Optimum Closure of Mill White Water System Reduces Water Use, Conserves Energy

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ABSTRACT

Advancements in papermaking technology and equipment designs, and changing pollutant discharge limits have initiated a renewed interest in restructuring the mill white water system. The pulp and paper mills operate much more efficiently today in terms of water consumption per ton of paper produced in almost all grades, compared to 20 years ago. The industry's focus has shifted over the years from simply meeting the stringent environmental pollutant discharge limits to significantly reducing the effluent discharge loadings well below those limits for economic advantages.

The changes in process technology have encouraged equipment manufacturers to develop state-of-the-art filtration equipment to achieve efficient white water clarification for reuse. Modern white water systems are designed to operate the equipment at maximum efficiency and accommodate system instabilities without sacrificing quality.Also maximizing the white water reuse significantly reduces effluent loadings without loss in equipment performance and life.

This paper discusses the principles and methods in closure of white water system and highlights the advantages.

Keywords: *White water, closure, design, energy, water consumption, effluent, TSS, BOD, COD, compliance, landfill.*

INTRODUCTION

In recent years the pulp and paper manufacturers faced additional constraints to modernization, namely, the raw water availability and limitations on wastewater discharge. This in turn means that, the conventional wisdom of end-of-pipe treatment for pollutant discharge may not be sufficient. Additional in-plant water conservation efforts are becoming necessary to reduce the volume of effluents discharged and also minimize solid waste for disposal. Recently, many mill modernization programs are being designed to address this area to become more efficient in terms of water usage and volume of effluent discharged to the treatment plant.

BACKGROUND

A survey performed by NCASI (1) showed that an integrated pulp and paper mill in U.S. on average consumes 60.0 - 64.4 m^3/t (16,000 -17000 gals/t) of paper. The average water consumption varies based on system design, operational factors, pulping processes, product type and range. For example, the

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water consumption for a facility producing linerboards or corrugating medium is significantly different from a mill producing newsprint or fine paper.

Paper mills in general consumes approximately 11.3 - 37.8 m^3/t (3,000 -10,000 gals/t) and constitutes 20-35 % of the total mill water consumption. Figure 1 gives a breakdown of water consumption for different sections in an integrated bleached kraft mill producing writing and printing. paper. As seen, paper mill is a major water consumption area after the bleach plant. This means that large quantities of effluent are also discharged from paper mill.

PAPER MILL EFFLUENT LOADS

Paper mills carry significant quantities of fiber, fines, filler and other wet end additives that contribute to total suspended solids (TSS), chemical oxygen demand (COD) and biochemical oxygen demand (BOD). The total suspended solids in the effluent discharged from paper mill varies based on the first pass retention, white water system design, clarification equipment, equipment arrangement, and system constraints in terms of water reuse.

The chemical oxygen demand in paper mill effluents depends on the suspended solids discharged such as fiber, fines, other chemically oxidizable additives such as starch, polymers, etc. The suspended solids discharged depends on the system design, accidental discharges and degree of closure of white water system.

The biochemical oxygen demand in paper mill effluent is high. Figure 2 shows an approximate distribution of BOD loads in effluents from different areas of the mill for a fine paper mill. The contribution of paper mill effluents to total BOD is significant. The contribution of paper mill effluents to total BOD varies based on the proportion of oxidizable materials such as fiber, fines, starch, wet and dry strength resins, drainage aids, dyes, sizing materials, and other dissolved organics. The relative distribution of the material contributing to BOD may vary from machine to machine and mill to mill. Major factors contributing to the variations are the type of paper/ board produced, type of additives used, first pass retention, and white water system design.

PAPER MILL WATER CONSUMPTION

The water consumption for paper mills differ in non-integrated and integrated mills. In a non-integrated paper mill, purchased pulp is a major fiber source. Pulp is delivered at approximately 90% solids. The web leaves the press section at 40-46% solids. So there is a net demand for mill water in paper mill.

In an integrated paper mill, the pulp from pulp mill is stored in a high density chest at approximately 12-16% consistency. Similar to the non-integrated mill, when the web leaves the press section at 40-46% solids, there is a net surplus of water.

Additional water is needed in both cases, for showers in wire and press sections, dilution for chemicals , process water make up for level control in tanks and for break dilution. Large amounts of water is also needed as seal water in the liquid ring vacuum pumps. Other minor areas of water consumption include showers for size press, cooling water for bearings, and hoses.

WHITE WATER SYSTEM

In a paper mill, pulp enters the headbox at 0.5% to 1.0% consistency. Water is removed by successive stages of dewatering by free drainage and with the aid of vacuum elements in the wire section is collected in wire pit/silo, seal pit or other storage tanks, Water collected from each stage of dewatering contains different proportions of fiber, filler, fines and other materials. Water collected from these stages can be reused before and/or after clarification.

Water removed from the web in the press section along with shower water is collected through the vacuum elements. In some mills, water removed from the press section is reused after clarification, as a make up for white water. In mills, where there is a continuous chemical cleaning of felts, the water removed in the press section is discharged as effluent.

Overall, there are many different ways in which the filtration equipment, silo and other white water storage chests/tanks can be arranged for handling the white water. This arrangement is known as mill's white water system.

An open white water system is one where the water reuse is less. this system results in significant water consumption in paper mill. Also substantial losses of chemicals, fiber and energy do occur in those cases.

OBJECTIVES

The general objectives in designing the mill's white water system are:

1. Minimize fresh water consumption without affecting runnability or quality.
2. Reuse clarified/unclarified white water at appropriate areas
3. Efficiently use the filtration equipment and storage capacities.
4. Minimize loss of chemical and fiber.
5. Allow operational flexibility in terms of control strategies, retention time and water reuse.

In greenfield mills, the white water system is designed taking advantage of the state-of-the-art technology to bring about the desired degree of closure without sacrificing quality.

In rebuilding efforts involving production increase in paper machines, increases in effluent discharge volumes from paper machine becomes an issue, especially in situations where the treatment plant has capacity limitations. Internal process modifications, to close the white water system becomes attractive in such cases.

For existing mills, the incentives to water closure are savings in fiber, chemicals, water and energy.

CLOSED WHITE WATER SYSTEM

In general, closing the mill white water system has the following advantages:

- Minimize fresh water consumption
- Less chemical consumption
- Lower losses of fiber, fines and fillers
- Reduced cost of heating white water
- Environmental compliance

Closing the white water system more than desired can result in the following detrimental effects:

- Higher preservation of thermal energy
- Higher suspended solids in white water
- Higher dissolved solids in white water
- Higher deposits and bacterial growth
- Corrosive effect

Higher retention of thermal energy than desired is of concern in terms of sheet formation, internal sizing, and vacuum pump efficiencies. Also in cases of neutral or alkaline papermaking (practiced in most of the fine paper mills in North America), higher pH in combination with higher temperature are unfortunately favorable conditions for biological growth. Mill experience suggests an optimum temperature of approximately 46°C - 54°C (115°F-130°F). Temperature tend to be on the lower side in alkaline mills, for avoiding problems with sizing.

Closed systems force more unretained materials back in to the papermaking process than the open systems. In fourdrinier machines, filler twosidedness and color two sidedness can be the result of lower retention and higher closure. Another problem associated with closed systems is the buildup of suspended solids in white water loops. This buildup is influenced by first pass retention, performance of filtration equipment such as saveall and in-line filters. Other factors that contribute include fraction of material rejected by stock cleanning systems, fines and ash content in the furnish. Higher suspended solids are a concern, mainly, in terms of deposits, lowered filtration capacity of saveall and plugging of wire and/or felts.

Higher concentration of dissolved solids are detrimental. Higher dissolved organics result in higher biological growth in the system, possible odor in paper high BOD and color in effluents. Dissolved inorganics can be categorized into anions and cations. Anions, such as, sulfates and chlorides are detrimental to equipment and hardware made of bronze, cast iron and mild steel. carbonates and silicates contribute mainly to scaling. Cations such as Fe^{+2} contribute to brightness reversion in paper. Accumulation of both Fe^{+2} and Al^{+3} salts do occur and contribute to corrosion. With mills using alkaline sizing (alkaline papermaking), use of alum is significantly less and accumulation of Al^{+3} salts is not a major concern.

Excessive closure of white water system, in some cases, also results in runnability problems, plugging or wires, shower nozzles, pitch and slime problems and poor sizing.

OPTIMUM CLOSURE OF WHITE WATER SYSTEM

Closure of the machine white water system is to be optimized to lower the undesirable accumulation

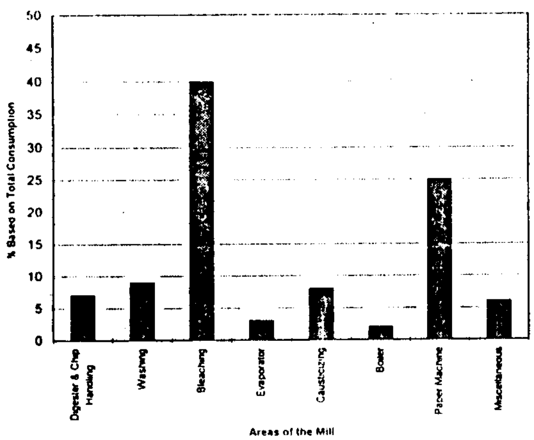

Figure 1: Relative Average Water Consumption in Different Sections in Pulp and Paper Mills.

of solids (dissolved, suspended) and heat in the system. Optimum closure depends on the type of equipment used for white water clarification and reuse, arrangement and performance of equipment operation, control strategies and an understanding of the chemistry of papermaking process.

Several types of filtration equipment are being used in mills today, to clarify and reuse white water. The primary filtration equipment used for white water clarification, is the saveall. As the name implies, savealls assist in the recovery of fiber, fines and filler in white water. Savealls operate on one of the principles of solid-liquid separation, namely, sedimentation, fractionation, flotation and filtration.

Sedimentation clarifiers are no longer preferred due to the long hydraulic retention time required, and considerable heat loss during that process. Fractionation screens are limited because of the narrow range of particle sizes, it can handle and ability to accommodate surge loads. Flotation clarifiers were prevalent in the past, but are less common today, because they occupy larger floor space, and have high operating costs and capacity limitations.

The filtration equipment, most commonly used for white water clarification are the drum and disc savealls. These filters are capable of handling large volumes, accommodate surge loads and achieve better filtrate clarify. Disc savealls have additional advantages, such as, higher filtration area for a given floor space, and ability to further separate filtrate into high clarity (clear) and low clarity (cloudy) filtrate. Disc savealls are preferred in many cases due to the above reasons and a satisfactory performance record. Detailed description of savealls is given elsewhere(2).

In mills, reusing white water for showers in wire and/or press section, additional clarification equipment such as gravity strainers, screens and/or in-line filters are generally required. A wide variety of equipment is available today for this purpose. Choice of any particular design, filtration media, slot width or mesh size is based on capacity required, operating conditions, equipment arrangement and type of application.

Operation and control strategies practiced in the mill are also of major significance. Piping arrangement, mixing of water streams of different clarity consistency), and control philosophies of water make up for level control in tanks influence satisfactory operation as well as overall water consumption.

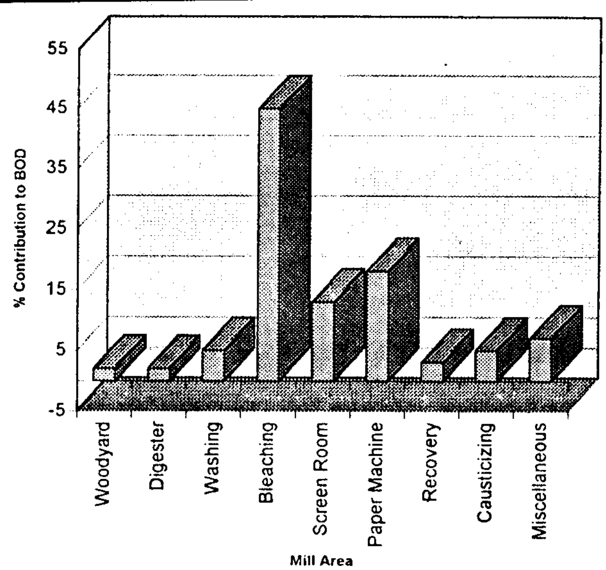

Figure 2: Relative Biological Oxygen Demand in Effluents from Different Sections in Pulp and Paper Mills

Segregation of water of different water qualities (consistencies) to facilitate water reuse at appropriate applications. The richest white water from the wire section, such as tray water, should be used as close to the headbox as possible. this helps to keep the high concentration of fines in a tight loop. Reuse of white water containing higher solids (rich white water) should be maximized, allowing lean white water to be sent to saveall. this minimizes solids loading in white water to be clarified to be clarified in saveall.

Some mills have broke system which are not adequately separated from white water system. In such cases, system instabilities are reflected in poor machine performance and breaks. Under steady state conditions, excess white water from the machine is constant while broke to be blended may not be depending on the broke inventory. The best arrangement in mills practiced today is to store the broke separately, thicken, deliver at the desired consistency and flow rate to the blend. chest.

SEAL WATER REUSE

Another area of high water consumption in paper mills is the seal water for vacuum pumps. General practice is to reuse this water in other applications or recirculate back in vacuum pumps. In some mills, cascading the seal water from high vacuum pumps to low vacuum pumps is practiced. Generally, in vacuum pumps the conversion of mechanical energy to heat energy causes an increase of about 11°C in seal water temperature. Some amount of mill water is used as make up to control the temperature.

Partial seal water reuse is commercially practiced by mills in an effort to reduce the water consumption, Use of cooling towers to lower the temperature of seal water after usage helps to reclaim and reuse 90% of the seal water. Other methods of reuse include use of temperature and pH control loops to recirculate seal water from the sump, which helps to reuse 50-75% of total seal water. Fresh water serves as make up in these cases.

In all these methods of water reuse caution should be exercised to maintain high vacuum separator capacities to avoid carryover of fiber and felt hair to vacuum pumps. Care should be taken to sewer the seal water during felt cleaning to minimize solids accumulation in vacuum pumps. Evaluation of vacuum systems and operating conditions are necessary before method of water reuse is selected.

In an effort to conserve water and also to recover the heat energy some mills. this is not recommended, in general, as the seal water temperature is normally lower than the white water temperature and varies appreciably based on mill water temperature. operation. Pumping of vacuum pump seal water to the white water system under steady state conditions, may result in increased fiber, chemical and energy losses.

DEGREE OF CLOSURE

A significant reduction in fresh water consumption along with higher stability of operations, can be achieved by optimizing the white water system design. Table-1 shows water usage in fine paper mills with average and good performance. Effluent loads also vary considerably based on the degree of closure. Conversion to alkaline papermaking facilitates white

Table-1

Approximate Effluent Loadings with Varied Degrees of Closure

	UNITS	GOOD	AVERAGE	POOR
Total Fresh Water Consumption	M^3/t	< 19	19 to 30	> 30
	gals/t	< 5,000	5,000-8,000	> 8,000
Suspended Solids in Effluents				
- Ash	%	< 0.4	0.4-1.2	> 1.2
- Fiber	%	< 1.0	1.0-1.7	> 1.7
Dissolved Solids in Effluent	kg/a.d.t.	< 16	16-25	> 25
	lb/a.d.t.	< 35	35-55	> 55
Chemical Oxygen Demand	kg/a.d.t.	< 18	18-32	> 32
	lb/a.d.t.	< 40	40-70	> 70
Biochemical Oxygen Demand	kg/a.d.t.	< 7	7-11	> 11
	lb/a.d.t.	< 15	15-25	> 25

water closure to some extent. Including recycled fiber in furnish may need some restructuring in mill white water system based on the level of contaminants carried along with the recycled pulp.

Variations in white water temperature can cause variation in drainage on wire. Also, as previously mentioned, in integrated paper mills that do not use market pulp in furnish, there is a water surplus under normal Millwide water conservation efforts are necessary to maximize the use of white water in paper mills and other areas. White water closure is more rewarding, if production is limited by environmental constraints on effluent discharges or other capacity limitations in existing waste water treatment facilities.

CONCLUSIONS

Optimizing the white water system closure has economic benefits. However, case studies are to be conducted to minimize the capital investment. The incentives for white water system closure are reduced water consumption, savings in energy, fiber and chemicals.

Closing the white water system is more attractive for mills where environmental compliance is a production bottleneck. The best closed systems are those with minimal water consumption, satisfactory equipment operation, good equipment life, and highest product quality. In general, poor white water system design result in high sewer losses, high BOD/COD of effluent discharges, instability of operations, and high operating costs.

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