

Valmet Technical Paper Series

Evaporator Issues and Technology

Executive Summary

Evaporators are used to evaporate black liquor from approximately 15% dry solids to 70-85% dry solids. As the dry solids percentage is raised, volatile compounds are released from the black liquor and separated from the condensate, which then gets collected for reuse in the mill reducing the demand for incoming water. Generally, the volatile compounds are incinerated in the gas form in kilns, boilers or stand-alone incinerators. More recently, processes for producing sulfuric acid or low-odor methanol have been introduced. Valmet has patented technologies for both processes, but neither will be covered in this paper.

Like all pulp mill unit operations, evaporators can have operating issues due to the processes occurring inside the system or due to the complex mill chemistry. Almost all these issues fall into six main categories including scaling, corrosion, liquor carry-over, vacuum issues, condensate segregation and foaming liquor.

Valmet's TUBEL concentrator addresses scaling, as does the mixing of ash, heavy black liquor (HBL) recirculation and on-demand washing. Corrosion is addressed by using 304L SS and duplex alloys in appropriate areas. Avoiding liquor carry-over is primarily a design issue relating to optimized vapor flow and entrainment separators. A properly designed condenser will limit forcing velocities and help vacuum equipment performance. Internal condensate treatment (ICT) and the effective use of the stripping column will improve condensate segregation. Foaming is reduced by any of several means, and multiple simultaneous control solutions can be used.

Evaporator technology focus

Traditionally, evaporators have been used to evaporate black liquor from approximately 15% dry solids when they leave pulp washing to 70-85% dry solids before being combusted in the recovery boiler. As the dry solids percentage is raised, volatile compounds are released from the black liquor and separated from the condensate, and the condensate is then collected for further use. This maximizes reuse of condensates in the mill and minimizes the environmental effect.

Modern evaporators are more complex and productive. They can maximize side streams that could then be used as a commercial by-product such as methanol, tall oil and other substances. They can also process other waste streams such as biosludge, chemi-thermomechanical pulping (CTMP) effluent, chlorine dioxide (ClO₂) generation effluent, etc. These capabilities allow mills to investigate how modern evaporators can optimize mill-wide operations.

Evaporators fall into a few categories, based on how they operate: rising film (RF) evaporators, falling film (FF) evaporators and forced circulation (FC) evaporators. In addition, all these types of evaporators can be classified as a concentrator whenever they operate above the solubility limit for one of the various salt species encountered in black liquor.

RF evaporators use vertical tubes where the liquor is introduced at the bottom, the tubes are steam heated on the outside to the liquor boiling point, and partial evaporation occurs in the tubes. In the FF evaporator, the liquor enters at the top and is distributed on a vertical heat exchange surface composed of plates or tubes. As the film of liquor moves downward it is partially evaporated. FC evaporators are tubular units that circulate enough liquor to flood the heat exchanger tubes which can be configured either horizontally or vertically while using steam outside the tube to drive partial evaporation of the liquor (FF or FC evaporators always provide the same high performance, while RF evaporators have poor performance at low loads). Concentrators are typically based on the FF or FC concepts and are designed to address the issues of high liquor viscosity and precipitation of components that have exceeded their solubility limits (and thereby can produce scaling).

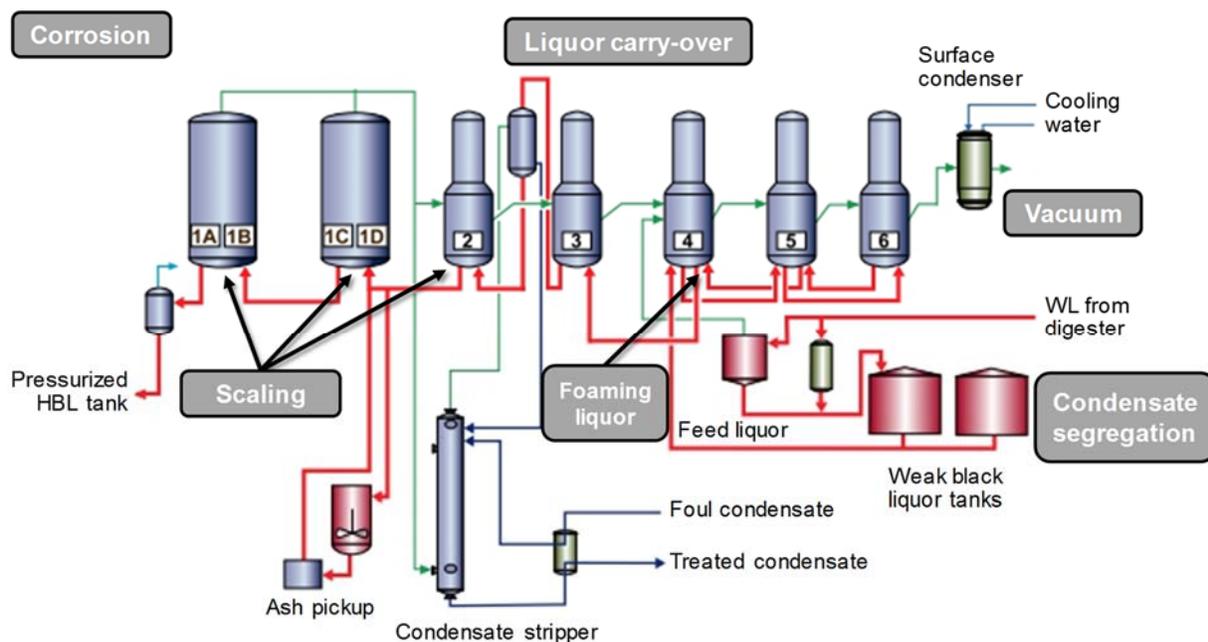


Figure 1. Problems inherent in the evaporator stage of the black liquor recovery process

As shown in **Figure 1 (previous page)**, most operating issues in evaporators will fall into the following six (6) categories. These include:

- Scaling
- Corrosion
- Liquor carry-over
- Vacuum
- Condensate segregation
- Foaming liquor

Let's look at the solutions to these problems and technology that can enable these solutions, starting with scaling...

Scaling

Black liquor is an aqueous solution of lignin residues, hemicellulose and inorganic chemicals used in the cooking process. Based on typical dilution factors in pulp washing, the production of one ton of pulp produces about seven tons of black liquor. In a kraft process, pulpwood is "digested" into paper pulp while lignin, hemicelluloses and other extracts are removed as black liquor containing these components as well as spent cooking chemicals. Major ionic species in the black liquor are carbonate (CO_3), sulfate (SO_4), calcium (Ca) and sodium (Na). Virtually all the black liquor is burned in the recovery boiler, supplying all the steam and much of the energy for electricity used by a typical mill.

As evaporation occurs, volatile components from the black liquor are released with the evaporated water as part of increasing the dry solids percentage. During evaporation, as these inorganic salt compounds reach their respective solubility limits, the liquor begins to supersaturate until it reaches what is known as the "meta-stable limit", it then begins to crystallize and dissipate the chemical inequilibrium of supersaturation, often very quickly. This formation of solid material from dissolved or ionic material will often form scale on the inside of the evaporator. Also, once this has occurred, further evaporation will constantly force additional dissolved salts to shift to the solid phase to maintain the solubility equilibrium. Crystallization theory provides that the released supersaturation will either form new crystal nuclei for other salts to deposit, will deposit on existing crystals or nuclei in the flowing liquor or will deposit on other solid surfaces. In the case of an evaporator this can be the tube wall, vessel walls or pipe walls. Because evaporation units that operate above the solubility limits are much more likely to scale, these units are referred to as concentrators rather than evaporators. All the evaporator suppliers employ additional design features that better deal with scaling. Scaling reduces the effectiveness of the evaporation process.

Two predominate salt scales which form are burkeite (which typically has a critical solids point at about 48-52% dry solids) and sodium dicarbonate (which typically has a critical solids point at above 55% dry solids).

TUBEL concentrator

TUBEL Concentrators (**Figure 2**) developed by Tampella, now part of Valmet, were introduced in 1994 and address the issue of scaling. An open design eliminates tube plugging. Falling film liquor is evaporated on the outside surface of the tubes by the steam/vapor on the inside. If scaling occurs, the convex shape of the tube surface and the open design of the unit make on-line washing easy.

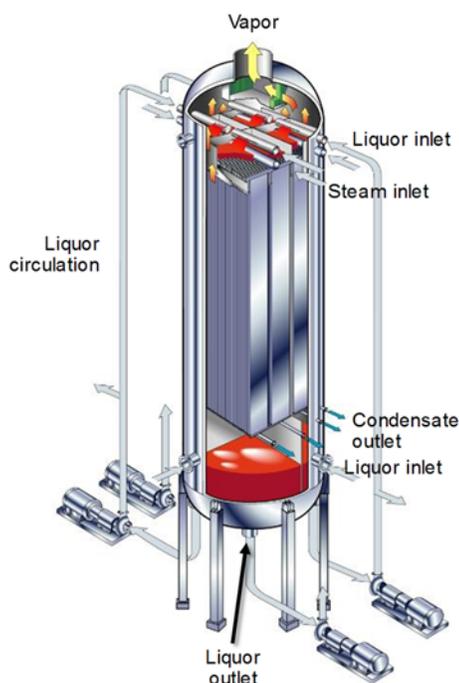


Figure 2. The TUBEL concentrator addresses scaling.

There is normally no need for off-line washing and no TUBEL unit has required hydroblasting in Kraft liquor applications.

TUBEL's mechanically rigid design handles the high steam temperatures and pressures that are encountered in super-concentrators and reduces the risk for mechanical failures.

Valmet has delivered more than 110 TUBEL concentrators throughout the world, including North America, South America, Australia, Europe and Asia. All these locations are producing high dry solids content, several at 80% DS or above, without scaling problems.

Figure 3 shows Valmet's evaporation technology at Suzano Papel e Celulose, Maranhão, Brazil. The new cutting-edge XXL size, 6-effect EVAPS plant includes a concentrator and Effect 2 which use TUBEL technology. The system can produce heavy liquor of 80% dry solids using only low-pressure steam at an evaporation capacity of 1600 tons/h.



Figure 3. TUBEL technology at the Suzano Papel e Celulose evaporation line

Avoid operation at critical solids point

Figure 4 shows a graph of the salt concentration vs. the percent dry solids in the liquor. The slightly declining line represents the solubility limit (Critical Solids Point) for Na, CO₃ and SO₄. We would prefer not to operate the feed section of the 1st Effect at this salt concentration.

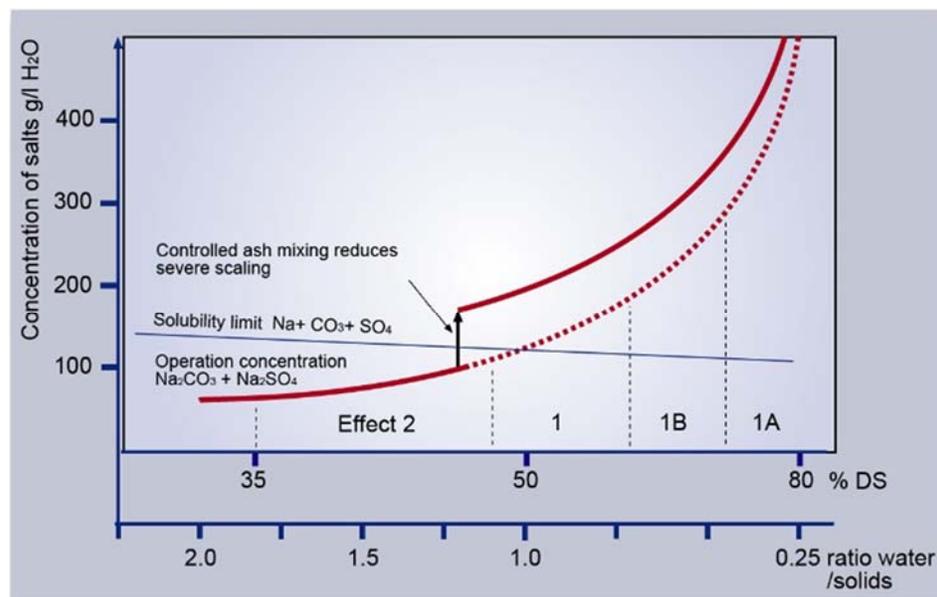


Figure 4. Recovery boiler ash mixing and heavy black liquor recirculation can avoid operation at the critical solids point.

Remember from the earlier discussion of

Crystallization Theory, released supersaturation will form new crystal nuclei, deposit on existing solid salts or nuclei or deposit on other solid surfaces. When operating right at the critical solids point there are

no salt crystals or nuclei in the circulating liquor. Controlled mixing of recovery boiler ash and heavy black liquor recirculation before getting to the critical solids point will bump the process past the solubility limit and reduce severe scaling by ensuring there are "seed crystals" and nuclei in the circulating liquor for newly released supersaturation to grow on. With this method, we can avoid the need to operate the first section in the concentrator at the critical solids point.

Multiple sections for on-demand washing

With Valmet's concentrators, washing is fully automated (**Figure 5**), thus better controlling the removal of scaling. Using controls supplied, the washing need is evaluated over time for each of the concentrator sections. Whenever the need to wash is signaled (i.e. on demand), the operator initiates washing of one individual section of the concentrator (i.e. washing only occurs when needed).

To execute the wash, weak black liquor is fed to the wash section lowering the circulating liquor concentration to a target of 35% dry solids. Washing occurs by dissolving deposits back into the circulating liquor. While this process begins once the solids are lowered below the critical solids point, the target of 35% dry solids has been shown from experience to allow an effect wash in as little as 30 minutes.

During washing, the product liquor dry solids content of the concentrator is maintained. Both steam flow and evaporation are continued in the section being washed. This ensures operational stability in both the recovery boiler and evaporation processes.

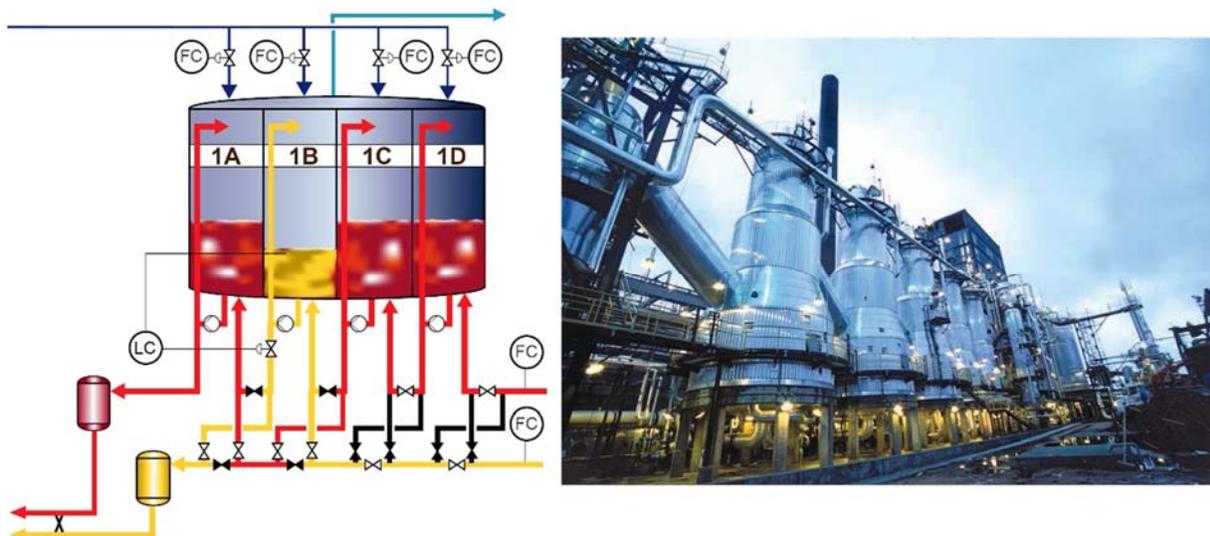


Figure 5. CMPC Celulose Riograndense, Brazil has a completely new train with on-demand washing and REVAP Concentrator. Evaporation capacity: 430 tons/h, 75% DS product.

Normal vs. inverse solubility

Solubility is a function of temperature. Normally, salts increase in solubility with temperature. However, some salts, such as calcium carbonate, become less soluble in water as temperature increases. This is called inverse solubility.

Salts with normal solubility will foul cooling surfaces. Salts with inverse solubility will foul heating surfaces. Since evaporation requires heat addition, the hottest portion of the liquor is immediately adjacent to the heating surface. Inverse solubility salts can become supersaturated as the hot heating surface lowers the solubility, causing solid salts to form near the tube wall. Controlling the differential temperature to lower levels is critical in concentrator design to prevent this type of scaling.

Corrosion

As mills look to increase production and energy efficiency, they are typically running with higher Residual Effective Alkali (REA) and at higher black liquor temperature and concentration in the recovery boiler. This causes corrosion problems with traditional steel materials in the evaporators. As can be seen in **Figure 6** below, corrosion is now being seen in three main areas:

- General thinning and stress corrosion cracking (SCC) in stainless-steel front-end bodies,
- General corrosion and pitting in carbon steel (CS) intermediate bodies, and
- Marine scale (barnacle type growth) with corresponding severe pitting in surface condensers.

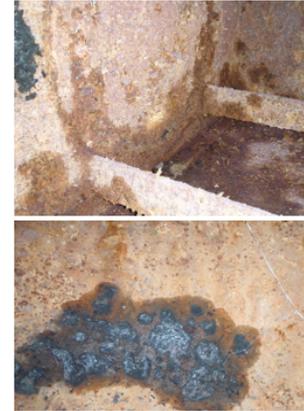
Left unaddressed, this corrosion can be a significant safety hazard as metal failure could cause the release of hot caustic liquor, potentially under significant pressure to the operating areas around the equipment. This can also cause unplanned outage time. Even if the corrosion doesn't progress to the point of metal failure - it can limit the evaporation capacity.



Tube thinning and SCC in concentrator units. Use Duplex above temperature threshold



CS – In back-end effects, both shell and tube sides. Use 304L SS or Duplex Lite throughout



Marine scale – SC water boxes. Heavy pitting behind scale. Use 304L SS throughout

Figure 6. Three main areas of corrosion in evaporators. SCC in the SS concentrator bodies, general corrosion and thinning in the CS back-end bodies and marine scale in the CS water side of the surface condenser.

An example of corrosion limiting evaporation capacity can be found in a case study of an existing FC concentrator at a Canadian mill. This concentrator vessel was supplied in 304L SS material with no corrosion allowance. General corrosion throughout the entire vapor body occurred in the cone, top shell and bottom shell, with several measurements below the minimum thickness. As a result, the vessel's vacuum capacity had to be derated from full vacuum to -70 kPa. There was also stress corrosion cracking occurring in the heaters. This forced the mill to adapt a maximum temperature limit of 145 °C on the operation of the concentrator. These two restrictions reduced the overall delta-T for the train by 22% and as a result the capacity of the overall evaporator system was decreased by about 15%.

To avoid tube thinning and stress corrosion cracking in concentrator units use duplex steel if operating above the temperature threshold of 145 °C. Duplex stainless steels are called "duplex" because they have a two-phase microstructure consisting of grains of ferritic and austenitic stainless steel. This ferritic component provides both superior corrosion resistance and better resistance to SCC.

For CS back end effects, both shell and tube sides, use 304L stainless steel or duplex lite throughout.

For marine scale of the surface condenser water boxes, and the corresponding heavy pitting which will usually occur behind the scale, use 304L stainless steel throughout.

Liquor carry-over

Liquor carry-over in the form of black liquor droplets carried through the evaporator system (also known as entrainment) negatively impacts the process, resulting in more chemical loss, poorer condensate quality (reducing the ability to reuse condensates and minimize freshwater usage) and increased corrosion and erosion of metallic surfaces. Cost-effective evaporator systems require very low or negligible liquor carry-over.

In older competing designs, a horizontal deck containing vertical flow chevrons occupied the annular area formed between the outer diameter of the heater section and the outer diameter of the vapor body of the evaporator.

To minimize liquor carry-over, Valmet applied Computational Flow Dynamic (CFD) modeling - typically done on recovery boilers - to the vapor body section of the evaporator. Results of this modelling showed that the flow of vapor should be symmetric about the vapor outlet between the primary and secondary sections in the vapor body section of the evaporator. There should be a horizontal flow through the chevrons in the secondary section. Lastly that primary droplet separation should occur before getting to the chevrons. **Figure 7** illustrates a properly designed vapor body section, which optimizes liquor droplet removal.

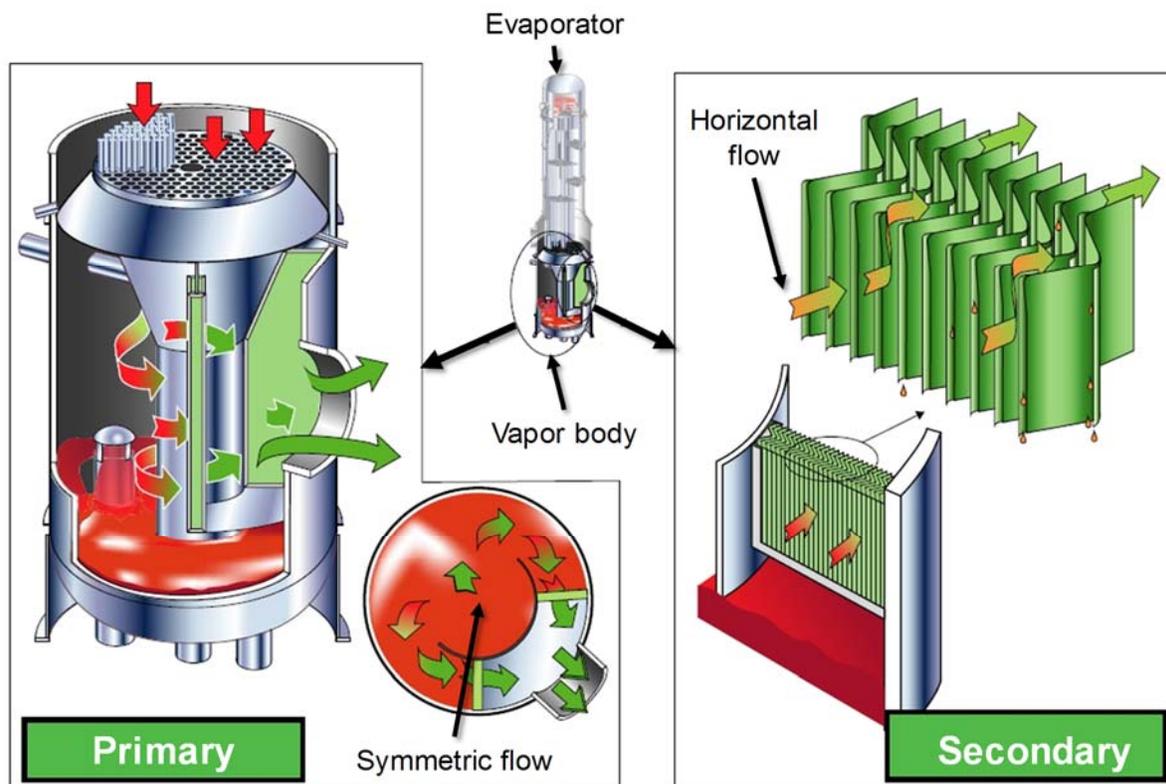


Figure 7. Properly designed vapor body section with symmetric flow about the vapor outlet and horizontal flow through the chevrons.

Valmet's optimized design also allows the vapor body diameter to be very close to the diameter of the heater, which can be significantly smaller diameter than the older designs with vertical flow chevrons. This reduced footprint saves on steel, concrete, piping and construction labor.

Vacuum

Vacuum equipment performance is important. Air leakage must be avoided. Operation at a poor vacuum level lowers both the system capacity and the steam economy of the system. A vacuum pump or steam ejector system allows the last effect in the evaporator to run at high vacuum (typically 25.4 in. Hg). These devices remove the concentrated non-condensable gases (CNCG) that are released during evaporation. A vacuum pump requires similar maintenance to other rotating equipment. While ejectors are less maintenance intensive the erosion of the steam nozzle throat over time can cause a decrease in performance, also scaling of any condensers supplied as part of the ejector system can also cause issues. For either an ejector system or a vacuum pump to work properly the very large volume of water vapor from the last evaporation effect must be condensed so that only saturated dry gas is handled by the vacuum system. This is done in a shell and tube surface condenser. In the condenser, cool water circulates inside the tubes and condenses vapor on the outside. Due to the high vacuum in the last effect, the vapor has a large specific volume. For example, a pound of vapor may occupy 158 cubic feet of space at the typical vacuum of 25.4 in Hg. This means there are extremely large volumetric flow loads on the shell side of the condenser. Even in properly designed condensers, vapor flow velocities approaching 200 fps are not uncommon. These high velocities can cause tube vibration and subsequent damage if the baffling on the shell side and the expanded vapor plenum (larger diameter at the steam inlet allowing vapor to move up or down prior to entering the tube bundle) are not designed properly. Valmet's design for a surface condenser limits forcing frequencies of the tube and vapor velocities in the shell side to ensure damage does not occur from tube vibration. In the example below Valmet used its design criteria to evaluate why damage was occurring in an existing surface condenser.

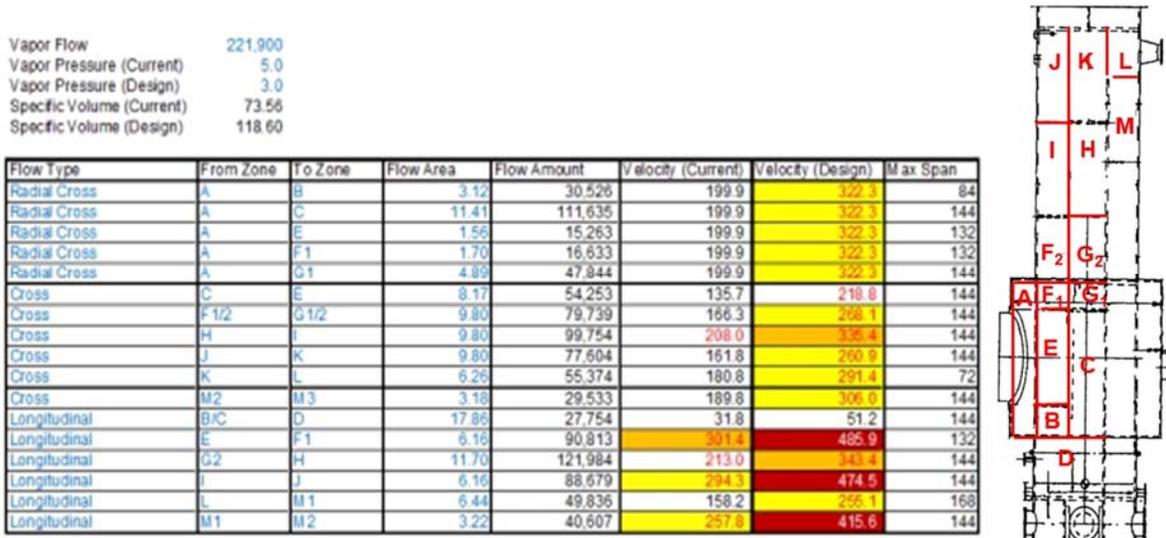


Figure 8. This typical condenser (right) is operating well past the design limits (shown in left chart as yellow, orange and red values). The result is vibration damage.

Figure 8 shows a side view of a typical condenser. Based on the shell side baffling and the inlet vapor plenum the unit can be divided into flow zones (red letters). From zone to zone the flow area provided by the baffling will dictate whether the flow is longitudinal, cross-flow or radial cross-flow. Then the velocities flowing through each "flow window" from zone to zone can be compared to Valmet's standards for that type of flow. In the chart in **Figure 8**, yellow, orange and red cells on the chart indicate flow velocities that exceed Valmet's criteria for a proper design, with yellow being the least severe and red being the most severe. This analysis successfully predicted areas where tubes were failing (i.e. corresponded to the areas indicated by red and orange velocities).

Condensate segregation

As stated earlier, when evaporation occurs other volatile compounds are released. In evaporators these are both TRS compounds such as di-methyl sulfide, di-methyl di-sulfide and methyl mercaptans as well as alcohol compounds primarily methanol (MeOH) but with smaller amounts of higher carbon chain compounds (ethanol, propanol, etc.). Under current environmental regulations a certain amount of these potential hazardous air pollutants (HAPs) must be removed to avoid the need for further biological wastewater treatment. Under this legislation, MeOH is also deemed a surrogate for all HAPs and will condense with the evaporated water to form contaminated vapor condensate. Valmet classifies the vapor condensate formed into three separate (or segregated) fractions based on the amount of MeOH present. Condensate with very little MeOH is classified as A-Condensate (often referred to as clean condensate), condensate with intermediate concentration of MeOH is classified as B-Condensate (often referred to as contaminated condensate) and the condensate with high concentration of MeOH is classified as C-Condensate (often referred to as foul condensate).

Untreated foul condensate is very odorous, cannot be reused in the mill and can't be released into the environment. Collecting and stripping the foul condensates will allow the MeOH to be driven off and burned in the vapor phase or condensed to liquid MeOH and used as a green fuel or as a chemical reagent elsewhere in the mill. Stripped foul condensate becomes clean enough to be reused for brown stock washing or as make-up water, thus reducing mill raw water demand.

Figure 9 shows Valmet's shell side design of the back-end evaporator bodies and potentially the surface condenser. This design utilizes a circular baffle to create an outer and inner section on the vapor side which are optimized to concentrate as much of the MeOH into as small a volume of condensate as possible. This both increases the amount of MeOH removed from the liquor to facilitate mill compliance under environmental rules and reduces further treatment costs for the foul condensate whether via stripping or by biological treatment.

Vapor from the previous effect is introduced at the bottom on the shell side. As the vapor rises, it flows counter-currently with the condensate forming on the tube. This action provides a stripping effect for the condensate (research has shown this effect to be equivalent to about 2.5 theoretical stripping trays). Vapor enriched in methanol turns and condenses, flowing down into the inner section. A central preheat pipe conveys the circulating liquor to a distribution plate in the top of the falling film units or is arranged as the first pass (coldest) with cooling water in a surface condenser. This combination of stripping in the outer section and sub-cooling on the inner section allows a large fraction (typically 80-85% of the total condensate) of contaminated condensate to be collected at the bottom of the outside section while a smaller fraction (remaining 15-20% of total) of foul condensate is collected from the inner section.

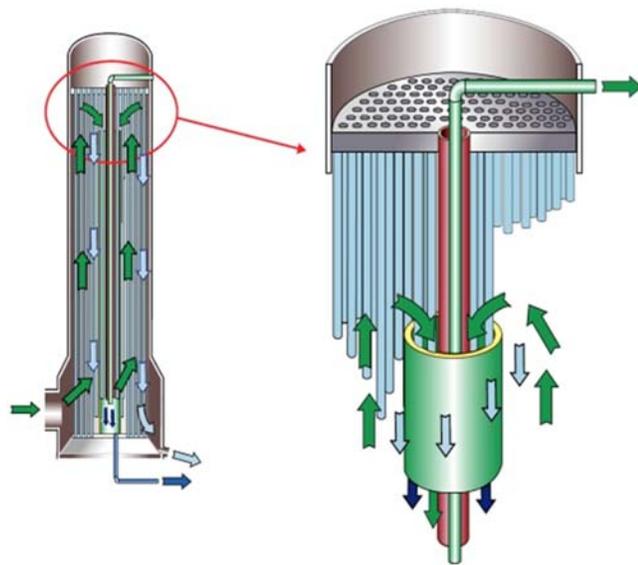


Figure 9. Valmet's shell side design improves condensate segregation.

Internal condensate treatment (ICT)

Valmet has patented an internal condensate treatment (ICT) which utilizes the stripping effect discussed above that occurs when vapor is arranged to flow counter-current to the condensate film flowing down the outside of the tube. Using this method, a portion of B-Condensate is introduced onto the top shell side baffle of the feed effect.

In **figure 10** below, the back-end bodies are shown for a typical six-effect evaporator. This has normal black liquor flow configuration for Valmet (4-5-6-3-2-1). Segregated shell sides as discussed in the previous section are provided in the shell sides condensing the first three evaporations of the feed.

In this example with feed to the 4th Effect, the evaporated water and volatiles are condensed in the 5th Effect shell side. Evaporation in the 5th Effect is condensed on the shell side of the 6th Effect and evaporation from the 6th Effect on the shell side of the surface condenser. Three stages of segregation are enough to remove nearly all the MeOH from the condensate.

Looking at an equilibrium diagram for MeOH in water at the conditions encountered in the back-end effects, 80-85% of the MeOH is volatilized in each evaporation stage (i.e. if you use 80%, 80% of the incoming MeOH in the feed to the Fourth Effect is evaporated and 20% stays in the liquor to the 5th Effect. In the 5th Effect, 80% of the remaining 20% is evaporated and only 4% goes to the 6th Effect. In the 6th Effect, 80% of that remaining 4% goes to the shell side of the Condenser. Therefore, after three stages less than 1% of the incoming MeOH remains in the liquor). Therefore, in evaporators there are almost always at least two segregated shell sides and seldom more than three.

Returning to **figure 10**, a portion of B-Condensate is introduced on the top shell side baffle in the 4th Effect and the nearly pure water vapor (remember less than 1% of the MEOH remained) is used as motive fluid to provide the stripping effect described earlier. In this fashion, Valmet's patented ICT design processes a portion of the B-Condensate to A-Condensate quality.

In summary Valmet optimizes the condensate segregation in the evaporator system by:

- the shell side design in the backend bodies which maximize the MeOH content to the minimum amount of C-Condensate and
- the patented ICT design which processes a portion of the B-Condensate to A-Condensate quality.

This maximizes the amount of the highest quality condensate.

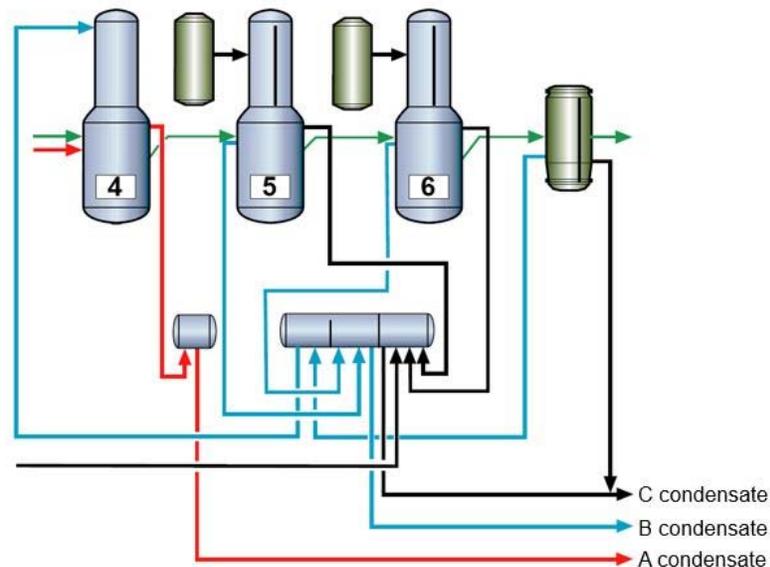


Figure 10. Valmet's ICT processes a portion of the B-Condensate to make A-Condensate in the shell side of the 4th Effect.

Condensate stripper

Foul condensates collected from the evaporators are combined with those formed from the digester. In most mills a condensate stripper is used to strip MeOH from the condensate. If these systems are well designed, the requirements for MeOH capture under environmental rules can be met. Regardless, the load on the effluent treatment plant is reduced and odor from the mill is minimized.

A properly integrated stripper is essential for improving the steam economy of the mill. While nearly all stripper suppliers will capture the overhead heat off the stripping column in reflux condensers that preheat the black liquor flowing from effect to effect in the evaporator train, many of these installations use live steam as the motive fluid in the stripper. Valmet integrates the stripper in the evaporators to use vapor from the first effect as the driving force. This maximizes the steam economy of the mill and prevents the loss of the live steam condensate when live steam is used. Condensate strippers usually operate at an efficiency of 95% for methanol removal (higher for total reduced sulfur (TRS) compounds) and upgrades the C-condensate to B-condensate quality or better.

CNCG opportunities

While not the focus of this paper, Valmet has two patented processes for producing additional revenue from the CNCG released in the evaporator. CNCGs are removed from two places in the evaporator train.

Vapor from the stripper, or stripper off-gas (SOG) is taken from the shell sides of any stripping system reflux condensers. This SOG is primarily MeOH with some water and TRS components. Today, several mills condense the SOG from the top of the stripper column to produce liquid MeOH. Unfortunately, the TRS compounds in this product make the liquid MeOH very malodorous. While the liquid MeOH is a very stable high heating value fuel that can replace fossil fuel usage in the mill, the significant odor prevents any possibility of selling the product and prohibits it from being used to make other higher value products such as chlorine dioxide for use in bleaching. Valmet has a patented PuriMeth process to remove the odor and produce a high value "green" product.

CNCG is also removed from the condensate hotwell. This CNCG is primarily TRS components and Valmet has a process to produce high grade sulfuric acid from these gases.

For properly designing or servicing any of these types of systems, the ability to execute a methanol balance is required. Surprisingly, not all service providers have this capability. Valmet has the software and modelling capabilities to do these balances.

Foaming liquor

Foaming can be caused by fatty and resin acids in the incoming wood chips, which are converted during the highly alkaline kraft process into sodium salts (otherwise known as tall oil soaps). The resulting salts are surface active and readily form stable foam.

Foaming liquor during evaporation can create production disturbances and unplanned downtime as well as increased chemical make-up and wastewater treatment costs. Foaming liquor is a function of dynamic surface tension and is influenced primarily by extractives and the percentage of dry solids in the liquor. Generally, higher extractive levels yield higher foaming tendency, while higher percent dry solids in the liquor lowers the foaming tendency. Foaming can also be caused by liquor side air leaks.

Adding or releasing energy can also cause foaming. This can occur via: recirculation and liquor transfer pumps, flashing liquor (liquor inlet above the body boiling temperature) and the initial boiling (on start-up).

Solutions to mitigate foaming potential

To keep the level of extractives minimized, it is essential to remove soap from the weak liquor. This is done by proper design in the weak liquor storage tank(s). Valmet has several methods to optimize soap removal. One solution unique to Valmet is to distribute the incoming liquor more evenly across the entire diameter of the tank. This allows for better up flow separation of the soap as it is less dense than the liquor and floats.

There are two main ways to increase the percent dry solids of the liquor. Generally, if the circulating liquor in a body exceeds 20% dry solids foaming will be controlled. Sweetening is the easiest control option. This can be done by mixing the feed or circulating liquor with intermediate or even heavy liquor.

This has a negative result in that between the point the liquor recirculation is added and the point from where it is taken, the hydraulic throughput increases by the amount of the recycled flow (increased power consumption and, depending on the flow, potentially increased pipe sizes). You can also bypass liquor around the effect. In a mass balance around the bypassed effect, a lower mass flow to the unit with the same evaporation will cause the concentration of the circulating liquor to be higher. Higher solids product then mixes with the bypassed liquor to provide the same feed solids to the next effect. This also has a negative result in that the amount of MeOH that is driven off in the bypassed stage will be less and an additional shell side of an effect may need to be segregated.

Air leakage can be addressed by regular and diligent maintenance checks of the vacuum effects using ultra-sonic leak detection equipment. Also, in the original system design the use of gasketed connections and body flanges, especially large ones, can be minimized.

Energy addition to the liquor by circulation or liquor transfer pumps can be addressed by designing the system to have lower speed pumps. Where foaming is a concern, pump speeds should be minimized and pump speeds of 1800 rpm or higher should be avoided where possible.

Energy release from foaming liquor can be mitigated by correctly designed flash nozzles which will both slow the liquor and orient the liquor on top of an inverted cone which introduces a shear force to the liquor to minimize foaming (similar to pouring beer down the side of a glass).

Foaming caused by the release of energy in the form of the first evaporation of the liquor (during start-up) can be mitigated by starting up with higher percent dry solids liquor. For mills experiencing significant foaming during start-up, one option is to fill with intermediate liquor rather than weak liquor in their start-up procedures.

Even with good design, it is likely there will be some time during operation where the process disturbances encountered may cause foaming. When foaming is occurring, some of the solutions above can be applied in operations (i.e. liquor sweetening). Various anti-foam chemicals are available and can be employed. These should be considered in the evaporation plant design, and automatic continuous delivery systems should allow addition to at least the two weakest effects in the train or at flash tanks or other vessels where foaming might be a concern.

Advanced control systems such as the Valmet Evaporation Optimizer can also mitigate foaming by maintaining more even operation and a more consistent dry solids content profile over the evaporation train by coordinating the feed, intermediate, and strong liquor dry solids controls.

Stack the deck to prevent liquor foaming. This doesn't have to be a fair game. Use as many mitigating solutions as you can.

Summary

The problems inherent to evaporators in the black liquor recovery process include scaling, corrosion, liquor carry-over, vacuum, condensate segregation and foaming liquor. Valmet's TUBEL concentrator addresses scaling, as does the mixing of ash and HBL recirculation and use of on-demand washing. Corrosion is addressed with 304L, duplex and duplex stainless steel in appropriate areas. Avoiding liquor carry-over is primarily a design issue relating to optimized vapor flow. A properly designed condenser will limit forcing velocities and help vacuum equipment performance. ICT and the effective use of the stripping column will improve condensate segregation. Foaming is reduced by any of several means, and multiple simultaneous control solutions can be used.

This white paper combines technical information obtained from Valmet personnel and published Valmet articles and papers.

Valmet provides competitive technologies and services to the pulp, energy and paper industries. Valmet's pulp, paper and power professionals specialize in processes, machinery, equipment, services, paper machine clothing and filter fabrics. Our offering and experience cover the entire process life cycle including new production lines, rebuilds and services.

We are committed to moving our customers' performance forward.