

WATER, WATER EVERYWHERE, BUT DOES IT NEED TO BE THAT WAY?

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THE LARGE CONSUMPTION OF WATER BY THE PAPER industry began to change in the 1960s and 1970s with the implementation of various environmental regulations. The most important of these was the Clean Water Act. Figure 1 shows information regarding the paper industry in the United States reported to the National Council for Air and Stream Improvement (NCASI) (1). By 1988, the industry had reduced its water requirements in gallons per ton of product produced by 70% from 1959 usages.

Raw water used in the paper-making process was more than the effluent flow. Figure 2 shows the total use in 1988 for pulping, paper machines, and cooling by three major categories of mills.

CURRENT STATUS

Today there are a dozen or more mills reported to have no effluent flows. Although these mills are mostly old corrugated container (OCC) recycle facilities, they do include two bleached chemithermomechanical pulping (BCTMP) mills in British Columbia. Some mills use exotic technology. Most are applying "creative but common sense" knowledge and paying attention to details, however. Recently Mannisto (2) reported that in 1994 50% of the bleached kraft mill production in the United States, Canada, Sweden, and Finland used total effluent flows less than 23,775 gal/ton (90 m³/a.d. ton) as Fig. 3 shows. Twenty percent of the production used less than 15,850 gal/ton (60 m³/a.d. ton). If the numbers reported by the U.S. bleached kraft producers in 1988 represented the four countries in the 1994 figures, there has been no significant reduction in water use during the last six years.

The highest use was over 52,835 gal/ton (200 m³/a.d. ton). The lowest number reported was 7925 gal/ton (30 m³/a.d. ton). This indicates that large reductions in water use are possible.

The mean effluent flow from the mechanical pulp and paper mills in the four countries ranged from 5280–10,560 gal/ton (20–40 m³/a.d. ton). U.S. and Canadian mills were over 10,600 gal/ton (40 m³/a.d. ton), and the Nordic mills were below 5,200 gal/ton. Mannisto

ALTHOUGH MILL WATER USAGE HAS DECREASED CONSIDERABLY SINCE THE 1950s, REDUCTIONS IN THE LAST DECADE HAVE BEEN SMALL. TECHNOLOGIES ARE NOW AVAILABLE FOR MILLS TO MAKE SIGNIFICANT REDUCTIONS, HOWEVER. USING COMMON SENSE AND PAYING ATTENTION TO DETAILS WILL ALLOW MANY MILLS TO ACHIEVE MODERATE REDUCTIONS. MILLS NEED TO APPROACH WATER REDUCTION PROGRAMS AS THEY APPROACH ANY MAJOR CAPITAL PROJECT WITH INVESTIGATION AND PLANNING.

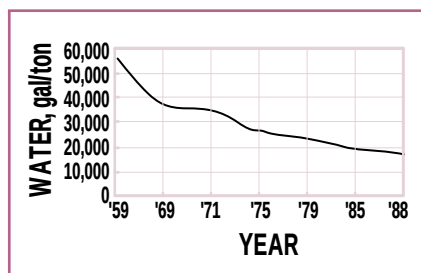
reported that the Nordic mills are either new or modernized. They have effluent flows ranging from 2640 to 7925 gal/ton (10–30 m³/a.d. ton).

Two Canadian mills have zero effluent flow. Raw water use at Millar Western's mill at Meadow Lake is approximately 530 gal/ton (2 m³/a.d. ton) to make up for water evaporated in the cooling systems, waste incineration, and pulp drying (3).

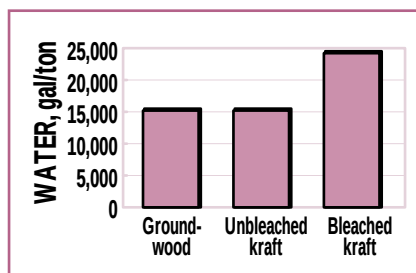
DRIVERS

The large decreases in water use seen during the 1960s resulted from simple economics. Mills could not afford to build the massive waste water treatment plants required for the large amounts of water used in the mills. To

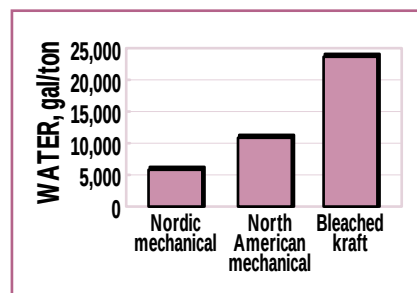
MINIMUM WATER USE



1. Final effluent flows from 1959 to 1988



2. Total raw water use in 1988



3. Total effluent flows in 1994

reduce the cost of the treatment facilities, mills started water reduction and water reuse programs. Water reduction has since come from making process changes driven by improvement in product quality or production. Reduction of water use was a secondary benefit.

A simple example is the installation of a closed screen room. More complex is converting all paper machine and brownstock washer showers to white water and installing a closed loop for the vacuum pumps, etc. This would allow doubling of the mill capacity without increasing the permitted effluent discharge.

Mills on water quality limited streams—those flowing only part of the year—face unique challenges. They have to impound their effluent for up to 10 months per year and hope for precipitation. Then they can discharge into a normally dry river.

The proposed cluster rules will have an impact on mill water use. Again mills will find that it is cost effective to reduce mill water use rather than install the equipment needed to treat the whole effluent stream to the new standards. This is the intent of the rules. The Environmental Protection Agency is trying to have mills make process changes rather than install end-of-pipe solutions. One estimate is that 80% of the cost of implementing the rules will be for process changes.

There have been regulatory pressures from decreasing permit limits and a policy of “no increase in limits” as production has increased. These have not resulted in significant or large decreases in water use. That may change, however. Many mills in remote locations now find they share their “paper mill community” with rapidly expanding planned retirement developments. Such mills must now share the raw process water that once was readily available for industrial use for only the pumping cost with these residential developments.

This sharing creates “cones of depression” or loss of aquifer water levels as everyone tries to use the same resource. As a result, the private citizens do not want to share. The conflict has heightened to the point that some areas are considering imposing a use tax on industrial water withdrawals from aquifers. The economics of high

water costs will cause the mills to again institute water reduction programs.

There is also a new school of thought. Several companies foresee that being labeled a “good citizen” could be a significant strategic advantage in the future. These companies are quietly investing in research and development programs to allow their mills to be “inert boxes” in a field with minimal waste products—liquid and solid. Such mills would be aesthetically pleasing—no odor or visible emissions. Although this may sound extreme, certain facets of the industry have already accomplished “zero effluent.”

APPROACH

To minimize its water use, a mill must approach the problem like any project. The following steps are suggestions:

- Identify the goal or objective.
- Define what is currently happening or where the water is presently going.
- Project future quality production, and regulatory requirements.
- Develop a list of solutions and alternatives.
- Determine the operating and capital costs and the risk for the alternatives.
- Develop the scope of the work and an implementation schedule.
- Obtain management support.
- Secure funding.
- Implement the changes.

Obtaining management support is especially important. Without that factor, one is simply wasting time.

UNDERSTAND THE SYSTEM

As absurd as it may seem, very few mills know where water goes or what the mill water system looks like. They have a gross idea, and they may distribute costs to the various operating departments. Water meters at a

mill are often the last items to receive maintenance or attention except during production disruption.

To begin, one must have a good drawing of the mill system. This can simply be a single line drawing showing the distribution system, all the major users, and flows. Although actual flows are best, estimated flows will usually suffice.

Developing the system drawing requires someone walking the mill to note the location of the pipes and uses. For most mills, determining the flows is more imaginative because of a lack of instrumentation. It is best to break the mill into blocks or systems. One can use flow measuring devices that are external or internal and temporary or permanent. It is possible to install some devices such as anubar or pitot tube by hot tapping a 2-in. nipple onto the water line similar to tapping a beer keg. Other movable devices strap to the outside of the pipe.

Another approach is basic engineering. One can obtain a good estimate of a pump flow from a manufacturer's pump curve by knowing the impeller diameter, motor load (amperage), and discharge pressure. Calculation of shower flows will result from the type and number of nozzles and operating pressures. Using sewer flows, one can check consumption in an area.

COLLECTING DATA

It is necessary to collect system or mill operating data at various operating conditions. This is especially important in extreme conditions such as summer and winter. If data such as major flows is not readily available, implementation of a program to collect key parameters will be necessary. The two most important items will be flow and temperature.

The system will contain nonprocess elements (NPE) or ions of manganese, silicon, calcium, chlorine, etc. These come into the system with the wood and other raw materials—water, lime, etc. Any buildup in the system will become extremely important as the mill closes. A program to identify, quantify, and monitor the buildup of NPE will be beneficial. Since the analysis of NPE is expensive, one must carefully consider the selection of the points for analysis and the frequency of collection.

Data collection will allow the user to build a model of the mill. If the mill is currently a large water user hoping for modest reductions, a simple spread sheet model may be all that is necessary to be certain heat will not be a problem. If the mill is already a low water user with an aggressive reduction goal, however, it will be necessary to develop a sophisticated model. Commercially available computer software may be necessary to model not only heat but also NPE buildup.

IDENTIFICATION AND CATEGORIZATION

Today, most mills have several water systems such as treated process water, clean and rich white water, and perhaps warm and hot water. Their establishment was probably due to sources other than final requirements. A successful water reduction program must identify the "class of service" required for each use in the mill. This will require determination whether the process requires cold or hot water, clean or dirty water, etc. After establishing the requirements, one can develop a system that cascades the water from one use to another—cold to warm to hot or clean to dirty. Remember that equipment manufacturers can be a good source of information about the minimum water quality requirements.

Tomorrow, the mills will again learn the three Rs—reduce, reclaim, and recycle:

- Reduce fresh water use by eliminating fresh water washing hoses, using mechanical or waterless seals, instituting programs to ensure that heat exchanges maintain their efficiency, and using reclaimed and recycled water instead of fresh water.
- Reclaim uncontaminated waters such as noncontact cooling water for reuse with minimal or no treatment.
- Recycle contaminated streams for reuse as is, for a lower class of service, or for treatment to reuse in a higher class of service. Treatment may be as simple as eliminating heat with a cooling tower or as exotic as processing secondary effluent through an ultra-filtration system or waste water evaporator for return to the treated process water system.

HEAT AS A PROBLEM

Undoubtedly heat will be a problem. Heat enters the system from pumps, refiners, steam mixers in the bleach plant, oil coolers, etc. Modeling the mill for various scenarios will allow solution of this problem. This technique will show the best place to introduce cool and hot water to minimize system impact. Implementing a millwide cascade system using cool to warm to hot is ideal. In many mills, however, this must be restricted to local area use because of the cost of modifying the mill's distribution system. Use of low-grade waste heat in a black liquor preevaporator or waste water evaporator is possible when combined with a vapor recompression unit. Installation of a heat sink such as a cooling tower should be the last resort. This is an expensive and energy intensive operation.

NPE AND DISSOLVED SOLIDS

NPE is a problem requiring solution as the mill approaches system closure. Traditional outlets for NPE have been the mill sludges—dregs, lime mud, and waste treatment—and the final product. These outlets will continue to be very important and will require optimization. One technique is the installation of improved equipment such as green liquor filters for sedimentary type clarifiers. Another method is through system enhancements such as using special polymers to ensure that inert materials combine with solids leaving the mill rather than stay in the recycled underflow.

Other new approaches will also be necessary. One very high water user is a bleached kraft mill using large quantities of shower water on the various bleach washers. Most of the resulting filtrates go to the sewer because they have high contamination. To reduce elemental chlorine, many mills are implementing bleaching sequences that will allow counter-current use of the filtrates. These systems concentrate the dilute filtrates in evaporators. The recovered, clean condensate returns to the bleach plant showers. The boiler recovering process chemicals burns the solids.

Union Camp's C-Free bleaching process uses O Z E D. It recycles counter-currently all filtrates from the E stage without worrying about the impact of chlorides. Champion International's Bleach Filtrate Recycle (BFR) process takes a different approach. Using $OD_{100}E_{op}D$ bleaching process, it recycles the E_{op} filtrate to the recovery boiler. The chloride removal process (CRP) maintains the chloride level of the system, and a metal removal process (MRP) controls the accumulation of NPE. The CRP removes chlorides from the recovery boiler's precipitator ash by using an evaporative salt crystallizer. The MRP uses an ion exchange system to remove NPE from the D_{100} filtrate.

Despite the system or technology used to reduce fresh water use, mills need to involve their chemical suppliers. The suppliers can help prevent problems from corrosion, biological growth, buildup of colloidal solids, etc., by supplying chemical systems tailored for specific mill problems. Supplier laboratories can also help monitor systems in the mill.

OWNERSHIP IS VITAL

Area owners are the keys to a successful program. A successful managing by objective (MBO) program requires setting measurable goals. After setting, the parameter—in this case water consumption per ton of product—requires tracking and trending. If the goal remains unsatisfied, remedial steps are necessary. If the owners do not have the tools to control their systems, however, they will not actively manage the system.

The most important tool is a good monitoring system. This will allow the owner to identify when and where a problem is occurring to correct it. Crews need ready access to the monitoring system that should have alarms to alert them to unusual conditions. This will prevent any unusual high use situation.

As a component of ownership and the MBO program, mill management must ensure that area owners are operating their areas within the prescribed limits. Attention to details will ensure a water reduction program. It can have the same success as the mill's safety program and contribute to the mill's production target.

RECIPE FOR SUCCESS

There is no single recipe for success because each mill is unique. In some mills, a few changes in operations may be the only requirements to reach the desired goal. For other mills, the program may have to be more innovative.

The first items usually examined are the reuse of the vacuum pump seal water and use of filtered white water for machine showers. Other items that mills consider are replacing the normal ion exchange demineralizers with reverse osmosis (RO) units that do not require routine back flushing, processing selected streams through ultrafiltration units to remove contaminants, and adding evaporation capacity to generate more clean condensate.

Ramamurthy (4) reported on the success of trials using clean white water for secondary dilution of starch and clays and for felt cleaning after screening. The mill tried to use clean white water for primary chemical dilution, but fines in the white water caused a loss of strength. There were further trials after removing the suspended and colloidal solids either by using membranes or evaporation. These trials indicated it was possible to use the cleaned white water for polymer dilution.

JUSTIFICATION

Using a survey of four North American mills, Wohlgemuth (5) reported that the cost of water typically ranges from US\$ 125–350 per million gallons. This means that the annual cost for a bleached kraft mill using 18,500 gal/ton (70 m³/a.d. ton) is approximately US\$ 0.7–2.3 million. Cost includes chemicals for raw and waste water treatment, energy for pumping, and maintenance. The study did not include the cost of energy needed for heat to meet process requirements or the energy lost with the final effluent.

Any installation of capital equipment or process modification must have a return on the investment to justify it. The rate of return necessary varies from company to company and may vary with the type of project.

Water reduction projects are no different. Justification requires payback.

Many engineers looking for justification examine only the cost of the raw water. Following are the actual costs one must consider in a water reduction project:

- Energy required to heat a process required in the effluent treatment plant and to pump water around the mill
- Chemicals required in the raw and waste water treatment plants
- Fiber losses that can be eliminated
- Chemical spills that can be eliminated
- Maintenance costs necessary to maintain the water distribution systems
- Production gains that can be reached by eliminating a bottleneck such as evaporation capacity or reducing downtime (losses associated with filled felts caused by using cold, wrong pH water)
- Quality improvements obtained by eliminating process variability
- Cost avoidance obtained by reducing use rather than installing new or larger systems.

Marketing is a major consideration for any producer wanting a competitive edge. Being a "good citizen who looks after the world's resources" rather than a "rotten industrial polluter" can offer that edge. Being a very low user of water can provide a strategic and marketing

advantage for a mill. The mill can convert this to increased sales and additional justification.

SUMMARY

Today, it is possible to operate bleached kraft mills with effluent flows as little as 8000 gal/ton (30 m³/a.d. ton). Mechanical pulp and paper mills and recycle based liner-board mills are operating with "zero" effluent flows. Technology is making rapid advances. Due to regulatory and public pressure, mills will institute major water reduction programs over the next several years. TJ

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The author thanks Marty Drake for her help with the preparation of this paper.

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