Characteristics of China's mercury pollutant emission in coal-fired power plants and fly ash adsorption removal control technology

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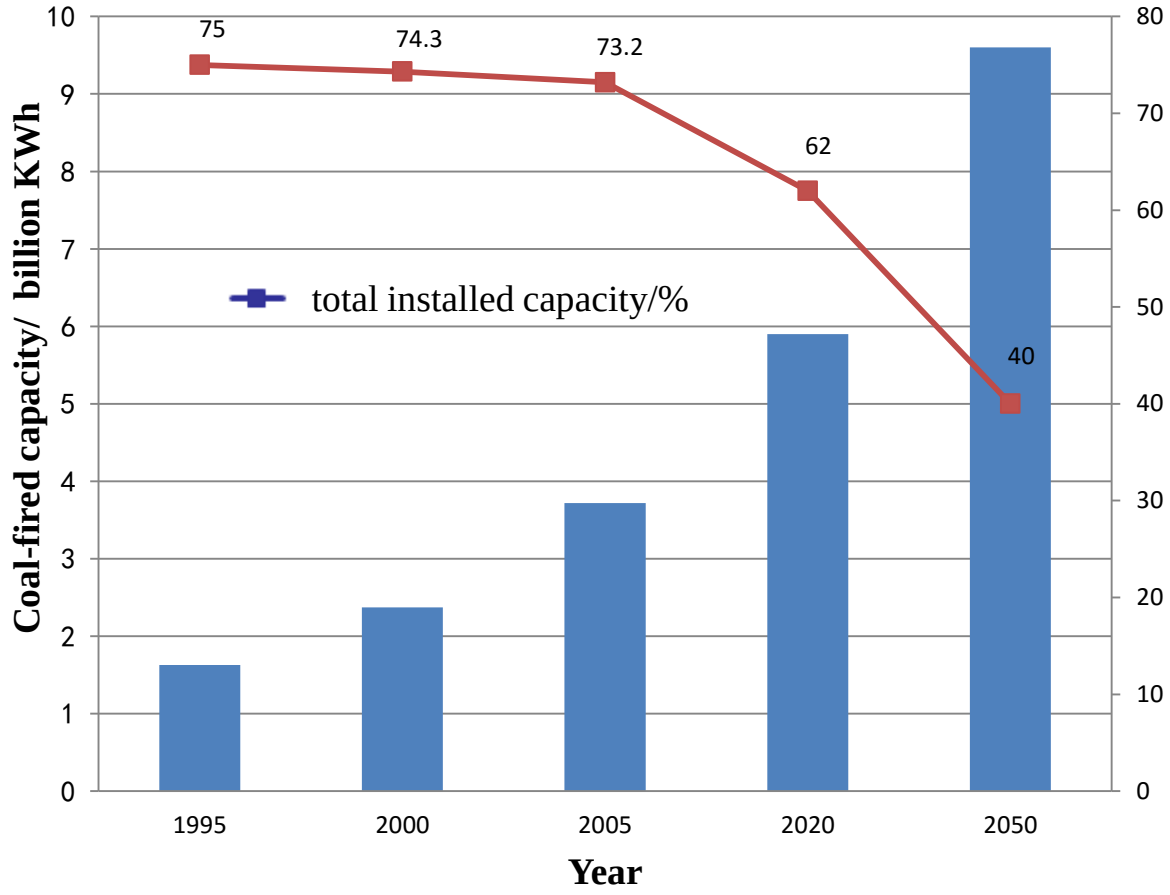
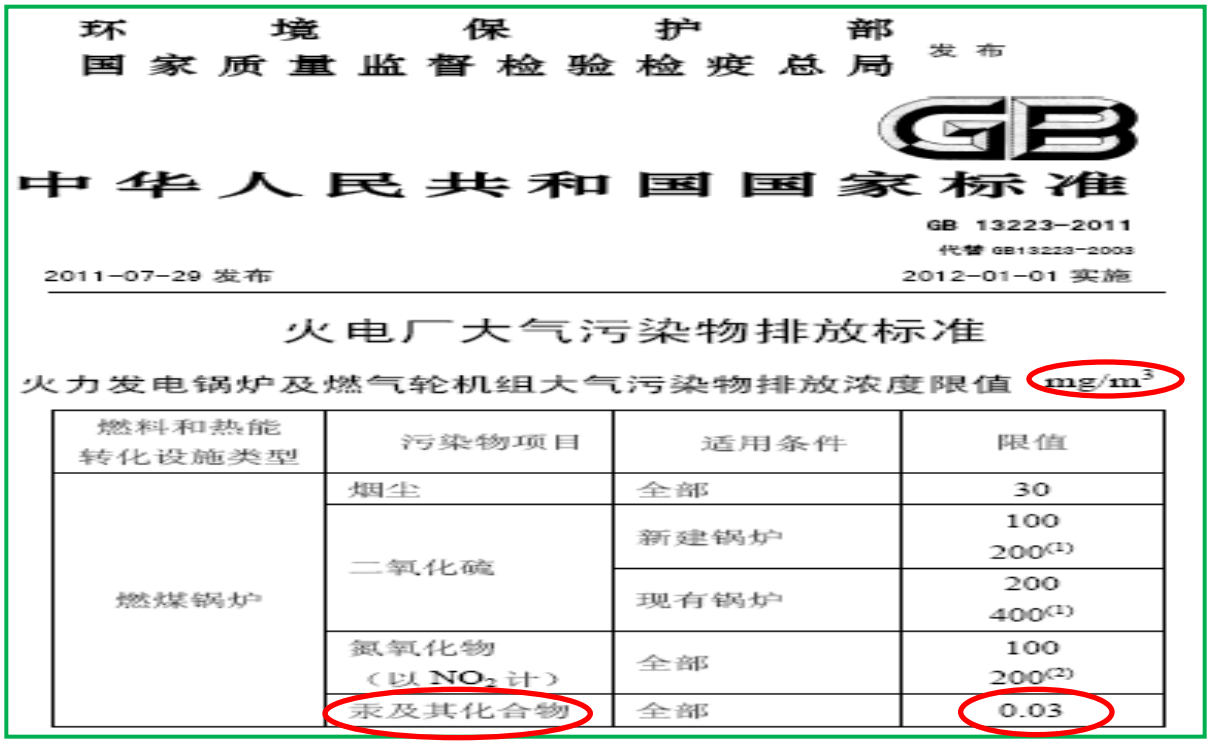
Coal consumption in China power plants



In future, the use of coal in power generation industry is still huge!

Mercury Emission Standards for Coal-fired Power Plants



环 境 保 护 部
国家质量监督检验检疫总局 发布

GB

中华人民共和国国家标准

GB 13223-2011
代替 GB13223-2003

2011-07-29 发布　　2012-01-01 实施

火电厂大气污染物排放标准

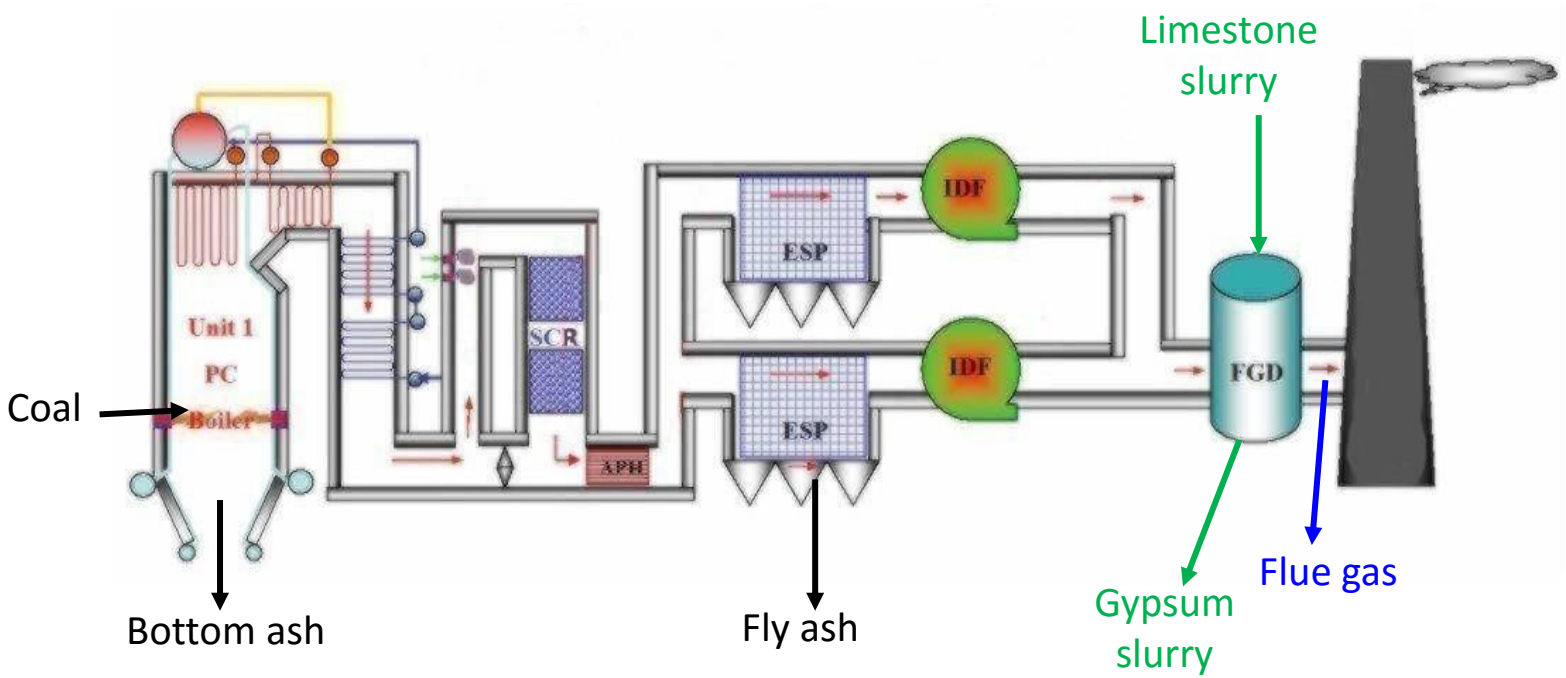
火力发电锅炉及燃气轮机组大气污染物排放浓度限值 mg/m³

燃料和热能转化设施类型	污染物项目	适用条件	限值
燃煤锅炉	烟尘	全部	30
	二氧化硫	新建锅炉	100 200(1)
		现有锅炉	200 400(1)
	氮氧化物（以 NO_2 计）	全部	100 200(2)
	汞及其化合物	全部	0.03

US：Mercury and air toxics standards (MATS) started on February 1, 2015. An 90% cut should be reached in mercury emissions from coal-fired plants on the present basis.

Power plants mercury sampling

Series of tests by CEMS, OHM, 30B method for the vapor mercury. solid and liquid samples got from the Boiler, ESP and FGD of power plants.



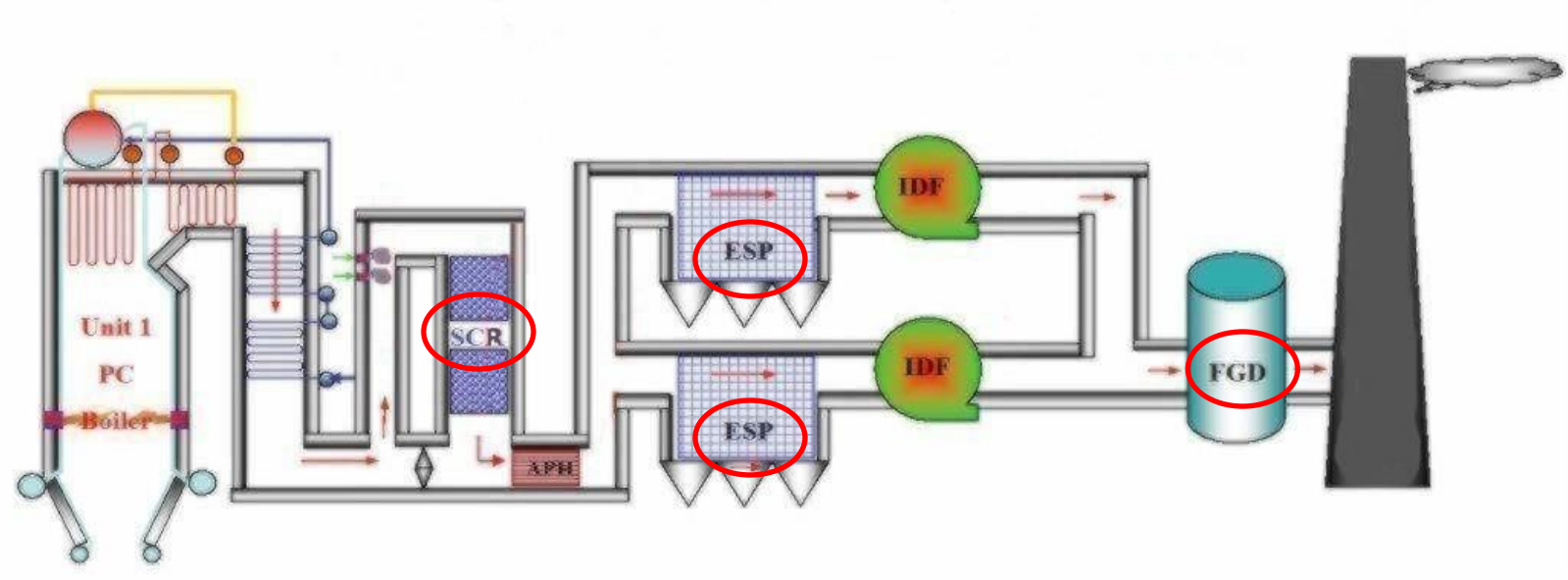
Mercury of flue gas in different power plants

Power plant	Power (MW)	Mercury in coal (ng/g)	APCD	Sampling	Mercury in flue gas (ug/m3)
1#	200	439	ESP +FGD	30B+OHM	11.3
2#	200	201	SCR+ ESP +FGD	30B+OHM	1.8
3#	300	43	SCR+ ESP +FGD	30B+OHM	2.0
4#	1000	108.3	SCR+ ESP +FGD	30B	3.0
5#	200	67	SCR+ ESP +FGD	30B+OHM	2.3
6#	300	/	SCR+ ESP +FGD+WESP	30B+OHM	5.9
7#	660	/	SCR+ ESP +FGD	30B	1.8

Existing air pollutant control devices on mercury removal

Three forms of mercury in the combustion flue gas: elemental mercury (Hg^0), oxidation mercury (Hg^{2+}) and particle-bound mercury (Hg^p)

- SCR Catalytic Oxidation
- ESP Adsorption
- FGD Adsorbtion

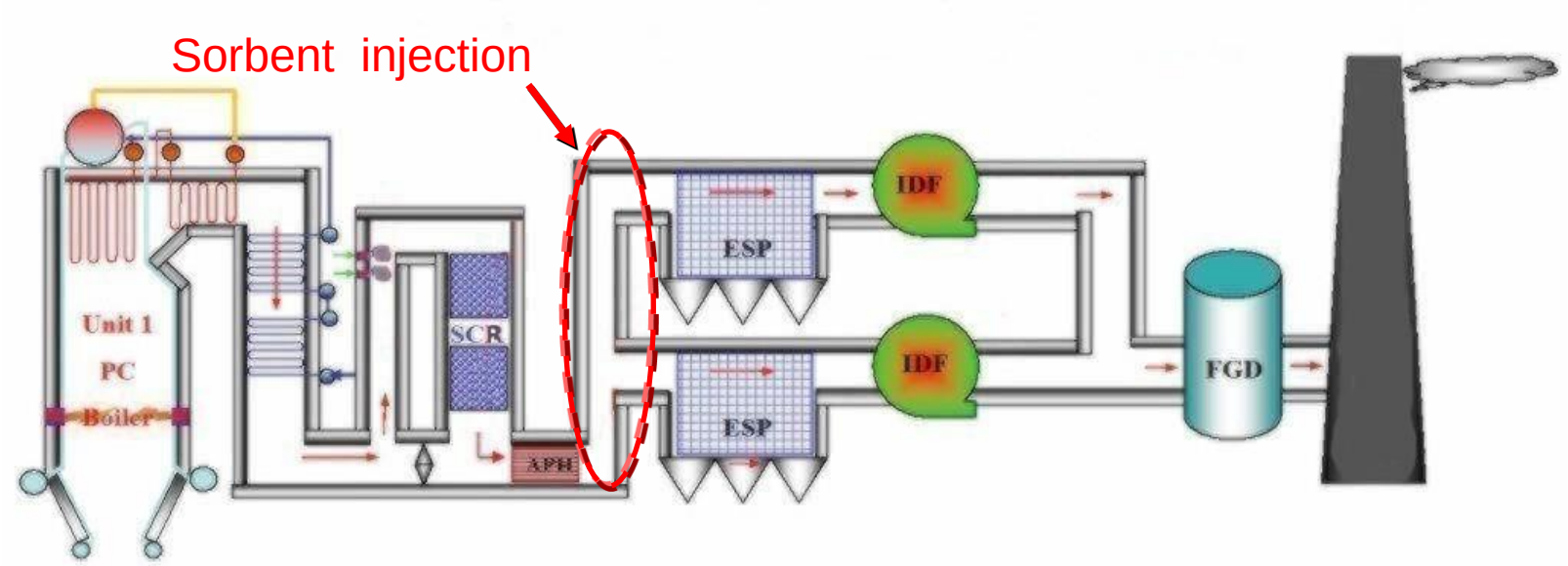


Removal efficiency of mercury in APCDs

Batch	Coal ng/g	Fly ash ng/g	Bottom ash ng/g	Gypsum ng/g	Limestone ng/g	Removal efficiency %
1	45±14	58±26	0.6±1	117±56	105±89	20.5
2	41±13	122±25	3±5	466±45	6±1	65.9
3	43±12	81±7	1±2	421±104	10±15	47.2
4	77±23	63±23	3±6	248±10	7±6	17.8
5	76±19	153±8	0.5±0.6	438±163	1.6±1.2	39.5

Control Ideas

➢Because of the difference of coal, boiler type, and APCD etc., Joint removal mercury efficiency for existing equipment is not stable and difficult to meet the future control target by them.



Coordination removal with highly efficient sorbent injection technology and APCDs!

Development effective sorbents

Carbon based	•Activated carbon •Modified AC
Non-carbon based	•Silica-based •Calcium-based •Modified fly ash

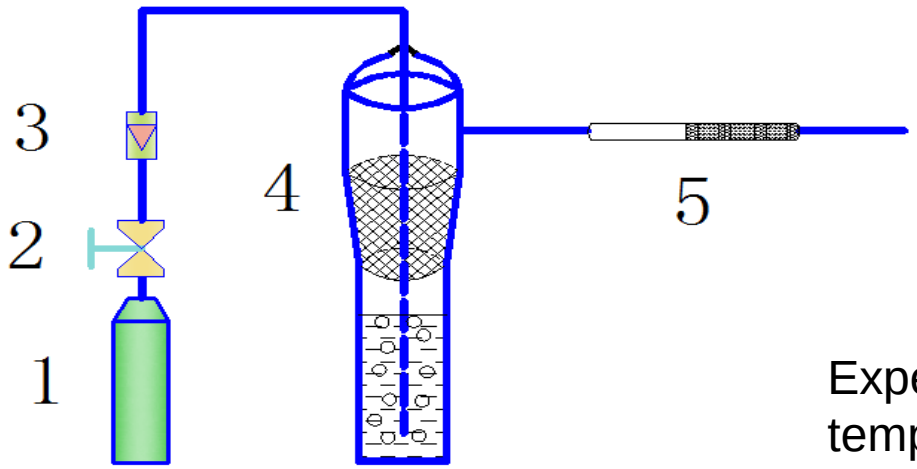
Existing Modified AC sorbents' problems

- High operation cost
- Influence of fly ash subsequent use

Research contents:

- Development of efficient and low-cost sorbent
- Packaged technology

Adsorption tube



1.Gas cylinder
2. Pressure relief valve
3. Rotor flow meter
4.Hg generator
5. Adsorption tube(30B)

Experimental temperature :The room temperature

Particle size of fly ash :200-300 mesh

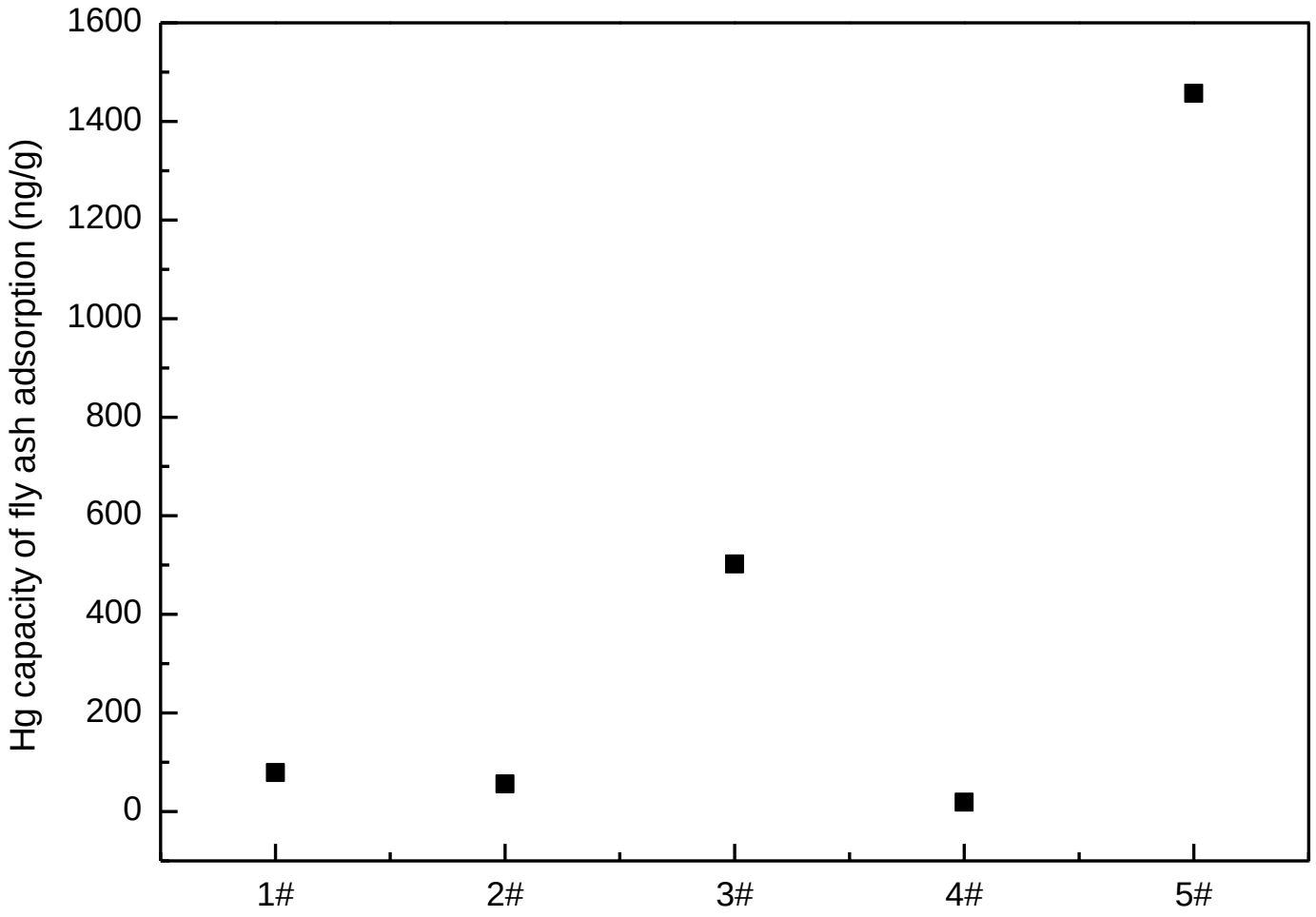
The carrier gas flow rate :50ml/min

The adsorption time :30min

Filling 3 segment of fly ash into adsorption tube, each segment 0.1g

Adding a certain amount of mercury standard solution in mercury generator and stannous chloride solution

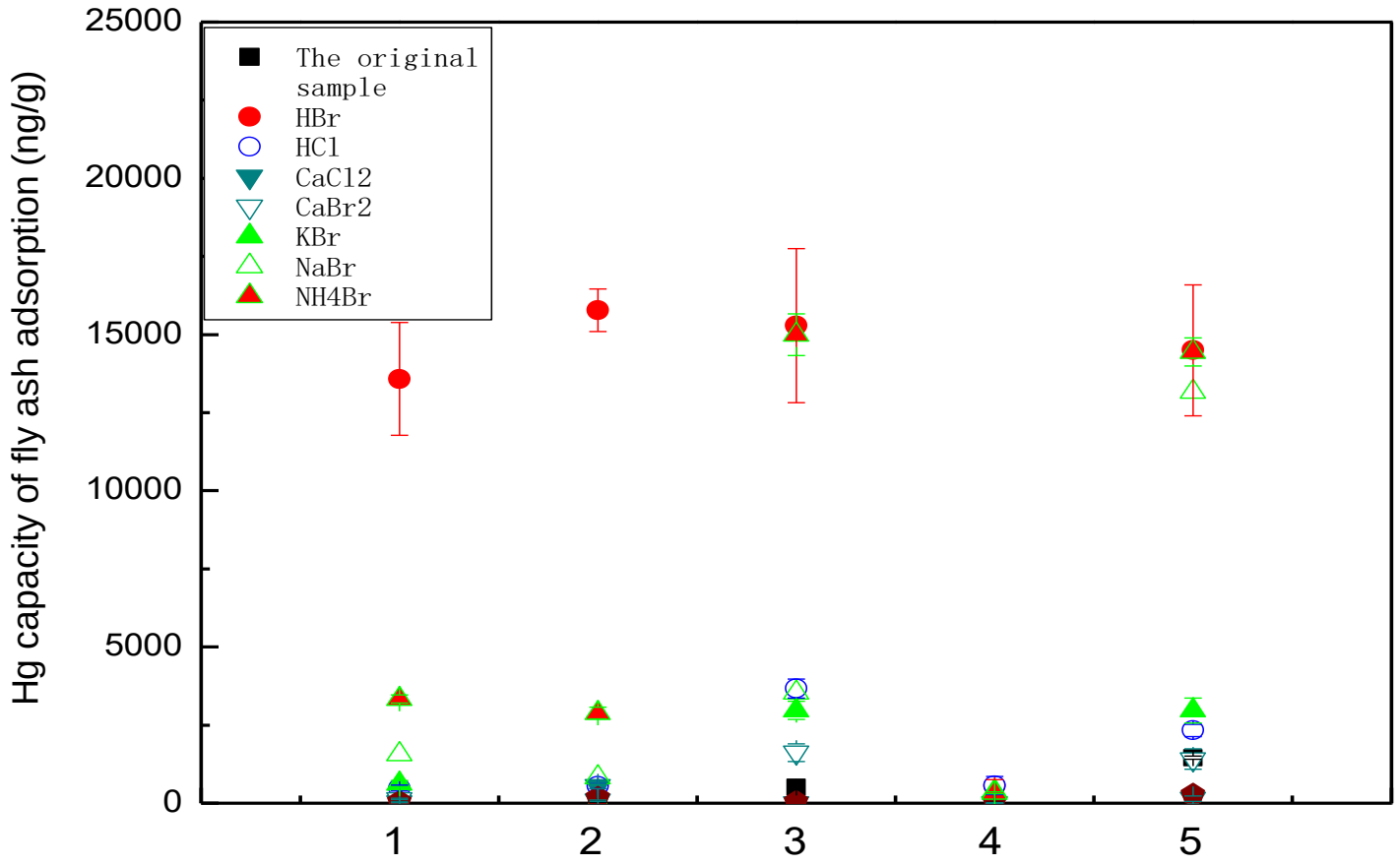
Hg adsorption capacity of fly ash



1. PC Blended coal A 2. PC Bituminous coal

3. CFB Blended coal 4. PC Blended coal B 5.PC Blended coal C

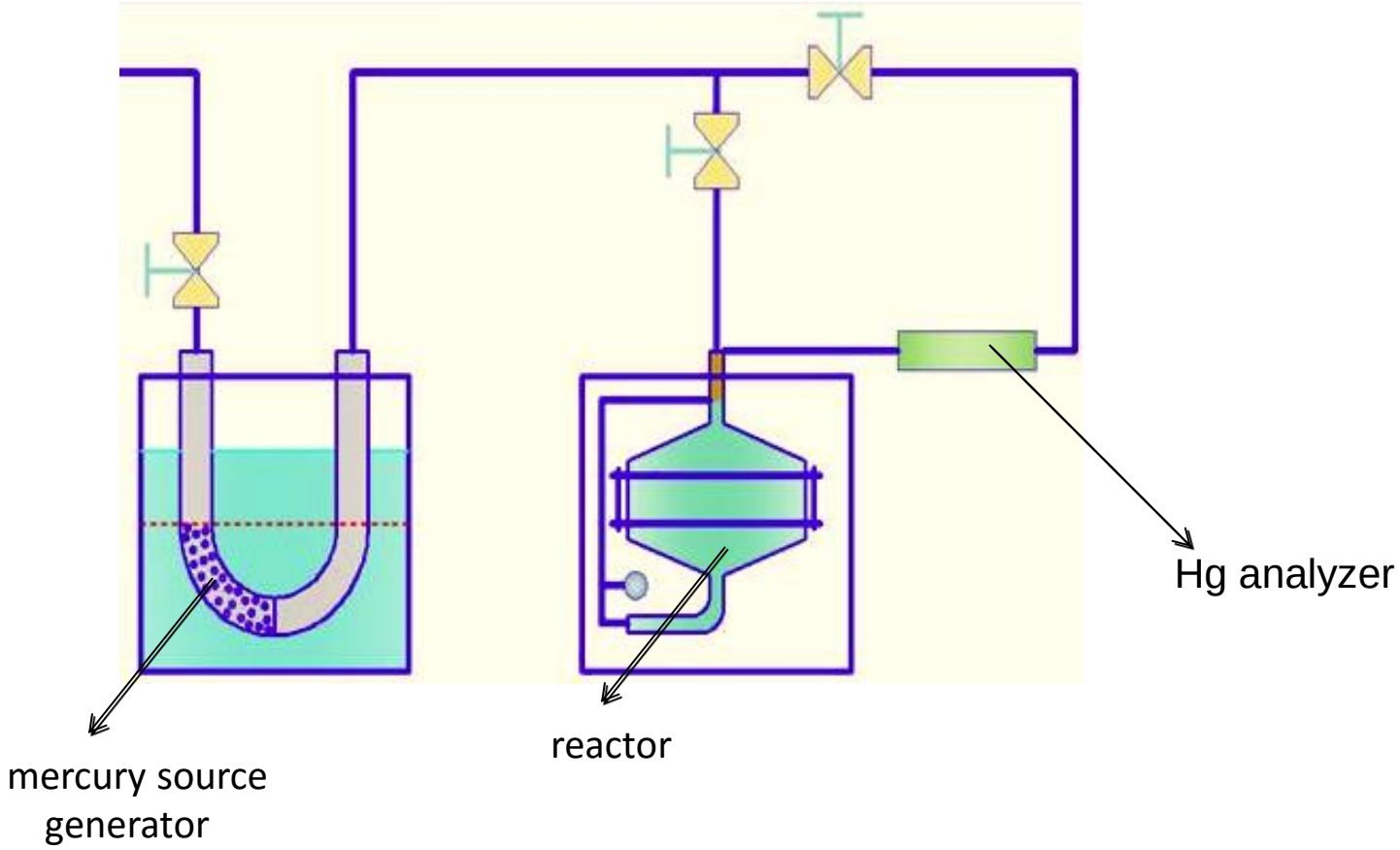
Hg adsorption capacity of modified fly ash



1. PC Blended coal A 2. PC Bituminous coal

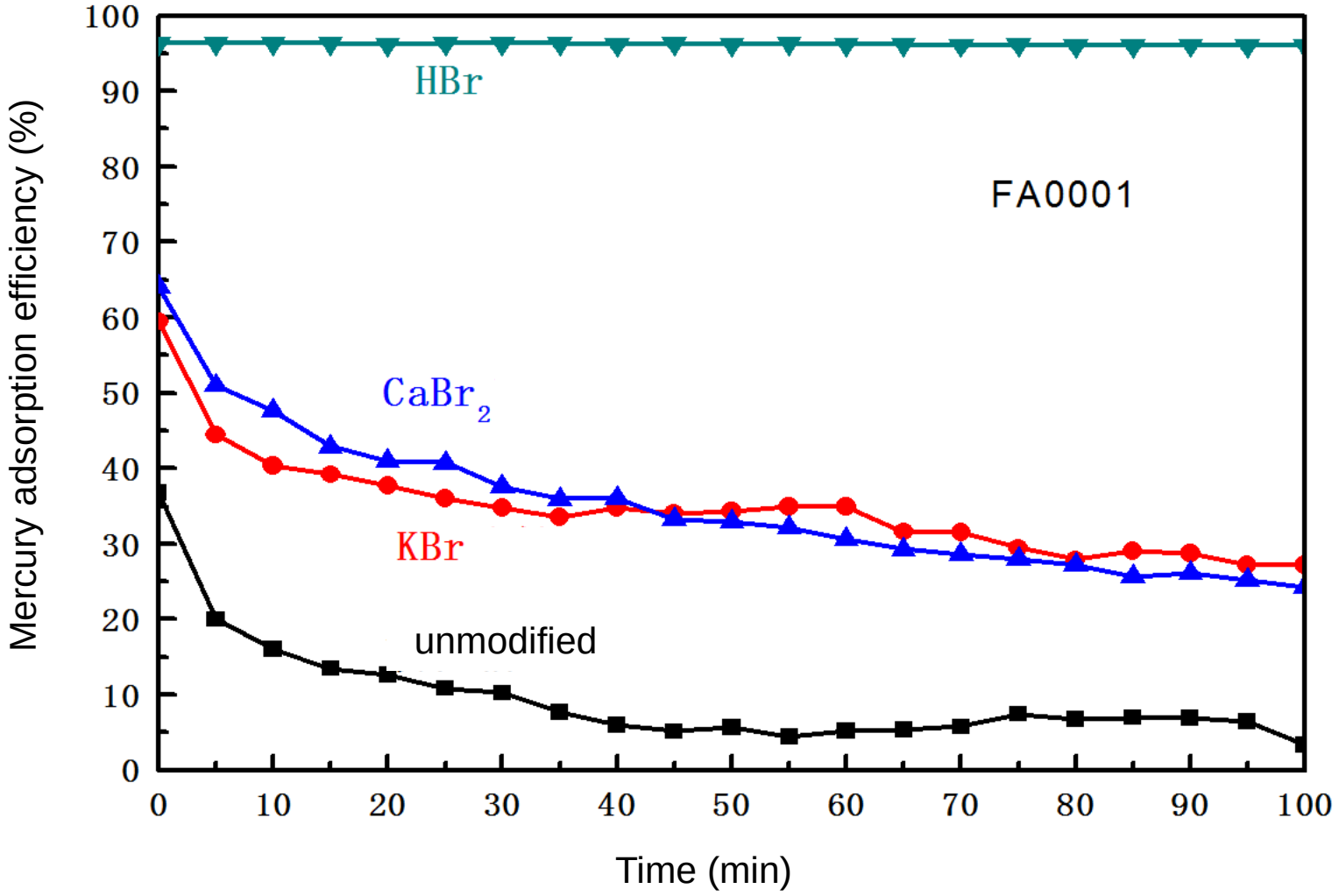
3. CFB Blended coal 4. PC Blended coal B 5.PC Blended coal C

Fixed bed

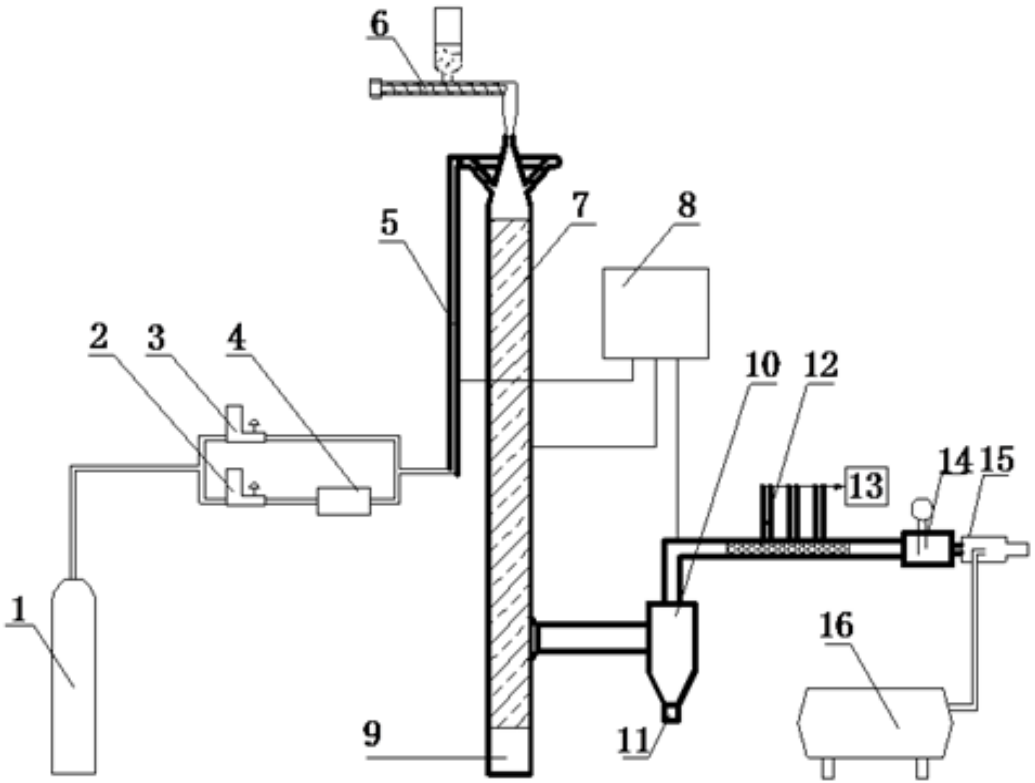


Fixed bed experiment for mercury removal efficiency

Hg adsorption efficiency of different bromide modified fly ash



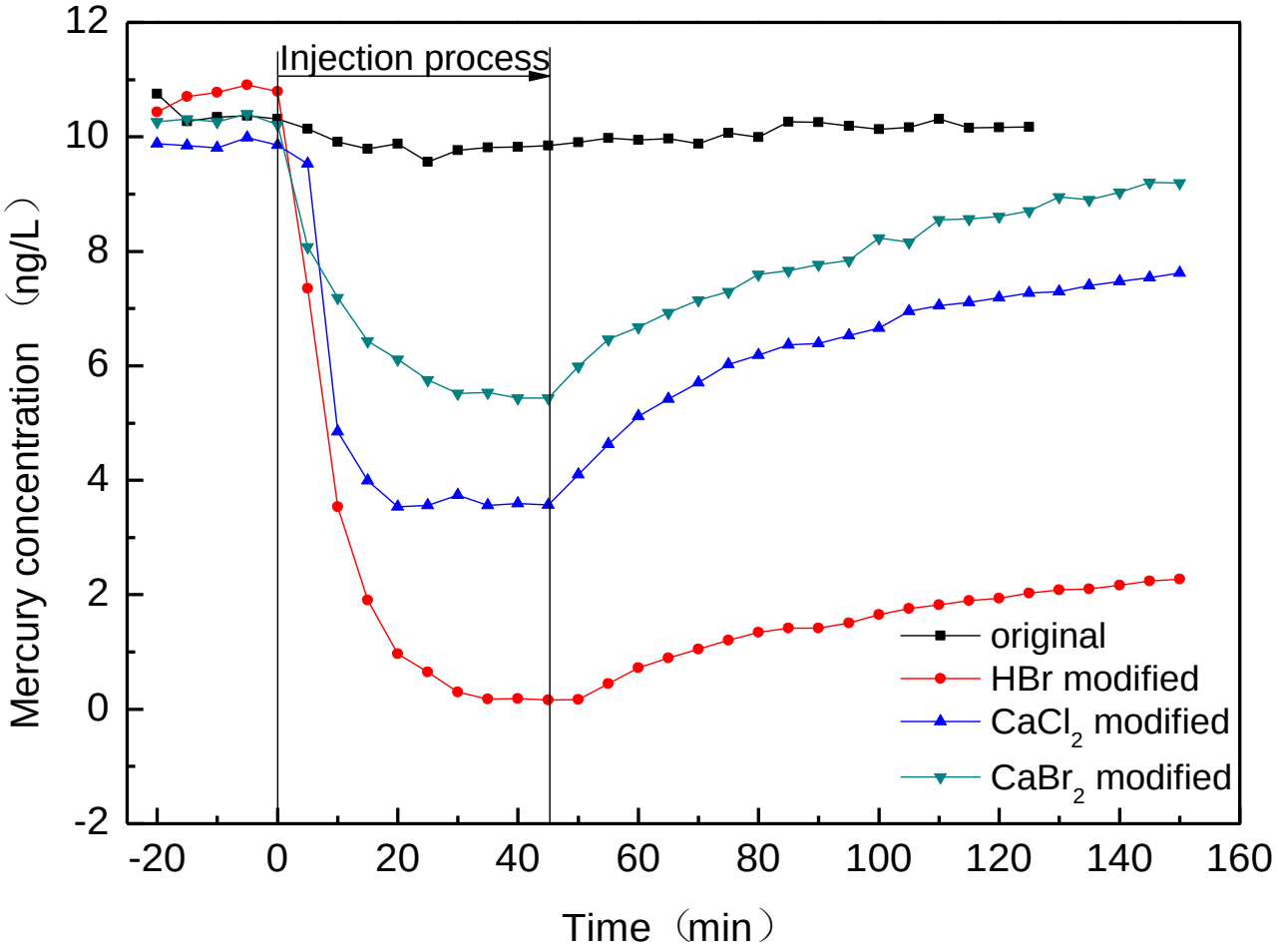
Entrained-flow reactor



1. Flue gas 2. MFC1 3.MFC2 4.Mercury vapor generator 5. Preheater 6.Spiral feeder 7. Reactor tube 8. temperature controller 9.Coarse ash vessel 10. Cyclone 11. Fine ash vessel 12. Filter medium 13.CEM analyzer 14. Flowmeter 15.Ejector 16.Compressor

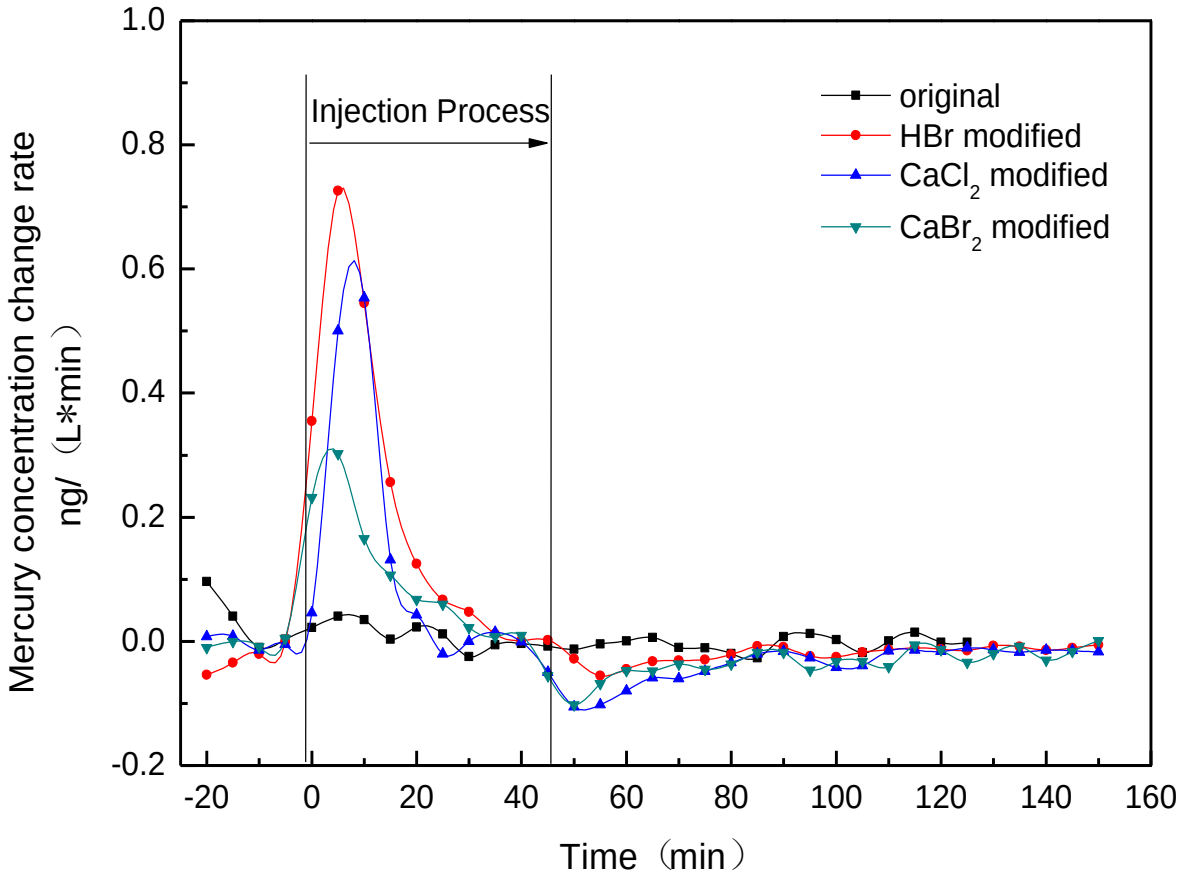
Entrained-flow Reactor

Hg adsorption efficiency of different modifiers



The mercury adsorption efficiency of HBr modified fly ash is best

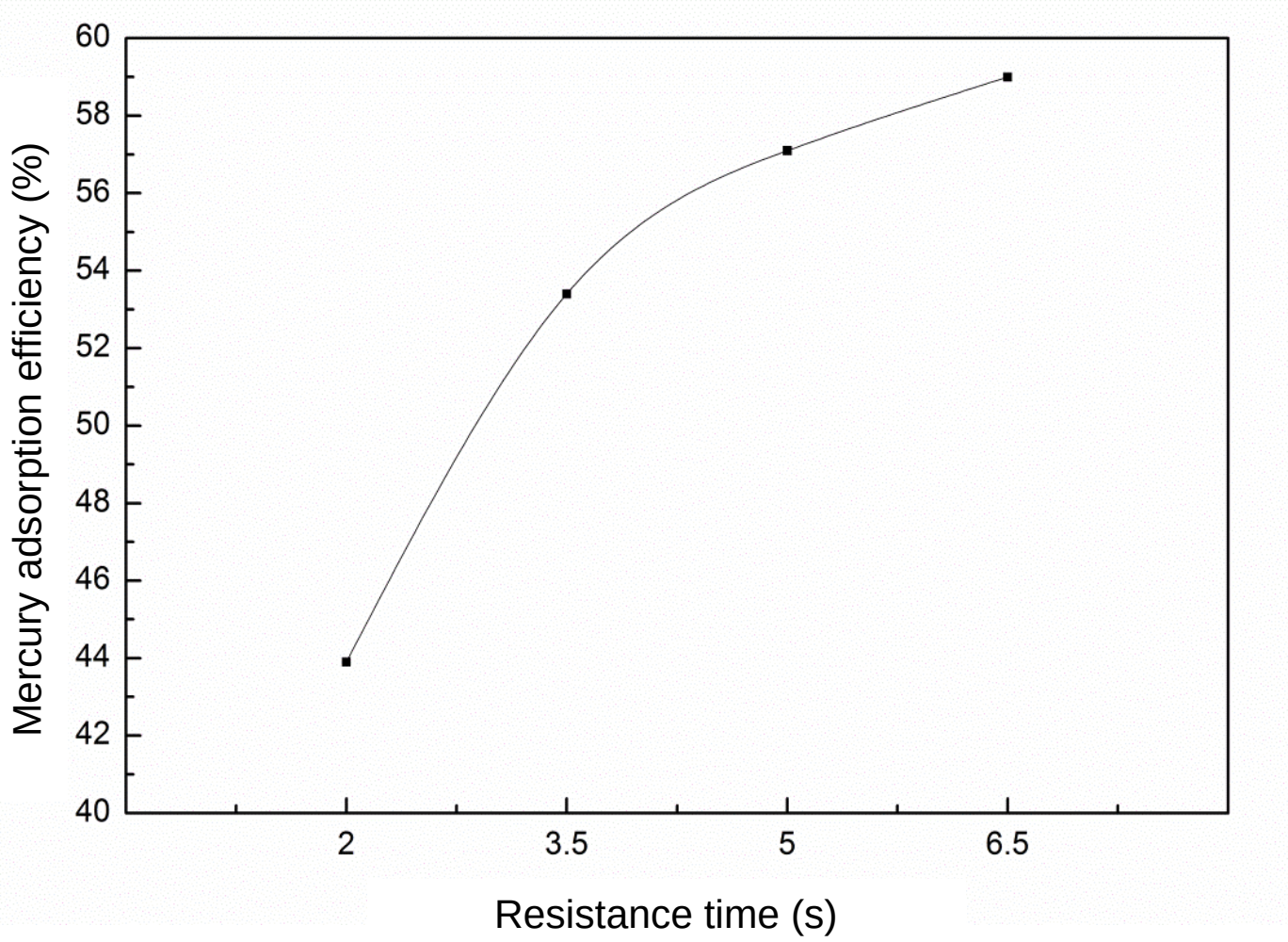
Hg adsorption rate of different modifiers



➢The first derivative of the adsorption concentration was used to calculate the adsorption rate of different adsorbents.

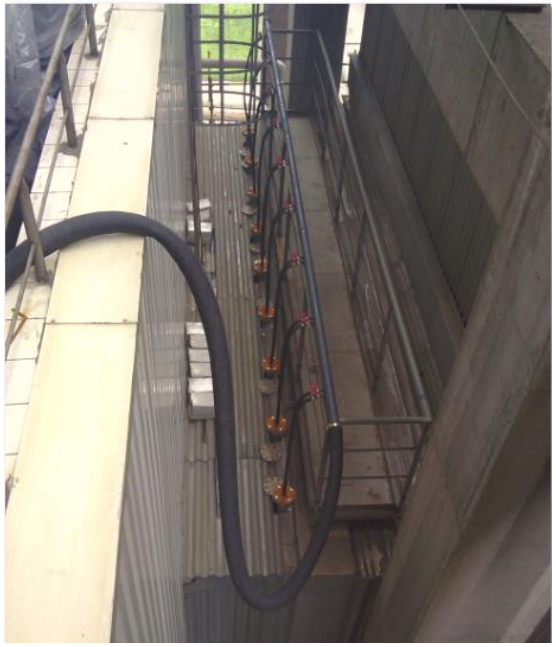
➢The peak size can more accurately evaluate their adsorption properties.

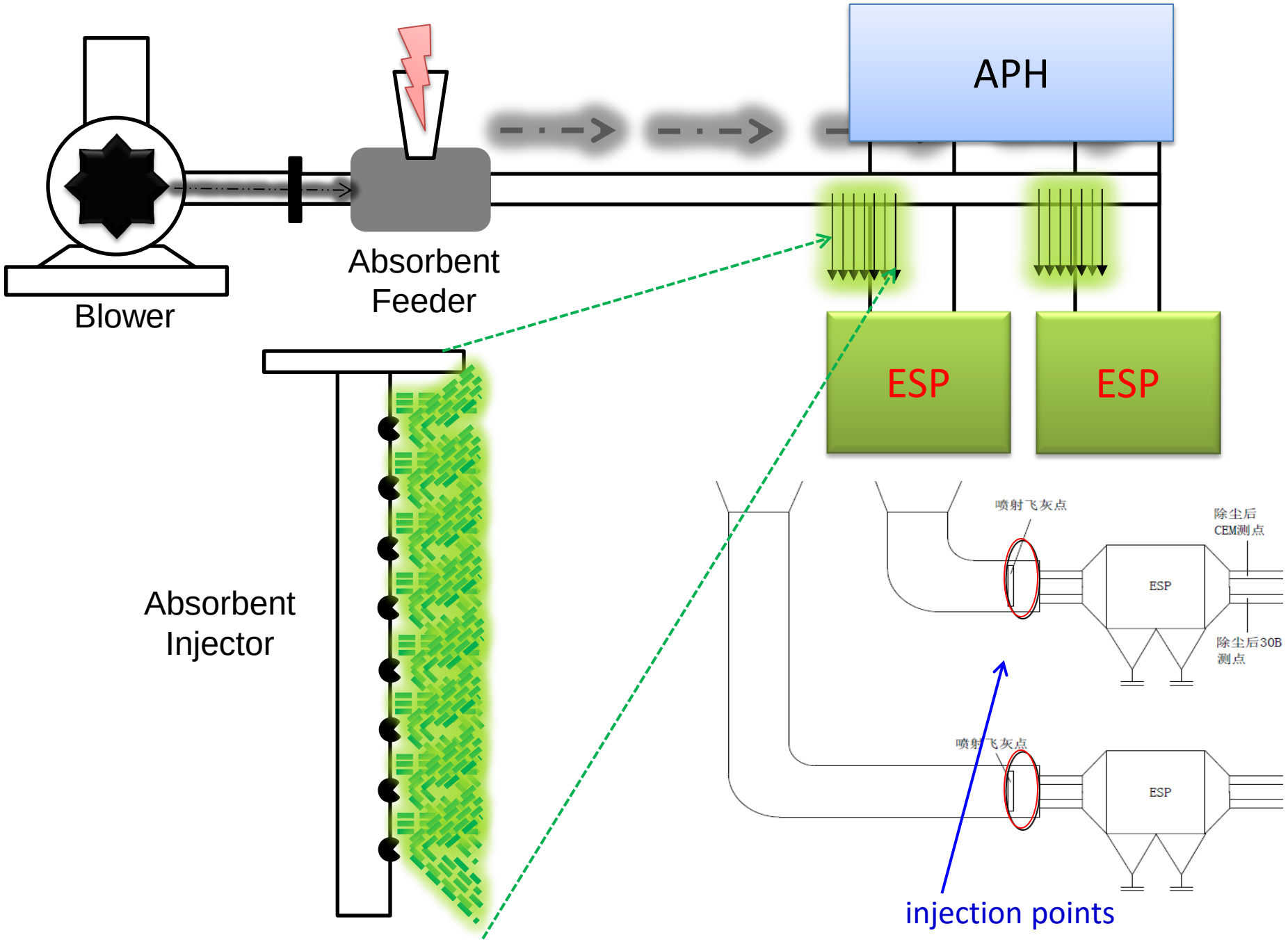
Effects of the resistance time



Field injection experiment in 300MW power plant

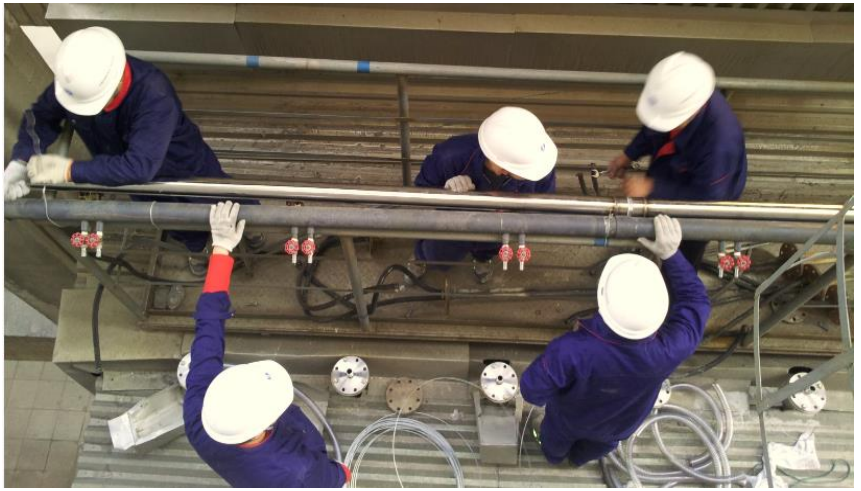
- Field injection and adsorption experiment on mercury pollution control has been executed in 300MW PC boiler.
- The mercury concentration of the flue gas decreased 30% due to the adsorption. Considering the APCD, comprehensive removal efficiency reached 75~90%.




APH
Blower
Absorbent
Feeder
ESP
ESP
Absorbent
Injector
喷射飞灰点
除尘后
CEM测点
ESP
除尘后30B
测点
喷射飞灰点
ESP
injection points







Experiment field of controlling mercury emissions

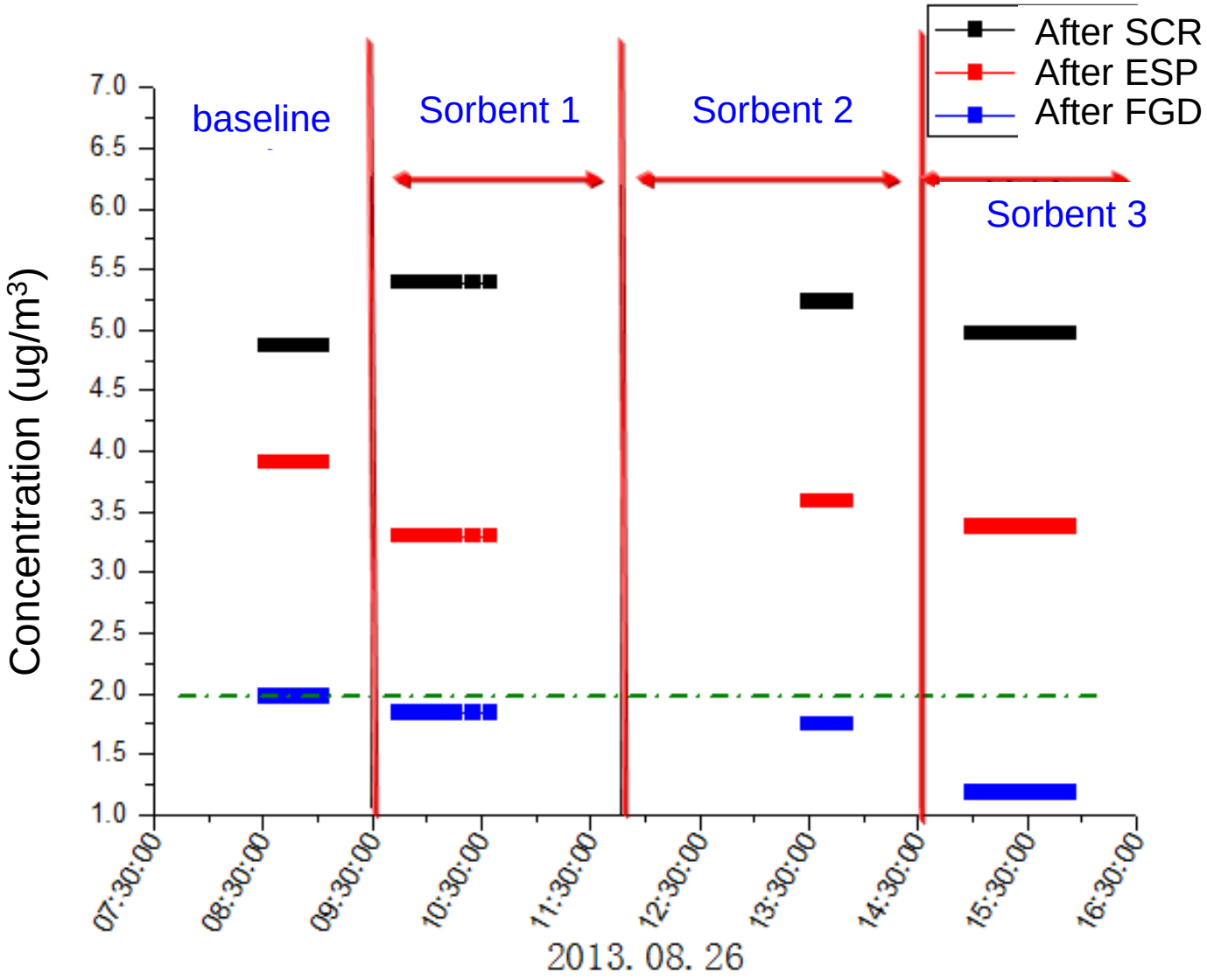
based fly ash sorbent injection technology

Measurement of mercury concentration in the flue

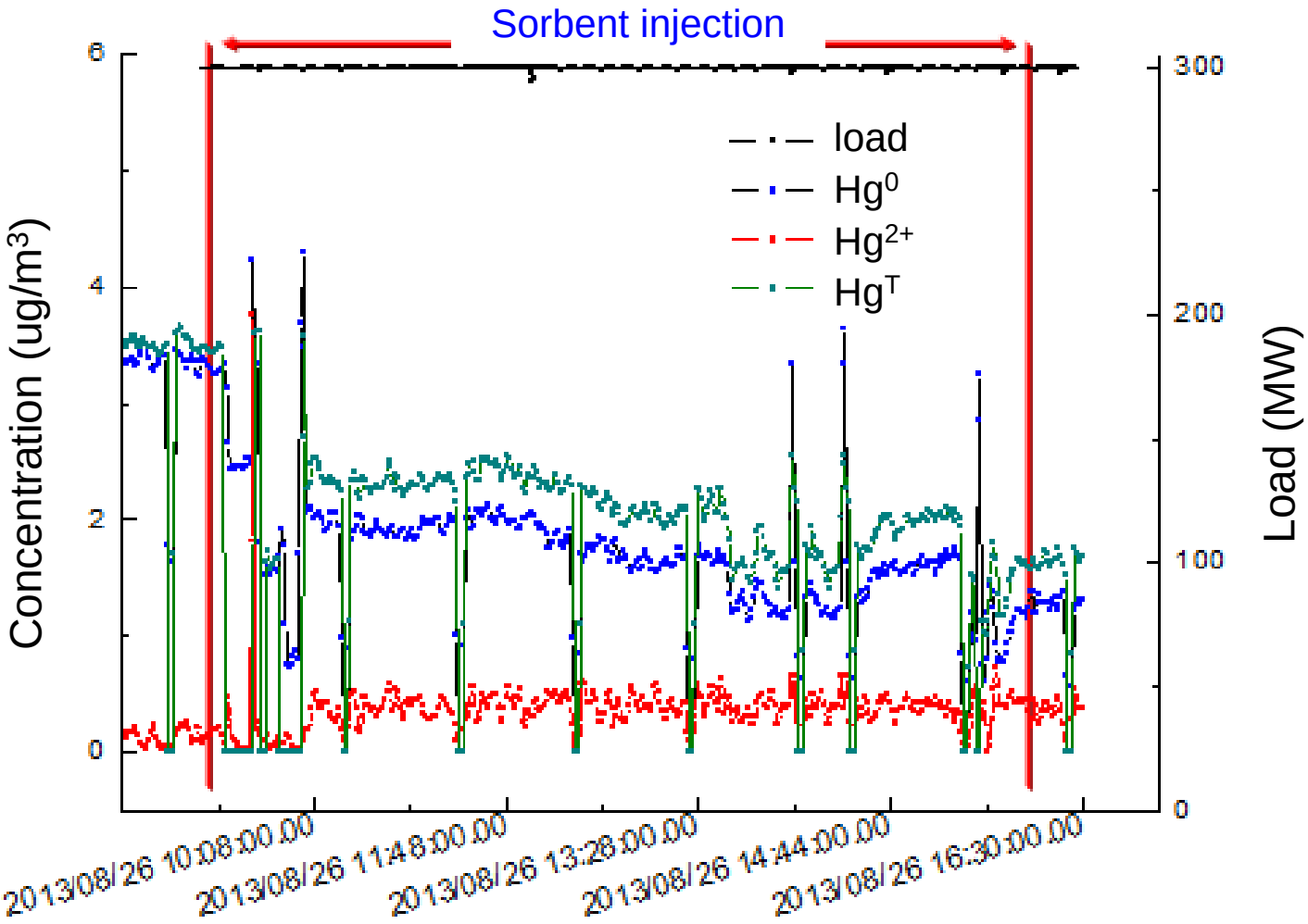
- Method 30B: On-line sampling, off-line analysis. Calculation the average over a period of time. Then got the concentration of total mercury in the flue gas. The results are relatively accurate.

- Method CEMS： On-line sampling and analysis. Concentrations of Hg^0 , Hg^{2+} and Hg^T in the flue gas can be displayed on the PC. The results are relatively quick.

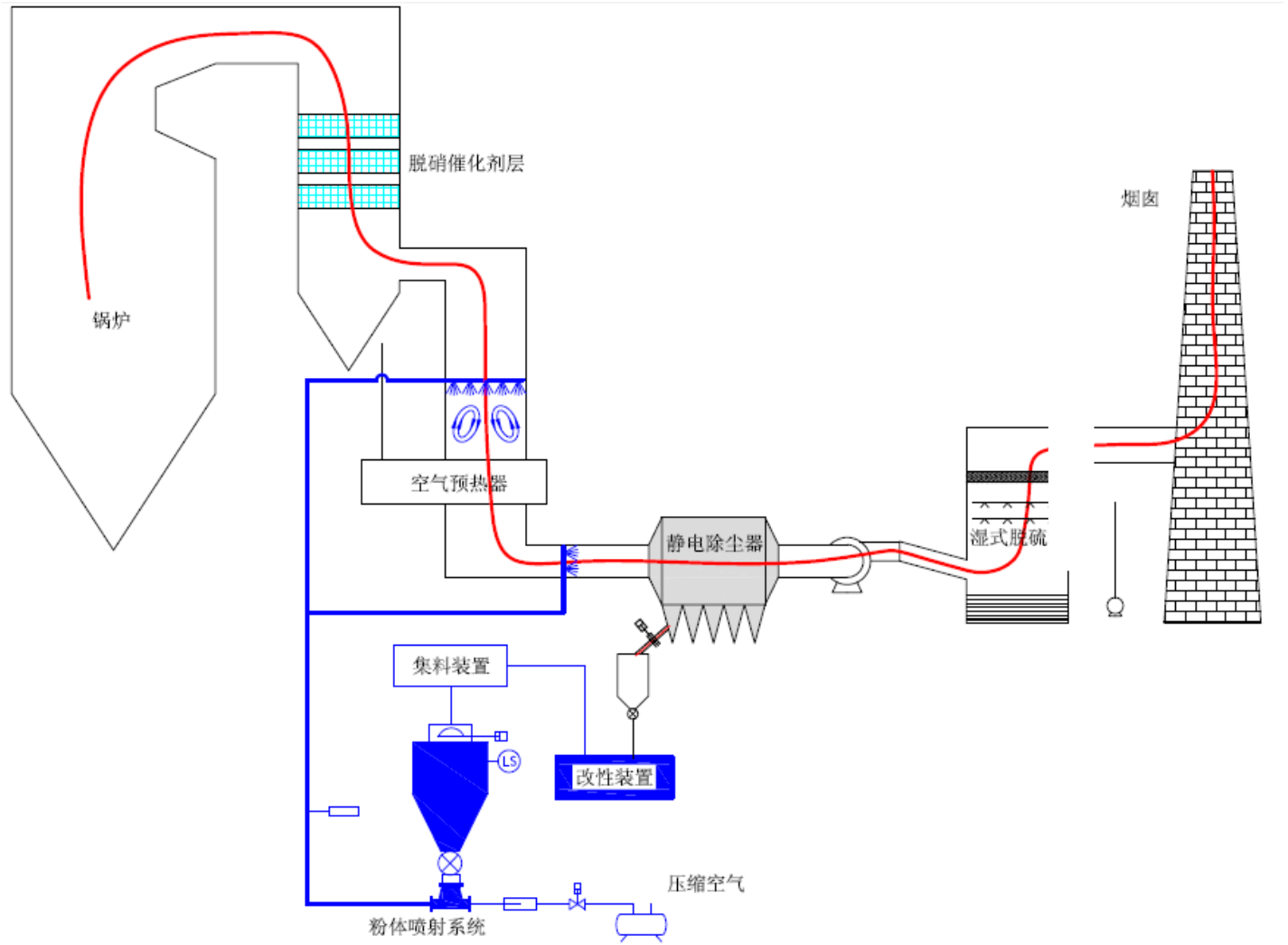
Results of field experiment (30B)



Results of field experiment (CEMS)



Integrated modification and injection mercury removal system



Construction

Conclusions

- mercury concentration in the flue gas has variability between 0.19 and 11.30 ug/Nm^3 for focused power plants.
- Joint removal mercury efficiency for existing equipment is not stable and difficult to meet the future control target.
- According to the mercury adsorption efficiency, the bromide modified fly ash is a better choice.
- With the injection of modified fly ash, the mercury concentration of the flue gas decreased 30% due to the adsorption. Considering the APCD, comprehensive removal efficiency reached 75~90%.

Thanks!