AQCS EXPERIENCE FOR INDIAN THERMAL POWER PLANTS

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Abstract

There is a growing need for Air Quality Control System (AQCS) under the situation that regulation on emission has become more stringent all over the world.
MHPS has developed and improved the SCR, FGD, ESP and related technologies continuously and provide the robust solutions to the new trends of AQCS technologies for example, Mercury oxidation catalyst, Seawater FGD and Ultra High Efficiency PM removal system, and Moving Electrode Electrostatic Precipitator named MEEP, and Water saving technology on FGD system. As a result, MHPS group has been delivered more than 3000 units of ESP and 300 units of FGD and 1000 units of SCR all over the world and holds the leading market share.

Regulation on emission is applied to existing power plants as well as newly-built power plants. When AQCS is applied to existing power plants, it is necessary to design AQCS with some restrictions, especially limitation of layout area. Space-saving design is one of the key technologies to retrofit AQCS to existing power plants.
MHPS has applied many AQCS to the existing thermal power plants with making the best use of their abundant experiences.
For example, MEEP is suitable not only for newly installation, but also retrofit of existing ESP to reduce dust emission without additional space. Therefore, this useful point has been approved and gotten an order for “Rihand project” is retrofit project in India.

In this paper, MHPS introduces operation and troubleshooting experience for SCR, FGD and ESP technologies.

1.0 INTRODUCTION

With the growing energy demands and installation of more thermal power plants in India has resulted in severe amounts of pollutants namely suspended particulate matter, SO2, and NOx. Coal being low cost fuel among all other fossil fuels, coal will remain as the primary fuel for years to come. There was no control of pollutants like SO2 and NOx from source and only ambient air quality standards were followed. The Ministry of Environment and Forest (MOEF) notification issued in December 2015 has necessitated review of existing technologies and looking for state of art AQCS technologies. It will be a challenging task in the existing thermal power plants owing to space constraints, change in operating conditions, fuel properties and execution of the job in the constrained environment.

This situation was similar to one faced in 1960 when Japan faced problem of severe air pollution and Japan Government stringent air pollutant emission regulation. Mitsubishi Heavy Industries, Ltd. (MHI) and Hitachi, Ltd. (HTC) respectively started the development of FGD and SCR technologies to contribute to activity of cleaning up the air pollution. With the advent of state of Art technology, MHPS provided integrated AQCS technology and retrofitted many thermal power plants to meet most stringent emission level requirements across the world. In this paper, we share our successful experiences in retrofitting of AQCS technology in thermal power plants.

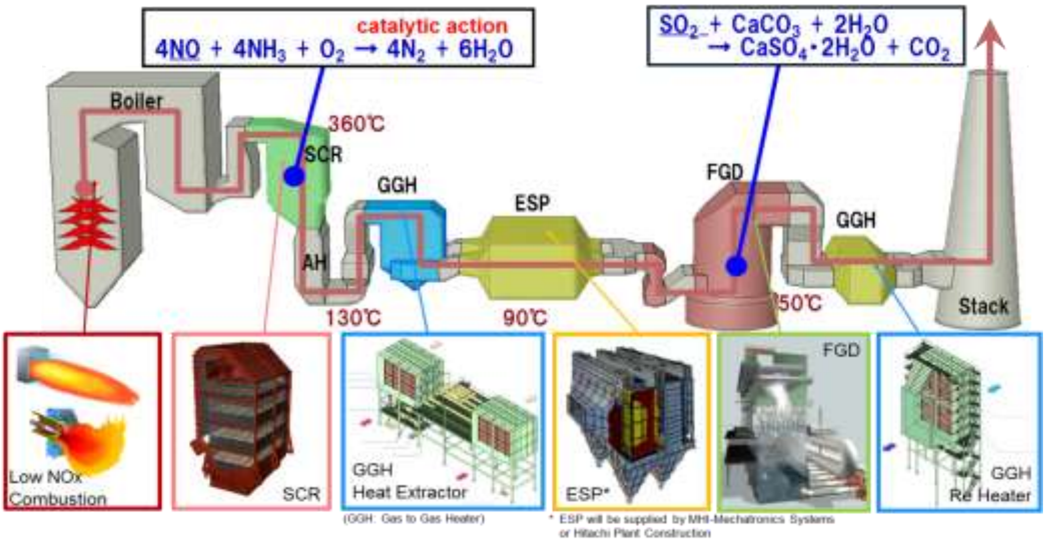


Fig. 1-1: Air Quality Control System components

2.0 ESP TECHNOLOGY

2.1 Method of Retrofitting ESP

Methods of retrofitting ESP to improve dust collection efficiency are summarized with features of each method in Table 2-1.

Table 2-1 Comparison table of retrofit method

	Foot print	Pressure drop	ID-Fans Modification	Performance upgrade
1. Replacement of the internal parts to Bag filter	Same ○	Increase ×	Replace x	High ○
2. Addition of new Collecting fields	Additional space ×	Increase △	Relocate ×	High ○
3. Upgrade of T/R set performance	Same ○	Same ○	Same location ○	Little △
4. Replacement of the internal parts to MEEP	Same ○	Same ○	Same location ○	High ○

- Replacement of the internal parts to Bag filter is effective but it is necessary to replace the existing ID-Fans with higher fan head because pressure drop.
- Power consumption after modification becomes much higher than ESP.
- Additional ESP fields in series either in series or in parallel is effective but will call for additional space, relocation of ID Fan and additional ash handing system.
- Upgrading T/R (Transformer Rectifier) and controllers may give marginal performance improvement.
- Replacement of the existing fields with MEEP (Moving Electrode Electrostatic Precipitator) does not require additional space and modification of the other existing facilities like the ID-fans. But improvement of dust collection performance is effective.
- Replacement to MEEP is one of the best ways to improve the performance of the existing ESPs.

2.2 Reference of Retrofitting ESP with MEEP

Especially for the upgrading project with improving performance of the existing ESPs, replacing the last field of existing ESP to MEEP is very effective. Such upgrading projects have already proceeded in Japan (already operating), India (commissioning stage), and Taiwan (design stage), to contribute to their environmental improvement, under the global trend of enforcing environmental regulations. Reference list of retrofitting with MEEP is shown in the Table 2-2.

Table 2-2 Reference list of retrofitting with MEEP

	Application	Flow rate [m^3N/h]	Gas temp. deg.C	Outlet dust Concentration [mg/m^3N]	Status
1. Steel plant /Japan	Sinter	268,000	140	≦10	1997 Start operation
2. Thermal power plant /India (500MW×2Units)	Coal	2,289,100	160	≦50	Completed in 2016
3. Thermal power plant /Taiwan (550MW×4Units)	Coal	2,173,913	150	≦15	Design stage

2.3 Actual Retrofit case in the ESP (Rihand TPS case)

2.3.1 Existing ESP Specifications and Actual Performance

Rihand TPS site layout is shown in Figure 2-1 and the existing ESP specifications and the collection efficiency prior to retrofitting is shown in Table 2-3. In this site, the existing facilities are being installed without any extra interspace that makes it difficult to carry out new installation. In addition, it is observed that the ESP collection efficiency is not enough to achieve 50mg/m^{3}N or less which is the value of outlet dust concentration required by the client. The performance has been improved by replacement to MEEP.

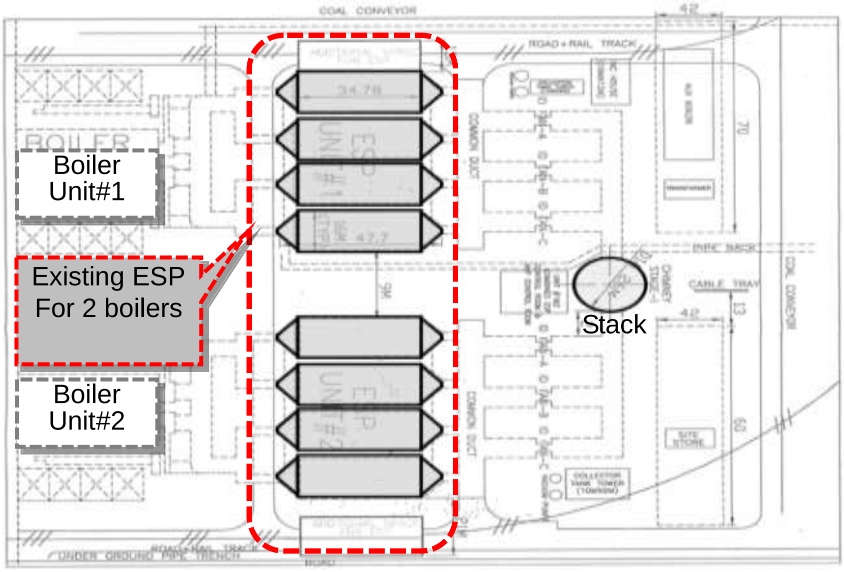


Figure 2-1 Rihand TPS site layout

Table 2-3 Existing ESP specification and performance

Boiler capacity	500 MW x 2 units		
Commissioned period	1988		
Collecting Electrode Size [m]	Width 5.0 x Height 13.7		
Space between collecting electrodes [mm]	300		
Gas passage	50		
Total collecting area [m^2] at 300 mm pitch	164,400		
Number of fields in series	6		
Design condition	Original	Actual	After retrofit
Gas volume [m^3/s]	756	1,050	1050
Gas temperature [deg.C]	140	160	160
Dust concentration at inlet[mg/m^{3}N]	47,500	44,000	56,000
Dust concentration at outlet [mg/m^{3}N]	≦100	≦600	≦50

2.3.2 Improvement plan in the Existing ESP Performance

An improvement plan in the existing ESP is described below.

1) Improvement plan using the technology of conventional type ESP

As a result of considering factors such as existing ESP efficiency, properties of flow gas and dust properties at the ESP inlet as well as client's requirements, it was found out that new ESP installation is required shown in Figure 2-2 in addition to an internal upgrading of the 6th fields of the existing ESP. This requires an enormous footprint for new installation of the collecting field, and this plan would not be feasible because there is no such large space available as described in the above. Even if an additional installation space has been given, problems such as retrofitting the existing duct work and relocating ID-Fans and other facilities would arise. Thus, the efficiency level required by the client would not be merely met by the conventional type of ESP technology.

2) Improvement plan using the MEEP technology

A plan using the MEEP technology is shown in Figure 2-3. This plan meets the client requirement by executing the following work:

・Internal upgrading of the 1st -4th fields (fixed and front section) of the existing ESP and increasing height

・MEEP retrofit in the 5th and 6th of the existing ESP

This plan cleared all problems raised in the conventional type ESP technology, “securing a space for additional installation”, “retrofitting duct work” and “relocation of ID-Fans and other facilities.”

In addition, this plan can significantly reduce the power consumption compared with the conventional type ESP due to its compact size.

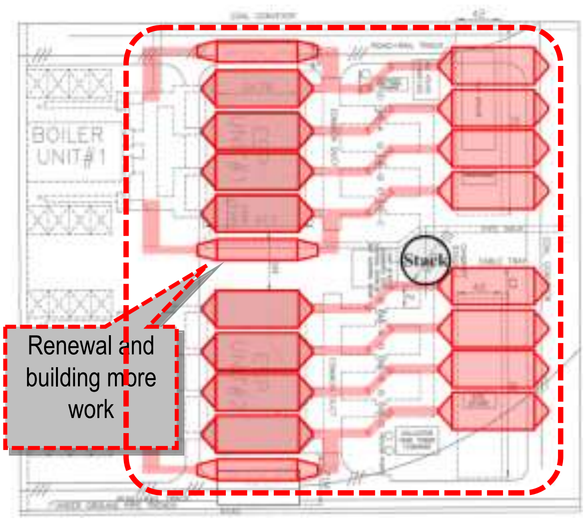


Figure 2-2 Rihand TPS site layout (Conventional type ESP plan)

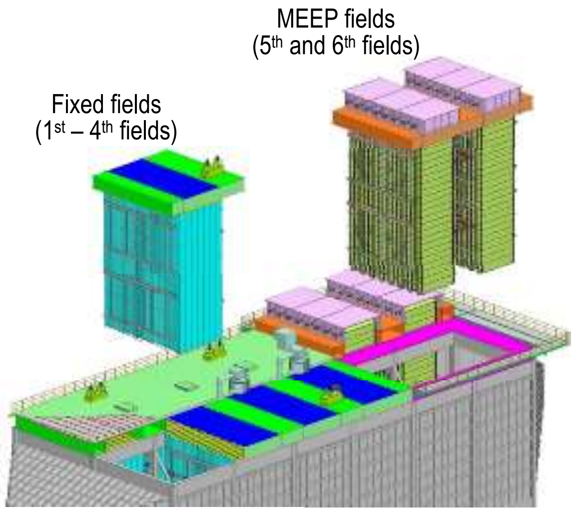


Figure 2-3 Retrofitting in existing ESP using the MEEP

3.0 SCR TECHNOLOGY

3.1 SCR System and Catalyst Overview

The primary function of the Selective Catalytic Reduction (SCR) system is to reduce the nitrogen oxides (NOx) emissions in flue gas and NOx is decomposed to nitrogen gas and water vapor using ammonia as a reducing agent. The design of the SCR catalyst is based on the following two major considerations:

- Selection of catalyst type and pitch to “best match” NOx reduction requirements to process conditions as specified for the boiler per the contract.
- Effective protection of the catalyst against operational mishaps and catalyst poisons.

Catalyst life may be shortened by chemical degradation due to trace elements such as sodium, calcium or arsenic, masking of catalyst micro pores by ammonium bisulfate, thermal degradation (sintering), and plugging / mechanical failures.

Trace elements are found in the fuel and there is nothing the operator can do to correct catalyst degradation. Therefore, yearly samples and analysis of the catalyst material may provide indication of a problem. Sodium (Na) and Potassium (K) are of prime concern especially in their water-soluble form. These particles are mobile and penetrate into the catalyst pores, plugging the catalyst. Calcium (Ca) reacts with SO3 absorbed within the catalyst to form CaSO4 that blinds the catalyst. Arsenic (As) chemically reacts with the active components of the catalyst material, leaving less material to interact with NOx.

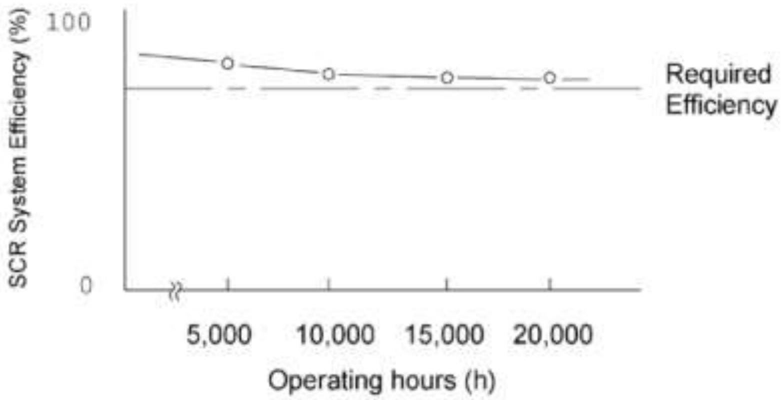


Figure 3-1 Typical Catalyst Life

3.2 SCR Catalyst O&M

It is recommended that catalyst samples be taken annually or coincident with scheduled outages. Catalyst is sampled by removing individual catalyst elements from some modules in various catalyst layers. Records should be maintained as to where and when catalyst samples were taken.

Typically the catalyst samples are sent to the catalyst manufacturer exams the following properties of the sample:

- Changes in catalytic properties

- Changes in external structure
- Changes in the inner surface and pore structure
- Changes in mechanical properties
- Composition of accumulated deposits

The catalyst remaining life is estimated and evaluated along with the plant operating history, projected use of the SCR system, fuels that are being used, the position where the samples were taken, and upcoming outage schedules.

Catalyst layers deactivate at different rates depending upon the fuel fired, the position of the catalyst, etc. Over time, ash build-up can cause physical clogging or blinding of the catalyst that affects the performance of the SCR. Additionally there are chemicals in the flue gas that act as catalyst poisons causing a gradual deactivation of the catalyst. Initially the decision that will have to be made is whether to add a new layer of catalyst or replace existing catalyst. Usually adding a layer of catalyst results in the best economic option followed by replacements or regenerations.

Most examples of catalyst management are based on two initial layers of catalyst and one future layer capability. Figure 3-2, represents a chart of a catalyst management plan comparing relative Catalyst Potential and Ammonia Slip to run hours. Catalyst Management companies such as Andover Technologies or catalyst manufacturers can aide in preparing site-specific plans.

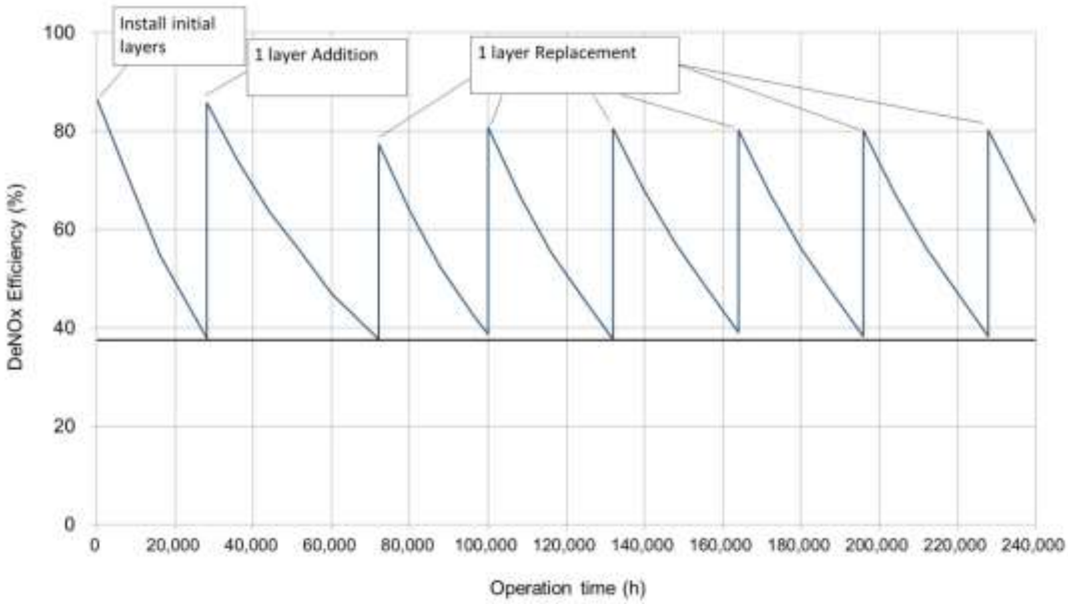


Figure 3-2 Typical Catalyst Management Plan

For the regeneration method of plate type catalyst, MHPS have experience of washing regeneration on site.

The regeneration process consists of two (2) major steps indicated in Figure 3-3.

- Removal of dust form the catalyst
- Removal of catalyst poisons by vacuuming and washing.

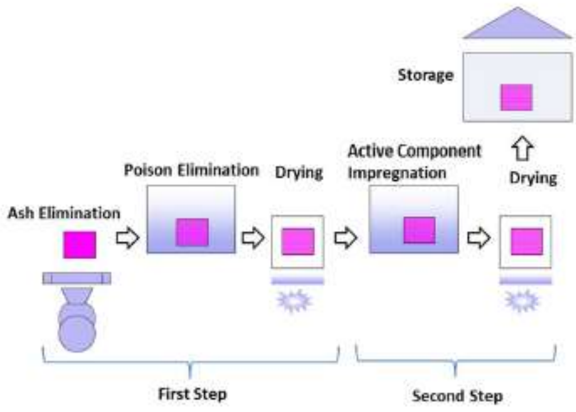


Figure 3-3 Regeneration steps of plate type Catalyst

Also, as part of catalyst material recycling, MHPS is engaged in the development of technology to recycle spent catalysts. In terms of the recycling method, MHPS recycles catalysts to meet customer needs through processes such as water-washing spent catalysts and coating catalytic component. The regeneration steps is indicated in Figure 3-4.

First, the catalyst module is removed from SCR reactor in power plant. And then, catalyst module is transported to recycle shop. After that, the catalyst module is disassembled, and catalyst is crashed into the powder. Furthermore, the catalyst powder is forming into honeycomb shape.

After that the catalyst components are coated for activation regeneration. Then the catalyst is calcined by electric furnace.

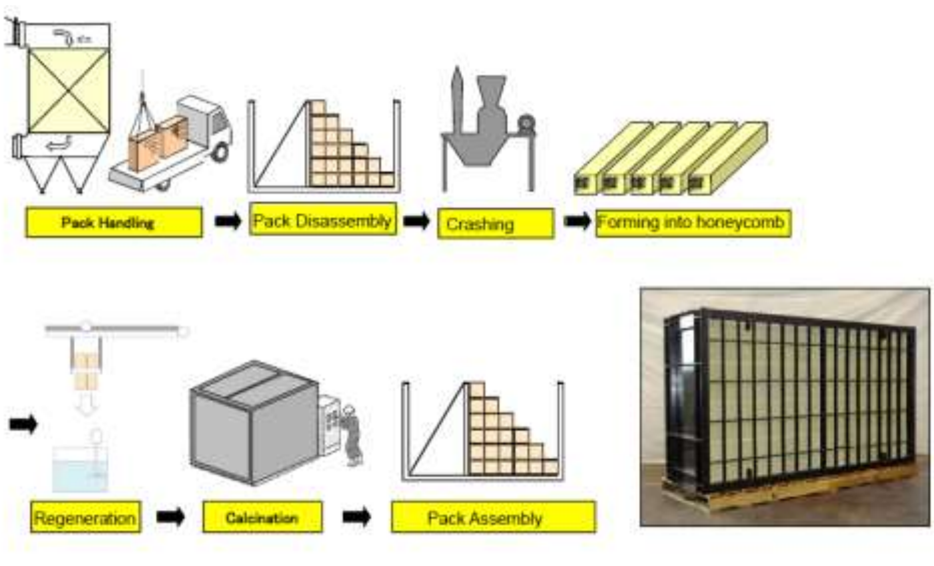


Figure 3-4 Regeneration steps of Honeycomb type Catalyst

4.0 FGD TECHNOLOGY

In this section, two unique technologies to enhance the operation reliability and maintainability of the FGD plant are introduced.

- Jet Air Sparger (JAS) System
- GGH installation on the top of aborber

4.1 Jet Air Sparger System

Jet Air Sparger System (JAS) is a forced oxidation system developed by Mitsubishi Hitachi Power Systems, Ltd. utilizing fluid dynamic mechanism. A part of the discharged fluid of the recirculation pump is distributed to several numbers of JAS nozzles and flown into the reaction tank of the absorber through the nozzles. (Refer to Figure 4-1)

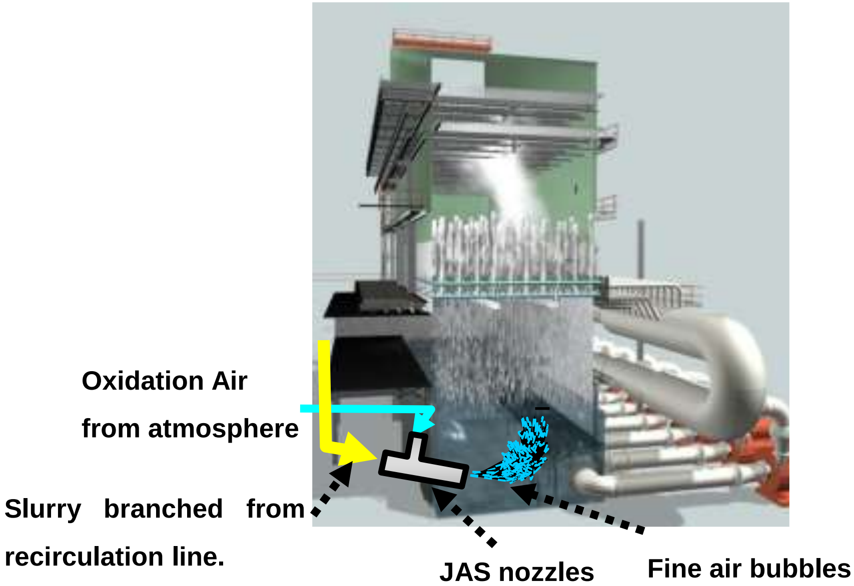


Figure 4-1 Outline of Jet Air Sparger System

An orifice plate is installed at the upstream of a point where oxidation air is introduced. (Refer to Figure 4-2) Low pressure zone generates at the point oxidation air is introduced by slurry flowing through the orifice plate. At this low pressure point, air is naturally aspirated into the JAS nozzle without oxidation air blower. By mixing air and slurry in JAS nozzle under the turbulent flow condition, fine air bubbles are generated and effectively dispersed into the tank to produce efficient gas-slurry contact and agitation condition. Therefore, oxidation reaction is carried out efficiently in tank. Further, jet stream from the nozzles widespread at tank bottom realizes a state of complete mixing in the absorber tank. This phenomenon prevents any sedimentation of solids at the absorber bottom without agitator operation..

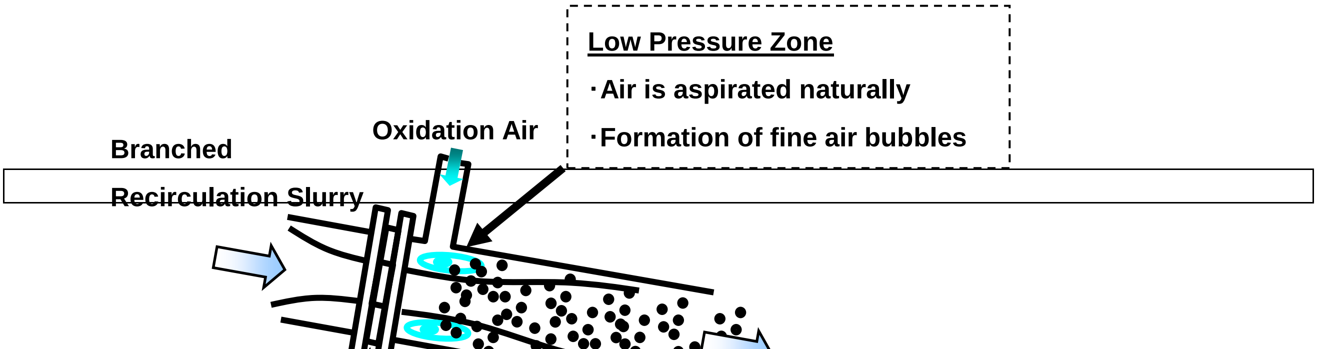


Figure 4-2 Mechanism of Jet Air Sparger System

As shown in **Figure 4-3**, in the JAS system, no rotating equipment and no structured parts inside the Absorber tank is required. That reduces maintenance and provides reliability to JAS system.

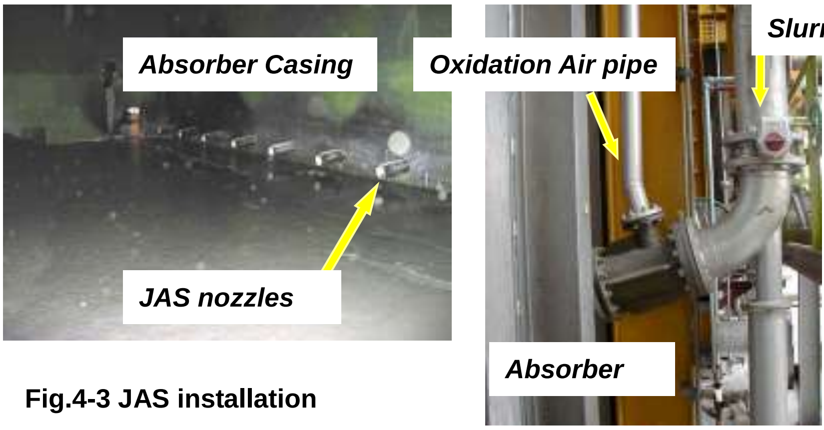


Fig.4-3 JAS installation

4.2 GGH installation on the top of the Absorber

Normally GGH is installed independently the absorber but GGH is installed on the absorber by using absorber structure in MHPS FGD system.

In this section, the features of GGH installation on the top of the Absorber are described comparing to GGH installtion on the ground.

Fig.4-4 GGH on the absorber

4.2.1 Risk of Acid-attack corrosion

In the process of heat transfer in rotary type GGH for FGD process (called GGH hereinafter), acid attack may occur due to creation of SO_3 mist.

In order to minimize corrosion risk by acid attack in GGH, it is important to establish duct arrangement so called “hot side top”. “Hot side top” is such duct arrangement that untreated flue gas enters from top of GGH while treated flue gas enters from bottom of GGH as shown in case-1 and case-2 of attached Table 4-1. On the other hand, “hot side bottom” is such duct arrangement that untreated flue gas enters from the bottom of GGH or treated flue gas enters from top of GGH as shown in case-3 in the Table 4-1.

In case that “hot side top” duct arrangement is applied, SO_3 mist, if appears, is generated at the lower part of the GGH and it flows down toward the bottom area. While in case that “hot side bottom” duct arrangement is applied SO_3 mist is generated at the upper part of the GGH and it flows down toward the bottom area. It is evident from the above phenomenon that corrosive area is limited at the lower part of GGH only in case of “hot side up” while corrosive area expands whole area of GGH in case of “hot side bottom”.

4.2.2 Duct Arrangement

If “hot side top” duct arrangement is to be realized to minimize risk of acid attack corrosion, the configuration of ducts for both GGH installation cases becomes as shown in case-1 and case-2 in the Table 4-1. As is shown, duct arrangement would be excessively complicated to realize “hot side top” duct arrangement in case of GGH installation on the ground due to necessity of many ducts bending. By this reason, in case of GGH installation on the ground, “hot side bottom” duct arrangement is reluctantly adopted to simplify duct arrangement as shown in case-3 in the Table 4-1 while sacrificing corrosion risks. On the other hand “hot side top” duct arrangement is easily realized in case of GGH installation on top of absorber as shown in case-1 in the Table 4-1.

4.2.3 Space-saving design

This absorber-mounted type can save space to install FGD plant. It is an effective technology when FGD plant is retrofitted with GGH.

Table 4-1 Comparison between separate GGH and GGH on absorber

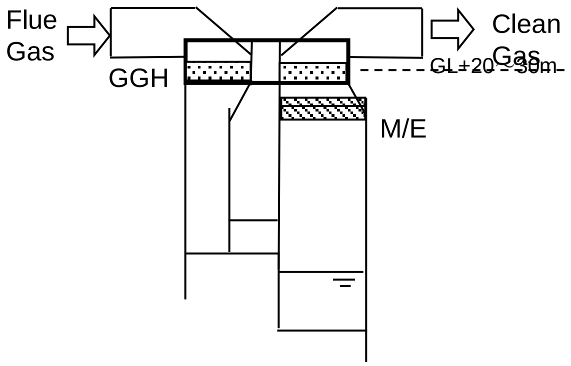
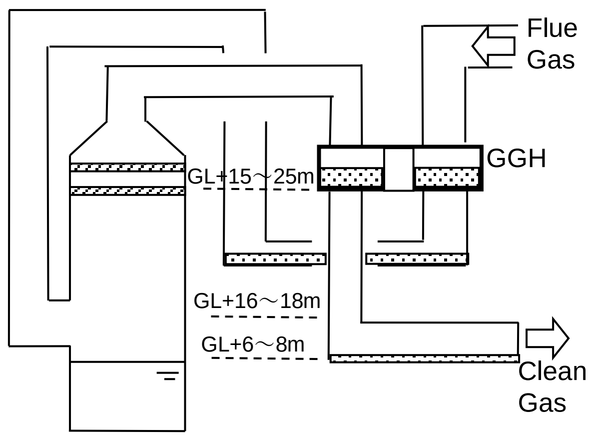
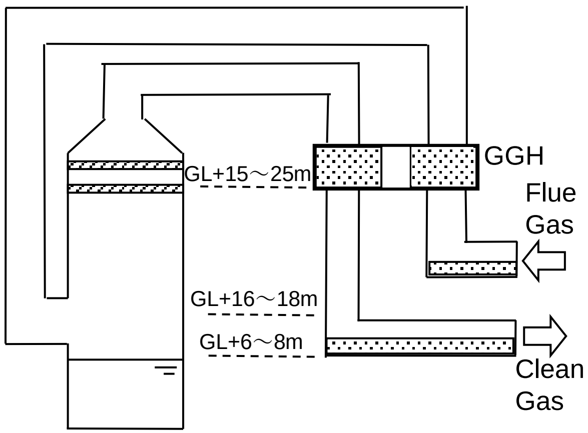
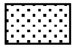
FGD plant	Duct Configuration	Duct Arrangement	Duct Work	Corrosion	Maintenance
GGH On Absorber (Case-1)		Hot side top	Simple	Corrosive area in GGH is limited at lower part only No deposit or drain accumulation is foreseen in interconnecting ducts between GGH and absorber.	Provision of permanent hoists is essential to cope with higher location of GGH. No sump, sump pumps and agitators are required.
Separate GGH (Case-2)		Hot side top	Most Complicated	Corrosive area in GGH is limited at lower part only Deposit or drain accumulation is foreseen in interconnecting ducts among GGH, absorber and downstream ducts of GGH. Subject area shall be protected from corrosion.	Provision of permanent hoists is preferred to cope with higher location of GGH. Sump, sump pumps and agitators are required to transfer GGH drains

Table 4-1 Comparison between separate GGH and GGH on absorber

FGD plant	Duct Configuration	Duct Arrangement	Duct Work	Corrosion	Maintenance
Separate GGH (Case-3)		Hot side down (Untreated gas side)	Complicated	Corrosive area in GGH expands to whole area of GGH Deposit or drain accumulation is foreseen in upstream or downstream ducts of GGH. Subject area shall be protected from corrosion.	Provision of permanent hoists is preferred to cope with higher location of GGH. Sump, sump pumps and agitators are required to transfer GGH drains

 : Corrosive area by acid attack in GGH and potential area for deposit and drain accumulation

5.0 REFERENCE

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