RILEY SCRUBBER PERFORMANCE AT CILCO

by

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ENVIRONEERING, INC.
A SUBSIDIARY OF THE RILEY COMPANY

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INTRODUCTION

A milestone was achieved by Riley this summer with the start-up and performance testing of our first module of a new generation absorber known as the Ventri-Sorber™ at the Duck Creek Station of Central Illinois Light Company. CILCO has contracted Riley Stoker for the design and procurement of a 400 MW flue gas desulfurization system using limestone slurry as the scrubbing medium. The boiler as supplied by Riley is designed to burn medium to high sulfur Illinois coal.

The heart of the flue gas desulfurization system is the second generation of absorbers designed by Environeering, a member of the Riley Stoker group. Since the success of an FGD system to a large extent depends on the performance of the absorber, CILCO's original approach with the concurrence of Illinois EPA was to test and optimize the performance of a single absorber module capable of handling 300,000 ACFM of gas flow equivalent to a 100 MW prior to the design and start-up of an additional three modules. However, the peripheral equipment of the system such as the limestone handling and sludge disposal systems have been sized for a total of 400 MW.

VENTRI-SORBER DESIGN

Our nearly two decades of experience with FGD systems and our first generation absorber namely the marble bed hydrofilter has educated us that the plugging and scaling commonly associated with the SO_2 removal systems could be avoided by providing minimum restriction in the absorber, self-cleaning scrubbing elements, conservative design of mist eliminator section and their continuous wash, and of course proper system chemistry, piping design know-how and hardware.

The absorber which incorporates the above features is the Ventri-Sorber. The Ventri-Sorber in principle is a counter current open "grid type" of tower depending on the turbulent layer on its stages to provide maximum mass transfer. A cross section of the Ventri-Sorber is shown in Figure 1. The gas enters the bottom of the absorber and makes

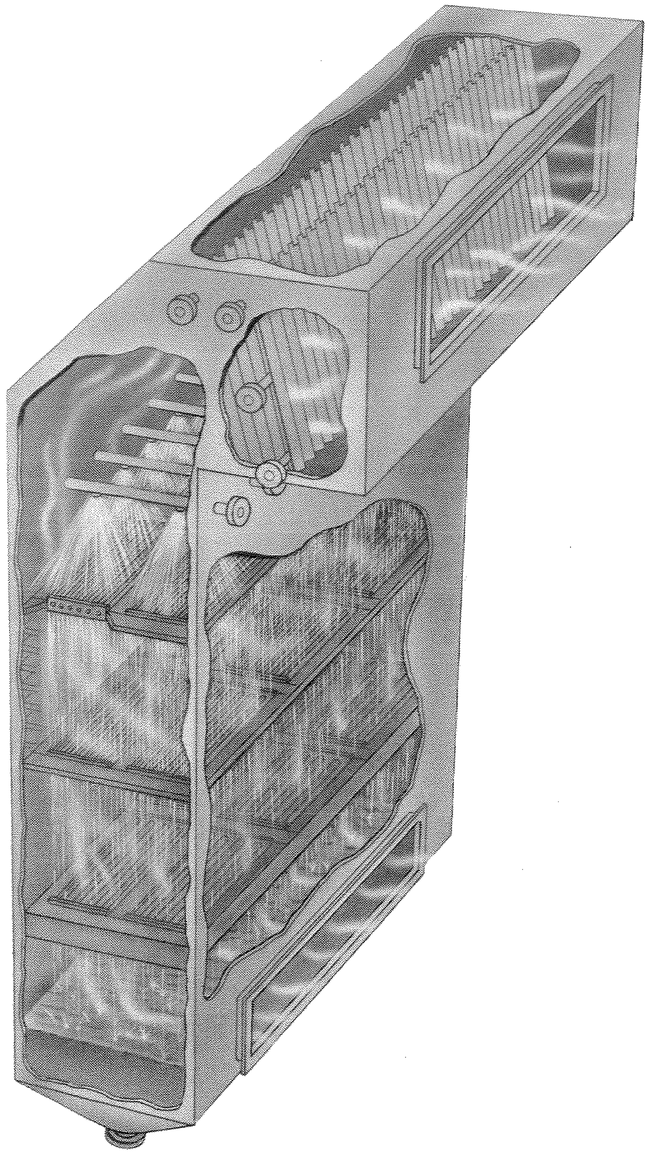

Figure 1 A-5 Ventri-Sorber™ Scrubber

a 90° turn and travels upward through the opening between rods strategically placed in eight decks. The limestone slurry is introduced at the top by means of open pipes and travels downward. The inter-mixing of the slurry and gas takes place on the turbulent layer maintained on top of each rod deck whereby scrubbing action takes place. The scrubbed flue gas then makes a 90° turn and drops most of its free liquor due to gravity prior to the entry into the mist eliminator section. The absorber and the mist eliminator sections are designed for 750 ft./min and 800 ft./min superficial velocities respectively.

Mist elimination is achieved by two sets of Chevron type mist eliminators inclined slightly from vertical position to facilitate proper draining and continuous wash. The mist eliminator blades have three bends and depend on impaction for their action and they are placed sufficiently wide apart to minimize plugging. It has been our belief from the very beginning that such a mist eliminator design would lead to superior drainage and greater washing flexibility and thereby we could avoid the problems associated with the performance of the mist eliminators in competitors' scrubber installations. Studies performed by TVA, Ontario Hydro Electric and EPRI have shown that vertical mist eliminators with horizontally approaching gas flow have superior design advantages for FGD absorbers.

SYSTEMS DESIGN AT CILCO

The limestone preparation system incorporates a KVS wet ball mill and associated equipment. The slurry is pumped from the storage tank to the main recirculation tank which is designed for a retention time of ten minutes. The storage pumps are rubber-lined steel and designed to handle 40% of limestone solids.

The demist wash system is divided and separated for the two demist sections. The demist tank is divided into two sections. The make-up water is added in one section of the demist tank and this clean water is used as the cleaning agent of the second stage mist eliminator to minimize solid carry-over. The overflow from the clean section is used to clean the first stage mist eliminator. Any solids that are scrubbed at this stage are allowed to settle out and drain into the recycle tank to minimize solids build-up. The solids are discharged from the recycle system to a pond and the supernatant liquor is recirculated back to the process. Figure 2 shows the system schematic employed at CILCO.

The CILCO FGD system is designed to be highly automated and can be operated with minimum operator intervention. The system is capable of operating in three operating modes: remote auto, local-auto and local-manual. The control philosophy is based on minimizing the reagent usage while simultaneously operating the unit at an acceptable pH range to control chemistry and minimize pluggage.

The SO_2 limestone scrubbing system has several chemical reactions that take place in the absorber. Some of these reactions are desirable while others are not. Environeering know-how of system chemistry has been predominantly responsible for minimizing scales within the system.

PERFORMANCE OBJECTIVES

During the start-up and subsequent testing at CILCO module 1, the following objectives were established:

1. Ventri-Sorber Characterization Tests:
   a. Turndown
   b. Pressure drop
   c. Gas distribution
   d. Liquid distribution
   e. Scale-up factors
   f. Solid build-up
2. Performance Tests:
   a. SO_2 removal efficiency
   b. Liquid carry-over
   c. Solid carry-over
   d. Scale-up factors
3. System Characterization Tests:
   a. Wet dry intersection
   b. Instrumentation
   c. Hardware design

RESULTS OF VENTRI-SORBER CHARACTERIZATION TESTS

The initial design of the absorber was for eight rod decks with each rod deck 50% open and the slurry introduction by pressure ceramic nozzles. The initial start-up results indicated that such a rod deck configuration would result in maldistribution of gas, excessive liquid carry-over and the nozzles were prone to pluggage with debris from the open recycle tank.

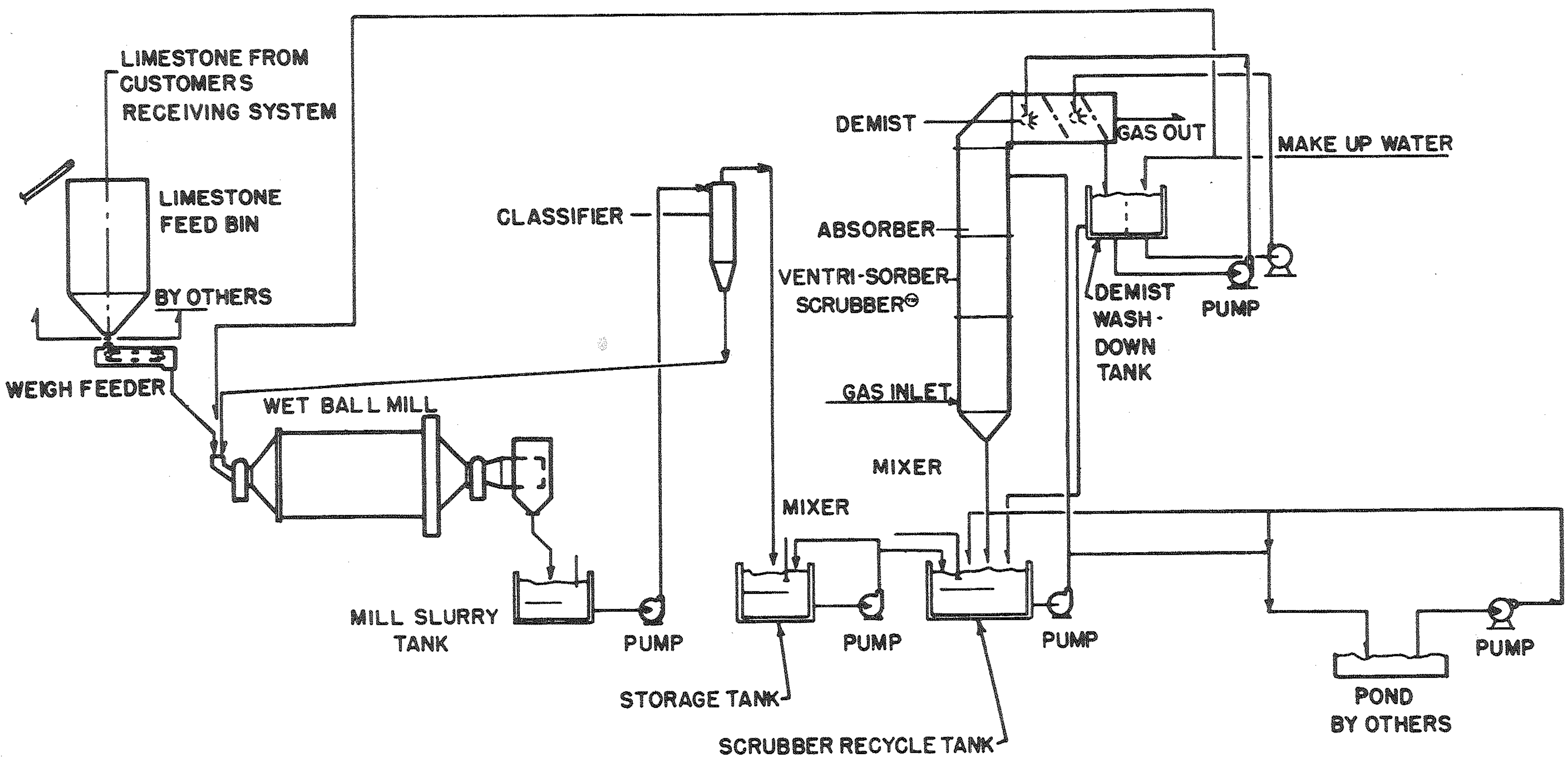

Figure 2 Scrubber System Schematic

The built-in flexibility in the design of the rod deck enabled a cure of this distribution and liquid carry-over problems by simply rearranging the open area between various rod stages while maintaining design total flange to flange pressure drop. The final configuration has been: first bottom stage with 25.9% open area, stages two through seven with 41.4% open area and the eighth stage with 45.6% open area.

The nozzle pluggage was overcome by simply removing nozzles and replacing them with open pipes and target plates fastened to the uppermost rod deck to achieve proper liquid distribution. These changes helped us to bring the total flange to flange pressure drop within twelve percent of the original design.

On the hydraulics of the unit an excellent correlation was obtained between the 300,000 ACFM CILCO module 1 and from our prior work with 2000 ACFM laboratory unit, and 6500 ACFM pilot unit.

The start-up also indicated that the CPVC pipe on the demist wash will not withstand erosion or temperature excursions and this has been replaced with high temperature FRP.

RESULTS OF PERFORMANCE TESTING

Figure 3 indicates the SO_2 removal efficiency obtained at CILCO and their comparison with prior work. One will notice the Ventri-Sorber is operating at 91.6% removal efficiency when compared to a commercial guarantee of 85.6%. It also indicated that the commercial unit achieved better efficiencies than the earlier pilot work.

	LABORATORY TEST UNIT		PILOT PLANT AT CILCO E.D. EDWARDS	COMMERCIAL UNIT AT CILCO DUCK CREEK	DESIGN CONDITIONS
GAS FLOW, ACFM	1700		6800	300,000	300,000
F-FΔP, IN WG	8.5		8.6	8.8	8.5
L/G, GAL/MACF	50		50	50	50
SO_2 INLET CONC., PPM	2000	3000	2000	3000	3000
SO_2 REMOVAL, %	88.1	81.5	91.5	91.6	85.6

Figure 3

Measurements for liquid carry-over indicated that they were negligible.

The results from testing a solid carry-over is summarized in Figure 4. The results definitely show a decrease in the particulate loading as the gases pass through the absorber. The outlet loading as measured were below the maximum allowable even when the inlet exceeded the design by a factor of 3 to 4 times.

SOLID CARRY-OVER TESTS: GRAINS/DSCF

TEST NO.	I	II	III
DESIGN INLET	.0476	.0476	.0476
MEASURED INLET	.2136	.1718	.159
MEASURED OUTLET	.039	.0208	.0837
DESIGN OUTLET	.0476	.0476	.0476

Figure 4

COMMENTS ON SYSTEM CHARACTERIZATIONS

No solid build-up was observed in the wet-dry transition zone and subsequently the soot blower originally supplied has never been operated. Inspections have indicated that the mist eliminator section shows minimal evidence of build-up. The internal rod deck also has no build-up.

The digital portion of the controls has been simulated for the process and appears to be working properly.

On the hardware design the pumps would require some design changes to improve their reliability. The module has not shown any corrosion attack either in the mist eliminator section or in other places.

SUMMARY

The performance of Ventri-Sorber at CILCO to date indicates that removal efficiency required to meet the current regulations and contract could be achieved at acceptable operation conditions, without any major modifications to the system. The present status at CILCO is that module 1 has been mothballed during the construction of the other three Ventri-Sorbers and the boiler is burning low sulfur coal as mandated by EPA, to meet the regulations. We are scheduled to begin start-up of the other units in March, 1978, and complete commercial operations by July, 1978, for a completely integrated 400 M.W. FGD system.