IMC FERTILIZER SULFURIC ACID PLANT

HEAT RECOVERY SYSTEM

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INTRODUCTION

The first Monsanto Enviro-Chem Heat Recovery Systems (HRS) were installed on two 1,500 STPD sulfuric acid plants in Korea and were started up in 1987. Since then, five other units have been built in Korea and Europe. The first HRS in the United States was installed for IMC Fertilizer at their New Wales Florida phosphate fertilizer complex. The following is a discussion of the development of the IMC Fertilizer project, the initial June 1991 start-up performance, subsequent modifications, and current operating status.

HRS BACKGROUND

The sulfuric acid Heat Recovery System (HRS) technology has been the subject of several previous papers and, therefore, only an overview is presented here. From a process standpoint, HRS is a typical absorption tower that operates with acid circulating temperatures of 380°F to 440°F. A boiler is used to remove heat in the form of medium pressure steam. Consequently, the absorption tower heat is recovered as useful energy, instead of being wasted to a cooling tower by conventional acid coolers. The invention that made this possible is rather common stainless steel alloys become virtually corrosion resistant at 400°F and higher when the circulating acid concentration is increased by less than 1%.

IMCF FERTILIZER HRS PROJECT BACKGROUND

In 1989 IMC Fertilizer (IMCF) and Enviro-Chem began the evaluation of the HRS project. This effort was initiated because IMCF was planning to replace or make major repairs to the interpass tower of their 03 sulfuric acid plant for maintenance reasons. The basic key to this evaluation was the site steam balance, including the steam flow to the No. 2 turbine generator condenser. The No. 1 turbine generator is a nominal 10 MW back-pressure machine, and the No. 2 turbine generator is a nominal 58 MW condensing machine. At the time of the evaluation, there were three steam header systems in the chemical plant: High Pressure (600 psig), Medium Pressure (250 psig), and Low Pressure (40 psig). The 250 psig header was supplied by letting 600 psig down across a control valve which meant it was being bypassed around the high pressure section of the No. 2 turbine generator. Based on this, IMCF evaluated operating the 250 psig header at 150 psig and subsequently demonstrated this could be done with no detrimental effect. The concept was to generate the HRS steam at 150 psig to supply the plant medium pressure steam header. As a result, the HRS steam has the effective equivalent of 600 psig steam, in terms of electrical power produced, as the medium pressure steam is no longer supplied from the 600 psig header.

The second key area evaluated was the No. 2 turbine generator condenser capacity. Historical information was obtained and then projections were made for future operation. From this it was determined that the No. 2 condenser could not handle all of the steam that could potentially be produced by the HRS. Therefore, the HRS heater and HRS preheater were deleted from the design. Deleting the HRS heater reduced the HRS boiler steam production. Deleting the HRS preheater increased the HRS deaerator steam usage. At a design capacity of 2500 STPD, the combined effect reduced the net HRS steam production from approximately 94,000 pph to 74,000 pph. Even with this, it was projected that at times there would be excess HRS steam (insufficient No. 2 turbine generator condensing capacity) that would have to be condensed in the existing fin fan air condenser.

This effort established how much electrical power could be produced. IMCF then completed an economic evaluation, and it was determined that the HRS project met their corporate internal rate of return.

IMCF PROJECT DESCRIPTION

The HRS design capacity is 2500 STPD. The HRS tower is a two-stage packed tower system. The initial design had a pipe type lower stage distributor, and the upper stage had a trough type distributor. The lower stage circulating pump is a Charles S. Lewis pump with a 310 S.S. impeller. The circulating pump is mounted on a pump boot attached to the HRS tower. Monsanto ES style Mist Eliminators are located in the tower above the second stage. Acid flow to the upper stage is from the outlet of the drying tower acid cooler.

The HRS boiler is a kettle type with acid in the tubes and elevated to automatically drain back to the HRS tower. A new deaerator and boiler feedwater pumps, dedicated to the HRS, were also provided. Other items are: two HRS system drain pumps, HRS boiler blowdown separator and chemical feed system.

Overall, the design philosophy was to improve the IMCF HRS reliability. This was a programmed approach to make certain the experience gained from the previous six operating HRS units was incorporated in the IMCF project. Most of this effort was directed at a potential HRS boiler leak. Here the basic concept was to improve the methods for separating the boiler reactants (sulfuric acid, water, and steam) in the event of a leak. By separating the reactants quickly, the potential of having a highly corrosive environment is greatly reduced. To accomplish this, the IMCF design has provisions for venting the boiler to the atmosphere (this not only reduces the boiler pressure but also quickly cools the boiler to 212°F), providing complete blowdown of the boiler on the water side, and draining the acid to the HRS tower. Also, there are two large, parallel HRS tower drain pumps, so the tower can be quickly emptied. The system is designed so that all these actions will occur within minutes. Improvements were also made in such areas as how instrumentation information is presented to the operator and automatic double block and bleed on the dilution water. In summary, HRS with over four years of operation has proven to be a safe system. Now with these improvements there is added insurance for the personnel as well as the equipment.

IMCF gave Enviro-Chem full authorization to proceed in September 1991, and the system was started up in June 1991 for an overall project schedule of ten months. The system was constructed in an open area adjacent to the existing interpass tower. Tie-in of the system was completed during the normal turnaround and was coordinated with IMCF so that it did not interfere with other turnaround work.

INITIAL START-UP

The initial HRS unit startup was June 8, 1991. During the first hours of operation, the HRS diluter sparger had excessive vibration. The acid plant was then shut down for two days to repair another item not related to the HRS unit. This provided time to modify the sparger. The modified sparger dramatically reduced the vibration and has been working well since that time. Also during these first days of operation there were problems with some of the simple instruments such as acid and steam flows. While not critical to operating the unit, this was an aggravation.

Following correction of the other plant problems, the plant was restarted. Formal demonstration was completed June 15, and all guarantees were met. In addition, testing at the outlet of the HRS tower showed mist was 0.24 mg/ACF, and SO_3 and H_2SO_4 vapor was 0.27 mg/ACF, which is good even for a conventional interpass tower.

POST START-UP MODIFICATIONS

While the initial start-up and early operation of the HRS went very well, performance began to deteriorate in July. During July, adjustments were made in various operating variables with some improvement in performance; however, by August, performance continued to deteriorate. There was measurable drainage from the HRS outlet duct, economizer, and the stick test was black. Measurement of the HRS exit gases confirmed the acid mist and vapor had increased by an order of magnitude. In late August the acid plant was shut down and the HRS system was inspected. The inspection showed the lower stage internal pipe distributor orifices had corroded/eroded as well as the pipe distributor feed holes. At the same time, the internal distribution pipe did not show any measurable corrosion nor did the external pipe from the diluter to the tower, the circulation pump, or other areas. The erosion/corrosion was limited to the high velocity distributor orifices and feed holes. A secondary problem was the upper stage trough distributor was partially plugged with cation resin in the dilution water.

The conclusion of this inspection was the poor lower stage distribution was overloading the upper stage. As a result, excessive mist was being generated and exit gas could not be cooled to design temperatures.

At that time temporary repairs were made by welding nuts over the enlarged feed holes, and larger orifices were installed. The acid plant was restarted and adjustments were made to the operating variables, primarily increasing the acid flow to the upper stage. There was a significant improvement in performance, but it was recognized that a permanent long-term fix was still required. For example, we knew erosion/corrosion of the lower stage distributor would continue and the increased upper stage flow reduced steam production.

Also during the August turnaround, several tubes in the cold gas-to-heat exchangers were plugged. These were the original plant heat exchangers located downstream of the interpass tower. Previous testing in June had already identified there were some leaking tubes. At the same time the poor HRS performance in August resulted in some additional corrosion to the cold head exchanger tubes.

Even though it appeared obvious what the problem was, the decision was made to conduct a formal problem solving analysis program. Given the importance of the situation, we wanted to make sure all aspects of the design were reviewed. The program was led by a corporate Monsanto person experienced in formal problem solving analysis. The team was composed of personnel from both IMCF and Enviro-Chem. After several weeks, an action plan was developed and set in motion. The two major corrective actions identified were first to replace the lower stage pipe distributor with a trough to eliminate the high velocity feed holes and second, to replace the upper stage 1 1/2" Interlox saddles packing with No. 1 Super Interlox, to improve the second stage performance. Another item was to install a strainer in the dilution water line to prevent cation resin contamination. These modifications were made in January 1992, in conjunction with other planned IMCF turnaround work. These design changes have also been incorporated in the seven HRS units presently under construction for Seminole, Agrico, and Texasgulf.

PRESENT STATUS

From August 1991 through January 1992, the HRS unit operated in an acceptable manner. As previously noted, permanent modifications were made in January 1992. When the unit was restarted in January, there was a significant improvement. The performance was equivalent to the original startup in June 1991. In fact, sampling results of the HRS exit gas taken in January are essentially identical: acid vapor and SO_3 of 0.18 mg/ACF and acid mist of 0.29 mg/ACF. Also, these results were achieved at the original design acid flow to the upper stage. As a result, steam production increased to the original design. Other testing was also conducted at that time. This showed that, while overall the HRS was performing well, there still was not uniform cooling of the gas in the upper stage.

From January to early March, the HRS had continued good performance. Sticks were lightly spotted, and a nominal amount of drip acid was being drained from the HRS knock-out pot. Starting in mid-March, the stick test exit the HRS became progressively worse and the drain acid rate increased. Several tests were conducted over the following weeks, and by mid-April good performance was again achieved. These tests basically confirmed that the lack of uniform gas cooling in the upper stage makes the tower performance sensitive to relatively small process variations and acid distribution. Therefore, the plan is to improve the upper stage acid distribution, and this will be completed when it is convenient to shut the acid plant down.

In conclusion, throughout the design, construction and operation of the HRS, IMCF and Enviro-Chem have worked closely to meet our mutual expectations. As a result of this effort, the IMCF HRS has proven to be a safe, reliable system.

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