A Review of DynaWave® Technology

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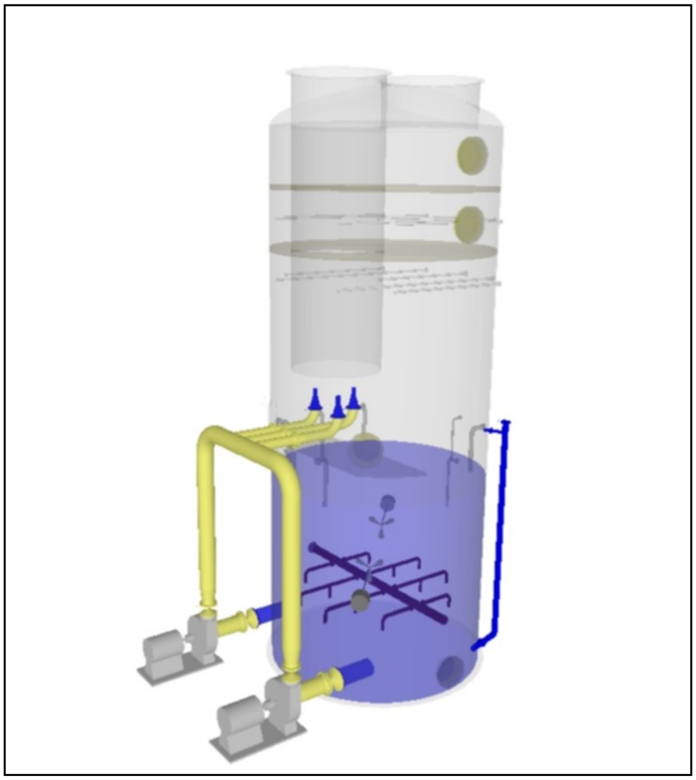
There is a considerable amount of experience with wet gas scrubbing of SO2 in the Utility Industry. However, there is also an extensive amount of FGD experience outside the Utility market. This includes scrubber designs that are not the conventional spray tower using lime, or limestone, as a reagent. This also includes process conditions that exceed the normal levels found downstream of a Utility coal fire boiler.

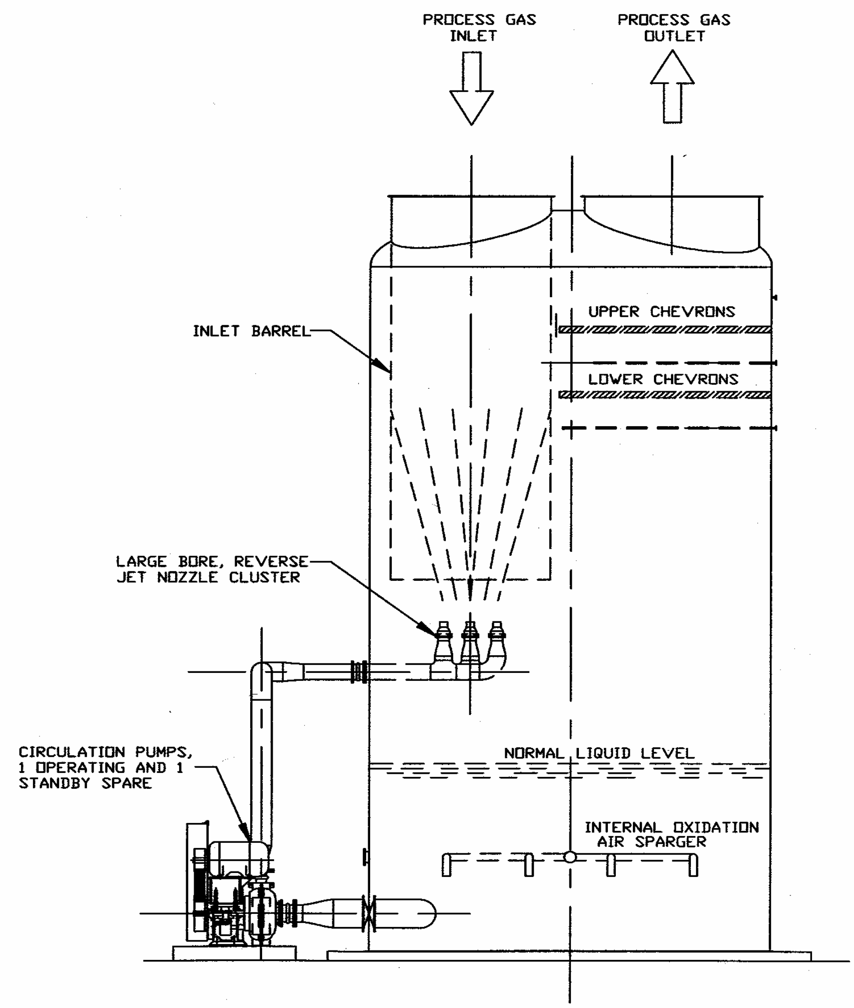
This paper explores one such scrubber design that has been used very successfully as a FGD scrubber, but on markets and process conditions, different from those of a Utility coal fired boiler.

First, just a short history of the company, which explains the information presented about FGD Scrubbers. MECS was originally a division working inside the Monsanto Company. In 1922, this division built their first sulfuric acid plant. This group became a world leader in the Sulfuric Acid industry, with extensive knowledge gained about SO2 and SO3. In 1987, MECS obtained the rights to the DynaWave Scrubber technology. During the last 20 years, MECS has built over 400 scrubber systems throughout the world. Finally, in 2005, a management buyout occurred, and Monsanto Enviro-Chem Systems became MECS Inc. However, the key point is that throughout the company's history, MECS has always dealt with the formation, handling, and collection of SO2 and SO3 when building Sulfuric Acid Plants. Generations before other firms were involved with FGD scrubbers and concerned with the properties of SO2, MECS was routinely involved with the sulfur molecule.



The DynaWave Scrubber is a wet gas scrubber system that can effectively be used for acid gas collection, particulate collection, or both. It can do so while using a wide variety of reagents. This makes it unique among scrubber systems. The MECS DynaWave, or Reverse Jet scrubber system, is shown in the figure to the side. The cylinder extending downward into the vessel is known as the inlet barrel. The spray nozzles are very large diameter nozzles, (up to 16" in size), that spray circulating liquid countercurrent to the process gas. Essentially, all the gas/liquid contact occurs in this inlet barrel. The remainder of the vessel is used as a sump and for mist elimination.

The figure below is a cut-away of the DynaWave Scrubber. Process gas enters the unit from the top, and travels vertically downward thru the inlet barrel. Circulated scrubbing liquid is injected from below the inlet barrel, countercurrent to the process gas. A very turbulent condition exists in the inlet barrel where the gas and liquid comes into contact. The liquid droplets slow, and then turn and travel in the same direction as the gas. The liquid, upon exiting the inlet barrel, falls to the sump in the base of the vessel. The gas exits the inlet barrel, turns upward, and passes thru two layers of chevrons used for mist elimination. In the sump, liquid is stored that will be circulated back to the spray nozzles. Also in the sump, air is forced in thru a sparger, and the sulfites are oxidized to sulfates.

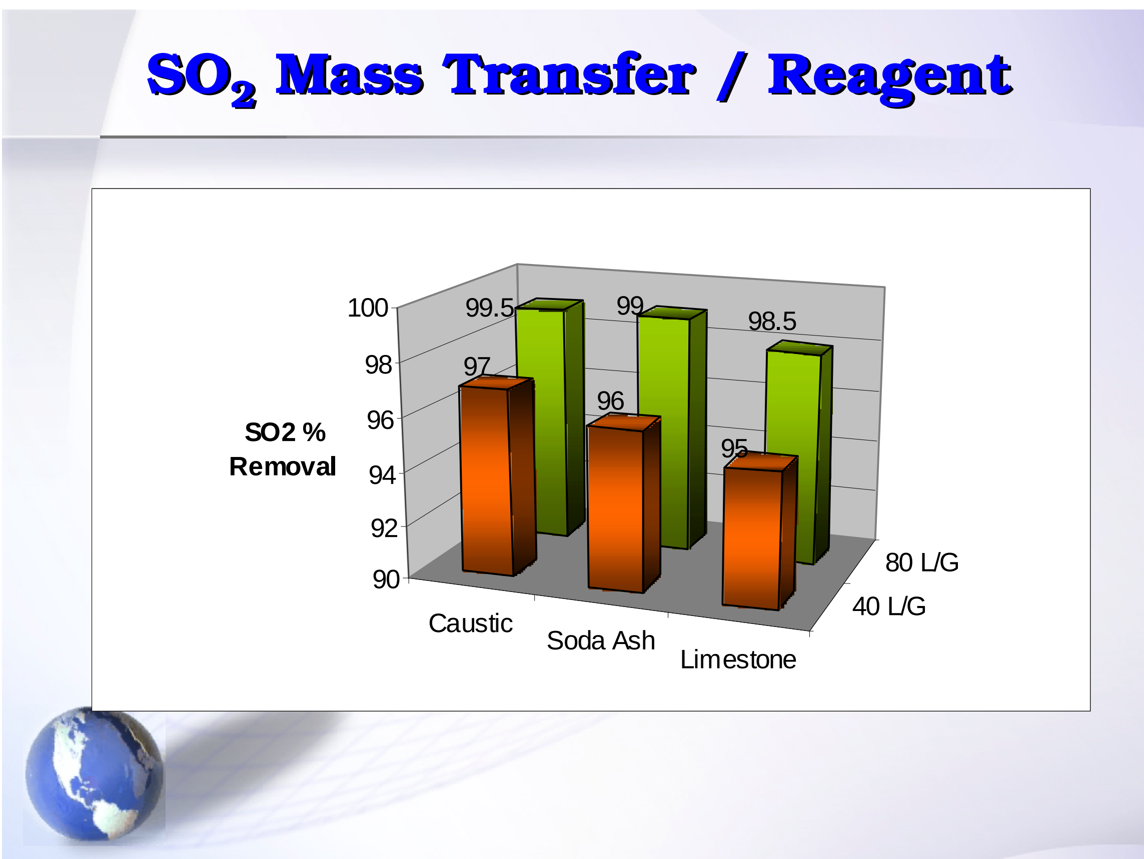


This unit is significantly different than most spray towers. First, the gas/liquid contact occurs in a high velocity area in the inlet barrel, rather than a low velocity region in the spray tower. Also, only a very few nozzles are installed, that are located just above the liquid level. These nozzles are high volume, low-pressure nozzles. The largest size of these nozzles that are currently produced mounts to a 16" flange. It is rated for more than 8000 gpm at only 10 psi pressure. Thus, this system requires slurry pumps with a very low pump discharge head. The discharge head required need only overcome the very low nozzle pressure and the slight increase in liquid elevation. The nozzles can be constructed of either silicon carbide or Teflon. For slurry applications, the silicon carbide nozzle is used. Shown below is a single, 16" nozzle that is part of a 3-nozzle cluster located below an inlet barrel.

The next photo shows the same nozzle cluster in operation. Again, there are a total of 3 nozzles pointed upward. Only the nozzle closest to the camera can be seen due to the large amount of liquid.

In the design of the scrubber for situations where only acid gas removal is involved, (and particulate collection is not an issue), gas velocities in the inlet barrel are on the order of 50 to 120 feet per second. This high of gas velocity, along with the high liquid flow rates that create the turbulent mixing, also creates a pressure drop across the inlet barrel of about 6" w.c., (and a total flange-to-flange drop of 7"). This differential pressure is higher than the 4 to 6" of drop across a conventional spray tower, and has a penalty of slightly higher fan power required to move the gas thru the scrubber. However, the DynaWave typically operates at lower liquid-to-gas ratios, and as already mentioned, pump heads are also significantly lower. Thus, pump power required is less than a conventional tower, and more than offsets the increase in fan power. In addition, the higher pressure drop across the barrel, along with turbulent mixing, insures that no leakage occurs around the liquid/gas contact zone.

The liquid-to-gas ratio used in the DynaWave unit is dependent upon the concentration of SO2 in the inlet gas stream, the reagent being used, and the desired removal efficiency. The chart below shows removal efficiencies for various reagents and for two liquid-to-gas ratios for the DynaWave Scrubber, (assuming SO2 at levels below 3000 ppm).



Some case studies of units currently in operation are presented below.

The first case study is for a DynaWave Scrubber unit downstream of a Cement Kiln that is located in Europe. The DynaWave is designed for removal of SO_2 only. Photo of the unit is shown below.

Inlet Gas Flow Rate:	230,000 acfm at 320ºF
SO_2 at Inlet:	900 ppmd
Design Removal Efficiency:	98%
L/G ratio at Design Conditions:	80
Reagent used:	Limestone Slurry or Cement Kiln Dust
Actual System Performance:	at L/G ratio of 40, 98% of SO_2 removed.
	at L/G ratio of 80, 99% of SO_2 removed.

The second case study is also for a DynaWave Scrubber unit downstream of a Cement Kiln. However, this kiln is located in the United States. The DynaWave was again designed for removal of SO2 only.

Inlet Gas Flow Rate:	550,000 acfm
SO2 at Inlet:	980 ppm
Design Removal Efficiency:	96%
L/G ratio at Design Conditions:	40
Reagent used:	Limestone Slurry or Cement Kiln Dust
Actual System Performance, SO2 Removal:	99%

The third case study is for a DynaWave Scrubber unit downstream of a Coal Fired Boiler that is located in South Africa. For this application, the boiler was not equipped with either a fabric filter or a precipitator. Thus, the scrubber was required to remove both SO2 and particulate matter from the flue gas. Inlet SO2 loadings were fairly low. However, aluminum fluoride was present that tends to inhibit SO2 collection.

Inlet Gas Flow Rate:	220,000 acfm
SO2 at Inlet:	360 ppm
Particulate Loading at Inlet:	0.7 gr/sdcf
Design SO2 Removal Efficiency:	95%
Design Particulate Removal Efficiency:	96%
L/G ratio at Design Conditions:	62
Reagent used:	Lime Slurry
Actual System Performance, SO2 Removal:	99%
Actual System Performance, Particulate Removal:	>96%

The fourth case study is for a DynaWave Scrubber unit downstream of a Coal Fired Boiler that is located in China. For this application, the boiler was equipped with precipitators, and thus the scrubber was concerned with SO2 removal only. A photo of the unit is shown on the next page.

Inlet Gas Flow Rate:	200,000 acfm
SO2 at Inlet:	5,500 ppm
Design Removal Efficiency:	98%
L/G ratio at Design Conditions:	120
Reagent used:	Lime Slurry
Actual System Performance, SO2 Removal:	>98%

The fifth, and final, case study is for a DynaWave Scrubber unit downstream of a Refinery Sulfur Recovery Unit. For this application, the scrubber is for SO2 removal only, and caustic is the reagent of choice. Due to the small gas flow, the inlet barrel is located external to the separation vessel.

Inlet Gas Flow Rate:	10,000 acfm
SO2 at Inlet:	6,000 ppm
Design Removal Efficiency:	99%
L/G ratio at Design Conditions:	80
Reagent used:	Caustic
Actual System Performance, SO2 Removal:	>99%

As noted previously in the paper, the DynaWave scrubber can be designed for both acid gas absorption and for particulate removal. Up to now, most of the discussion has centered on the use of the DynaWave for SO2 absorption. However, a very unique feature of this scrubber is that it can handle acid gas absorption at the same time it can also remove particulate matter from the flue gas. It can do this, while still using any reagent, including lime or limestone slurries. The particulate removal is accomplished by increasing the pressure drop in the inlet barrel. The inlet barrel can be designed for up to 40" w.c. differential pressure. Increasing the gas velocity in the barrel, and also increasing the liquid flow and pressure accomplishes this. Particulate removal efficiencies are dependent upon particle size distribution, and gas side pressure drop. In this respect, the DynaWave performance for a given size distribution and pressure drop is essentially that same as that found for a venturi scrubber with the same conditions.

The final benefit of this scrubber technology is that it is well suited for retrofitting existing scrubber units on the market. As previously discussed, the real technology is in the inlet barrel where all the gas and liquid contact occurs. For older scrubbers in operation, a new inlet barrel can be fitted to the inlet of the existing vessel. Then the old scrubber vessel can be reused as just a liquid sump, and for mist elimination. This minimizes costs and downtime needed to upgrade an existing unit.

In summary, the DynaWave is a unique wet gas scrubber. It has a proven track record. However, design of this unit is significantly different than that of a conventional spray tower. The gas-contacting zone is at a velocity significantly higher than what is attempted in a spray tower. Removal efficiencies for SO2 meet, or surpass those found in a spray tower, but at lower liquid-to-gas ratios. Finally, the DynaWave has the versatility to operate as a particulate collector and acid gas absorber all in one vessel.