A NEW APPROACH TO SULFURIC ACID COOLING

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INTRODUCTION

The purpose of this paper is to acquaint the sulfuric acid manufacturing industry with the development of a clean, practical and simple air cooled exchanger specifically designed for sulfuric acid cooling. The system to be discussed has now been proven in a number of European installations to be a viable and reliable method of cooling acid. This cooler, developed in France by AIR WORLD THERMIC, which we will refer to as A.W.T., will be marketed in the U.S.A. and the rest of the Western Hemisphere by SPELNA, Inc. of Fredericksburg, Va.

Need For A Better Way To Cool Acid

With the growth of ecological awareness and the proliferation of anti-pollution regulations of various kinds, which have now become a permanent part of our lives, the elimination of probable and possible sources of pollution has assumed an importance that would have been unimaginable a few short years ago. Most of the problems in this connection are traceable to the use of water as the cooling medium, which until now, was all we really had available.

In addition to the pollution aspect, the water related difficulties imposed on the acid plant operation have always been a matter of concern, inconvenience, expense and lost production. In addition to our familiar enemy - external scale and corrosion with its attendant reduction of heat transfer efficiency, the probability of acid leaks due to joint failure not only contributed to water pollution in large measure, it also caused the unpleasant side effects of aggravated corrosion of the rest of the system. Even the growing popularity of stainless steel shell and tube exchangers has not eliminated these problems, as interleakage due to internal failure is still a threat, and the water vapor generated by the big water cooling towers can still eat away at the rest of the plant.

DEVELOPMENT

Direct air cooling, for a long time, was seen as the answer by many of us, if the proper materials could be adapted to this kind of service, and provide an economically viable system. The simple, relatively inexpensive fin fan cooler, as we know it, was unsuitable because of material limitations, and the use of stainless steel rather than base metals, was inhibited by metal temperature limitations. Old reliable cast iron, long the stand-by of the sulfuric industry seemed to be the answer, if there were some way to get the necessary extended surface externally. Integrally cast outside fins were not the answer, as the writer found to his chagrin a good many years ago, there was no way to economically cast enough extended surface in the body to do a decent job. Attaching an inexpensive fin material to a rough "as cast" surface was always looked upon as an insoluble problem.

A.W.T., in concert with the major supplier of cast iron pipe in France, PONT-A-MOUSSON, has come up with a viable answer.

A relatively small diameter centrifugally cast iron pipe, with a very smooth surface, was made available for the base tube. A.W.T.'s associate organization, ARPENT, had developed a process for hot forming mild steel fins on the outside of the cast pipe, which provided a bond between fin and tube that permits excellent conduction and fin efficiency.

The ARPENT process consists of heating and annealing suitably dimensioned steel strip and in its soft, cherry red state simultaneously crimping and rolling it onto the cast iron tube. This resulting tube can handle maximum plant operating temperatures of 98% sulfuric acid, up to 250^{O}F, at velocities of 1 meter per second and more with virtually no iron pick-up.

A method of connecting these tubes together for constructing a practical exchanger also had to be developed. This was accomplished by adapting the lock ring and back-up flange (an idea long used on internal floating head heat exchangers) on each tube end for connection to return bends and elbows. The inlet and outlet connections are conventionally fed into manifold headers much in the manner of the familiar cascade coolers; the difference here being that everything is dry instead of wet, and shielded from the flow of cooling air. It was on this basis that the A.W.T. cooler was developed to its present advanced state.

HISTORY AND EXPERIENCE

The first A.W.T. acid cooler went in service almost 12 years ago at the GRAND QUEVILLY plant in Pechiney St. Gobain in southern France. Initially, some of the design details, such as a tandem arrangement of (2) 6 meter long sections providing longer series travel was changed to enhance the structural integrity and to eliminate any internal tube joints in the air stream. Also, it was found that the original 5mm wall thickness developed some problems, so this was corrected to provide adequate back-up metal at the snap ring groove, by increasing the thickness of the tube to 8mm, which has proven completely adequate.

It was found that by adding a modest amount of chromium, in the order of one half of one percent to the gray iron analysis, a completely trouble-free air cooled tube for acid cooling service was obtained and it routinely handles temperatures up to 120^{O}C (250^{O}F) inlet temperatures. This tube design was literally given its "acid test" when, in another installation, the unit was run without fans for a considerable time at full absorber tower temperature with no detectable corrosion or erosion of the tubes. A.W.T.'s oldest installation, the 12-year old plant of Pechiney mentioned before, has just recently provided us with corrosion data showing that their entire plant has no more than 6 PPM iron pick-up, indicating practically zero contamination by the coolers, further reinforced by measurements, which show no measurable metal loss over the years.

SERVICE EXPERIENCE

In addition to the original unit at Pechiney in 1967, units have been installed and have been in continuous operation at:

- Rhone Poulenc in Salindres, France - 1971 (2 units)

- S.I.C.N.G. in Salonika, Greece - 1976 (2 units)
- Societe Metallurgie Hoboken & Overpelt, Belgium - 1977 (2 units)
- Zuid Chemie at Sas De Gand, Netherlands - 1977
- Sud Chemie at Kelheim, Germany - 1978 (2 units)

This speaker visited most of these plants last winter and can report firsthand that the coolers operate as designed. They are clean and trouble-free and have very satisfied operating personnel.

A.W.T. COOLERS - PHYSICAL DESCRIPTION

The units currently offered are relatively standardized cells, all containing parallel or series-parallel stacks of 8 to 14 tubes, 6 meters (approx. 20 ft) long supported by a simple structural steel frame work on which the fan deck for air moving equipment in mounted topside.

The tube stacks are mounted in support brackets, which act as tube sheets, enclosing each end of the cell, and are supported from the overhead beams, which form the base for the fan deck. Transite or similar light paneling encloses the sides. It will be seen that this arrangement keeps all acid connections out of the air stream and, in the unlikely event of a joint failure, acid will drip full strength to the base, without causing water pollution. So far, we can report that no incidents of this type have occurred. Tubes are interconnected by return bends of the same chrome cast iron material as the tube base with adequate cadmium plated bolts and teflon or similar inert gasket material. The tube ends are precision machined to exact length during this period of their manufacture, likewise, the grooves for the snap rings.

Individual stacks of tubes have conventional chromium cast iron sweep ells top and bottom for connections to chromium cast iron manifolds.

Erection of an A.W.T. cooler is simple and easily accomplished by plant personnel. Basic foundation footings of reinforced concrete are poured by the purchaser or his contractor to A.W.T. dimensions and loading specs, and the uprights are bolted to this foundation. After completing the simple box structure, the fan and motor equipment are installed, while the stacks of tubes are assembled horizontally on the ground below. The stacks are positioned by means of small electric winches placed fore and aft at base level, which remain on the unit for maintenance operations.

For rating purposes, the individual tubes are 3" O.D. x 2.36" I.D. with 1 1/2" high fins on 0.6" pitch, external surface 7.52 sq. ft/ft, internal surface 0.62 sq. ft/ft. Lateral tube pitch would be about 6", center to center of the stacks. The number of tubes per stack and number of parallel rows would, of course, be a function of duty, flow and temperature differential, as in any other exchanger. Likewise, the quantity of air and the power requirement to move it would be similarly determined.

As a typical example, a unit to cool 205 m^3/hr 98% acid (900 GPM) from 97C to 80C (207F to 176F) would require 20 stacks of tubes for a velocity of between 1 and 1.5m/sec. maximum.

This represents a duty of 2,370,000 KC/hr (9,400,000 BTU/hr) and with a 40^o air temperature rise, 940,000 #/hr of air (205,000 SCFM) would be needed for a heat balance. The log MTD would be 50C (90F) and a valid trial transfer rate would be 4BTU/hr/sq ft/^{o}F. The resultant external surface required would be 26,000 sq ft or 183 tubes. Arranged in 20 stacks, 10 tubes would be required per stack to achieve an even number for arrangement convenience.

Power 2-25KW fans (33 H.P.). Cell size would be approximately 11' wide x 20' long x approximately 20' overall height. For larger capacity installations, multiple cells of somewhat greater numbers of tubes both in series and parallel can be used. Generally the maximum width per cell is 24 tubes and the maximum height of stack is 14 tubes.

ENGINEERING SERVICE

Development of specific recommendations from process requirements is handled by computers at A.W.T.'s headquarters in France, providing complete thermal and physical design data and cost figures, which would include all material, shop pre-assembly and matchmarking, and field erection supervision.

ECONOMICS

The first cost of air coolers must be considered in balance against the water handling equipment, treatment systems and cooling tower cost and maintenance, as well as the results of corrosion in the plant as well as the cooling equipment.

A clean and dry, thoroughly reliable cooling system is far preferable to one that is wet, dirty and subject to frequent maintenance breakdowns.

In addition to being a better partner in plant operation, it is a more acceptable neighbour. The concept is well worth serious consideration.

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