

Using Evaporators to Achieve Zero Effluent At a BCTMP Pulp Mill

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Pulp-making is a very water-intensive enterprise, but the water recovery system at Millar Western Pulp allows the plant to use eight times less water than a conventional mill of its type (68 m³/hr makeup water vs. 568 m³/hr for the same size conventional mill) and eliminates any effluent discharge to the local river. The plant is the first pulp mill in the world to operate a successful zero liquid discharge system.

Effluent from the thermomechanical pulping process is concentrated from 2 percent solids to 35 percent solids by three falling film vapor compression evaporators, followed by two steam-driven concentrators which further concentrate the effluent to about 70 percent solids. Of the 400 m³/hr of effluent sent to the system, 391 m³/hr is recovered as high purity water for reuse in the pulping process. Solids are burned in the boiler; the smelt is cast into ingots and stored on site for future chemical recovery.

INTRODUCTION

When Millar Western Pulp (Meadow Lake) Ltd. announced plans to build a mill in northern Saskatchewan, the community was concerned about the pollution it would generate, especially effluent discharged to the Beaver River. Though a biological treatment system planned at the mill have made the effluent cleaner than river water, Millar Western decided to go one step further and eliminate all effluent discharge from the pulp mill [1].

The zero effluent system at Meadow Lake is the first of its kind in the world. It was devised by Millar Western Pulp and

the NLK Consultants, Inc., the engineers for the project. The evaporator system, the key equipment in the water recovery process, was designed and supplied by Resources Conservation Company (RCC).

All effluent coming out of the mill is treated in the water recovery plant. As a result, the mill only needs about 68 m³/hr of makeup water to replace water lost to the atmosphere by evaporation [2]. The same type of pulp mill without a water recovery plant would need about 568 m³/hr of raw water makeup.

The effluent treatment system started up in January, 1992, when the mill went on line.

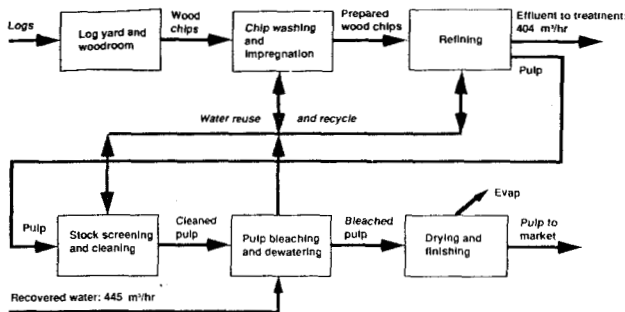


FIGURE 1. Water use in the BCTMP pulping process.

THE MEADOW LAKE MILL

The CDN \$350 million Millar Western Meadow Lake Mill is located on a 100 ha site about 320 km northwest of Saskatoon, Saskatchewan. It uses mechanical action supplemented by mild chemicals to turn aspen wood chips into bleached chemithermomechanical pulp (BCTMP), about 240,000 metric tons per year. More efficient than the kraft process, this approach uses half the trees to make the same amount of pulp, producing almost one ton of pulp for each ton of wood on a water-free basis. The Millar Western BCTMP process also eliminates chlorine compounds and odorous sulfur-based impregnation chemicals. This environmentally-friendly mill uses hydrogen peroxide to increase the brightness of the pulp, making it suitable for printing and writing grades of paper as well as for tissue and paper towels.

Figure 1 shows the BCTMP pulping process and its use of recovered water.

THE ZERO EFFLUENT WATER RECOVERY SYSTEM

The effluent produced by the BCTMP process is discharged at a rate of about 409 m³/hr. It has a temperature of 66°C, a pH of about 8 and contains about 20,000 ppm dissolved solids. Figure 2 shows the overall water treatment process including softening of the raw water makeup. Figure 3 shows a more detailed view of the water recovery portion of the system, consisting of five stages: clarification, evaporation, concentration, stripping, and incineration.

Clarification

The first unit operation to receive pulp mill wastewater is the floatation clarifiers. Since removal of fiber is very important to the performance of the evaporators, the mill decided

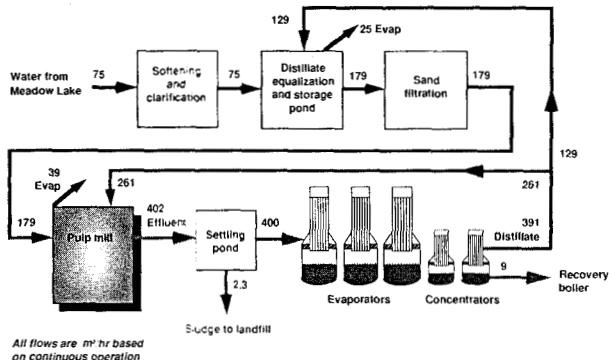


FIGURE 2. Millar Western water recovery process overview.

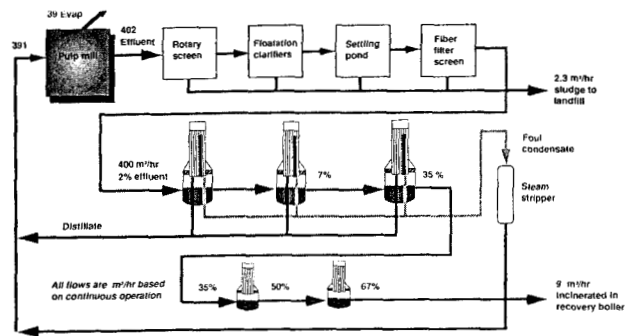


FIGURE 3. Millar Western effluent treatment system.

to install two clarifiers instead of one. This allows for maximum removal efficiency and flexibility. Chemicals are added to aid in flocculation and floatation of the solids.

To ensure that upsets in the pulp mill do not directly affect the evaporators, an on-line meter measures suspended solids in the clarifier accepts stream. When the suspended solids exceeds 900 ppm, the clarifier accepts are directed to the settling ponds. Clarifier accepts normally go directly to the evaporators in the winter to conserve heat. In the summer the accepts go preferentially to the settling pond to dump heat since the heat balance changes from season to season.

Evaporation

The heart of the zero effluent system is three vertical-tube, falling-film vapor compression evaporators. At 30 m tall, and with thousands of square meters of heat transfer surface, this is the largest train of mechanical vapor recompression evaporators in the world. The evaporators concentrate effluent from 2 percent to 35 percent solids, using an energy-efficient mechanical vapor-compression process to recover distilled water from the effluent. The evaporator consists principally of a heating element, vapor body, recirculation pump, and a vapor compressor (Figure 4).

The effluent is pumped from the vapor body sump to the top of the heating element (tube bundle). A distributor is installed in the top of each tube, causing the effluent to flow down the inside of each tube in a thin film. The distributor helps prevent fouling of the heat transfer tubes by keeping them evenly and constantly wet. It also allows the mill to operate at reduced capacity if desired, since the heating surfaces will remain wet regardless of the amount of effluent being processed. (The evaporators are also capable of handling 1.2 times more than design flow rates from the pulp mill which

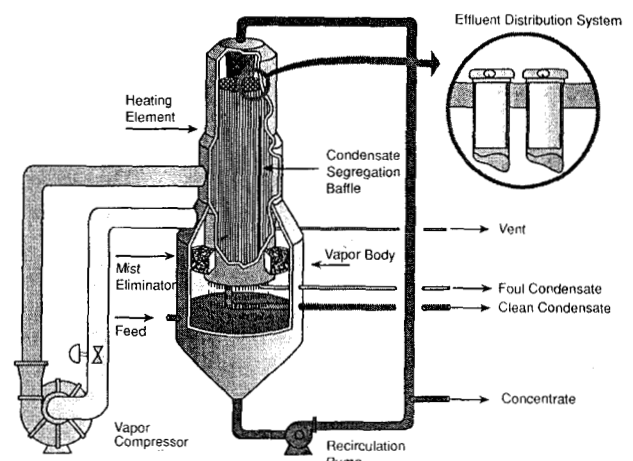


FIGURE 4. Evaporator.

gives the mill a significant amount of catch-up ability.) When the effluent reaches the bottom of the tubes, the recirculation pump sends it back to the top for further evaporation.

As the effluent flows through the heated tubes, a small portion evaporates. The vapor flows down with the liquid. When it reaches the bottom of the tube bundle, the vapor flows out of the vapor body through a mist eliminator and then to the compressor, which compresses it a few psi. The compressed steam is then ducted to the shell side of the tube bundle, where it condenses on the outside of the tubes. As it does so, it gives up heat to the tubes, resulting in further evaporation of the liquid inside. A large amount of heat transfer surface is provided, which minimizes the amount of energy consumed in the evaporation process. Operation of the vapor compression evaporator system requires only 17 kWh per m³ of feed.

As the vapor loses heat to the tubes, it condenses into distilled water, which flows down the outside of the tubes. Because the water that first condenses out of the steam is cleaner than water condensing later, baffles are provided within the heating element to create two separate regions for condensing. Steam flows first through the clean condensate region where most condenses. The remaining vapor, which is rich in volatile organics such as methanol, condenses in the foul condensate region of the heating element.

A major portion (70 percent) of the clean condensate is sent directly to the pulp mill for use as hot wash water at the back end of the mill. The balance of the clean condensate goes to the distillate equalization pond where it is combined with makeup water from Meadow Lake and serves as the cold water supply to the mill. The foul condensate, which contains the volatile organic materials, is reused after stripping in a steam stripper.

Virtually nothing more than a minor vibration problem in the evaporator electrical motors was encountered during the startup, allowing continuous operation with no unscheduled down time to affect pulp mill production.

Concentration

Like the three evaporators, the two concentrators are vertical-tube, falling-film design. Rather than using a vapor compressor to drive the system, the concentrator is operated with steam generated by the recovery boiler.

The evaporation process in the concentrators is essentially the same as in the evaporators, but the effluent is concentrated further, to about 67 percent solids. The concentrated effluent is incinerated in the recovery boiler. The lead concentrator takes the liquor from 35 percent to 50 percent, while the lag concentrator goes from 50 percent to 67 percent solids.

During startup, there was some concern that the final liquor might be too thick to pump. As it turned out, the liquor was easy to handle at operating temperatures. Since startup, no serious plugging has occurred in the concentrators and scaling has been minimal. Each concentrator can be switched to water wash mode while liquor storage tanks are drawn down, then placed back in service with no shutdowns upstream at the evaporators or downstream at the recovery boiler.

Stripping

The foul condensate, only about 10 percent of the total condensate, is stripped of volatile organics in a packed column stripper. Volatile organics are selectively concentrated in the foul condensate because of the condensate segregation features built into the evaporator heating elements. Process steam from the concentrator is sent to a reboiler, which generates stripping steam from a portion of the stripped condensate. The stripped condensate is combined with the clean condensate and reused

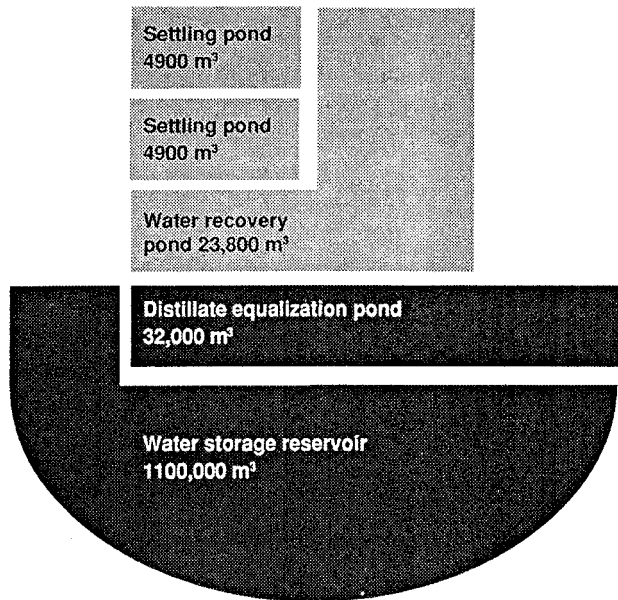


FIGURE 5. Millar Western water ponds.

in the mill. The stripped volatile organics are incinerated in the recovery boiler as a concentrated vapor.

Incinerator

At the recovery boiler, the organic components of the effluent are incinerated, a process that also generates steam to operate the concentrators. Inorganic chemicals in the effluent are recovered in the smelt from the boiler, which is cast into ingots and stored on site. The mill is considering recovering the sodium carbonate, which would then be converted to sodium hydroxide, a major chemical used in the BCTMP process.

WATER STORAGE

In the mill there are many tanks and chests for storing white water, pressates, and wastewaters. Likewise, in the water recovery plant there are storage chests for mill water and various concentrations of liquor. But the heart of the water storage system lies in five major ponds holding 182,000 m³ (Figure 5). The ponds are split into two settling ponds and one water recovery pond holding all wastewater volumes. The two settling ponds hold 4,900 m³ each and are concrete-lined to facilitate dredging when required. The water recovery pond holds 23,800 m³ of wastewater and is concrete-lined along the sides to prevent erosion and clay-lined on the bottom.

The distillate equalization pond and water storage reservoir hold all the clean water. The distillate equalization pond is a bio-polishing pond where the small amount of volatile organics that come over with the distillate are consumed by biological action. This pond holds 32,000 m³ while the water storage reservoir holds 1,100,000 m³. Both ponds have a 1.5 mm poly liner.

Having the large storage basins for wastewater give the pulp mill two days of run time with the water plant completely shut down. If makeup water from the lake is down, the pulp mill can run for 20 days from clean water inventory in the water storage reservoir. Also, if there is a recovery boiler outage, the pulp mill and evaporators can continue to run for 30 days without being affected.

Without the pond system, the operation of the pulp mill would be totally dependent on the operation of the water

recovery plant. An evaporator trip or recovery boiler outage would directly cause lost production in the pulp mill. Because the design is so flexible, an evaporator trip has no effect whatsoever on pulp mill production. An emergency shutdown in the pulp mill allows for slow turndowns in the water plant.

CONCLUSION

Perhaps the best way to describe the success of the water recovery plant is that the pulp mill operators barely recognize that they are in a zero effluent environment. They have access to all the water they require and it is better quality than lake or river water. The water recovery plant has not caused any lost production in the pulp mill other than for normal maintenance of the equipment. No off-grade pulp has been produced as a result of water quality. Washing efficiencies have been excellent and the cleanliness of the pulp, not only in terms

of debris, but also organic loading, has been better than expected [3]. In short, the zero effluent mill has proved to be a success.

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