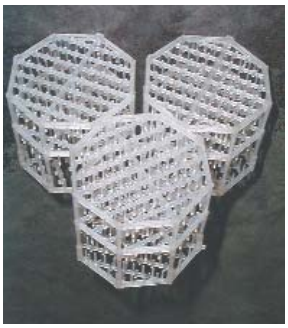
Optimization of a Kraft Pulp Mill Chlorine Dioxide (ClO_2) Scrubber - With Q-PAC Repack Power Costs are Reduced by Over $80,000 per Year and Emissions are Non-Detectable

Abstract

An existing ClO_2 (chlorine dioxide) scrubber tower at a pulp mill was repacked during a planned maintenance shut down. As the result of replacing 3" Kynar and 2" CPVC Norton Super Interlox saddles with Q-PAC from Lantec Products, the scrubber tower is now operating at a greatly reduced pressure drop compared to when the tower was packed with saddles. The reduced pressure drop has resulted in a significant power savings for mill. Immediate savings of over $80,000 per year in reduced power cost has been realized by the mill. The ClO_2 emissions from the scrubber to the atmosphere are also now below detection level with Q-PAC in service in the tower.

Figure 1. Q-PAC from Lantec Products:



Introduction

Chlorine dioxide, ClO_2, is commonly used to bleach wood pulps produced at kraft pulp mills. ClO_2 imparts a high degree of whiteness to a pulp at reasonable cost. The physical properties (burst, tear, tensile, viscosity) of wood fibers bleached with ClO_2 are superior to that offered by alternate bleaching methods [1]. Chlorine dioxide has been designated by the US EPA as a "Best Available Technology" [2]. Chlorine dioxide bleaching is also widely accepted in Europe as the best method to produce strong, white papers in an environmentally responsible manner [3].

Additionally, by eliminating the need to adopt totally chlorine free (TCF) pulp bleaching, chlorine dioxide bleaching helps extend forest resources. Pulps produced using TCF make papers that have poor tensile strength. If adopted by the entire pulp and paper industry in North America, TCF bleaching would require additional harvesting of 100 million trees per year to compensate for the weak pulps so produced [2].

A very active and unstable chemical, ClO_2 is always produced on site just prior to being used in the bleaching process [4]. As such trace levels of chlorine dioxide emissions to the atmosphere are the subject of operating air emission permits. ClO_2 is classified as a severe irritant to both the eyes and respiratory system. The threshold limit value (TLV) for exposure to ClO_2 is 0.1 ppmv [5] and the short term exposure limit (STEL) to ClO_2 is 0.3 ppmv [6]. Most mills choose to control emissions of chlorine dioxide with traditional scrubbing (or absorption) technology. The ClO_2 is scrubbed from the air using white liquor as the scrubbing (or absorbent) agent in a packed tower (or scrubber). The choice of packing used to fill the tower will affect both the operating efficiency (rate of mass transfer or chemical recovery) and the operational costs of the chlorine dioxide scrubber system.
Typical of most mills in the pulp and paper industry using the chlorine dioxide bleaching process is a

large mill in the northeastern USA. This mill has a scrubber tower dedicated to removal of ClO_2 prior to discharge to the atmosphere.

Figure 2. Typical pulp mill, photo courtesy of Trane Company [4]:

The Problem

The cost of operating the ClO_2 scrubber tower is directly related to the pressure loss across the packed bed of the scrubber. The greater the pressure drop, the more horse power must be used to drive the air through the tower. And more horse power means large electric costs. A chlorine dioxide scrubbing tower at a pulp mill has been traditionally considered to be a high cost unit operation as a result of the packing products available with which to pack the tower.

The primary reason for the high costs of operating a chlorine dioxide scrubber is because the traditional choice of packing for ClO_2 scrubbers has been saddles. Saddles have a large pressure drop (i.e., large power costs), tend to nest (so pressure drop and power consumption goes even higher) as well as have the tendency to foul and plug (i.e., even higher pressure drop and added maintenance costs).

As an example, the ClO_2 scrubber at this pulp mill treats 45,000 cfm of air in a 12'6" diameter tower with two packed beds in series of 30' each (so 60' total packed depth). The white liquor flow to the tower is 2400 gpm. This scrubber operated with a pressure drop of about 30" water column with 3" saddles (Kynar saddles in the bottom 30' packed bed) and 2" saddles (CPVC in the top 30' packed bed). The 30" WC pressure drop was observed when the saddles were first installed into the scrubber. During normal operation the pressure drop across the scrubber would continually creep up until it reached 38" WC. This gradual increase in pressure drop was due to both breakup of the saddles as well as to plugging of the saddles from solids present in the white liquor used to scrub the ClO_2. At 38" WC pressure drop the scrubber would be repacked with new saddles - both to lower the cost of operating the scrubber as well as to keep the scrubber operating within emission permit values for ClO_2. As a result the chlorine dioxide scrubber consumed a large amount of electric power and the packed beds of the chlorine dioxide scrubber had to be repacked with new saddles every 2 ½ to 3 years.

The Solution

Patented in 1996, Q-PAC from Lantec Products offers kraft mills the opportunity to both increase capacity as well as to reduce operating costs of an existing ClO_2 scrubber. Q-PAC's unique design of all rounded surfaces with many needles forces the white liquor to pass the tower as a shower of many droplets. This shower of droplets means that air - white liquor interface surface is increased by a factor of 2 or 3 times when compared to a traditional packing such as saddles, so mass transfer of the ClO_2 is increased into the white liquor.

After discussions between the mill and Lantec Products, mill personnel decided to cancel the planned repack of the ClO_2 scrubber with new saddles during their maintenance shut down in the early fall of 2001. Rather the decision was made to remove the old saddles (as was originally planned) and to replace this packing with Q-PAC supplied by Lantec Products. The bottom 30' packed bed as well as the first 4'in the upper 30' packed bed would be filled with Q-PAC in Kynar. The remaining 26' of the top packed bed

would be filled with Q-PAC in glass filled polypropylene. Kynar was required because of the aggressive nature of chlorine dioxide. The glass filled polypropylene was placed in the upper section of the scrubber to offer protection against a temperature upset.

The reason why the entire scrubber tower did not need to be packed with all Kynar packing is explained later in this discussion.

Q-PAC also has a specific void volume of 96.3%. This is the highest void volume found in any commercially available packing. Note in Figure 3 that at any given operating conditions Q-PAC will operate at the lowest possible pressure drop possible when placed in a scrubber tower. This means the power costs of operating the ClO_2 scrubber would be greatly reduced after Q-PAC was placed in operation.

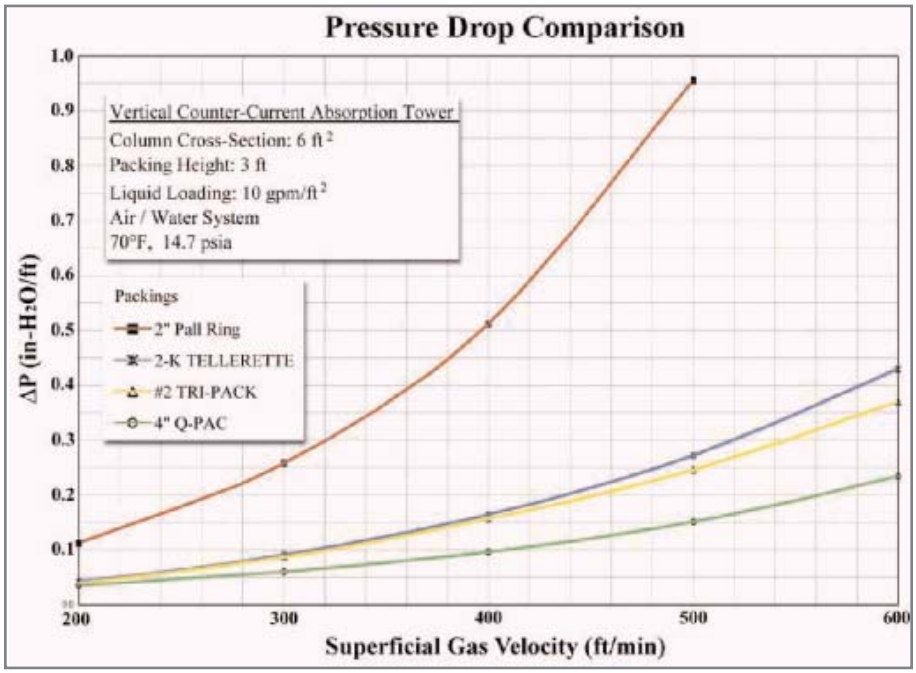


Figure 3. Pressure drop of Q-PAC compared to several competitive packing products.

In actual practice the pulp mill reported that the pressure drop across their ClO_2 scrubber fell to 4" WC, total, after the repack with Q-PAC. As mentioned above, the normal pressure drop for that scrubber had been 30" WC with (new) saddles. Even with a low electric power cost the mill expects to recover the cost of the Q-PAC in less than three years as the result of this reduction in power consumption. As a matter of fact the amperage load on the fan supplying air to the chlorine dioxide scrubber (600 hp) has been reduced from a 95% to 50% load as the result of packing the scrubber with Q-PAC. This means that the mill has eliminated the need for 270 operating horse power. The direct power savings as the result of this horse power reduction is over $80,000 per year.

As previously mentioned, the mill has a permit level of ClO_2 allowable in the air exiting the stack of the chlorine dioxide scrubber. With Q-PAC in place, not only is this legal requirement being met, the scrubber is operating with non-detectable ClO_2 emissions. This is a direct result of Q-PAC supporting much more efficient mass transfer than was possible using the old saddles. Although the tower has 60' of packed depth, with Q-PAC in place > 99.99% absorption of ClO_2 is accomplished in the first 30' packed bed of the scrubber. Therefore, with Q-PAC in place in the scrubber, the additional 30' packed bed is

acting as an extremely large safety factor to prevent any escape of ClO_2 into the atmosphere. Also, as previously noted, this means that the packing in the top 30' packed bed has minute exposure to ClO_2 during normal operation of the scrubber. No need to pack the top bed entirely with Kynar packing therefore existed. Taking advantage of Q-PAC's high efficiency allowed for most of the top section to be filled with glass filled polypropylene Q-PAC. As a result the cost of the packing order placed with Lantec Products was reduced by over $100,000.

The results of this repack project are summarized in the table below.

ClO2 Scrubber Operating Parameters

	With Saddles	**With Q-PAC**
Air Flow	45,000 cfm	45,000 cfm
Packed Depth	60 feet	60 feet
DP	30" WC*	4" WC**
ClO2 Emissions	Within permit	Non-detectable
Fan HP	570	300

*Pressure drop observed after initial installation of saddles. Over time pressure drop observed to gradually increase to 38" WC.
**No incremental increase in pressure drop observed.

This extremely large safety factor can be used by the mill in several possible ways. At current conditions the top 30' packed section of the scrubber tower is acting as a backup to the bottom 30' packed section. Should the bottom section begin to fail for any reason the top section has enough packing to assure that ClO_2 will not escape from the stack. Even if the entire bottom section fails, the top section will continue to function at 99.9% removal efficiency of chlorine dioxide. Should any such failure ever occur the 4' depth of Kynar Q-PAC in the bottom of the top packed bed will act, somewhat, to protect the packing from oxidative attack by ClO_2. Also, if the mill so desires, the current flow of 2400 gpm white liquor to the scrubber can be reduced to achieve further operational cost savings to the mill.

And the benefits to the mill of a Q-PAC repack do not stop here. Recall Q-PAC has a void fraction of over 96%, the highest void fraction of any commercially available packing. So the amount of plastic resin needed to produce a cubic foot of Q-PAC is far less than the amount of resin needed when producing other packings. This means that Q-PAC, when compared to other packings of the same material of manufacture, will always be the less expensive packing on a cubic foot to cubic foot comparison basis. Additionally, the high void fraction of Q-PAC results in little opportunity for deposits to form on Q-PAC packing. Q-PAC is also made of all rounded surfaces, so deposits have little opportunity to adhere to any individual piece of packing. Also 'bridging' of deposits across the packed bed is extremely difficult with Q-PAC. So many mills have seen their maintenance costs reduced significantly when using Q-PAC in their scrubber towers compared to all other commercially available packing products.

The actual lifetime of a packing product is difficult to predict, but as the pulp mill in this discussion has observed no incremental 'creep' in pressure drop in more than half a year of operating their ClO_2 scrubber with Q-PAC in place, it is reasonable to predict that the mill will not need to change out the packing in the chlorine dioxide scrubber on the regular basis required when saddles were used as the packing. So in

addition to greatly reducing the power costs of the mill, it is reasonable to assume that at least one repack of the ClO_2 scrubber, per previous experience, will be avoided by the mill. This will represent additional savings in both materials and labor costs to the mill additional to the power savings already being realized by mill.

Finally, if a mill is considering the need to either construct a new ClO_2 scrubber (or any other new scrubber), if Q-PAC is used to design the scrubber a much smaller tower, when compared to any competitive packing, will be practical. This is a result of Q-PAC's ability to readily accept operating air velocities from 600 - 750 fpm with no loss in absorption efficiency. The needed cross sectional area of the scrubber tower to accept the air being treated is therefore significantly reduced in new tower design when using Q-PAC. Therefore the new scrubber will not only be smaller (and be much less expensive to fabricate), it will also have a smaller footprint (so less expensive to transport and erect) and the smaller blower and pumps (further costs savings!) will also mean the scrubber tower will not be nearly as noisy in normal operations compared to ClO_2 scrubbers in kraft mills of the past!

Please feel free to contact Lantec Products for trade references and design advice regarding your ClO_2 or other scrubber projects.

References

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