In-Situ Cleaning of Kraft Liquor Lines Utilizing the BubbleUp™ Process

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Abstract

Carbonate based scales typically found in white liquor, weak wash, green liquor and lime mud slurry lines results in decreased flow rates, which in turn impacts efficiency and performance of the kraft mill process. Extreme scale conditions can limit white liquor production at mills, and negatively impact pulp production. Often mills must wait for area shutdowns, or annual outages in order to clean liquor lines to return process flows to acceptable ranges.

Historically, kraft mills have utilized numerous methods to keep liquor line scale problems under control. From magnets, and continuous chemical applications to breaking apart lines to high-pressure wash, an easy, convenient and less expensive alternative has not been available.

DuBois Paper Technologies has developed the BubbleUp^{TM} process which utilizes foam cleaning technology from the papermill to chemically remove inorganic and organic scales and deposits typically found in kraft mill liquor lines. The BubbleUp^{TM} process is less time consuming than high-pressure washing, and can typically be completed at less cost. Results from BubbleUps^{TM} performed in mills across Canada have resulted in line flow increases from 22% to 900%, with returns on investment from 2.4% to 84%.

Introduction

Few mills in North America have been spared when it comes to dealing with scale, scale control and deposit control issues. From pirssonite scale in green liquor lines, to AQ deposits in evaporator trains, scale and deposit problems can cause production losses and flow restrictions in down stream processes, and result in the costs of high-pressure cleaning and continuous anti-scalant programs. Fortunately, a new method called the BubbleUp™ process has been brought forward to kraft mills in the past year by the cleaning experts at DuBois Paper Technologies.

DuBois Chemicals– The History of a Soap Company

DuBois Chemicals originated in 1920 as the DuBois Soap Company. The founder, T.V. DuBois located the company in Cincinnati, Ohio where the large number of rendering plants gave the company a plentiful supply of raw materials. In 1964 the company was acquired by W.R. Grace, who made it a part of the specialty chemicals division that later became the Chemed Corporation of the W.R. Grace Company. In 1982 Chemed became fully public with DuBois its largest operating division. In 1991 Chemed accepted an offer of $243 million dollars from Molson's Diversey Corporation, with Unilever acquiring the company in 1996. Today, DuBois operates as four business units; food, industrial, paper, and transportation, and employs 800 people in sales across North America, and in the Sharonville, Ohio research and development facility. In Canada, DuBois operates from Oakville, Ontario with manufacturing plants in London, Candiac, Winnipeg, and Edmonton.[1]

DuBois Paper Technologies (DPT) is recognized as the number one downtime-cleaning supplier in North America, and employs 145 persons with an average service of 18 years. DPT is aligned with Miami University in Ohio, and Sault College in Sault Ste. Marie, and also hires chemists, engineers, and persons with direct mill experience to ensure a continuous influx of talent to the corporation. DPT is known for the innovations it has brought to the pulp and paper industry such as liquid caustic to replace caustic flakes in paper machine boilouts, non-caustic products to improve the safety and the environmental aspects of cleaning products, as well as foam cleaning and the BubbleUp™ process.[2]

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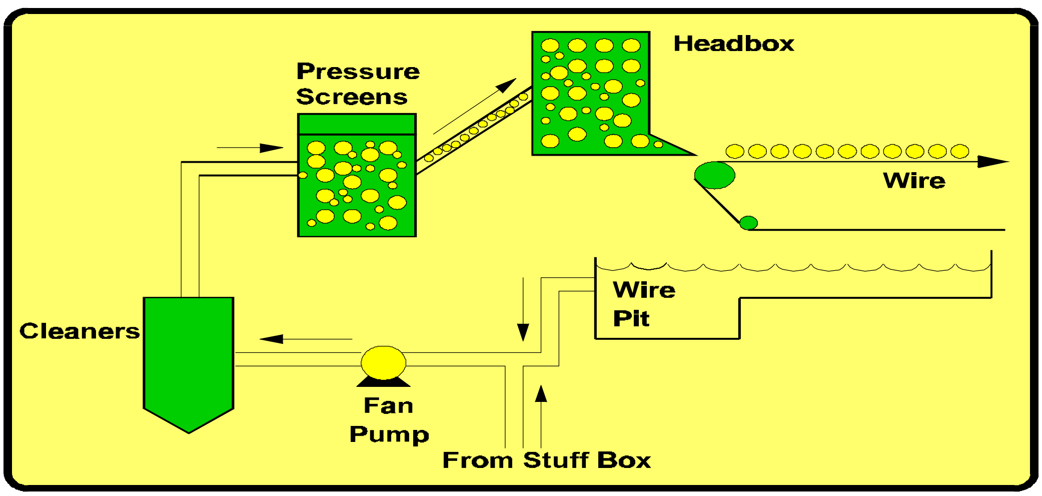
[1] Barras, Mike, DuBois Paper Technologies Corporate Capabilities Presentation, January 15, 1997.
[2] Ibid.

The History of the BubbleUp™ Process

The BubbleUp™ was first used to apply a self-foaming product to the pressure screen of a paper machine to clean inaccessible areas such as the paper machine headbox and approach piping. The process reduced the occurrences of holes in the sheet, and decreased dirt counts, thus increasing overall paper quality. A diagram of the paper machine BubbleUp™ process can be seen in Figure I.[3]

Figure I – Papermachine BubbleUp™ Process[4]



In early 1997, a customer was having problems maintaining bleach plant production rates due to flow restrictions in an oxidized white liquor line. The line was not easily accessible for high-pressure cleaning, and DuBois was asked to develop a solution. We accepted that challenge! The scale was analyzed and found to be mainly calcium carbonate based, so an acidic based product was recommended. The cleaning was successful, and the application was repeated again in 1998. As a result of this new interest in kraft mill process line cleaning, an initiative was taken by DPT to introduce the BubbleUp™ process to kraft mills across North America.

[3] Barras, Mike, DuBois Paper Technologies Corporate Capabilities Presentation, January 15, 1997.
[4] Drawn by Harold Laser DPT Canada Technical Manager

The Kraft Mill BubbleUp™ Process

The purpose of the BubbleUp™ is to chemically remove inorganic and organic deposits from pipelines and process equipment utilizing a high foaming detergent that has been matched to the soil. Traditional cleaning methods consist of:

- High-pressure washing
- Acid recirculation
- Continuous additives
- Magnetic devices
- Electrical devices
- Line replacement
- Line insulation
- Rubber Lines

All of these applications have been proven effective in maintaining flow rates to keep processes operating at peak production levels, but for lines which scale on a routine basis, or for a mill that is facing a lengthy shutdown due to flow limitations, the BubbleUp™ has some benefits.

The first benefit is that the process is flexible and can be completed on an annual outage, an area shutdown, or on the run. The process will restore line flows to normal limits in a few hours minimizing downtime requirements for the mill. The process can be less expensive, and eliminates the need to high-pressure wash lines. The kraft BubbleUp™ process offers the convenience of less downtime, and less labour hours because lines do not have to be disconnected to high-pressure wash.

Kraft BubbleUp™ Applications - Recausticizing

Typically in the recausticizing area of the Kraft mill many problems are experienced due to flow restrictions in process liquor lines. The main deposit is pirssonite scale a combination of sodium carbonate and calcium carbonate that forms in green liquor lines due to the nature of its solubility behaviour, process temperature fluctuations, and TTA fluctuations.[5] Pirssonite scale is typically seen in process lines from the green liquor clarifier through the heat exchangers into the slaker and from the slaker to the first causticizier. In a worst case scenario flow restrictions in green liquor lines can result in white liquor production limitations. For a mill that is white liquor limited, production losses can add up quickly.

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[5] Ayers, R.J., Fredrick, W.J. Jr., and Krishnan, R., Pirssonite Deposits in Green Liquor Processing, TAPPI Journal February 1990. (pgs. 135 to 140)

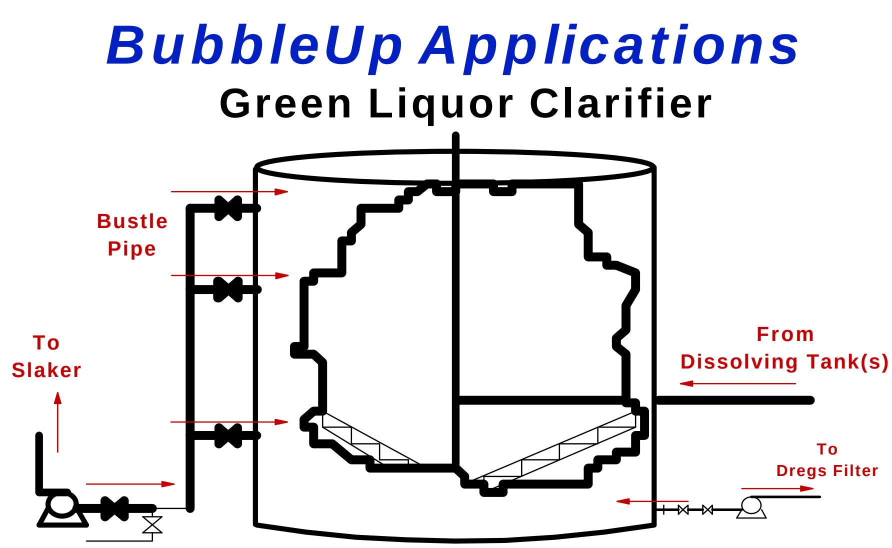
Example – Impact of Green Liquor Flow Restrictions on Production Losses

For this calculation we will assume that the green liquor lines are restricted such that white liquor production cannot meet digester demand. Thus, pulp production is slowed to the rate of white liquor production. For a mill producing 800 admt per day of brown stock, with an EA charge of 14.75% and EA of 92 g/L as Na_2O, 1700 lpm of white liquor would be required. If flow were restricted to 1500 lpm of white liquor then the mill would only be able to produce 700 admt per day of brown stock. The production loss is 100 admt per day. Assuming the variable cost of kaft mill production is $350/tonne, and the price of pulp is $400/tonne, this is a loss per day of $5000.00.

Mills have been able to alleviate green liquor line scale problems by insulating lines to maintain temperature, by adding lime mud in the weak wash, or by allowing lime mud carryover in the weak wash, by using magnets, and by using continuous anti-scalants. However, on each annual outage, the majority of mills must still shutdown to high-pressure clean these lines. And, in order to access these lines mills must “dump” the green liquor clarifier to sewer. This can result in upsets to the effluent treatment system, as well as spending money on expensive chemicals to make-up the sodium and sulfidity which was lost in the “dump”.

If the BubbleUp™ process were used in place of high-pressure cleaning the clarifier, the mill can save the time and money in dumping the clarifier by chemically cleaning the lines during the shutdown process such as during the recovery boiler water wash. Attached as Figure II is an example of the cleaning that can be performed in place of high-pressure cleaning which may allow a mill to dump the clarifier once in five years for inspection of the rake mechanism, and to check for corrosion in the tank.

Figure II



The second deposit typically found in the recausticizing area of the kraft mill is a calcium carbonate build-up in lime mud slurry lines typically at mills that have a wet scrubber system on their lime kilns. Restrictions have been observed in sewer lines, scrubber lines to the mud mix tanks, and the feed to the lime mud filter. Mills can shutdown their lime mud washing area as frequently as once per quarter in order to clean lime mud slurry lines. Flow restrictions in lime mud lines to the lime mud filter can result in mills having to purchase up to 20 tonnes/day of fresh lime.

Example – Impact of Lime Mud Flow Restrictions on Makeup Lime Costs

One can assume that a mill has a fresh lime makeup requirement of 5 tonnes per day; the flow to the lime mud filter is typically 1000 lpm with an average solids content of 25%, with a discharge solids content of 75%. If we assume that lime availability is 95% then the mill is making approximately 270 tonnes per day of CaO, with a makeup of 5 tpd or 2%. If the flow is restricted such that only 800 lpm of flow can get to the filter then approximately 218 tpd of CaO is produced requiring the mill to either slow production, or purchase fresh lime. If it assumed that the mill must purchase the fresh lime then approximately $50 tpd must be purchased at an assumed cost of $100/tonne. This would result in an increased cost of $5000.00 per day.

In this case, the mill could attempt to run the recausticizing area in order to build white liquor inventory for the pulp mill. Then the mill would be able to shutdown the process for a period of four to six hours in order to clean the line using the BubbleUp™ technique.

Kraft BubbleUp™ Applications – Recovery

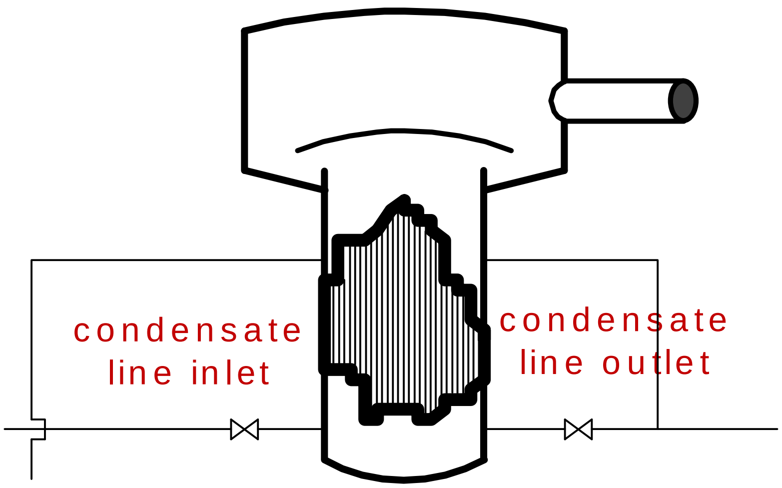
In the recovery area of the kraft mill there are again two main points of process line restriction. The first is of course pirssonite scale found between the dissolving tanks, and the green liquor clarifier, which can be cleaned in a similar manner to the green liquor clarifier shown in Figure II.

The second area of scaling is the evaporator train. The types of deposits observed on the tube side of the evaporator are, baked on black liquor deposits, calcium oxalate scales, calcium carbonate scales, silica, and soap/fibre scales. The most recent deposit observed is a thin film of Anthraquinone mainly seen on the shell side of the evaporator tube sheet. Scaling of the evaporator train can result in an increased use of steam in order to maintain solids to the recovery boiler, and can also result in pulp mill production losses due to excessive weak black liquor inventories. Typically, anti-scalants are used to combat the growth of the scale over time in order to keep the train running until the next major outage, with the scale being cleaned via high-pressure cleaning. Attached as Figure III is a diagram of an evaporator body as a suggestion on how a chemical cleaning could be used in place of anti-scalants and high-pressure cleaning.

Figure III

BubbleUp™ Applications

Evaporator - Shell Side



Kraft BubbleUp™ Applications – Fibre Line

In the fibre line area of the kraft mill there are three areas where scales and deposits have been observed. The first area is the white liquor line to the digester that typically has problems with calcium carbonate and iron sulfide scaling. Again, this line is normally cleaned on a major outage using a high-pressure cleaning company. At times, mills have elected to run for extended periods with white liquor restrictions. As shown in the green liquor clarifier example, production losses due to white liquor limitations can quickly add to approximately $5000.00 per day of losses. Restrictions have also been observed at mills with batch digesters.

Example – Impact of White Liquor Flow Restrictions in Batch Digesters

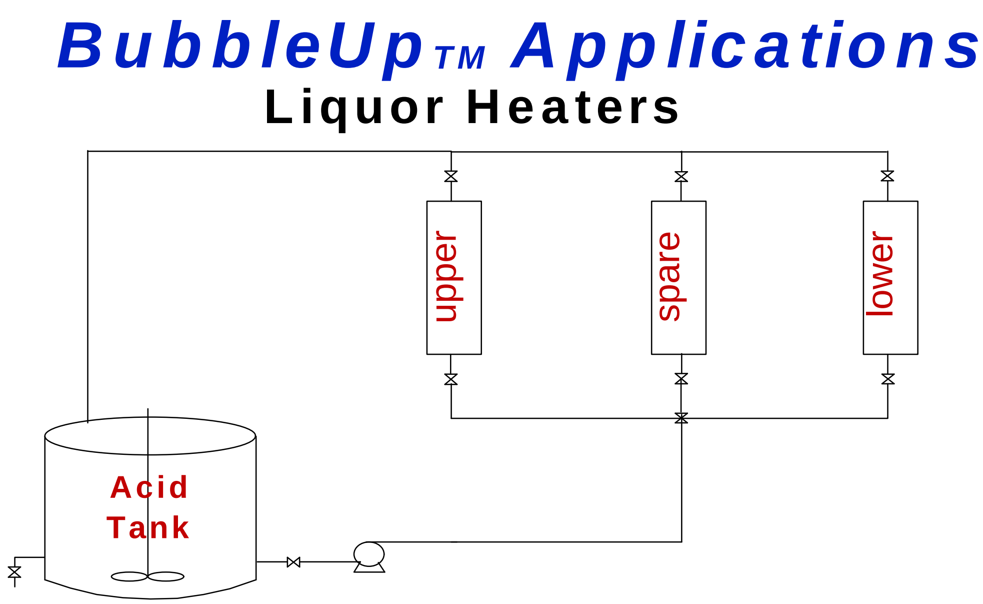
If one can assume that a mill produces 400 admtpd of brown stock with 5 batch digesters, at 20 tonnes per blow, and four blows per day. Normal cycle time is 360 minutes with a digester fill time of 60 minutes. If one can assume that white liquor flow is restricted such that digester fill time is now 75 minutes, then the mill will only be able to complete 3.84 blows per day for a total production loss of 16 tonnes. Using the mill net from the green liquor example of $50/tonnne, this mill will lose $800/day in production or $5600.00 per week. If there is one month left until the annual outage, this mill will have lost $22,400 in production prior to being able to clean out those lines.

Again, assuming the mill has the capacity for storage of brown stock, the mill can build pulp inventory and take six to eight hours of down time to chemically clean this line utilizing the BubbleUp™ process. The digester area could be up and running before the bleach plant operators ever noticed a shortage of pulp.

The second well-known area of fibre line scale is in the digester liquor heaters. Some mills will clean one liquor heater per week in order to keep scale under control. It typically will take one shift for the heater to be taken off line, and switched to the spare. Then it will take one shift for the heater to be cleaned via an acid recirculation process, and a third shift to bring the heater back on line. The process is time consuming, is not always successful, and some mills have experienced corrosion of the tube sheet as a result of incompatible acids being used in certain applications. Because of this problem, some mills have resorted to high-pressure cleaning of the digester heaters in place of acid recirculation. As well, the buildup in the heater can sometimes be a soap/fibre-based scale that a normal acid recirculation will not be able to clean.

In a situation such as this the BubbleUp™ process could be used in place of high-pressure cleaning. An analysis of the deposit would be taken prior to the heater cleaning to ensure the right cleaning chemical was used for that particular application and metallurgy. The process would be less time consuming than high-pressure cleaning, would require fewer personnel, and could be completed at a lower cost. Attached, as Figure IV is an example of how a BubbleUp™ could be used in much the same manner as an acid recirculation.

Figure IV



Other applications of the BubbleUp™ process in the fibre line area include the cleaning of caustic lines in the bleach plant, and oxidized white liquor lines for mills with oxygen delignification systems. The BubbleUp™ process could also be used for cleaning pitch and fibre deposits from bleach plant scrubbers, as well as normal applications around the pulpmachine.

In order to show some examples of the benefits that the BubbleUp™ process has given pulp mills in the past year, some case histories from across Canada have been compiled.

BubbleUp™ Case Histories

Case History One

Line: Lime Mud Slurry Tank to Lime Mud Mix Tank
Line Length: 350'
Line Diameter: 3"
Scale Thickness: 0.75"
Time to Clean: 2.5 hours
Result:
Maximum flow on the line was 419 lpm at 100% pump output. This was improved to 510 lpm (maximum the flow meter could measure) at 50% pump output. This was a flow improvement of 84% at a return of 22% over the cost of high-pressure washing.

Case History Two

Line: White Liquor Line from Storage to Digester
Line Length: 1300'
Line Diameter: 6"
Scale Thickness: 0.125"
Time to Clean: 6 hours
Result:
It was believed that friction losses due to scale restricted white liquor flow to the digester. The mill was ready to cut the line apart in order to high pressure clean over the one-week annual outage. The line was cleaned in 6 hours at one third of the cost of high pressure washing for a return of 161%.

Case History Three

Line: Green Liquor Clarifier Bustle Pipe
Line Length: 25’
Line Diameter: 10”
Scale Thickness: 0.5”
Time to Clean: 1.5 hours
Result:
The mill was experiencing flow restrictions due to pirssonite scale in the bustle pipe, and was expensive to high-pressure clean on the annual outage. Flow was measured at 596 gpm at 100% pump output. After cleaning the flow was 580 gpm (maximum flow) at 50% pump output. The return was 13.7% over the cost of high-pressure cleaning.

Case History Four

Line: Green Liquor Clarifier Feed Piping
Line Length: 25’
Line Diameter: 6”
Scale Thickness: 1.0”
Time to Clean: 2.5 hours
Result:
Pirssonite scale was limiting flow to the clarifier causing excessive dregs carryover. Flow prior to the cleaning was 150 lpm. After cleaning flow was measured at 1500 lpm. To traditionally clean this pipe would have resulted in the clarifier being dumped to sewer. The return was the flow improvement of 900%.

Case History Five

Line: Green Liquor Line from Dissolving Tank to Clarifier
Line Length: 1000’
Line Diameter: 8”
Scale Thickness: 0.5”
Time to Clean: 6 hours
Result:
Pirssonite scale was limiting flow to the clarifier. The line was broken apart in five locations for inspection prior to and after cleaning. The line was cleaned to bare pipe. The return on this application was 107% versus the cost of high-pressure cleaning.

Case History Six

Line: Green Liquor Line from Slaker to First Causticizer
Line Length: 25’
Line Diameter: 6”
Scale Thickness: 0.5”
Time to Clean: 2.5 hours
Result:
Pirssonite scale was limiting flow to the first causticizer. The line was broken apart in two locations and inspected prior to and after cleaning. The line was cleaned down to bare pipe. The return was break-even in comparison to high-pressure washing

Conclusion

The BubbleUp™ has many tangible and intangible benefits for kraft mills. Tangible benefits include:

- Relieving line flow restrictions that have been causing production slowdowns
- The process is more convenient, and less time consuming
- The process in many cases is less expensive than the alternatives of high-pressure cleaning or the use of continuous anti-scalant products
- The BubbleUp™ process can allow a mill to clean in-situ such that process chemicals do not need to be dumped to sewer thus, saving in make-up chemical costs, and problems with upsets in the effluent treatment system

The intangible benefits include:

- The ability to utilize pipefitters for more important preventative maintenance tasks on a shutdown or area outage instead of pulling apart lines for a high-pressure cleaning company.
- Save time on shutdowns by minimizing the number of lock outs required because cleaning of lines can take place during the shutdown process
- Vessels do not have to be entered to access piping inside of tanks

By introducing this new method of process line cleaning to kraft mills DuBois Paper Technologies hopes to give pulp mills another choice in combating process line scale and deposit control issues that will help keep pulp mills operating at peak production levels.