Advanced Technology of Flue Gas Desulfurization (FGD)

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Mitsubishi Heavy Industries, Ltd. (MHI) has been developing and introducing various Double-Contact-Flow Scrubbers and Jet Air Sparger as part of flue gas desulfurization technology. The double-contact-flow scrubber features (1) super-high desulfurization performance, (2) simple structure and easy maintenance, and (3) no problems of scaling; and the Jet Air Sparger is characterized by (1) high air utilization efficiency, (2) possible elimination of oxidation air blower, and (3) no rotating elements and easy maintenance. A full scale FGD model has been constructed for the purpose of early development of next generation double-contact-flow scrubber technology, and expansion of sales to overseas markets. In actual plants, a desulfurization rate of 99.4% has been achieved by modifying the scrubber used in another process into a double-contact-flow scrubber.

1. Introduction

Recently, in its efforts against global warming, MHI has developed technology for desulfurization of flue gas using a wet lime/limestone gypsum process as a means of reducing sulfur dioxide (SO_2) emissions, and has applied it in the treatment of flue gas from thermal power plants ever since 1972.

As of July 2004, a total of 167 desulfurization systems using this wet lime/limestone gypsum process have been installed and are working both inside and outside Japan, and MHI is leading the world in this field.

While the performance of desulfurization plants is steadily advancing, users are making increased demands every year for reduction of facility cost.

Users' requests include:
(1) Easy maintenance
(2) Low cost
(3) Energy saving

To meet these demands, MHI has developed the double-contact-flow scrubber and the jet air sparger. Outlines of the double-contact-flow scrubber and jet air sparger are introduced in this paper, together with recent operation results.

2. Latest technology of flue gas desulfurization

2.1 Double-contact-flow scrubber

An example of a double-contact-flow scrubber developed using original MHI technology is shown in **Fig. 1**.

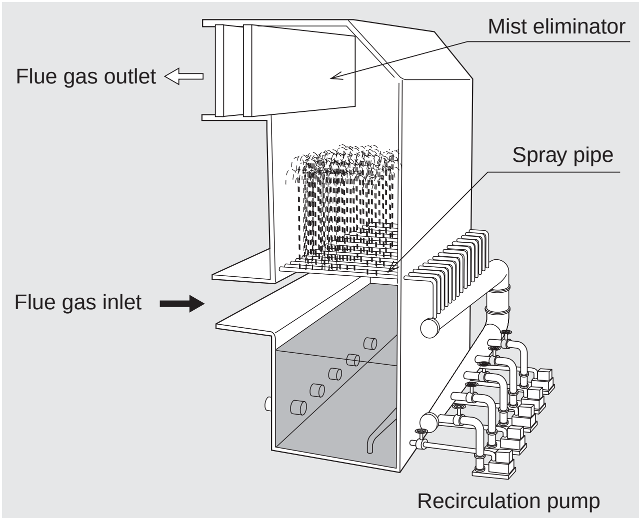

Fig. 1 Counter-current type double-contact-flow scrubber

Flue gas flows in from the inlet duct. The flue gas is purified after contact with absorbent liquid, and is discharged out of the system by way of the mist eliminator. The absorbent liquid is sprayed upward from a special wear-resistant nozzle installed in the bottom of the tower, and desulfurize flue gas after gas-liquid contact.

In a conventional scrubber, the inside is filled with packings, porous plate, multiple spray piping network and other structures, but this scrubber is very simple in structure, having only spray pipes installed immediately above the inlet duct. Accordingly, as compared with the conventional system, maintenance is easier, the cost is lower, much energy is saved, and the size is compact.

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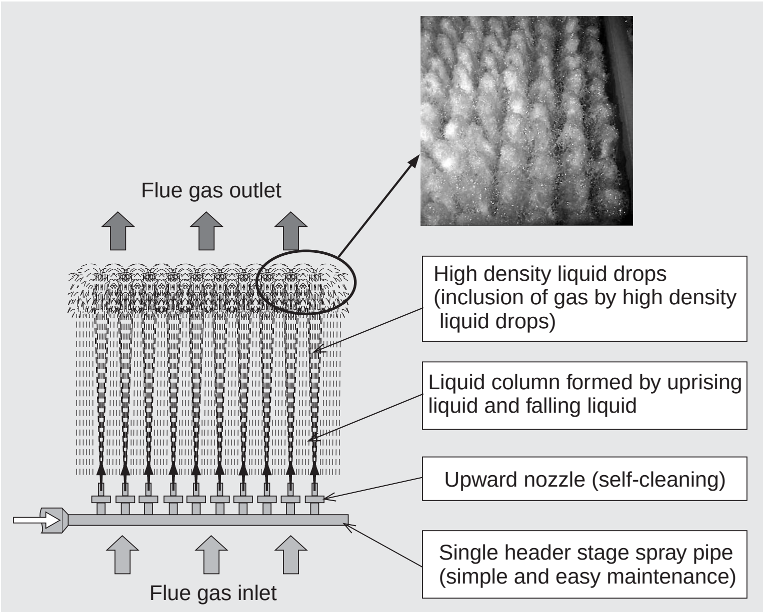

Fig. 2 Function and "Spouted Up" condition of liquid column

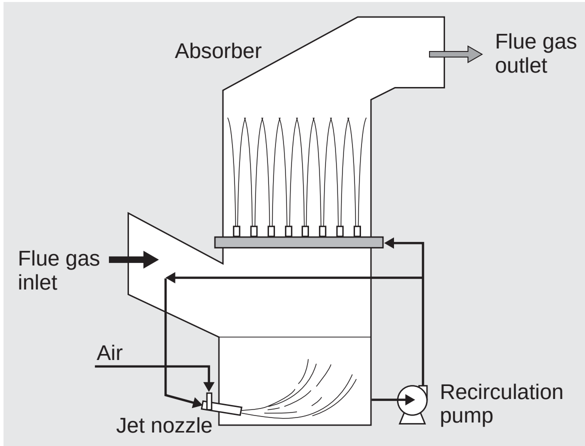

Fig. 3 Concept of installation of jet air sparger

Fig. 2 schematically shows the injection state of the liquid. By interaction of falling fine liquid drops and uprising liquid drops, liquid layers of high gas-liquid contact efficiency and high density are formed, and a super-high desulfurization performance is achieved.

The double-contact-flow scrubber has a simple structure, with only spray pipes immediately above the inlet duct. Scaling does not occur inside the scrubber because there is no source of scale. In addition, since upward nozzles are used, the spray nozzles and spray pipes are always self-cleaned by the falling slurry.

- Features of double-contact-flow scrubber

(1) Super-high desulfurization efficiency

Desulfurization efficiency is more than 99% because the scrubber has high gas-liquid contact efficiency.

(2) Easy maintenance

Maintenance is easy because the scrubber has no internal parts except for a single stage of sprays.

(3) Free from scale

Scale does not form because the inside of the scrubber is simple and internal parts (such as spray pipes and spray nozzles) are self-cleaned.

2.2 Jet Air Sparger

The oxidizer was originally developed for the purpose of saving utilities. **Fig. 3** and **Fig. 4** show the concept of the water-stream oxidizer.

The oxidizer operates as follows: (1) Jet streams are carried out using the part of the discharge liquid from a scrubber circulation pump into a scrubber tank, (2) turns air into fine bubbles using this liquid stream, (3) enhances air-liquid contact with slurry, and (4) achieves efficient oxidizing of absorbent liquid by small amount of air.

The jet nozzle can self-suck the air into the nozzle by ejector effect, and an oxidation air blower can be eliminated.

The structure is simple because no rotating element is used and only the stationary nozzles, resulting in easy maintenance.

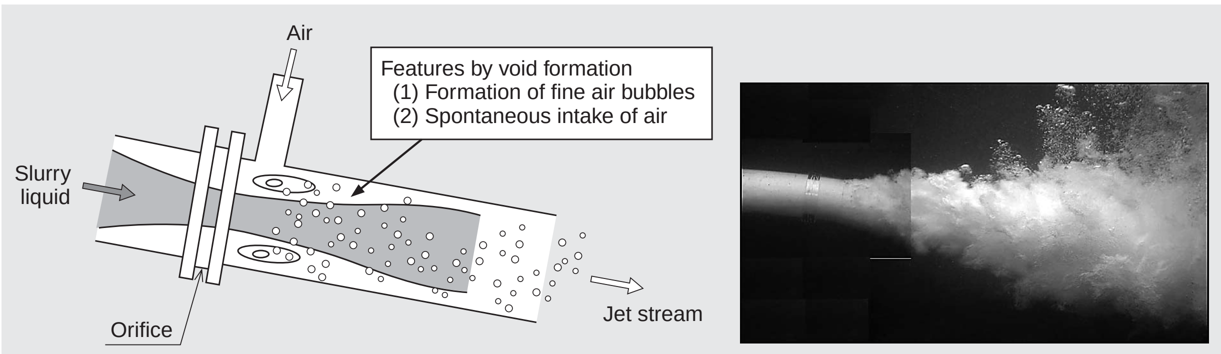

Fig. 4 Concept of jet nozzle

- Features of Jet Air Sparger
  (1) Air utilization Efficiency is high and energy consumption is much less than with a conventional oxidation lance with horizontal agitator.
  (2) Oxidation air blower can be eliminated.
  (3) No rotating element, easy maintenance.

2.3 Full Scale FGD model

So far, MHI has been developing new technology for flue gas desulfurization by gradually upscaling the test plants at the Hiroshima Research and Development Center and others, and has applied it into the commercial plant after completion of the verification, but recently projects are increasing overseas in the United States, Europe and China, for example, and in order to promote sales in overseas markets, there is now an urgent demand to develop next generation double-contact-flow scrubbers of low cost and high performance.

Accordingly, Full Scale FGD model has been built at the Mihara Works, with the following two purposes in mind. An outline diagram of the Full Scale FGD model is shown in **Fig. 5**.

(1) Quick development of new double-contact-flow scrubber technology for next generation plant
(2) Promotion of sales of double-contact-flow scrubbers to overseas markets

It is a big feature of this Full Scale FGD model that the desulfurization process can be tested and analyzed for performance at nearly the same scale as an actual plant of 400 MW.

By verification and testing in Full Scale FGD model, various tests (bench scale test, pilot test, scale-up verification test by small-size demonstration plants) normally required in development of new technology can all be skipped, and new technology can be realized into practical plant in a very short time.

Henceforth, through analysis of the test results of this Full Scale FGD model, new generation double-contact-flow scrubbers will be produced for sale on the overseas market in a short time.

- Specifications of test plant

  Capacity: Equivalent to FGD for 400 MW Boiler
  Gas flow rate: 1 200 000 m^3N/h (w)
  Inlet SO_2: Injection by SO_2 cylinder
  Location: Mihara Works of MHI

- Features of test plant
  (1) Actual scale test plant
  The following items can be tested for an actual scale test plant. Desulfurization performance can be analyzed and confirmed.
  (a) Desulfurization performance confirmation test
  (b) Oxidation performance confirmation test
  (c) Gas flow test
  There are a total of 184 points of measurements, so data can be collected at every part of the scrubber.
  (2) Use of actual limestone and gypsum slurry
  With its own limestone supply system and gypsum dewatering system, tests can be made using actual limestone.

3. Recent case of installation

As an example of a flue gas desulfurization plant that uses a double-contact-flow scrubber system, a case of modification of existing desulfurization plant for Unit 3 boiler at Kashima-North Electric Power Corporation (operation resumed after modification to double-contact-flow scrubber in 2003) is introduced below.

In this case, an existing Wellman-Load technology scrubber (sulfuric acid production process) was modified into a counter-current type scrubber using a wet lime/limestone gypsum process.

(1) Principal modification and features
(a) Modification of existing Wellman-Load technology scrubber into double-contact-flow scrubber
Fig. 6 shows a concept diagram of the modification.

Fig. 5 Outline of full scale FGD model

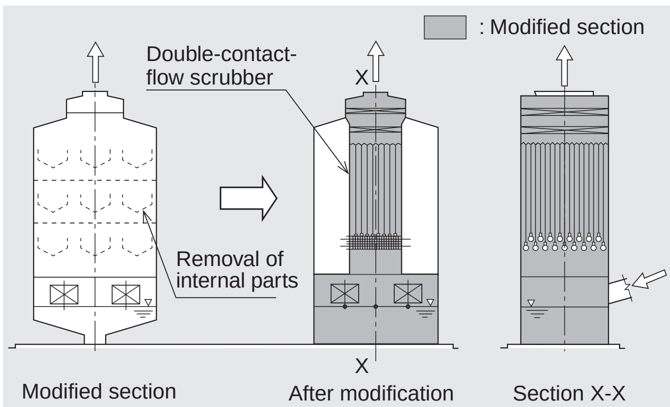

Fig. 6 Desulfurization plant Unit 3 at Kashima-Northern Electric Power Corporation
Wellman-load technology scrubber is modified into double-contact-flow scrubber.

Fig. 7 shows the appearance of the plant.

After removal of internal parts from the existing scrubber, the new system of spray pipes and spray nozzles was installed, and the scrubber vessel was left as it was, and the inside was remodeled as a double-contact-flow scrubber.

(b) Installation of Jet Air Sparger

A Jet Air Sparger was used in the oxidation system, and the need for an oxidation air blower was eliminated.

(c) Features of modification

The existing scrubber vessel structure was utilized as far as possible, and so the construction time was shortened, and expenses were saved as compared with the cost of new construction.

By the use of the double-contact-flow scrubber and the jet air sparger, energy saving and low maintenance costs have been achieved, as compared with the existing Wellman-load technology scrubber.

(2) Plant specifications after modification

Specifications after modification are as follows.

Type: Counter-current type
double-contact-flow scrubber

Flue gas rate: 579 000 $m^3{}_N$/h (w)

Scrubber dimensions:
9 000 (W) X 13 000 (L) X 3 500 (H)

Internal scrubber section:
9 000 (W) X 5 400 (L)

Oxidation system: Jet Air Sparger

Desulfurization efficiency:
Design 98%
Actual 99.4% (in performance test)

Fig. 7 Outline of desulfurization plant Unit 3 at Kashima-North Electric Power Corporation

4. Conclusions

The double-contact-flow scrubber features:

Super-high desulfurization rate
Easy maintenance
No scaling

Further improvements are planned demonstrating by Full Scale FGD Model by utilizing the latest desulfurization technology in order to contribute to global atmospheric protection.

Reference

(1) Ukawa et al., Development of Double-Contact-Flow Scrubber for Flue Gas Desulfurization, Mitsubishi Heavy Industries Technical Review Vol.33 No.2 (1996)


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