# Issues with Water Audit in Waste Paper Based Paper Mills

**Introduction**

Water is probably the maximum used item on earth, by weight. It is so heavily used that today we have started facing the shortage of it and we need to conservethe same. For the same, it is necessary to identify and analyze all inputs and outputs of any process to evaluate the genuineness of requirement of the same as well as process use efficiency for water. This process itself is called water audit. Compared to other sectors, the paper making process uses large quantities of water, which of course, can be recycled again. Not only this, there are many thickening and dilution operations in the papermaking process, that make the whole audit process a little complicated one. This article highlights such issues and the way forward.

**Importance of Water**

Water is used by many industries, for one or other purpose.Water acts as holding-mixing agent for small solid particles, solvent, heat transfer fluid, heat reservoir, carrying fluid, lubricant, bonding agent in different applications and processes, depending upon the need. Most of the water consumed in industry is used in cooling towers where the high latent heat of water helps in efficiently cool the system.

However, compared to other sectors, the use of water in different processes during pulp & paper making makes the whole process a complex one, for the purpose of audit. If we consider a conventional cooling tower, we have water having some dissolved solids in it, the concentration of which increases during operation. As the concentration rises, we purge some amount of water, and makeup for the purging as well as for the evaporation losses. The whole exercise now works how we can increase CoC (Cycle of Concentration) and thus reduce the amount of makeup water to be used. Exactly is the case for boilers running with softener for water treatment, RO plants etc.

However, in paper mills, the water is used to control the mechanical characteristics (specially the flow behavior) of pulp slurry (rheology) which is a must for various operations. Most operations need specific concentration to work at optimum efficiency levels, like pressure screens, centricleaners, refiners etc. To decrease the consistency, we need to add some water topulp, but that water, in itself contains some fiber fines and other process solids. Quite obviously, this happens as the thickening systems remove some amount of fines too along with water. To make the process more complex, water is also used in different equipment and pumps for gland cooling, which is also recycled back to process to save water. Furthermore, a significant amount of water is also used for wire and felt cleaning. This water is also reused again along with process water.

**Solids & Mass Balance:**

Being paper making fibers and other solids in slurry form with water too, only mass balance does not give a proper process understanding. For such cases, solids and mass balance gives a good process overview. To understand this, let us consider a typical dilution operation, where two different streams having different consistency are mixed to form another stream. Such a process schematic is shown in figure-1.

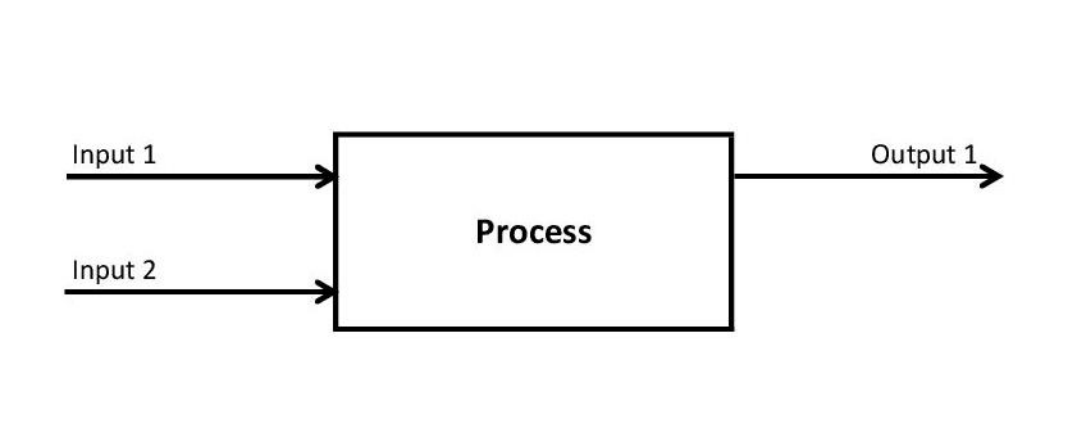


Figure 1: Two input streams joining (Typical dilution operation)

Stream 1: Consistency1, Solids1, Flow 1
Stream 2: Consistency2, Solids2, Flow 2
Stream 3: Consistency3, Solids3, Flow 3

Now, we know that

Consistency = solids * 100 / flow, (1)

The above equation has to be valid for each of the streams.
Not only this, the mass flow for solids as well as flow must also match-

Solids1 + Solids2 = Solids3 (2)
Flow1 + Flow2 = Flow3 (3)

This way, in case there are three streams (one input and two outputs; or two inputs and one output), we have a total of 9 variables. To solve, we have the following five equations-

- 3 Equations of type (1) (for each stream)
- 1 Equation of type (2)
- 1 Equation of type (3)

Mathematically, if there are four independent variables known in such a system, the remaining may be calculated. Here, independent means, the available four variables must not be a part of any of the five equations to make it already balanced. Once, all the variables are obtained, we move to the next block and keep on doing the exercise till all the parameters are known.

In several cases, the thickening of pulp is desired, where a stream of pulp is thickened and the back water is generated in the process. Again, this back water contains significant amount of solids. A schematic of such a process is shown in Figure 2. For example, the input stream is the pulp at 1% consistency, the output 1 is pulp at 4% consistency and the output 2 is the back water having say 0.1% consistency.

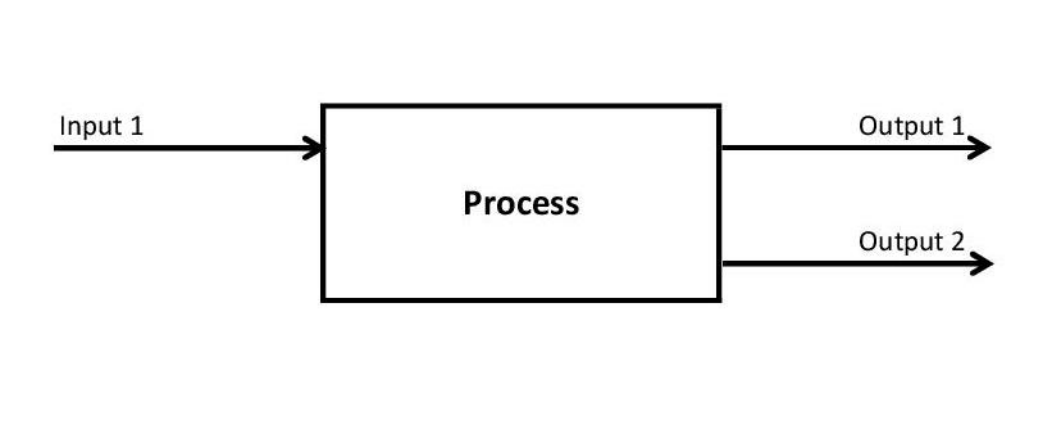


Figure2: Typical thickening operation

This exercise is necessary as most of the time, the back water contains significant amount of solids (papermaking fibers, fiber fractions –fines-, and other filler materials), which alters the solids mass flow in output stream.

Such a mass balance helps in finding the volume and concentration of each of the process stream, and to identify the status of reject streams. In any reject stream, if we find that the reject flow is high, or the reject consistency is high, appropriate approaches may be identified to reduce the losses. The same approach also helps in identifying the streams where freshwater can be replaced with back water to reduce fresh water consumption as well as to reduce the effluent discharge.

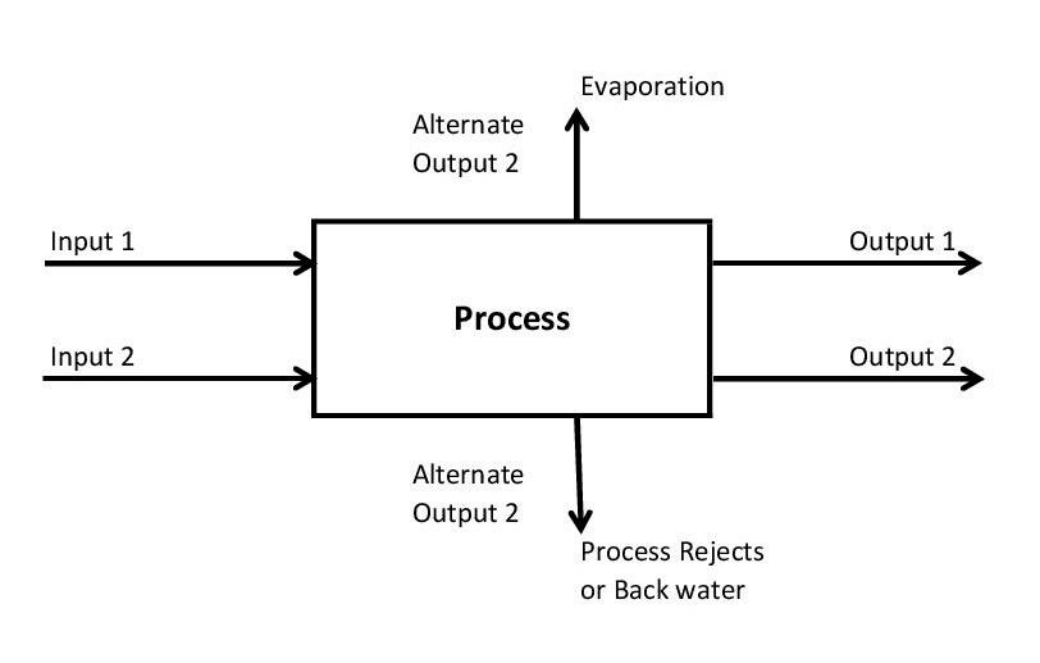


Figure 3: A general schematic of process operation

As we know that the papermaking process includes a lot of unit operations like cleaning, separation, thickening and dilution etc., the overall mass balance is a combination of various blocks as shown in figure (4). Various input streams like several showers on paper machine etc. make it difficult to accurately and reliably measure and compile the data, as these may also vary with time as per the process requirement.

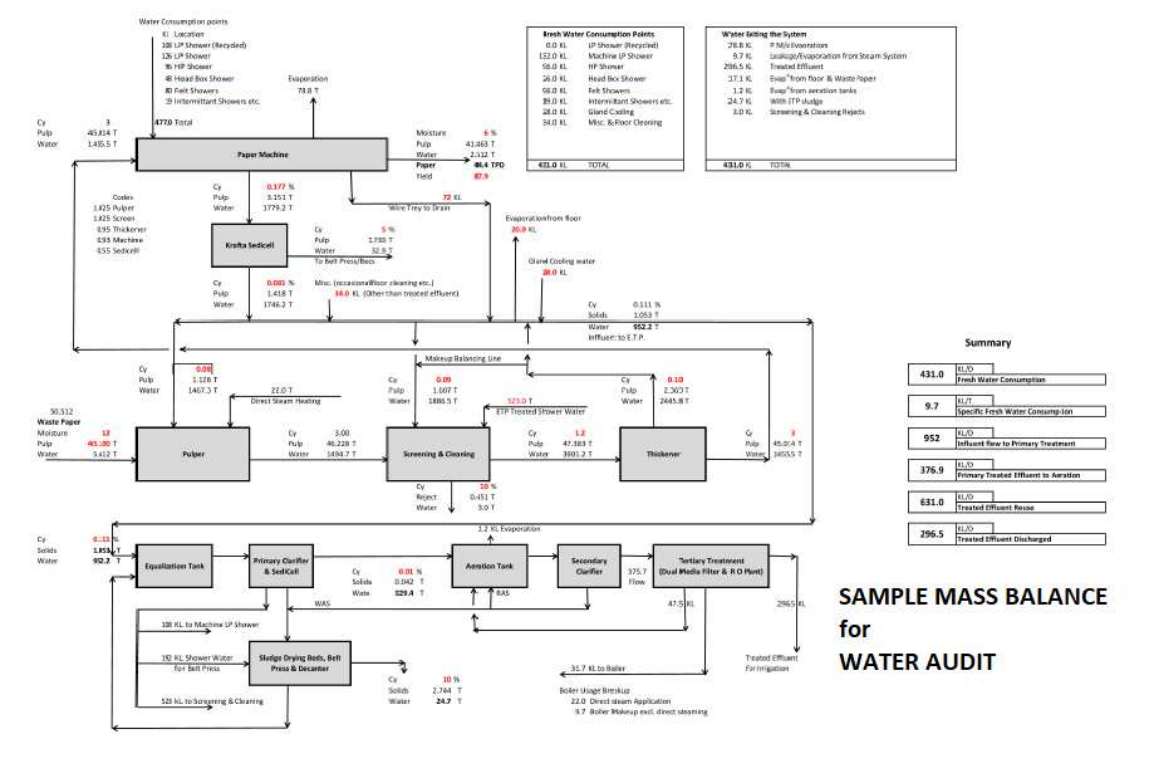


Figure 4: Typical overall mass balance for a waste paper based mill

**Recent Developments and Their Effect on Mass Balance**

For long duration of times, most of the pulp & papermaking parameters like the consistencies, the flow rates remained unchanged. However, things started changing rapidly after CPCB came up with a new Charter "Charter for Water Recycling &Pollution Prevention in Pulp & Paper Industries in Ganga River Basin" for paper mills in the year 2012. The charter presented detailed guidelines and strategies to reduce the effluent load. The implementation presented positive vibes in the industry to reduce water consumption and pollution loads.

Later, another charter "Charter for Water Recycling and Pollution Prevention in Pulp & Paper Industries" was presented in the year 2015, which envisaged up-gradation of the status of Pulp & Paper industries in terms of process technology, practices and environmental performance, besides substantial reduction of fresh water consumption and wastewater generation to meet objectives of the National Mission for Clean Ganga.

The charter changed the paper industry from the core. The mills started understanding the need to reduce fresh water consumption, the effluent generation and the pollution load generated. With time, the water conservation became more and more important. Mills started exploring the ways to reduce fresh water consumption; and in most applications, use of backwater became a necessity. To ensure adequate availability of backwater as well as to ensure that there is minimal overflow of backwater to ETP, enough thrust was given to increase the storage of backwater.

So far, the whole system had already become a complex one. But add to it the fact that mills are really working hard to reduce water consumption, and in paper machine showers, have provided arrangement for filtered back water as well as fresh water too. Most of the mills try to use filtered back water in wire part, and if possible in press part too, but in case there is occasional more cleanliness of wire and felts is required, the mills use fresh water for some short period of time. Not only this, please do not forget the amount of water evaporated from paper machine. This evaporation is not only from the dryer part- some small amount of water gets evaporated from wire part too. Some water also gets evaporated from floor etc.

**Water Audit &Mass Balance:**

Any water audit involves detailed analysis of fresh water (say borewell water) used, its breakup at various consumption points; water evaporated during the whole process and the quantities of wastewater/effluent generated. Then an overall water mass balance is made. Here again, another level of complexity has appeared. Let us first understand that.

For any process, we may have various input and output stream. Typically, it is said that

$$\sum \text{Inputs} = \sum \text{Outputs} \qquad (4)$$

In other words, the sum of all inputs must be equal to sum of all outputs. In fact, the same concept has been used in equation (2) and equation (3) above. However, in the present circumstances, the volume in storage tanks and chests might vary during the observation period, as their volumes have significantly increased while the flow rates have reduced. In such a situation, we must use the upgraded form of equation (4) as given below.

The proper equation is-

$$\sum \text{Inputs} = \sum \text{Outputs} + \text{Increase in Accumulation} \qquad (5)$$

Earlier, in many of the processes, the holding volume (accumulation) used to be either constant or almost insignificant compared to the input or output streams. But, in today's scenario, it has become a significant factor as earlier, paper mills used a lot of water, and hence the effluent discharge was very high. Compared to this, the holding capacity in storage tanks and chests was very large.

**Dynamics of Accumulated Volume**

The accumulated volume, sometimes, vary according to the flow rate. To understand further, if we consider a clarifier having an aeration tank having 15mX15M size, with an outlet of 0.20M wide, a 1cm level above the outlet shall give a flow rate of 1.4kL/Hr. However, at a level of 5cm, the flow rate shall be 14.4kL/Hr. Obviously, while raising the level from 1cm to 5cm, the aeration tank holding volume has already increased by 9kL.

In other words, the moment you increase the input flow from 1.4 to 14.4kL/Hr, the outlet flow does not increase instantaneously, but gradually. This is also possible that during this period the input flow itself has further gone down. In case the outlet was not a rectangular channel but a circular pipe, the situation might be more different.

In fact, this happens in each and every section where the flow is by means of overflowing of any system; be it the paper machine silo overflow, backwater tank overflow, clarifiers and even the open drains also. As a result, the sum of all input streams does not equal to the sum of all output streams in the short runs.

**Operational Flexibility**

As indicated earlier, many mills are going a little fanatic towards water conservation. Most of the mills have started using back water, or filtered back water or treated mill effluent in place of fresh water at various places, including the paper machine showers. The purpose of paper machine showers is to clean the paper machine clothing (wire and felt) to ensure desired production rates and quality of product. However, to maintain quality and production requirements, the operators are forced to use fresh water occasionally for shorter durations. Such decisions are often taken on the basis of operator experience, quality of raw material (waste paper), desired quality of finished paper, condition of (new/old) of paper machine clothing etc.

In India, the quality of waste paper also varies significantly. Let me give you an example. Old Newspaper (ONP) is a generally standard grade of paper. However, ONP collected from South Delhi is much superior compared to that from East Delhi, than to NCR than to small cities and towns from NCR states. In a study, it was found that the COD of the filtrate of a 5% consistency pulp of different grades of corrugation made in distilled water varied between 120-3200.

In case someone collecting data for audit visits that particular section when fresh/back water is being used for some time in a particular shower, he might be misguided. In such a case, the only source of information is the discussions with the operators.

**Impact of Duration of Water Audit**

Well, in most of the case, the duration of audit is just 1-3 days, which might not provide sufficient information about the process. Having much longer audit duration is not practically feasible.

Let us consider a typical example-
A waste paper based paper mill produces 50TPD kraft paper. As per the norms, the mill is allowed to use 10kL/T of fresh water and effluent discharge must be below 6 kL/T. The figures compute to 500kLD fresh water and 300kLD effluent discharge. Most of such mills have gone a step further towards water conservation and this way have been successful to reduce their effluent to just 100-120kLD.

Now, compare the figure with storage available with the mill- 8-10 pulp storages chests, each with 60-70kL volume each, a fresh water tank of 100kL capacity, a backwater tank with say 100-150kL capacity. In addition to it, an equalization tank of 100-150kL capacity to hold influent to avoid any shock load to ETP. All these add to nearly 900-1000kL volume. A just 10% overall storage volume variation means use of equation (4) will produce serious inconsistencies in water and mass balance. We must also not ignore the volume in miscellaneous drain channels and other parts of ETP. Even the clarifier and aeration tank levels vary slightly according to flow rates, and in case of fluctuating flow rates, even this minor change can result in mismatched readings.

**Conclusion**

It can be seen that in most of the waste paper based paper mills, detailed water audit is very difficult and impractical. However, audit itself is a good tool to monitor and explore ways to further reduce water consumption.

Water audit has been mandated as per the CGWA guidelines for all industries consuming more than 100kLD water. Not only this; as per the guidelines, only a few agencies have been accredited to do the water audit. At present, the accredited agencies for water audit are-

Confederation of Indian Industries (CII)
Federation of Indian Chamber of Commerce and Industry (FICCI)
National Productivity Council (NPC)
PHD Chamber of Commerce & Industries

However, considering the large number of industries using more than 100KLD water as well as the varied nature of water usage pattern and purpose, specifically in paper mills, I feel it advisable that the paper mills must be trained to conduct water audit themselves. This audit can be done as per the guidelines specifically developed for paper mills, by the mill's technical managers.

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