APPLICATION OF WET TYPE ELECTROSTATIC PRECIPITATOR FOR UTILITIES' COAL-FIRED BOILER

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ABSTRACT

Many new coal-fired power plants in Japan are using imported coals, which have a wide range of ash characteristics. The conventional flue gas cleaning system can only limit the dust emissions to about 30 mg/m^{3}N. Yet coal-fired power plants near large cities are required to reach emissions similar to oil-fired units, which are below 10 mg/m^{3}N, an almost invisible stack.
To handle this need, Mitsubishi Heavy Industries, Ltd. (MHI) designed a total flue gas treatment system which consists of dry ESP, FGD and wet ESP. The advantages of the wet ESP are 1) dust is not reentrained,2) dust resistivity is not a factor, and 3) dust build-up on electrodes is not a problem. Furthermore, wet ESP has the advantage of being able to collect SO_3 mists and sub-micron size particles effectively. We have already delivered more than 10 wet ESPs for boiler flue gas, in addition to many wet ESPs supplied to steel, gas and chemical industries.
Here, we will describe recent application of the wet type Electrostatic Precipitator for utility coal-fired boiler plants.

INTRODUCTION

Electrostatic Precipitator (ESP) used for boiler flue gas treatment is usually so called "dry ESP". On the other hand "wet ESP" has been also used widely in the field of the iron and steel industry, gas industry, and chemical plant etc.

Since wet ESP has some advantages over dry ESP, we took these advantages and adopted them for boiler flue gas.

In utility coal-fired power plants in Japan, although dry ESP and wet type flue gas desulfurization system (FGD) has been used and 20 to 30 mg/m^3N of dust emission are achieved nowadays, recently these figures tend to be reduced further.

The background of the above-mentioned requirement comes from the idea to control emission level in the specified area when a new power station is installed, to attain the same emission level as in current oil-fired power plants, or to give a good impression to coal-fired power plant by achieving almost invisible stack.

For this purpose, the reliable method at present can be considered to install wet ESP downstream of FGD system, which has been developed and improved by Mitsubishi. We have more than 10 years' experience in improving and operating these actual system and the reliability of those systems is already reached to an enough level to apply even for the large-scale power plant.

We would like to introduce here the outlines of features and structure of wet ESP, our progressive development, improvement and application results for large-scale coal-fired power plant.

Principle and Features of Wet ESP

Table 1 shows the general comparison between wet ESP and dry ESP. Although dust collection mechanism of wet ESP is same as that of dry ESP, the collected dust is removed by hammering on dry ESP, while on wet ESP electrodes are washed by water and dust is discharged as slurry. As results of these differences, there are following advantages and problems on wet ESP.

<u>Advantages</u>

(1) Collecting performance independent of dust resistivity
(2) No dust reentrainment makes it possible to achieve lowest outlet dust concentration.
(3) High reliability from no moving parts such as hammering device.
(4) Compact arrangement is available since higher inside gas velocity in ESP is applied and hopper angle is reduced.
(5) Effective collection for sub-micron size particles including SO_3 mist and infinitesimal materials.

Problems (Precautions)

*(1) It is necessary to reduce gas temperature below water saturated temperature.
*(2) It is hard to use wet ESP under high SOx concentration gas condition.
*(3) It is hard to use it in high dust concentration.
*(4) It is necessary to install waste water treatment apparatus.
(5) It is necessary to take good corrosion protection.

However, if installed at the FGD system outlet, those problems marked "*" can be solved.

STRUCTURE OF WET ESP

Casing

Fig. 1 shows a basic structure of wet ESP.
Casing is usually made of normal steel of which inner surface is lined with flaking to protect from corrosion.
Corrosion is preserved by mean of using stainless steel for internal parts material like as electrodes, and by pH control of washing water.
Thermal insulation of outer casing is not necessary, since there is almost no gas temperature drop because of the low gas temperature below the water saturated condition.

Electrode

Collecting electrode of wet ESP has a flat shape to obtain good characteristics in water film formation.
Special precautions are required for discharge electrode, since troubles on wire breaking is easily apt to occur in wet ESP in which local corrosion is progressed.
The dust treated in wet ESP consists of the fine dust and sulfuric acid mist which can not be collected at dry ESP and FGD. Relatively high inside gas velocity as well as the above mentioned dust cause high space charge effect, so that it is need to have some measures to prevent electric current shortage. As for this measure, we adopt the discharge electrode with long spikes to ensure enough electric current.

Water Washing

If the dust adhered on collecting electrode and dishcarge electrode is not satisfactorily washed out, charging problem such as operating voltage drop or electric current shortage and local corrosion problem happen. To prevent these problem, enough cleaning is necessary. Atomizer nozzles are arranged on the top of the electrode to keep it clean at all times.
Washing water used in wet ESP is recirculated in order to save the water consumption so that a small amount of fresh water is made up.
For such a purpose, suspended solution concentration of circulated water and pH are controlled within the appropriate range that is free from pipelines' and nozzles' blockage.

The fresh water is added only on the last field of ESP to prevent splashing contaminated water into clean gas.
Fig. 2 shows the flow diagram of wet ESP.

APPLICATION OF WET ESP FOR BOILER FLUE GAS TREATMENT

Problems to be Solved

Wet ESP has been used mainly in iron and steel industry, and we have many experiences to supply for this industry. However, there was almost no case in the world using wet ESP downstreams of FGD system for boiler flue gas treatment, so that we concluded that following problems should be made clear and their measures should be established.

(1) The collection characteristics for dust and SO_3 mist should be clearly grasped.
(2) The optimum electrode structure should be developed to keep high collecting performance.
(3) Corrosion by SO_2 gas and SO_3 mist should be prevented.
(4) Washing method and waste water treatment systems should be established.
(5) Discharge electrode breakage should be prevented.

Application for oil - fired boiler

Of the sulfur oxides exhausted from boiler plant firing fuels such as heavy and crude oil, SO_2 can be efficiently removed in FGD system, but SO_3 which is converted from SO_2 , exists in fine mist particles and it can not be removed in FGD system. When it is discharged from the stack, it floats in the sky as bluish smoke and causes visible pollution.
Even if the flue gas once humidified and cooled through FGD is reheated at the stack entrance, much SO_3 mist still remains and the acid dew point of flue gas is high. Accordingly the bluish smoke cannot be eliminated unless heated up more than the acid dew point temperature. To solve such problems, by installing the wet ESP at the downstream side of FGD and removing SO_3 mist, it has become possible to prevent drift of bluish smoke and reduce the reheating cost.
We conducted the pilot ESP test before actual plant experiments, since gas characteristics to be treated might be different from the type of boiler and FGD system.
We could obtain the quantitative data as well as design concepts for planning actual plant through these tests.
Since the first set of wet ESP applied for a oil - fired boiler plant was put in operation in 1975, it has been widely used, and typical plant example applied is shown in Table 2.

Application for Utilities Coal - fired Power Plant

Verification test in pilot plant

At the begining of construction of new power plants firing imported coals in Japan, various verification tests in pilot plant were conducted jointly

with some electric power companies in order to prove applicability in various kinds of coals and reliability of each component equipment, and to establish optimum flue gas treatment system. As a part of the system, the wet ESP was also incorporated into the varification tests.
Throughout these tests, the prospect of wet ESP application for coal-fired power plant had been achieved.
The outline of the principal joint research projects is shown in Table 3.

Application to Utilities Coal-fired Power Plant

Although large scale power plants using overseas coal have been continuously constructed in Japan, environmental issues are so widely realized that strict measures are demanded for environmental protection.
Especially in plant in the suburb area of large cities, high performance flue gas treatment system is required which can suppress to almost invisible smoke emissions.
This system consists of wet ESP and non-leakage type gas-gas heater (GGH) along with dry ESP and FGD, and low emission not more than 10 mg/m^3N can be attained.
As wet ESP to be adopted on this system makes no dust reentrainment and is not affected from electric dust resistivity even on the coal-fired power plant, it is the most reliable way to achieve the lower emission level as a part of the total flue gas treatment system. Actual plant have been already operated in a large scale coal fired power plant.
One of this system was applied to Tokyo Electric Power Co., Yokosuka unit 1(265MW) which has been satisfactorily operated from commercial operation start on February in 1985.
This system was also adopted to Chubu Electric Power Co., Hekinan Unit 1, 2 and 3 (700MW ×3), of which Unit 1 and 2 started operation in 1991 and 1992 respectively, and Unit 3 is on a trial run. All of them are satisfactorily operating with good performance.
Table 4 shows the outlines of the design specification of both plants.
Fig. 3 shows entire view photograph for Hekinan.

APPROACH TO ADVANCED WET ESP

As the need for wet ESP is mounting, to attain the ultimate compactness of wet ESP, we developed and put in use "High Velocity Wet ESP (HV-WEP)" for the first time in the world, featuring the maximum treating gas flow velocity of 10 m/s, that is, about five times faster than the conventional wet ESP. As a result, it is possible to build it in the duct after FGD, and to save the area for installation remarkably.
In 1992, the first set was installed in the duct at the downstream side of FGD for oil cokes fired boiler plant, and it is exhibiting steadily its good performance as SO_3 mist collecting equipment.
Henceforth we are putting efforts in the development of larger-scale "HV-WEP" for use in utility power plants.

CONCLUSION

We have practically used wet ESP for large scale coal - fired power plant through our developing in wet ESP for boiler flue gas based on the actual long - time results on the application of wet ESP to many fields.

We are expecting that wet ESP, which can meet the necessity for low particulate emission, would be widely applied so far as the requirement are more strict for the environmental pollution.

Under these circumstances, we are planning to continue further efforts to cope with the development and improvement including the advanced technology for the wet ESP.

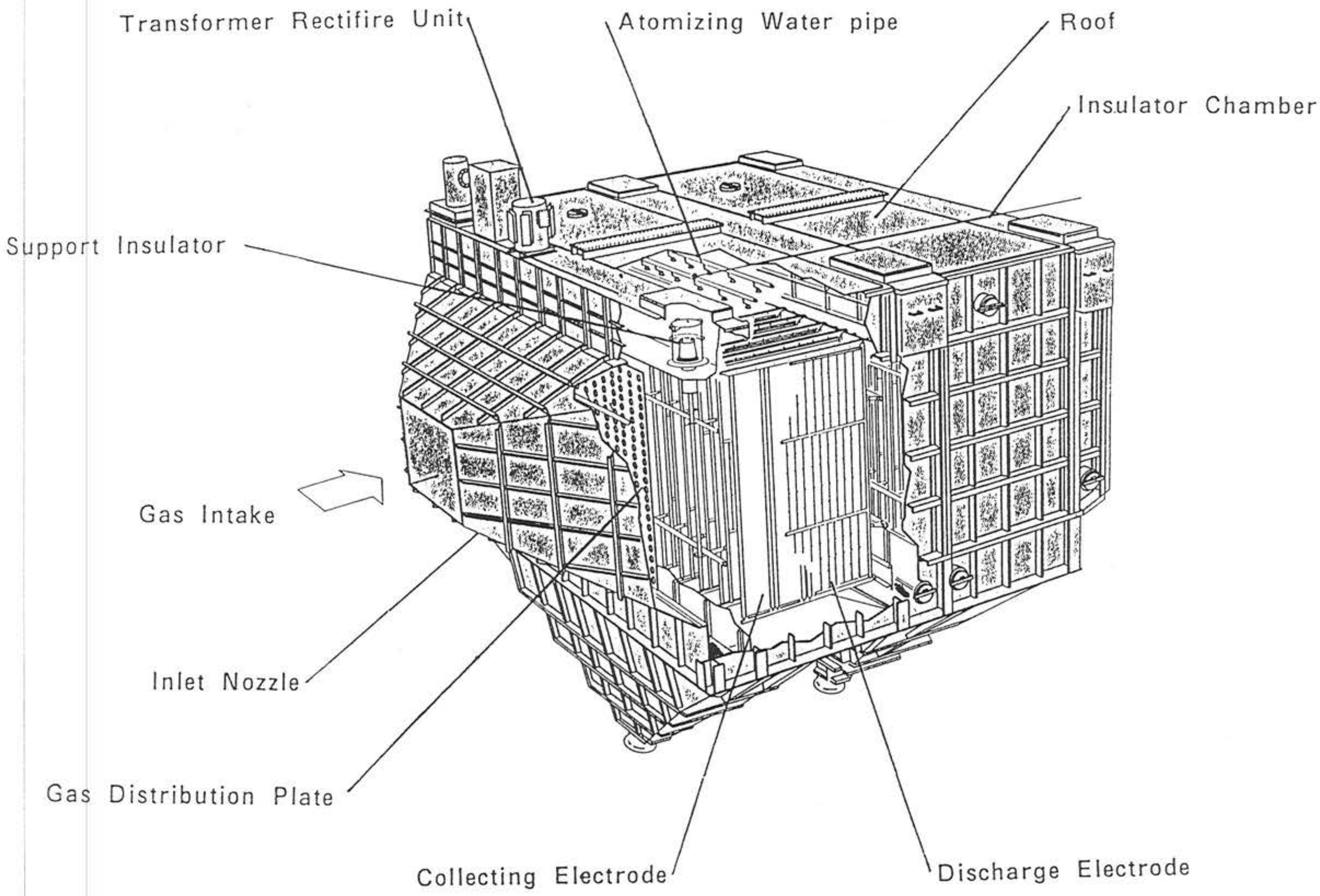


Fig. 1 Structure of Wet ESP

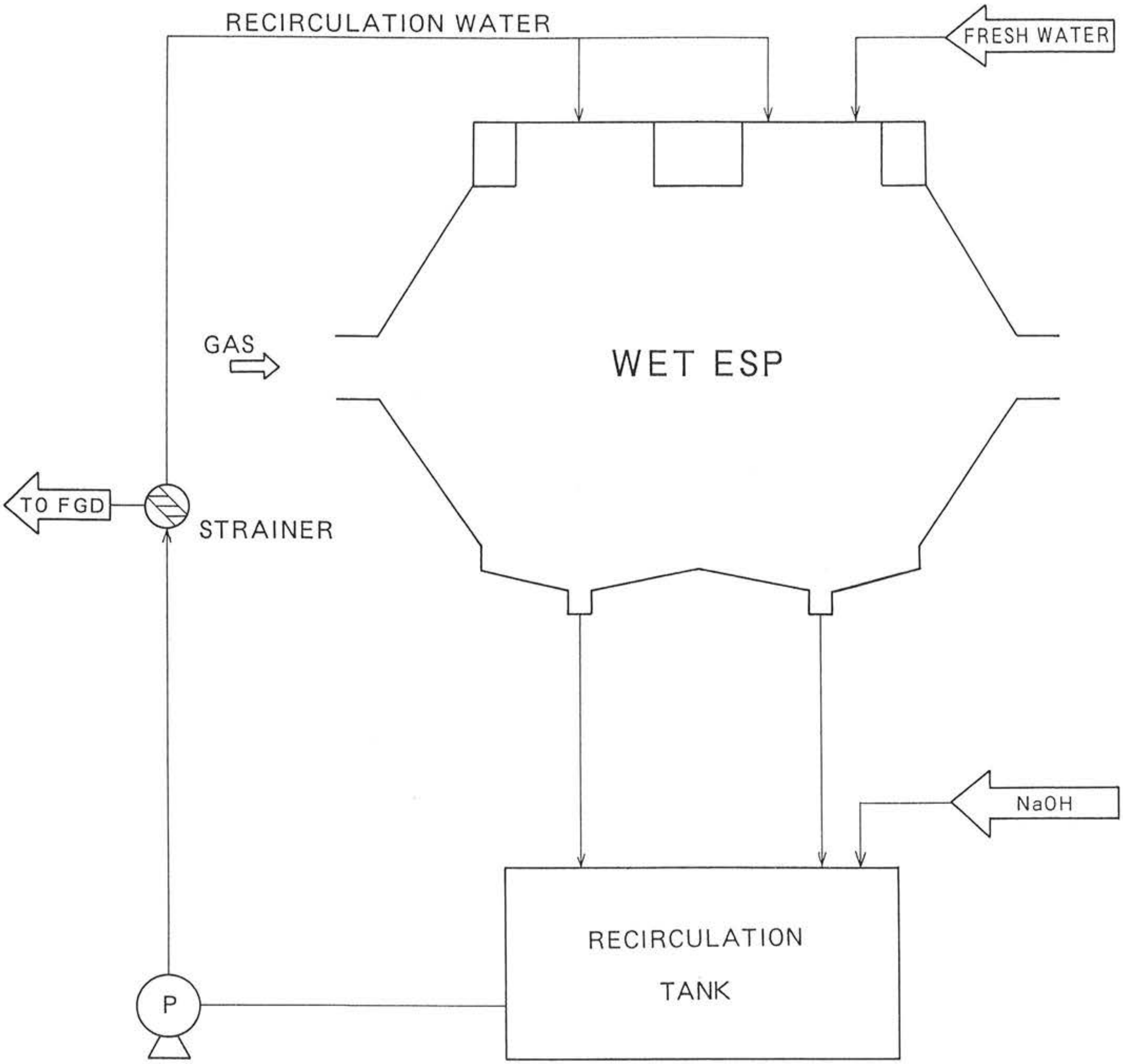
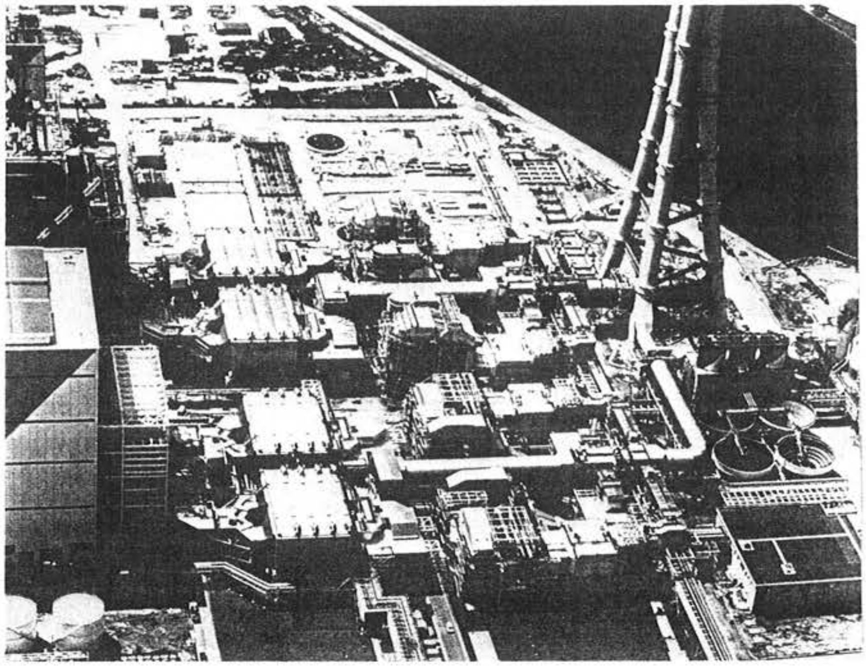
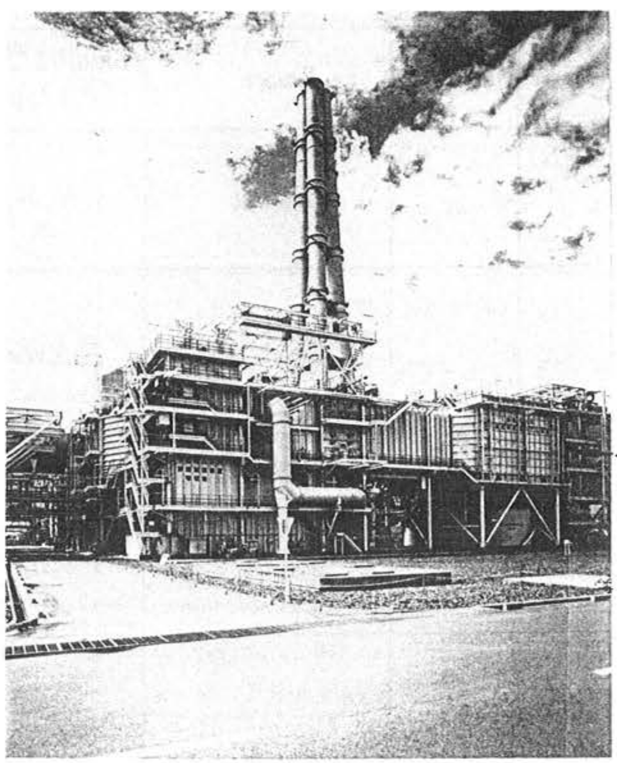


Fig.2 FLOW DIAGRAM OF WET ESP



Flue Gas Treatment System



Wet ESP

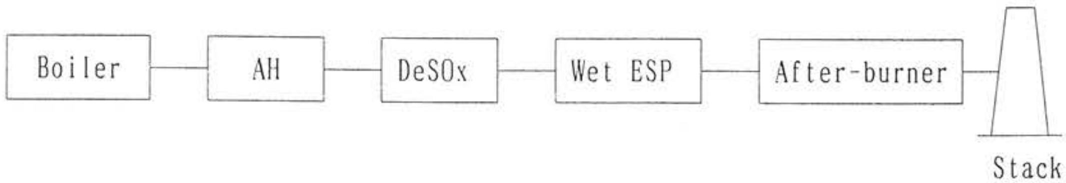
Fig. 3 View Photograph of Hekinan Power Station

Table 1 Comparison between dry ESP and wet ESP

	Items		Units	dry ESP	wet ESP	Remark
Dust collection principle	Dust collection mechanism			Corona discharge -colomb force	same as left	
	Removal of dust on electrode			hammering	washing	
	Disposal of collected dust			dry (mechanical or vacuum)	washing water	
Utilize limitatation	Gas temperature	Below saturation point		inapplicable	applicable	
		Above saturation point		applicable (+10~20℃)	※inapplicable	※pre-cooling is necessary
	Electric Resistivity of Dust		Ω-cm	$(+10^4 \sim 10^{12})$	Not limited	
	Dust concentration limit at outlet		mg/m^3N	5~ 20	Practical even under 1	
	SO^2 concentration limit		ppm	Not limited	less than 100 (~ 200)	
Other general comparison	Dust collection Area			Large	Small(1/2~1/3) of dry type)	
	Moving parts			Existing	※ Non	※Less mechanical troubles
	Seal off performance			Good	※ Excellent	※Good for noxious or explosive gas
	Water treatment facilities			Not need	※ Need	※Not need if using blow water in DeSOx system
	Life time			Base	Comparable long life with dry type with proper operation control	

Table 2 Application example of Wet ESP for industrial oil-fired boiler

Flow



Design Condition

Fuel	Heavy oil
Gas volume	350,000 $m^3N/h \cdot wet$
Gas temperature	60 ℃
Inlet dust burden	200 $mg/m^3N \cdot dry$ (boiler soot 90 $mg/m^3N \cdot dry$, SO_3 mist 110 mg/m^3N)
Outlet dust burden	20 $mg/m^3N \cdot dry$
Collecting efficiency	90 %

Table 3 Principal Joint Research Project of Flue Gas Treatment System for Utilities Coal-fired Power Plant

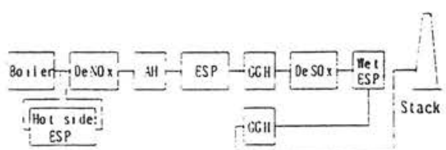
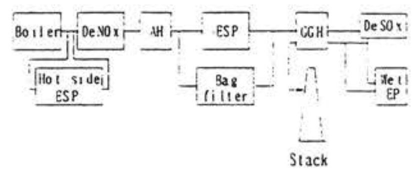
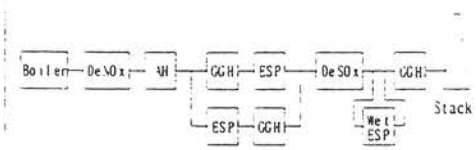
Project Name	TTJM P/J	WH P/J	CCT P/J
Participation Company	Tokyo Electric Power, Tohoku Electric Power, Joban Joint Electric Power, Mitsubishi Heavy Industries	Kansai Electric Power, Mitsubishi Heavy Industries	Chubu Electric Power, Mitsubishi Heavy Industries
Schedule	Apr. 1979 ~ Sept. 1980	Oct. 1982 ~ Jun. 1987	Sept. 1988 ~ Jun. 1990
Place	Joban Joint Electric Power Co. Nakoso P/S	Kansai Electric Power Co., Himeji No. 1 P/S	Chubu Electric Power Co., Shin-Nagoya P/S
Main Purpose	Development of total flue gas treatment system	Verification of total flue gas treatment system	Development and verification of Advanced Dust Collecting System
Gsa volume Test coal	4,000 m^3N/h · wet Domestic Coal	170,000 m^3N/h · wet Overseas Coal and domestic Coal (Ten (10) brands)	17,000 m^3N/h · wet Overseas Coal (Seven (7) brands)
System Flow	 Note : GGH is non-leakage type.	 Note : GGH is regenelative rotary type.	 Note : GGH is non-leakage type.

Table 4 Design data of Wet ESP for Utility Coal-fired Boiler

Plant Name	Yokosuka Unit 1 Tokyo Electric Power Co.	Hekinan Unit 1, 2 & 3 Chubu Electric Power Co.
Power Generation (MW)	265	3×700
Fuel	COM (Coal and Oil Mixture)	Coal
Treated gas volume ($m^3N/h \cdot wet$)	935,000	2,500,000
Treated gas temperature (℃)	50	49
Outlet dust burden (mg/m^3N)	not more than 10	not more than 10
Operation start	1985	Unit 1 : 1991 Unit 2 : 1992 Unit 3 : 1993