Water conservation in textile industry

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The textile Industry is in no way different than other chemical industries, which causes pollution of one or the other type. The textile industry consumes large amount of water in its varied processing operations. In the mechanical processes of spinning and weaving, water consumed is very small as compared to textile wet processing operations, where water is used extensively. Almost all dyes, specialty chemicals, and finishing chemicals are applied to textile substrates from water baths. In addition, most fabric preparation steps, including desizing, scouring, bleaching, and mercerizing use aqueous systems. According to USEPA a unit producing 20,000 Ib / day of fabric consume 36000 liters of water.

In textile wet processing, water is used mainly for two purposes. Firstly, as a solvent for processing chemicals and secondly, as a washing and rinsing medium. Apart from this, some water is consumed in ion exchange, boiler, cooling water, steam drying and cleaning.

Textile Industry is being forced to consider water conservation for many reasons. The primary reasons being the increased competition for clean water due to declining water tables, reduced sources of clean waters, and increased demands from both industry and residential growth, all resulting in higher costs for this natural resource. Water and effluent costs may in the more common cases, account for as much as 5% of the production costs.

Water usage

Water usage at textile mills can generate millions of gallons of dye wastewater daily. The unnecessary usage of water adds substantially to the cost of finished textile products through increased charges for fresh water and for sewer discharge.

The quantity of water required for textile processing is large and varies from mill to mill depending on fabric produce, process, equipment type and dyestuff. The longer the processing sequences, the higher will be the quantity of water required. Bulk of the water is utilized in washing at the end of each process. The processing of yarns also requires large volumes of water. The water usage of different purposes in a typical cotton textile mill and synthetic textile processing mill and the total water consumed during wet process is given in table 1 and table 2 respectively.

Table 1: Water usage in textile mills

Purpose	Percent water use	
	Cotton textile	Synthetic textile
Steam generation	5.3	8.2
Cooling water	6.4	--
Deminerialised or RO water for specific purpose	7.8	30.6
Process water	72.3	28.3
Sanitary use	7.6	4.9
Miscellaneous and fire fighting	0.6	28.0

Table 2: Total water consumed during wet processing

Process	Percent water consumed
Bleaching	38%
Dyeing	16%
Printing	8%
Boiler	14%
Other uses	24%

Wide variation is observed in consumption mainly due to the use of old and new technologies and difference in the processing steps followed types of machines used.

Every textile processor should have knowledge of the quantity of water used for processing. The volume of water required for each process is tabulated as under:

Table 3: Water requirements for cotton textile wet finishing operations

Process	Requirements in litres/1000 kg of product
Sizing	500-8200
Desizing	2500-21000
Scouring	20000-45000
Bleaching	2500-25000
Mercerizing	17000-32000
Dyeing	10000-300000
Printing	8000-16000

Table 4: Water requirements for synthetic textiles wet finishing operations

Process	Requirements in Litre/1000 kg of product				
	Rayon	Acetate	Nylon	Acrylic/ Modacrylic	Polyester
Scouring	17000-34000	25000-84000	50000-67000	50000-67000	25000-42000
Salt bath	4000-12000	--	--	--	--
Bleaching	--	33000-50000	--	--	--
Dyeing	17000-34000	34000-50000	17000-34000	17000-34000	17000-34000
Special Finishing	4000-12000	24000-40000	32000-48000	40000-56000	8000-12000

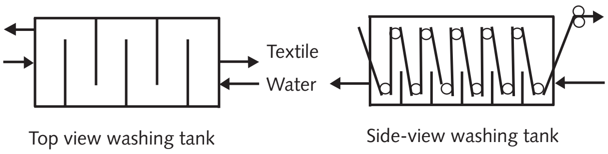

Figure 1 Scheme of a washing tank.

Washing efficiency

Washing process is characterized by its washing efficiency that is the amount of the compound that is removed divided by the total amount that could have been removed. Washing efficiency is not directly dependent on the amount of water used but is a function of:

- Temperature
- Speed of fabric in the washing range
- The properties of the fabric
- The properties of the washing range

Temperature

The temperature is important in washing because the temperature influences;

a. The viscosity of water. At a lower viscosity water can better penetrate through the fabric and washing will become more effective.
b. The affinity of compounds. At a higher temperature the affinity decreases and results in a better washing away of the unwanted components.
c. Migration of the components from the inner fibre to the water around the fiber. This migration is important for the total time the washing process will take.

Speed of fabric in the washing range

The speed of fabric in the washing range determines the amount of water that is hanged in the fabric by passing a roller in the washing compartment. That is the liquor that was in the fabric before passing the roller with a high concentration of the unwanted components that is replaced by the washing liquor with a low concentration of the unwanted components.

The properties of the fabric

The properties of fabric influence the washing effectiveness by the amount of water that can be pressed through the fabric during washing. The openness of the fabric as well as the openness of yarn determines the length of the way the unwanted component has to migrate to the fluid that can be exchanged in the washing process. In the washing process generally only very little water from the pores between the fibres is exchanged when the yarns are strongly twisted this will be practically zero. As migration is a very slow process it will take much longer for all the components to be washed out. The same holds more or less for thicker yarns and heavy weight fabrics.

The properties of the washing range

The effectiveness of the washing range is determined by the number of washing tanks, the number of compartments in each tank, the diameter of the roller and the way the fabric is led through the washing range. The washing effectiveness can be improved by placing rollers on top of the top-rollers. This squeeze off the excess water in the fabric and a better exchange of washing liquid will be realized. Also at high speed these top rollers will prevent water to be taken with the fabric to the next compartment.

Water conservation and reuse

Water is expensive to buy, treat, and dispose. If the industry does not have water conservation program, its pouring money downs the drain. Now, water conservation and reuse are rapidly becoming a necessity for textile industry. Water conservation and reuse can have tremendous benefits through decreased costs of purchased water and reduces costs for treatment of wastewaters. Prevention of discharge violations as a result of overload systems can be a significant inducement for water conservation and reuse. By implementing water conservation and reuse programs, the decision to expand the treatment facilities can be placed on hold, and the available funds can then be used for expansion or improvements to process equipment.

The first step in developing a water conservation and reuse program is to conduct a site survey to determine where and how water being used. It would be extremely helpful to develop a spreadsheet and/ or diagram of the water usage with specific details as shown below:

- Location and quantity of water usage.
- Temperature requirements.
- Water quality requirements, i.e. pH, hardness and limitations on solid content, must meet clean water standards, etc.
- Any special process requirements.

Water conservation measures

Water conservation measures lead to:

- Reduction in processing cost.
- Reduction in wastewater treatment cost.
- Reduction in thermal energy consumption.
- Reduction in electrical energy consumption.
- Reduction in pollutants load.

Water conservation significantly reduces effluent volume. A water conservation program can cut water consumption by up to 30 percent or more, and the cost savings can pay for the required materials in a very short time. Since the average plant has a large number of washers, the savings can add up to thousands of rupees per year. Other reasons for large effluent volume is the choice of inefficient washing equipment, excessively long washing circles and use of fresh water at all points of water use.

The equipment used in a water conservation program is relatively inexpensive, consisting in most cases of valves, piping, small pumps, and tanks only. The operating costs for these systems are generally very low. Routine maintenance and, in some cases, electricity for the pumps, would be the major cost components.

The payback period for a water conservation system will vary with the quantity of water saved, sewer fees, and costs for raw water and wastewater treatment. In addition to the direct cost savings, a water conservation program can reduce the capital costs of any required end-of-pipe wastewater treatment system. Personnel from textile industry need to be aware of water conservation potential so they can help their organization realize the benefits.

Water conservation methods for textile mills

Numerous methods have been developed to conserve water at textile mills. Some of the techniques applicable to a wide variety of mills are discussed.

Good Housekeeping

A reduction in water use of 10 to 30 percent can be accomplished by taking strict house keeping measures. A walk through audit can uncover water waste in the form of:

- Hoses left running.

- Broken or missing valves.
- Excessive water use in washing operations.
- Leaks from pipes, valves, and pumps.
- Cooling water or wash boxes left running when machinery is shut down.
- Defective toilets and water coolers.

Good house keeping measures often carried out without significant investments, but leading to substantial cost savings and the saving of water, chemicals and energy. Good house keeping measures are essential for a company, which is critical about its own behaviors. Implementing the following can make significant reductions in water use

- Minimizing leaks and spills.
- Plugging leakages and checks on running taps.
- Installation of water meters or level controllers on major water carrying lines.
- Turn off water when machines are not operating.
- Identifying unnecessary washing of both fabric and equipment.
- Training employees on the importance of water conservation.

Water reuse

Water reuse measures reduce hydraulic loadings to treatment systems by using the same water in more than one process. Water reuse resulting from advanced wastewater treatment (recycle) is not considered an in-plant control, because it does not reduce hydraulic or pollutant loadings on the treatment plant.

Reuse of certain process water elsewhere in mill operations and reuse of uncontaminated cooling water in operations requiring hot water result in significant wastewater discharge reductions. Examples of process water reuse include:

1. Reuse of water jet weaving wastewater

The jet weaving wastewater can be reused within the jet looms. Alternatively, it can be reused in the desizing or scouring process, provided that in-line filters remove fabric impurities and oils.

2. Reuse of bleach bath

Cotton and cotton blend preparation are performed using continuous or batch processes and usually are the largest water consumers in a mill. Continuous processes are much easier to adapt to wastewater recycling/reuse because the waste stream is continuous, shows fairly constant characteristics, and usually is easy to segregate from other waste streams.

Waste stream reuse in a typical bleach unit for polyester/cotton blend and 100 percent cotton fabrics would include recycling j-box and kier drain waste water to saturators, recycling continuous scour wash water to batch scouring, recycling washer water to equipment and facility cleaning, reusing scour rinses for desizing, reusing mercerizes wash water or bleach wash water for scouring.

Preparation chemicals, however, must be selected in such a way that reuse does not create quality problems such as spotting.

Batch scouring and bleaching are less easy to adapt to recycling of waste streams because streams occur intermittently and are not easily segregated. With appropriate holding tanks, however, bleach bath reuse can be practiced in a similar manner to dye bath reuse and several pieces of equipment are now available that has necessary holding tanks.

3. Reuse of final rinse water from dyeing for dye bath make-up

The rinse water from the final rinse in a batch dyeing operation is fairly clean and can be used directly for further rinsing or to make up subsequent dye baths. Several woven fabric and carpet mills use this rinse water for dye bath make-up.

4. Reuse of soaper wastewater

The coloured wastewater from the soaping operation can be reused at the back grey washer, which does not require water of a very high quality. Alternatively, the wastewater can be used for cleaning floors and equipment in the print and color shop.

5. Reuse of dye liquors

The feasibility of dye liquor reuse depends on the dye used and the shade required on the fabric or yarn as well as the type of process involved. It has already been applied whilst disperse dyeing polyester, reactive dyeing cotton, acid dyeing nylon and basic dyeing acrylic, on a wide variety of machines. However, commission dyeing where the shades required are much more varied and unpredictable would make the reuse of dye liquor difficult. But, given the right conditions dye liquor could be reused up to 10 times before the level of impurities limits further use.

6. Reuse of cooling water

Cooling water that does not come in contact with fabric or process chemicals can be collected and reused directly. Examples include condenser-cooling water, water from water-cooled bearings, heat-exchanger water, and water recovered from cooling rolls, yarn dryers, pressure dyeing machines, and air compressors. This water can be pumped to hot water storage tanks for reuse in operations such as dyeing, bleaching, rinsing and cleaning where heated water is required or used as feeding water for a boiler.

7. Reusing wash water

The most popular and successful strategy applied for reusing wash water is counter-current washing.

The counter-current washing method is relatively straightforward and inexpensive. For both water and energy savings, counter-current washing is employed frequently on continuous preparation and dye ranges. Clean water enters at the final wash box and flows counter to the movement of the fabric through the wash boxes. With this method the least contaminated water from the final wash is reused for the next-to-last wash and so on until the water reaches the first wash stage, where it is finally discharged. Direct counter-current washing is now generally built into the process flow sheet of new textile mills. It is also easy to implement in existing mills where there is a synchronous processing operation.

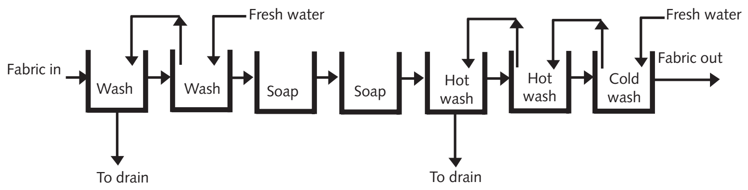

Figure 2 Recommended Counter-Current Flow of Washing on a Soaper Range.

Use of automatic shut-off valves

An automatic shut-off valve set to time, level, or temperature controls the flow of water into a process unit. One plant estimated that a reduction in water use of up to 20 percent could be achieved with thermally controlled shut-off valves.

Use of flow control valves

A flow or pressure-reduction valve can significantly reduce the quantity of water used in a wash or clean-up step. These valves are particularly useful in cleaning areas where operators are not always aware of the need for water conservation.

Flocculation of clean water of pigment printing

A rotary screen printer uses as much water as a continuous washing range. All this water is used to wash the belt, to rinse the pipes and pumps and to clean the screens and squeegees. The water does not come in contact with the fabric. When only pigments are used for printing, it is relatively easy to coagulate the pigments and let them settle. The result is the clean water, which can be used for cleaning purposes.

Use single stage of processing

Knitted fabric process combined bleaching/scouring and dyeing giving considerable saving in water. The scouring and bleaching process takes place for 10-20 minutes and without draining the bath the dyeing is carried out without any loss of depth of colour value. In some cases the finishing process can also be carried out along with the dyeing process.

Use of low material to liquor ratio systems

Different types of dyeing machinery use different amounts of water. Low liquor ratio dyeing machines conserve water as well as chemicals and also achieve higher fixation efficiency but the washing efficiency of some types of low liquor ratio dyeing machines, such as jigs, is inherently poor; therefore, a correlation between liquor ratio and total water use is not always exact. Typical liquor ratios for various types of dyeing machines are given below:

Table-5: Liquor ratio in different dyeing machines

Dyeing machine	Typical liquor ratio liquor/goods at time of dye application
Continuous	1:1
Winch	15:1-40:1
Jet	7:1-15:1
Jig	5:1
Beam	10:1
Package	10:1
Beck	17:1
Stock	12:1
Skein	17:1

Water conservation measures in dyeing equipment

Washing and rinsing are both important for reducing impurity levels in the fabric to pre-determined levels. Water and wastewater treatment prices are increasing, the optimization of water use pays dividends. One possible option is to reduce rinse water use for lighter shades. Here are some successful water reduction projects in batch and continuous operations.

Winch Dyeing: Dropping the dye bath and avoiding overflow rinsing could reduce water consumption reduced by 25%.

High and Low: Replacing the overflow with Pressure jet dyeing batch wise rinsing can cut water consumption by approximately 50%.

Beam Dyeing: About 60% of water preventing overflows during soaking and rinsing may reduce consumption. Automatic controls proved to be quite economical with a payback period of about four months.

Jig Dyeing: A wide range of reductions ranging from 15% to 79% is possible by switching from the practice of overflow to stepwise rinsing. Rinsing using a spray technique is also effective.

Cheese Dyeing: A reduction of around 70% is possible following intermittent rinsing.

Continuous Operation: A 20%-30% saving was realized by introducing automatic water stops. Counter-current washing proved to be the most effective method. Horizontal washing equipment delivered the same performance as two vertical washing machines, using the same amount of water.

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