Application of DynaWave Scrubber for Particulate and Sulfur Dioxide Control in a Chemical Recovery Boiler

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ABSTRACT:-- A DynaWave Reverse Jet Scrubber was installed at the Scott Paper ammonia-based sulfite paper mill in Everett, Washington, USA in 1990. The system was designed to treat 230,000 AM³/hr of gas to remove residual sulfur dioxide (SO_2) and particulate exiting a recovery boiler. The Reverse Jet Scrubber uses sodium hydroxide based on pH control to absorb SO_2 from approximately 150 ppm down to 6 ppm. The particulate removal achieved by the scrubber increases the service life of the downstream fiber bed Mist Eliminators and lowers maintenance costs associated with acid washing of the fiber bed elements.

INTRODUCTION

Gas cleaning operations to remove particulate matters and objectionable gaseous impurities by scrubbing have conventionally utilized venturi type scrubbing towers. However, when particulate removal and gas absorption with hot gas quenching are required, DynaWave scrubbers have proven to be viable alternatives to venturi scrubbers in many industries. DynaWave scrubbers utilize Froth Scrubbing Technology developed by Du Pont in the 1970's to solve a difficult acid mist and particulate emission problem. In 1987 Monsanto Enviro-Chem Systems, Inc. entered into licensing agreement with Du Pont to design, market and supply the Forth Scrubbing Technology for industrial gas cleaning/air pollution control applications.

PRINCIPLE OF OPERATION

DynaWave Reverse Jet is an annular orifice scrubber with liquid injected through a non-restrictive opening into a straight walled barrel countercurrent to the gas flow. The process gas collides with the liquid, forcing the resultant mixture radially outward towards the wall. This creates a high turbulence zone in the region of gas-liquid interface. Flow momentums are balanced and the equipment sized to develop a stable standing wave with intense gas to liquid contact. Particulate collection, gas absorption, and hot gas quenching occur in the froth zone due to gas contact with the large area of constantly renewed liquid surface.

As shown in figure-1 the key to design is for liquid and gas velocities to lie within a specific, near

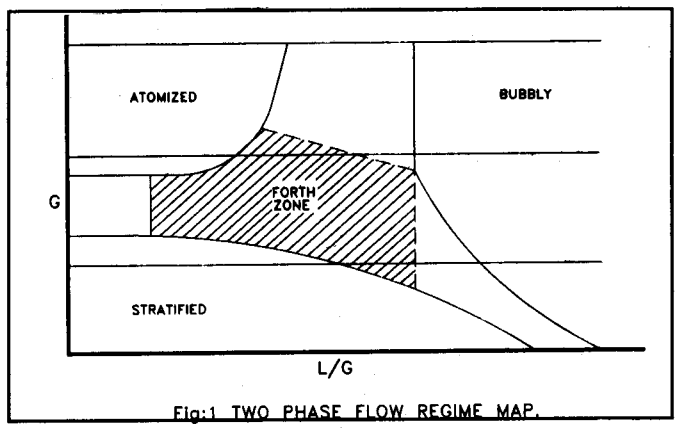

Fig:1 TWO PHASE FLOW REGIME MAP.

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flooded region - the froth zone. The figure shows two phase flow regime map showing region of proper operation. At the lower left of the chart, gas and liquid velocities are low and gas and liquid both are stratified. As the gas flow is increased, waves begin to form and their tops are clipped off. At a high enough gas velocity, the liquid is atomized into small droplets. This region is analogous to the operation area of a venturi or other wet scrubbing device which functions via impactions. As the liquid flow is increased, eventually a state in which the gas bubbles through a continuous liquid phase. The froth zone is a broad flow regime which lies between these boundaries. The boundaries are sufficiently large such that a froth scrubber can easily be designed to quench hot gas or absorb acid gases with up to 2 : 1 turndown in gas flow.

As shown in figure-2 typical scrubber system designs incorporate one or more than one reverse jets or stages in series. Staging allows for the optimum use of pressure drop while achieving high particulate removal and absorption efficiencies. The system is simple and easy to operate, requiring minimal instrumentation and operator attention.

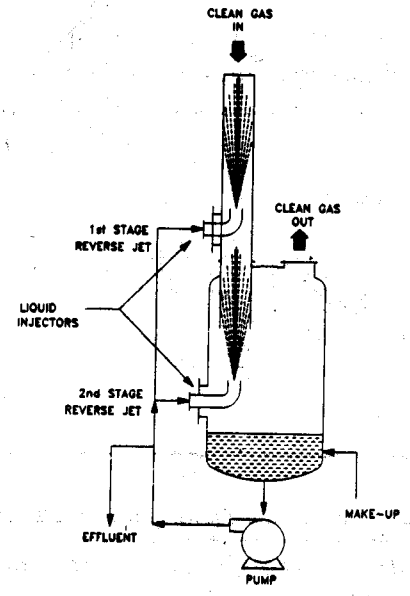

Fig:2 Dyna Wave Staging

ADVANTAGES

Followings are the major advantages of the DynaWave Scrubbing Systems

* No plugging due to large, open bore liquid injectors and non-restrictive open vessel. It can handle dirty gases that contain high solids loading. It can scrub with slurries of lime, limestone, magnesium hydroxide with high solids content, as much as 20% suspended or dissolved solids.
* Accomplish multiple functions such as particulate removal, acid gas absorption, liquid effluent concentration and hot gas quenching in one scrubber.
* Broad turndown range of up to 2 : 1 for hot gas quenching or acid gas absorption.
* Low maintenance as no internal moving part.
* Simple to operate with minimal instrumentation.
* High on-stream reliability.

APPLICATIONS IN CHEMICAL INDUSTRIES

DynaWave scrubbers are installed at more than 100 places in areas like Sulfuric Acid Plants, Metal smelters, Wood products, Sulfonation, Boilers, Cement kiln, Incinerators and various chemical process. Some of installation examples with application and gas flow rate are given below.

Application	Company	Gas m^3/hr
Metallurgical SA Gas cleaning area	Lucky Metals, Korea Copper Smelter	138860
	Guixi, China Copper Smelter	234600
	Indogulf, India Copper Smelter	166900
	Western mining, Aus. Nickel Smelter	301400
Chemical waste incinerator particulate, SO_2 & HCl removal	DuPont, New Jersey	47600
Boiler off gas SO_2 scrubbing using $Mg(OH)_2$	Kelchikan, pulp Alaska	79900
Cement kiln off gas SO_2 scrubbing using limestone	ESSROC materials Pennsylvania	241400

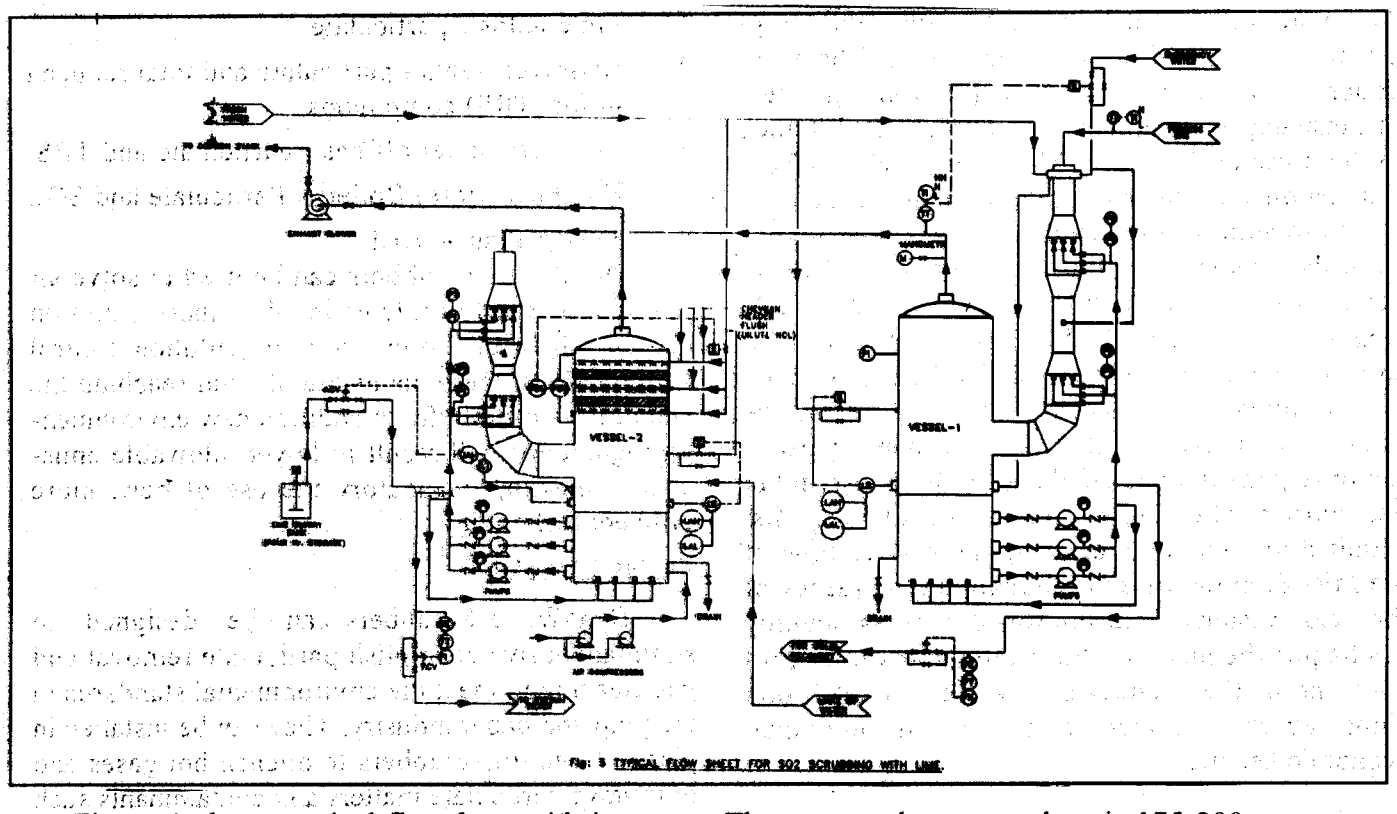

Fig: 3 TYPICAL FLOW SHEET FOR SO2 SCRUBBING WITH LIME

Figure-3 shows typical flowsheet with instrumentation for hot gas quenching, particulate removal recovery (up to 50 mg/NM^3) and SO_2 removal using lime scrubbing (from 2% inlet SO_2 to less than 50 mg/NM^3) from copper smelter off gas using two numbers of DynaWave scrubbers in series, first one being used for particulate recovery and hot gas quenching and second for SO_2 scrubbing. Resulting calcium bisulfite slurry is oxidized in second scrubber sump itself to get good quality of filterable gypsum which can be sold as by-product.

CASE STUDY-SCOTT PAPER MILL

In April 1990, a DynaWave Reverse Jet Scrubber was installed at Scott Paper in Everett, Washington, USA. The scrubber was designed to remove sulfur dioxide and particulate from 230,000 AM^3/hr of recovery boiler offgas. Although the plant was operating at only 150 ppm of the SO_2 level permitted by the state, the plant voluntarily installed the scrubber to further reduce SO_2 emissions to satisfy residents living near the mill. Operating data indicates the DynaWave Scrubber has reduced SO_2 emissions from approximately 150 ppm down to 6 ppm. The Scrubber uses sodium hydroxide, the addition of which is based on pH control, to absorb the SO_2. The measured pressure drop is 175-200 mm wc.

Scott is an ammonia-based sulfite paper mill, the less common type of pulp and paper plant. Figure-4 shows the flow diagram of the mill indicating the location of the DynaWave Scrubber.

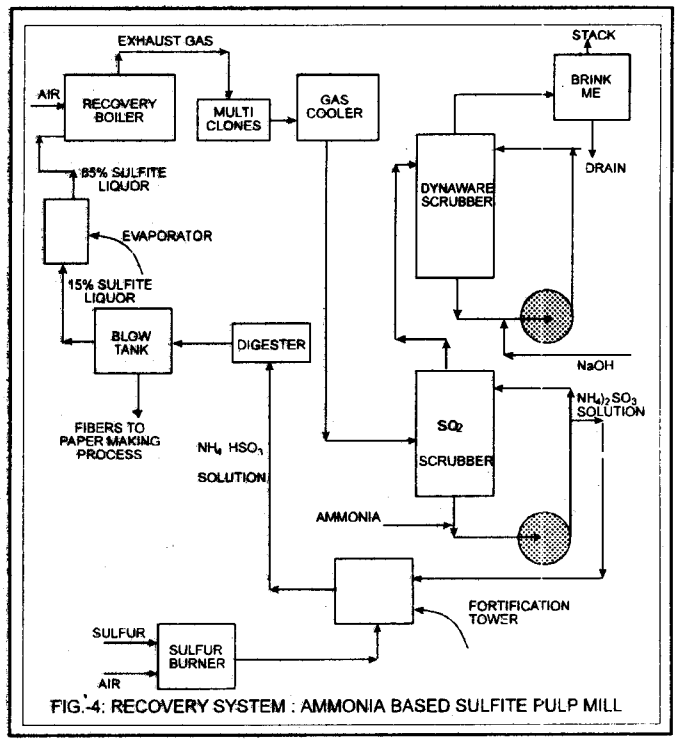

FIG.-4: RECOVERY SYSTEM : AMMONIA BASED SULFITE PULP MILL

Ammonium bysulfite is used in the digestor to dissolve the lignin from the wood fibers. The spent liquor is concentrated and combusted in a furnace. The resulting ammonium bysulfite solution is returned to the digestor for reuse. Monsanto fiber bed Mist Eliminators have been installed at the plant since the 1970's to eliminate the emissions and stack opacity from the existing scrubbers. The Mist Eliminators become fouled with ash and must be periodically cleaned using an acid wash. Scott had been spending approximately $ 250,000 US per year on Mist Eliminator maintenance. In addition to the efficient removal of SO_2 the excellent particle removal performance of the DynaWave Scrubber has substantially slowed the fouling of the Mist Eliminators, thereby increasing the service time of the Mist Eliminators and reducing the frequency of the acid washing. The improved process stability has helped the plant to obtain the improved control over one of the chemicals they use to cook wood chips which provided a substantial additional economic benefit.

Kraft process is the predominant pulp and paper process and kraft mills have several sources of particulate and air pollutant emission as listed.

* Lime Kilns - particulate.
* Dissolver Vents - particulate and total reduced sulfur (TRS) compounds.
* Recovery boiler off gas - particulate and TRS.
* Hog Fuel (Bark) Boilers - Particulate and SO_2.
* Bleach Plant - HCl.

DynaWave Scrubbers can be used to solve air pollution control problems in all of these emission source. Much of the existing air pollution control equipments in these plants are old and reaching the end of their useful life. In addition new environmental regulations will result in lower allowable emissions, making mandatory the use of new, more efficient technology.

CONCLUSION

DynaWave Scrubbers can be designed to simultaneously accomplish particulate removal and gas cleaning to meet the environmental standards in the pulp and paper industry. They can be installed in place of venturi scrubbers to quench hot gases and to remove particulate matters and contaminants such as SO_2, HCl, So_3, etc., by efficient contact with the scrubbing liquid or slurry using the Reverse Jet and Froth Scrubbing Technology.