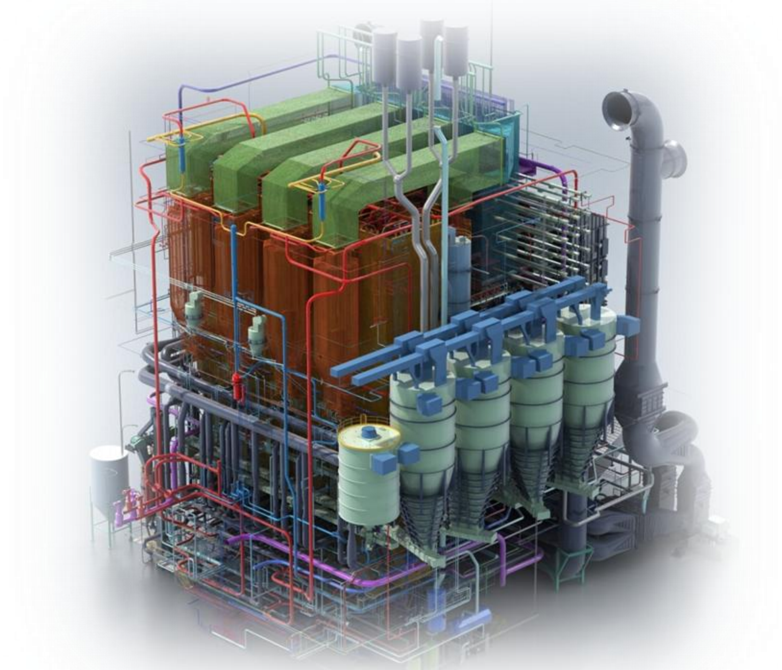
Operation Experience & Considerations in a Large Scale CFB Boiler

[69th IEA-FBC Meeting, Aix-en-Provence, France]



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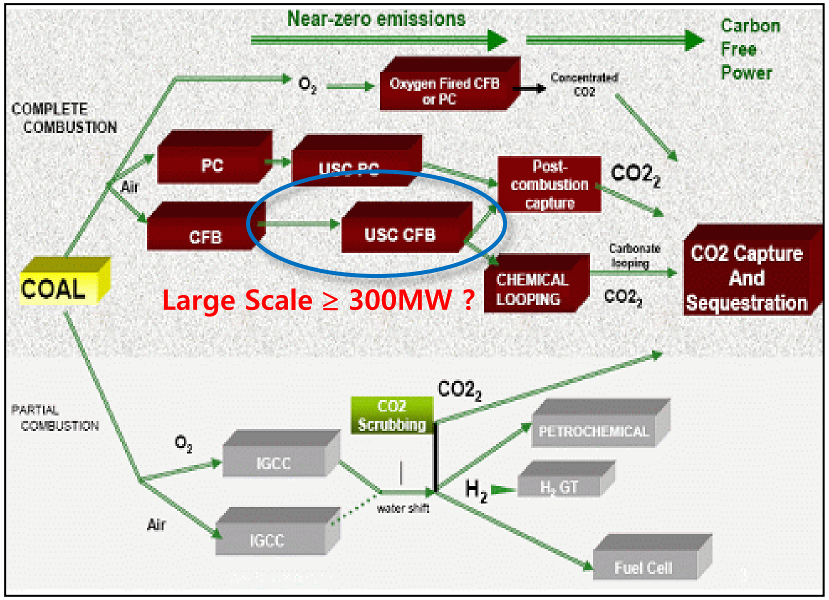
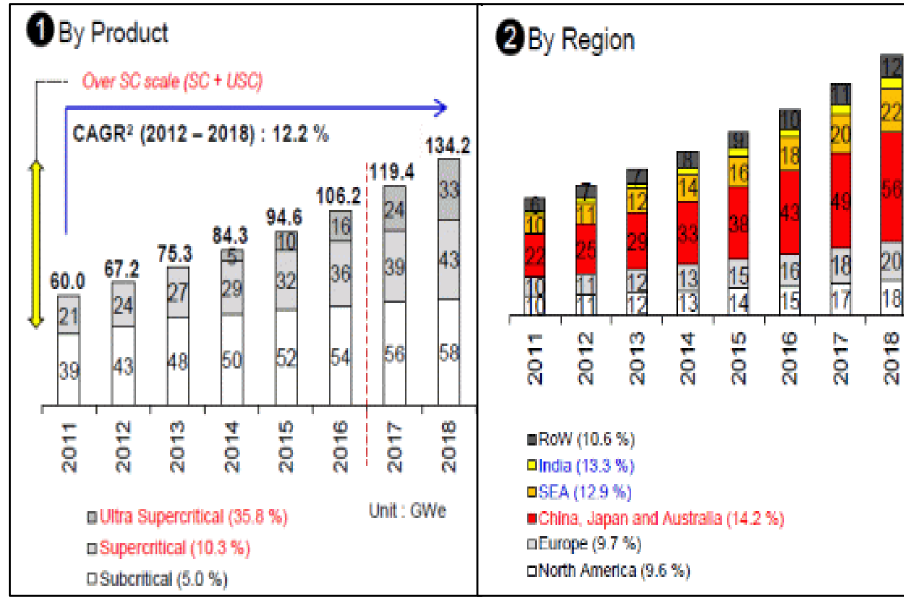
Technology & Market Trend (1)

• Coal Conversion for Electric Power Generation



• CFB Market Growth in the World



▪ **Coal Conversion Tech. Trend**
- Stable & Economic Electric Power Supply
  → high efficiency, large scale [SC/USC]
- CO_2 Reduction Measures Preparation
  → high efficiency, Co-combustion, CCS

❖ Optimum Tech. : CFB Conversion Tech.
  : optimum for fuel flexibility
  : highly adaptable to SC/USC steam circuit

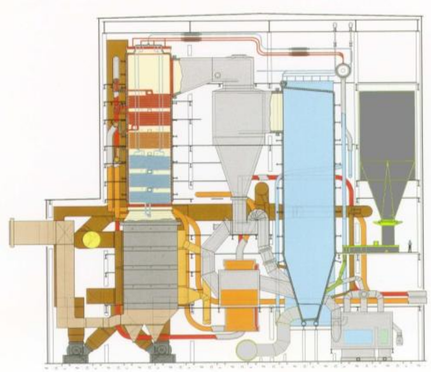
▪ **CFB Market Prospect**
- Since '95, more than 500 CFB units BD
- Increase of SC[USC] CFB
  : '11~'18,
  - CFB annual growth - 12%
  - SC[USC]-CFB annual growth - 36%
- Increase of CFB market share
  : more than 17% market share to '20

Status of CFB Plant [KEPCO Group's]

Cebu CFB

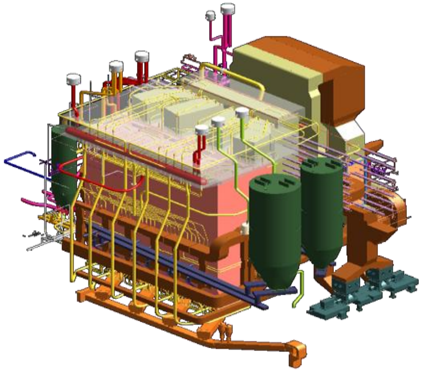
- Capacity
  - 100MW x 2units
- Commercial Op.
  - #1 : '11. 2
  - #2 : '11. 5
- Designer
  - Foster Wheeler
- Feature
  - Compact Cyclone
  - INTREX
  - Sub-bituminous
  - Prob.: Erosion

Donghae CFB



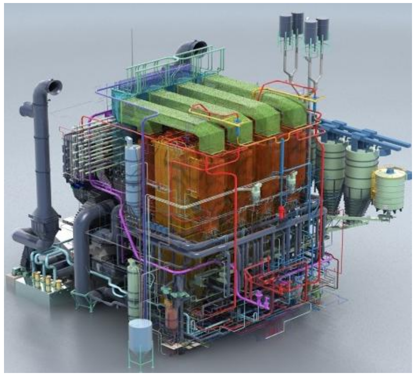
- Capacity
  - 200MW x 2units
- Commercial Op.
  - #1 : '98. 9
  - #2 : '99. 9
- Designer
  - Alstom
- Feature
  - FBHE
  - FBAC
  - Korean Anthracite
  - Prob.: Coal supply

Yeosu CFB



- Capacity
  - 300MW x 2units
- Commercial Op.
  - #1 : '16. 3 (Cons.)
  - #2 : '11. 10
- Designer
  - Foster Wheeler
- Feature
  - Compact Cyclone
  - w/o INTREX
  - Wingwall Tube
  - Prob.: Erosion etc

Samcheok CFB



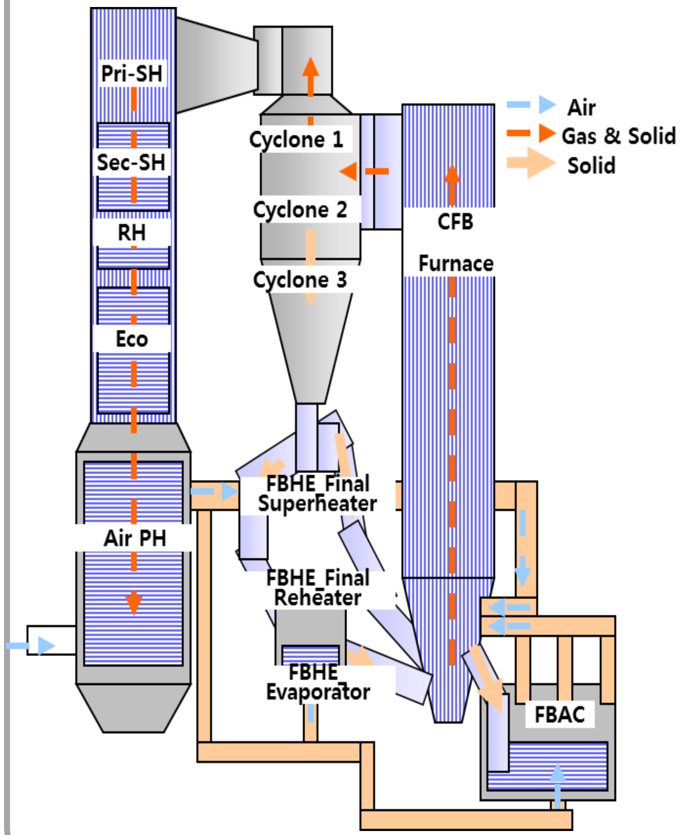
- Capacity
  - 2units [550MW x 2-CFB x 1-Turbine]
- Commercial Op.
  - #1 : '15. 12 (Cons.)
  - #2 : '16. 06 (Cons.)
- Designer
  - Foster Wheeler
- Feature
  - SC-CFB type
  - 257bar/603°C
  - 3,900 kcal/kg

More than 30 units of small & medium scale CFB boilers in Korea

Schematic Diagram of Large CFBs

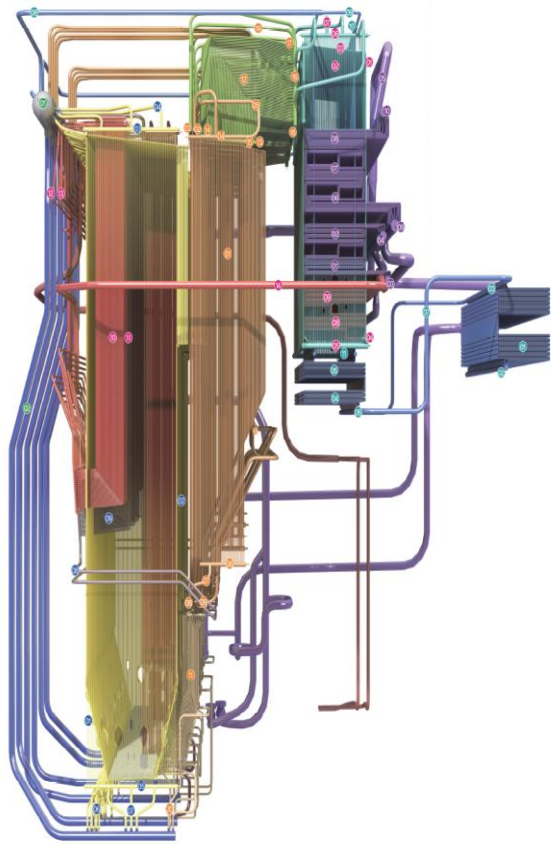
Alstom

❍ **DongHae 200MWe CFB**

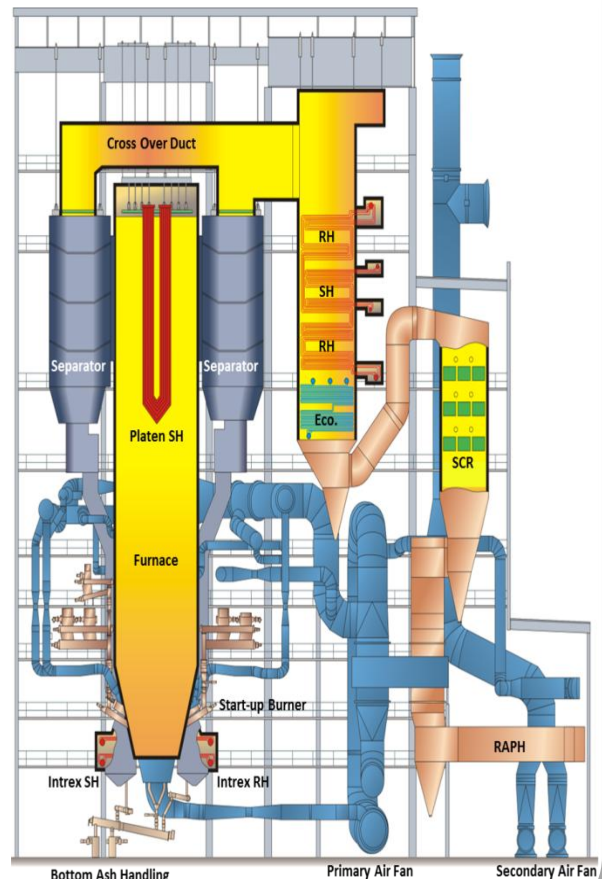


Foster Wheeler

❍ **YeoSu 340MWe CFB**



❍ **Samcheok 550MWe CFB**



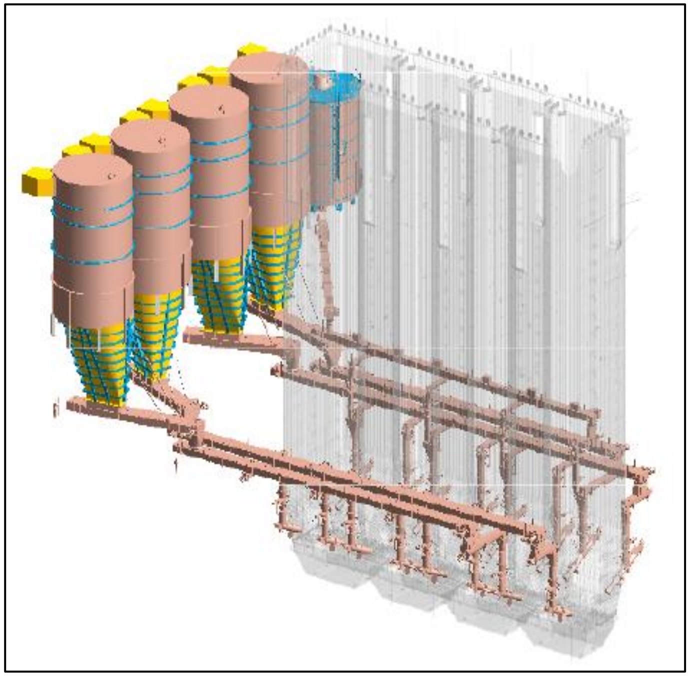
Furnace Size of Large CFBs

Unit [m]	Cebu [100MWe]	Donghae [200MWe]	Yeosu [340MWe]	Samcheok [550MWe]	Sumsel-5 [150MWe]	Lagisza [480MWe]
Furnace LP Width	15.2	18.9	33.8	39.6	19.5	27.6
Furnace LP depth	**3.0**	**3.8**	**4.1**	**5.4**	**3.8**	**5.3**
Furnace LP Height	**4.9**	**7.6**	**6.2**	**8.3**	**5.8**	**8.1**
Furnace UP Width	15.2	19.2	33.8	39.6	19.5	27.6
Furnace UP Depth	**6.0**	**7.2**	**8.1**	**10.8**	**7.5**	**10.6**
Furnace UP Height	22.9	24.4	35.2	43.7	29.5	39.9
Furnace Total Height	27.8	32	41.5	52	35.3	48.0
Taper angle	**18°**	**15°**	**18°**	**18°**	**18°**	**18°**
Fuel	**sub-bituminous**	**anthracite**	**sub-bituminous**	**sub-bituminous**	**lignite**	**bituminous**
Design	**FW**	**Alstom**	**FW**	**FW**	**Dongfang**	**FW**

Feeder Arrangement of Large CFBs

CFB	MW	Design coal	Feeder #			Bed area/ feeder (m^2/feed)	Feeder type
			Front	Rear	Sum		
Cebu	100	Sub bituminous	4	-	4	21.0	Volumetric
Dong-hae	200	Anthracite	6	-	6	25.3	Gravimetric
Yeosu	340	Sub bituminous	6	4	10	27.7	Volumetric
Sam-cheok	550	Sub bituminous	8	8	16	26.7	Volumetric
Sumsel-5	175	Lignite	6	0	6	24.4	Gravimetric
Lagisza	460	Bituminous	7	7	14	20.9	Volumetric

Samcheok CFB Feeder Arrangement

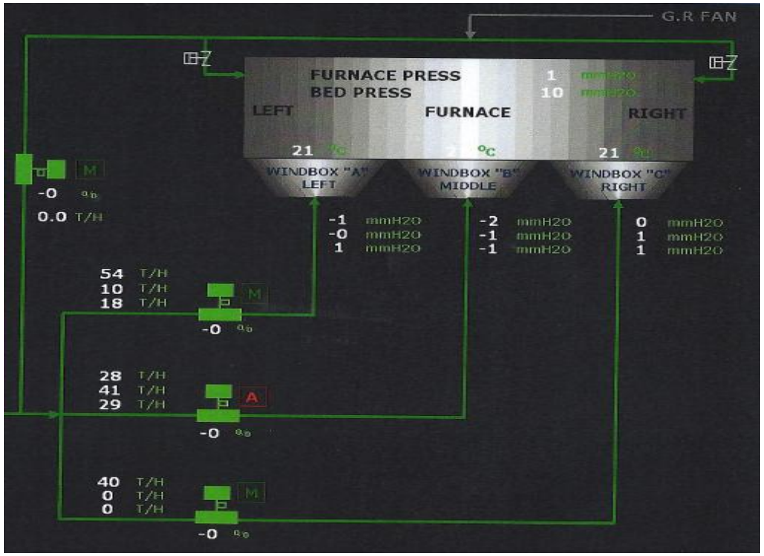


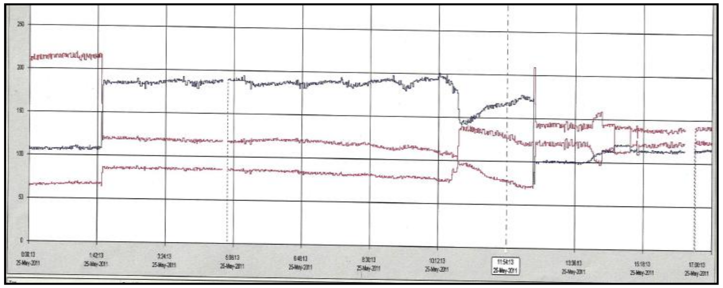
- **Fuel Feeder Number and Arrangement**
  - Generally symmetric arrangement → Yeosu CFB : non-symmetric – affects bed temp. control
  - Bed area per feeder (20~28 m^2/#) → depends on fuel (moisture, volatile, size)

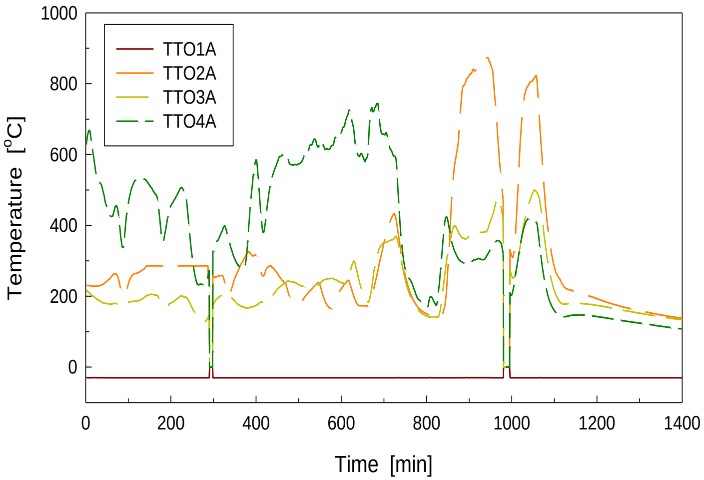
Operation Experience in Large CFBs (1)

- **During start up,**
  - PA control failure
    - → separate windboxes(2~3) in large CFBs
    - → needs uniform PA distribution

- **Defluidization [during heating up BM]**
  - Local poor fluidization
    - → flatten the bed surface [swing PA]
    - → careful operation [training operators]

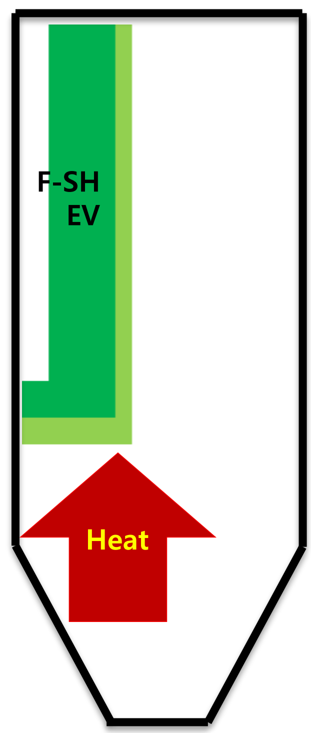






Operation Experience in Large CFBs (2)

- **Main Steam Temperature Lower than Designed** [ex: Yeosu 300MWe etc]
  - ✓ **needs to review basic design** (heat absorption area/arrangement etc)
  - ✓ **needs to review heat & mass balance** btw boiler and turbine [FW/RH/SH 's temp, FR)
  - ✓ **needs to increase HT** to SH [Yeosu : wingwall in the furnace]



Operational Control

- Generally, to increase HT
  - ✓ increase solid hold up
    : PA/SA ratio control
    : inventory control
    : solid particles size control
    and so on

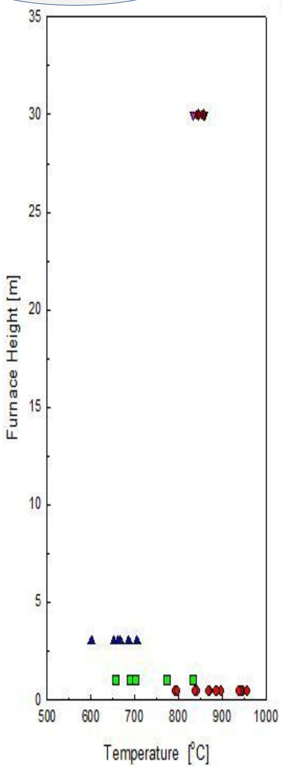
Modification

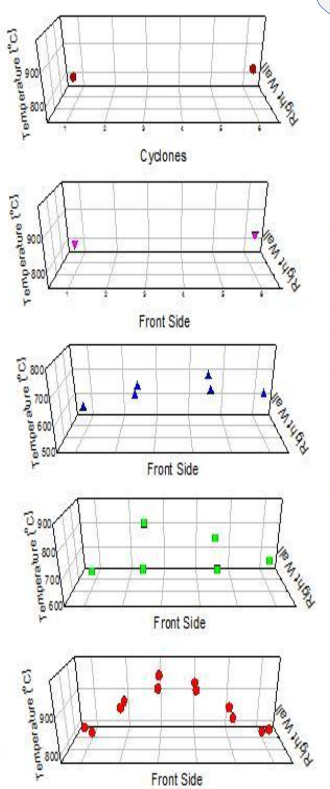
- Heat absorption area control (reducing EV)
  - ✓ increase refractory lines
    → bed temperature ↑

Operation Experience in Large CFBs (3)

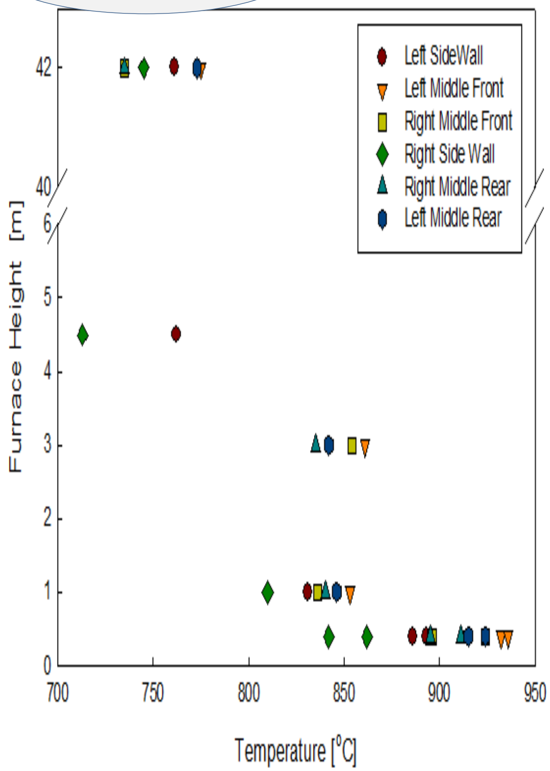
- Bed Temperature Higher than Designed, and Un-Uniformity
  - ✓ depends on coal de-volatilization and combustion reactivity
  - ✓ depends on coal size distribution and feeding point
  - ✓ needs to check solid circulation rate & cyclone efficiency [Donghae : cyclone modification]

Cebu CFB

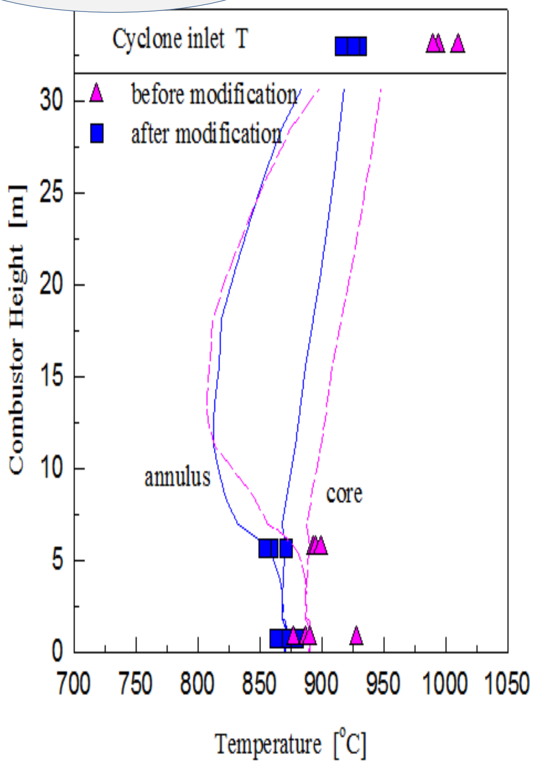




Yeosu CFB

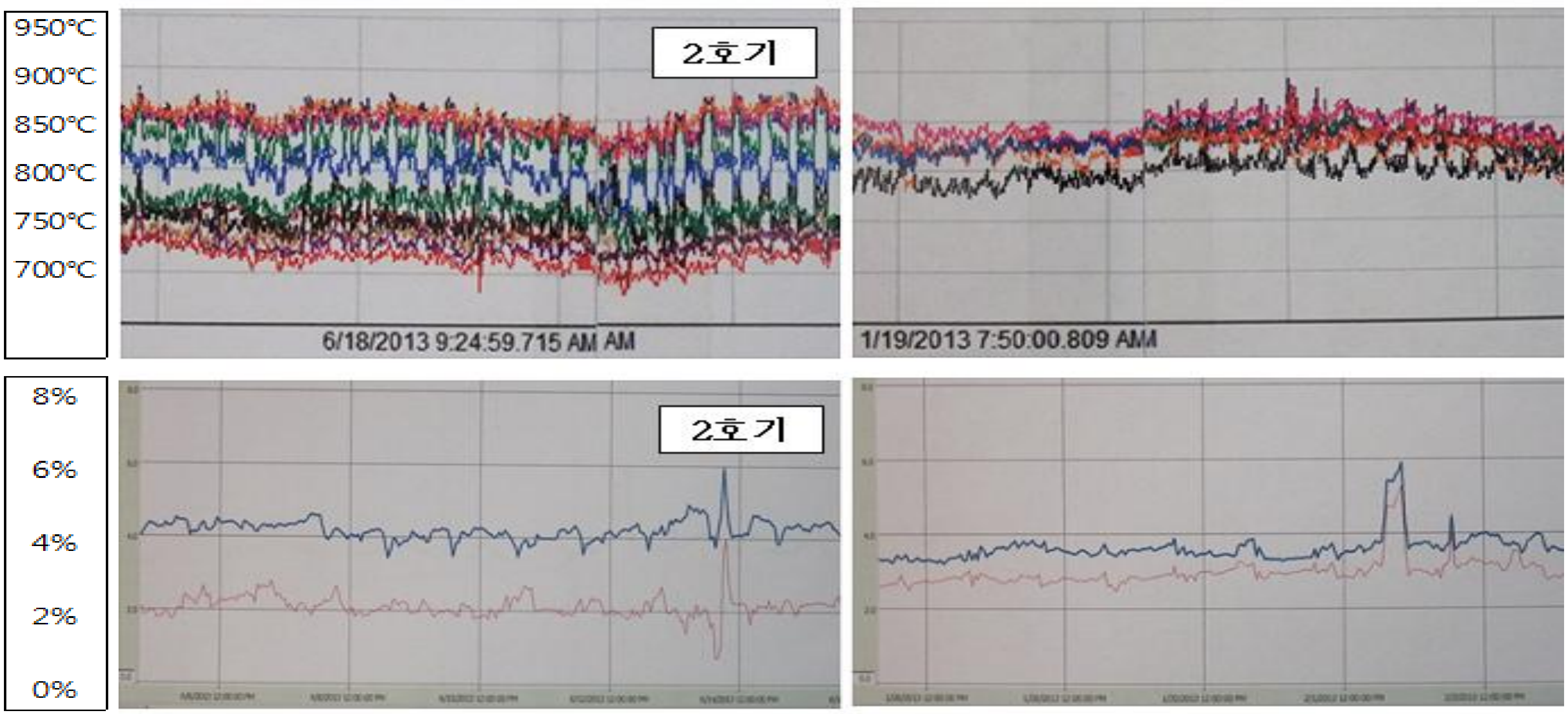


Donghae CFB



Operation Experience in Large CFBs (4)

- **Un-Uniform Temp. in Horizontal Direction of the Furnace** [due to uneven fuel feeding]
  - ※ fuel feeing : possibility of error if done by volume control of each feeder
  - ※ air : difficult to control PA flow in horizontal direction except with separate windbox
- ✓ Horizontal monitoring of O_2 conc. in flue gas → control the fuel feeding rate at each feeder



Operation Experience in Large CFBs (5)

If design is acceptable,

- How to control bed temperature & un-uniformity ?

When?

- Higher Bottom Temp. [> 950 °C]
- Higher Upper Temp. [> 950 °C]
- Un-uniform Temp. [> 100 °C]

Reason/Phenomena !

Higher Bottom Temp.

- ✓ fuel reactivity ↑
- ✓ lower solid circulation
- ✓ lower cyclone efficiency
- ➢ combustion efficiency ↑
- ➢ SO_2 capture efficiency ↓
- ➢ Operation stability ↓

Higher Upper Temp.

- ✓ fuel reactivity ↓
- ✓ Lower solid circulation
- ✓ Lower cyclone efficiency
- ➢ combustion efficiency ↑
- ➢ SO_2 capture efficiency ↓
- ➢ Operation stability ↓

Un-uniform Temp.

- ✓ fuel reactivity(volatiles) ↑
- ✓ fuel size ↓
- ✓ local excess air unbalance
- ✓ feeder #/location/space
- ➢ SO_2 capture efficiency ↓
- ➢ Operation stability ↓

How to ?

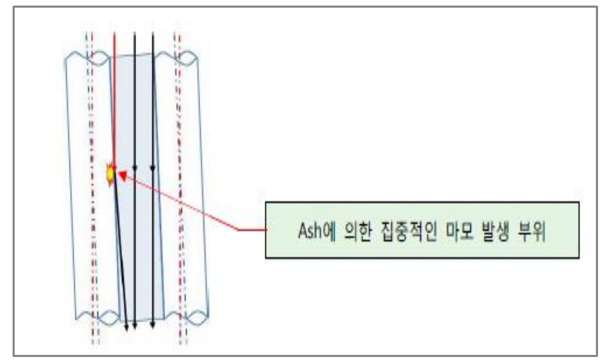
- Higher bottom temp. : PA ↑ / [PA/SA] Ratio ↑ / Inventory ↑ / Bed media size ↓
- Higher upper temp. : PA/SA Ratio ↑ / Inventory ↑ / Bed media size ↓
- Un-uniform temp. : control of PA(through separate windbox) and fuel size, SA ↑

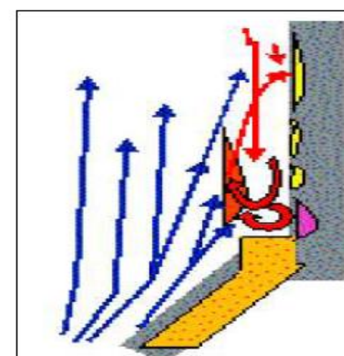
- if not, consider modification of cyclone and feeder location/space [Donghae, Yeosu]

Operation Experience in Large CFBs (6)

- **General Tube Erosion Cases**
  - ✓ Erosion of boundary aspect between refractory and wall tube
  - ✓ Erosion of tube coating boundary aspect
  - ✓ Erosion of irregular tube surface due to overlaying and poor extent of tube straight
  - ✓ Erosion of lower part of wall tube [in the vicinity of kick out] due to up-flowing particles

육성 용접부 불량에 의한 침식마모(좌) 및 직관도 불량에 의한 침식마모(중, 우)

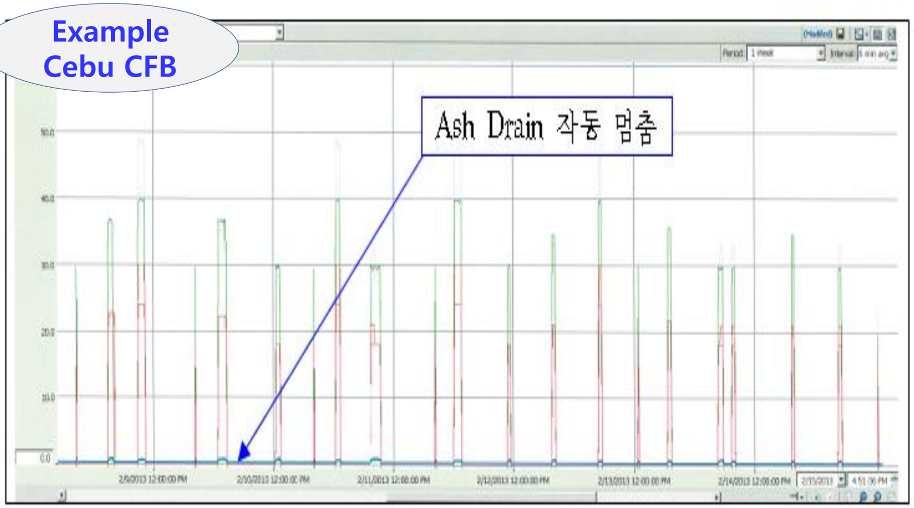


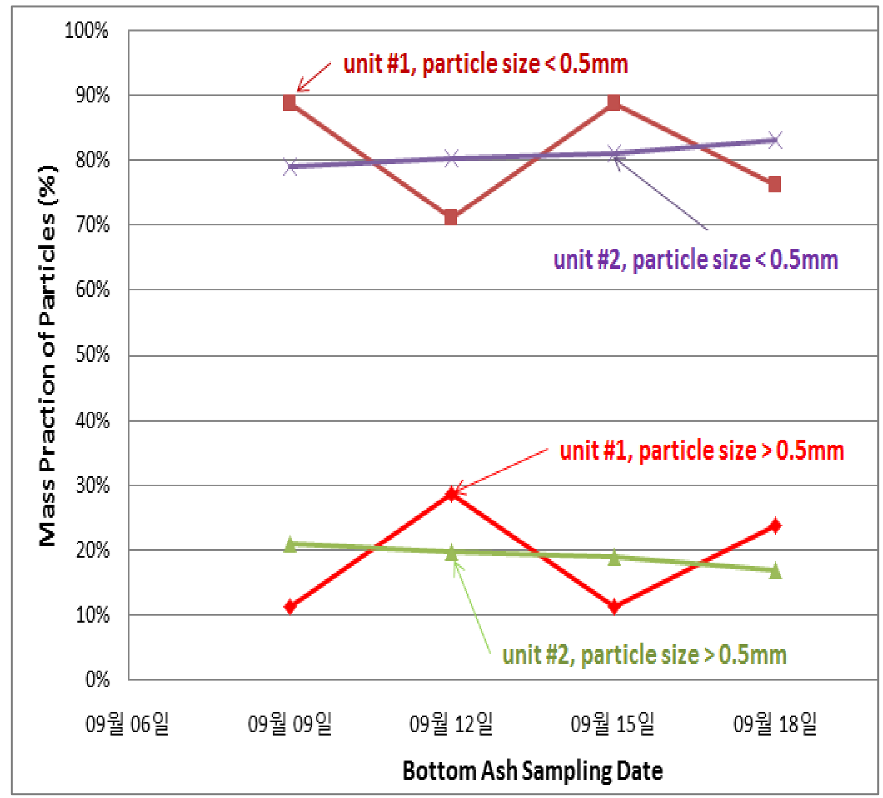


Operation Experience in Large CFBs (7)

- Management of Particle Size and its Distribution in the Furnace
  - ✓ Check bed media drain-injection system & quantity and period

Example
Cebu CFB





Summary of Experiences in Large CFBs

- **Considerations relating to Design Aspect of Large CFB Boiler**
  - ✓ Needs to consider Easy control of PA relating to fuel feeding conditions
    - Combustion and temperature control for low grade fuels
    - Local erosion control around and upper part of fuel feeder
    - Easy start-up and preventing particle agglomeration
  - ✓ Needs to check heat transfer coefficient in the furnace
    - Steam quality and heat balance in the system
  - ✓ Needs to check cyclone efficiency in the CFBS
    - Temperature control in the furnace
    - Increase of SO_2 capture efficiency and operation stability
  - ✓ Needs to develop easy management system of particle size in the furnace
    - such as monitoring system of particle size in the furnace
    - automatically drain and injection systems for good bed media quality

Thank You for Your Attention~ !