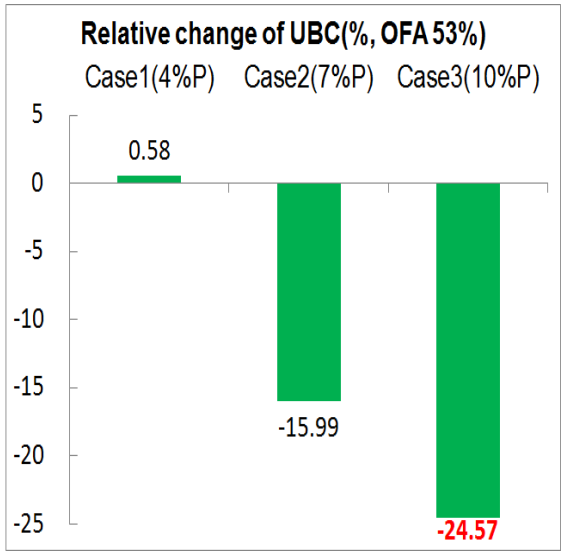
when OFA damper 10% → EL. CD Damper 3%P

when OFA damper 25% → EL. CD Damper 7%P

when OFA damper 53% → EL. CD Damper 10%P



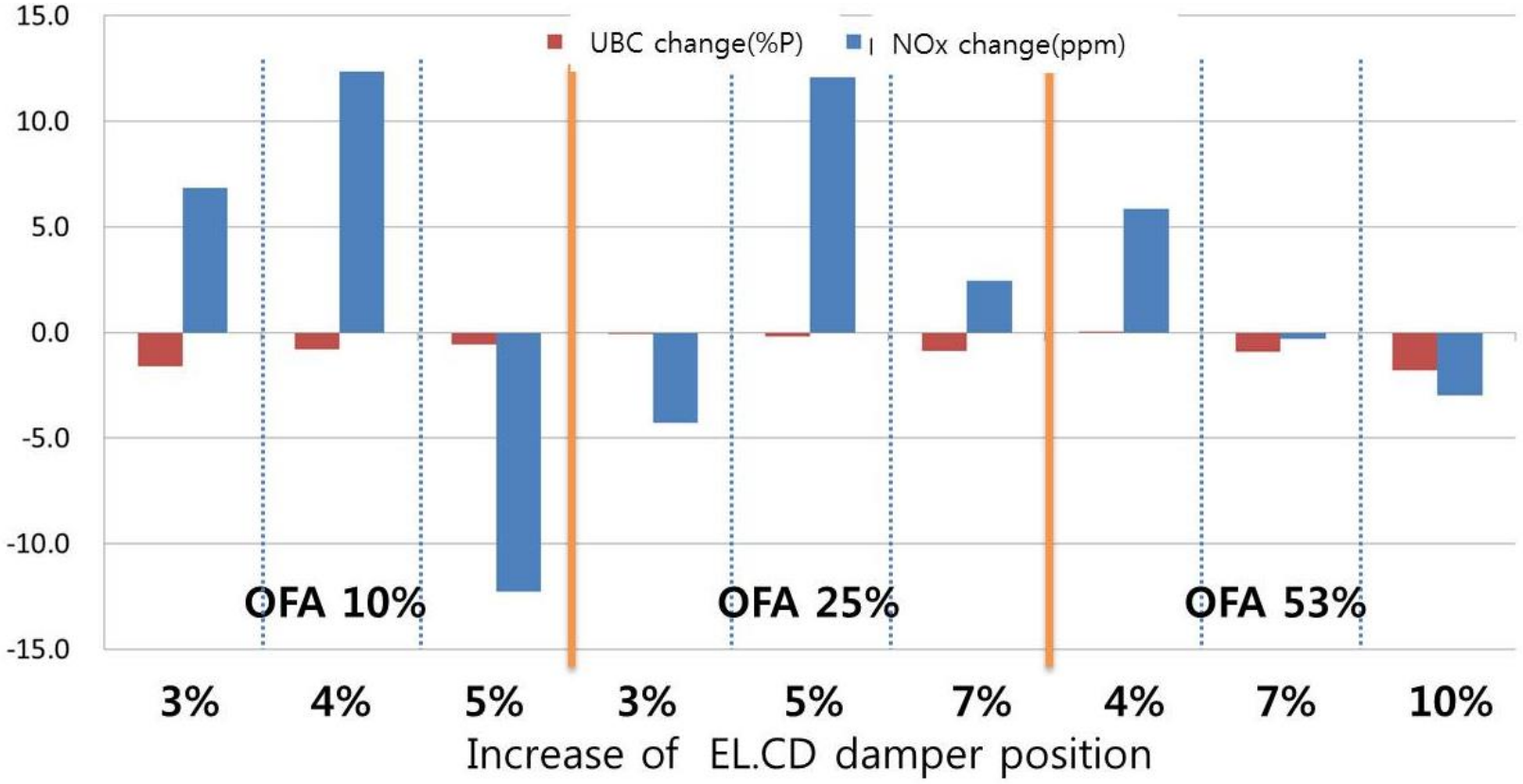




Combustion Test 2

- **Test Results (SCR inlet NOx)**

  - ✓ When OFA 10, 25 % : NOx is inversely proportional to UBC
  - ✓ **When OFA 53% : Both NOx and UBC reduced at same time**



Combustion Test 2

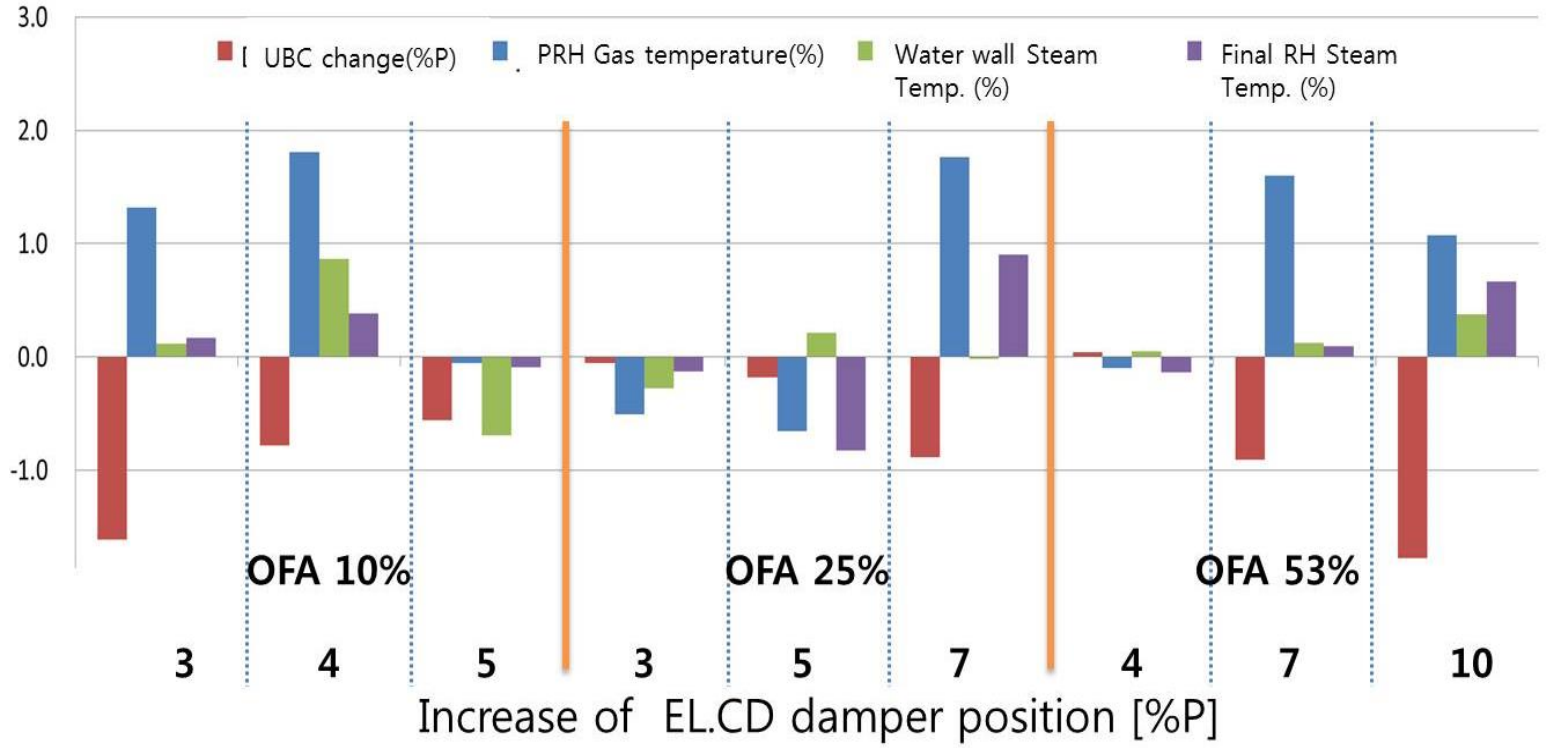
- **Test Results (Steam and Gas Temperature)**

  ✓ Gas Temperature (at Primary Reheat) increase 592→ 602℃

  but, Gas Temperature (at Gas Air heater inlet) is similar

  ✓ Vertical Evaporator and Final Reheat Steam Temperature Increase

  ✓ **Heat absorption rate Increase and Plant efficiency Increase**



Combustion Test 3

- **Test Objective** : Demonstrate effect of EL.CD Combustion Air Flow Optimization
- **Test Schedule** : ‘16. 6. 27 ~ 6. 28(2day), 7.19 ~ 7.20(2day)
- **Baseline Test Conditions**

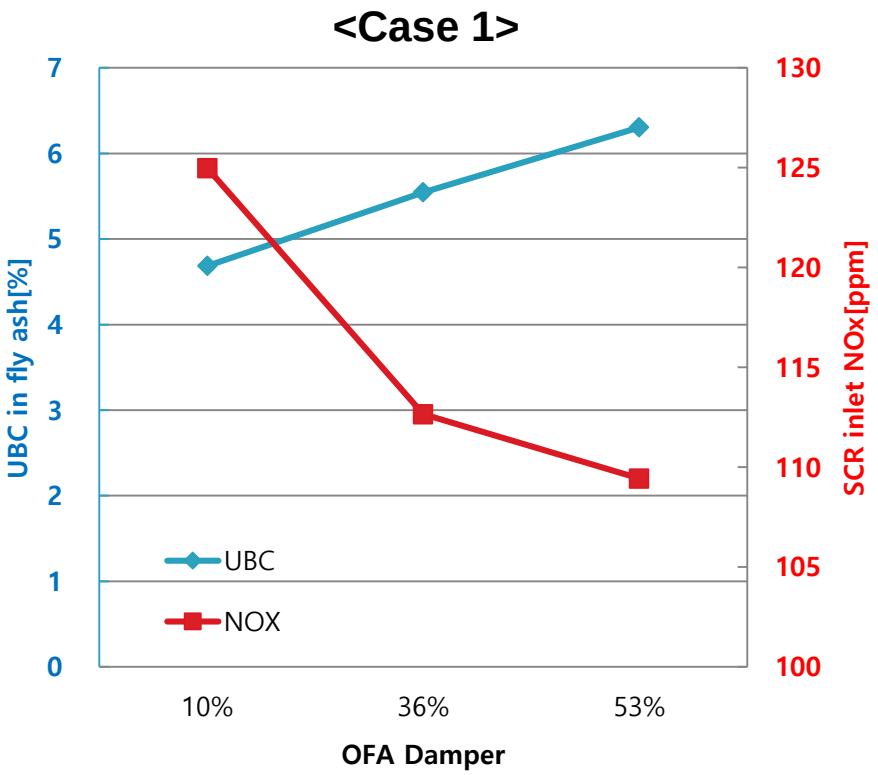
Items	Contents
Gross Power Output	Automatic Generation Control, 490~500 MW
Test Coal	2~3 Blended coals, 5600kcal/kg
Coal Flow	190~200ton/hr
Air Flow	340Nm3/s

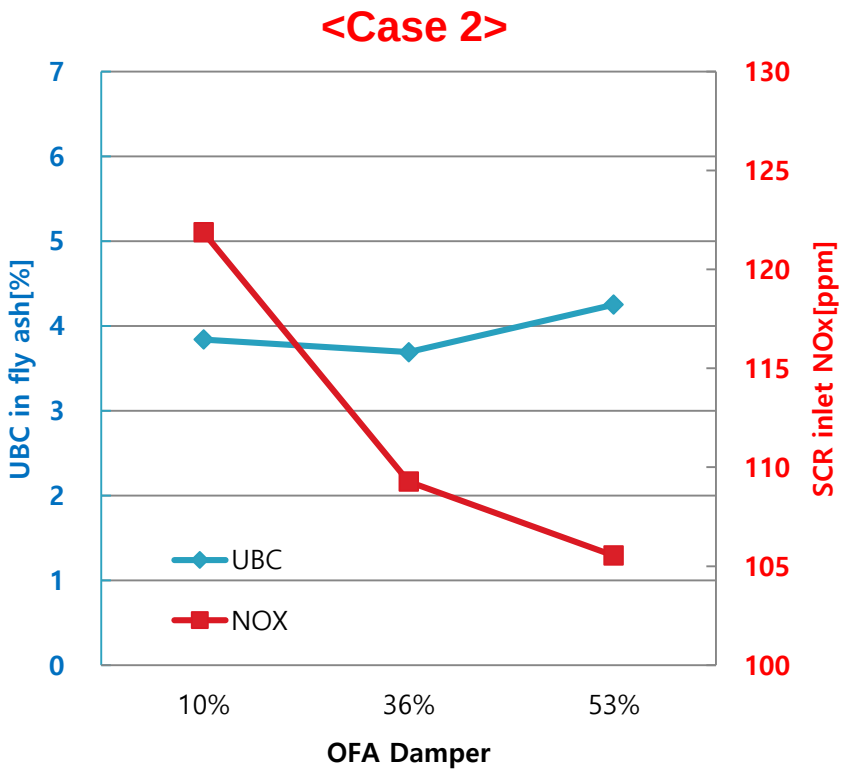
- **Parametric Matrix**

OFA Damper	schedule	Test Condition	
		1 day (Case1)	2day (Case2)
10%	10:00~12:00(2H)	Baseline	EL. CD Increase At Optimum Condition
36%	13:00~15:00(2H)		
53%	16:00~18:00(2H)		

Combustion Test 3

- **Test Results (UBC & NOx)**
  - ✓ Case1 : Adjusting OFA Damper
  - ➔ UBC is inversely proportional to SCR inlet NOx (Normal)
  - ✓ **Case2 : Adjusting OFA Damper & EL. CD Air Damper**
  - ➔ **Decrease NOx without increasing UBC**





Conclusion

- **Economic Effect**
  - ✓ **Savings Operational Cost about 330,000$/year**

OFA damper	Increase of EL. CD damper	UBC [%]	Final RH Steam Temp. [℃]	RH Spary [t/h]	Unit Efficiency [%p]	Cost Savings [$/year]
Close 10%	Baseline	6.76	539.71	6.73	0.099 ↑ ~ 0.135 ↑	average 330,000
	Case1 (3%P)	5.14	540.63	6.86		
	Change	1.62 ↓	0.92 ↑	0.13 ↑		
Open 25%	Baseline	5.69	534.20	1.48		
	Case3 (7%P)	4.80	539.02	4.40		
	Change	0.89 ↓	4.81 ↑	2.92 ↑		
Open 53%	Baseline	7.22	531.66	1.29		
	Case3 (10%P)	5.44	535.18	1.30		
	Change	1.77 ↓	3.52 ↑	0.02 ↑		

Conclusion

- ✓ Optimum operating condition of combustion air distribution was derived
- ✓ Decrease UBC by optimization of coal and combustion air distribution
- ✓ Decrease NOx, UBC by adjusting OFA damper and EL.CD Aux. Air damper
- ✓ Increase heat absorption without increase of furnace exit gas temperature
- ✓ Increase Plant efficiency and Decrease Operating Cost

Question ?

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