Efficient Water Utilisation in Textile Wet Processing

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The amount of water used in various textile wet processing mills vary depending on the equipment, process adopted and types of fabric. However, improper operation and lack of maintenance have resulted in excessive water usage in these units. A recent study on water audit in selected textile processing units at Tirupur cluster have confirmed this fact. Water is becoming scarce and also the quality of available water is deteriorating. Hence it is worthwhile to consider various steps in order to reduce the consumption and also the amount of effluents discharged from the plants. In this paper, a review of various water conservation techniques is being presented so that industry can benefit to a considerable extent by adopting these measures.

Keywords : Specific water consumption; Material-liquor ratio; Soft-flow machine; Winch; Water treatment

NOTATION

TDS : total dissolved solids

RFT : right first time

M :L : material to liquor ratio

INTRODUCTION

Water is used extensively throughout the textile processing operations. Almost all dyes, speciality chemicals and finishing chemicals are applied to textile substrates from water baths. In addition, most fabric preparation steps including desizing, scouring, bleaching, mercerizing use aqueous systems. The process flowsheet with water input in the wet processing units is given in the Figure 1. It is estimated that Tirupur produces about 1 21 600 t of fabric and 608 M pieces/year and the total water consumption is 90, 120 kl/day.

SPECIFIC WATER CONSUMPTION

The specific water consumption is calculated using the following formulae.

Specific water consumption

$$= \frac{\text{Amount of water consumed}}{\text{Amount of product produced}}$$

Water is consumed both in process operation like washing and also in boilers for getting steam. The specific water consumption of the various processing units audited is given in Figure 2.

There is a wide variation of specific water consumption in these units in view of the variation of the product being produced, the variation in the machinery used and also due to the variation in the process applied in different stages of processing. However, after accounting for these variations based on the benchmarks, it is observed that all these audited units still consume excessive water. Hence, there is a considerable potential for water conservation. These

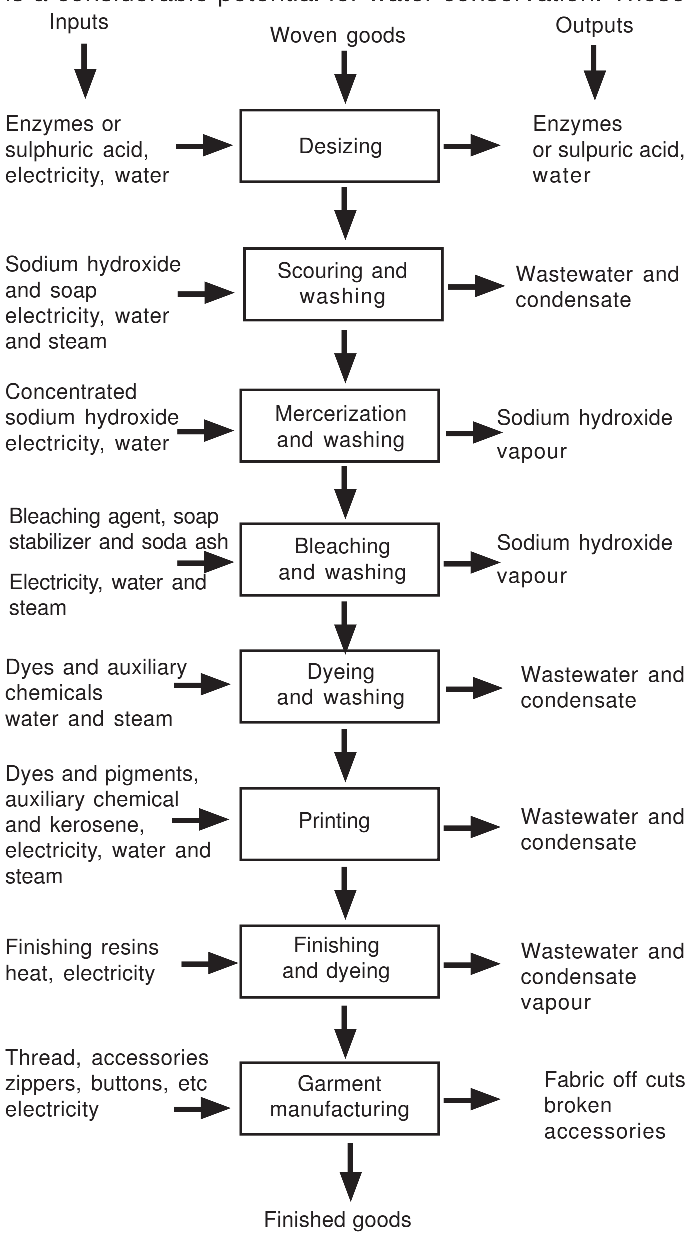

Figure 1 Water flow diagram

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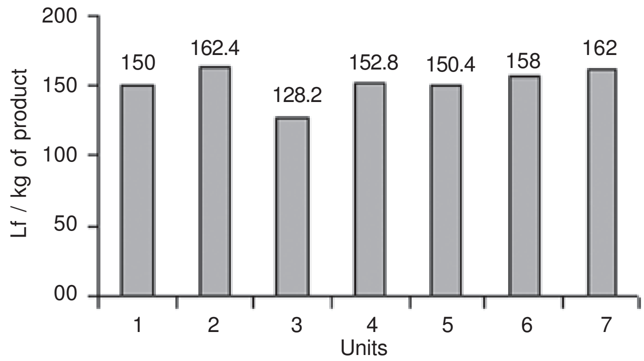

Figure 2 Specific water consumption in the processing units

excess usages occurs due to the following factors.

- Over-usage of water in the winches.
- Due to high temperature, flash steam escapes from the dye liquor.
- Leakage of water in pipelines and equipments, etc.
- Dead storage in the sump and feed water tank and also leakage in these systems.
- Excessive usage of water for cleaning, gardening and labour usage.
- Improper process sequencing.
- Reprocessing operations.

Normally the excessive water usage considering the wastage alone in most of the units works out to be 10% –20% on the average. Since the water is bought from outside, it is necessary to reduce the wastage to the lowest minimum, which will decrease the overall production cost.

WATER BALANCE IN UNITS

Figure 3 provides the average water use balance of the audited units. From the total water balance, it is observed that about 12% to 15% of water is lost due to washing and other leakages.

WATER CONSERVATION MEASURES

A number of measures can be adopted for saving the water consumption, which are listed below.

1. Reduction in wastewater volume.

2. Washing and rinsing improvements.

3. Improvement in the quality of water by proper water treatment.

4. Recovering the condensate from the indirect use of steam and using it as process water. Use of steam in indirect manner helps to recover the pure condensate and this can be used as boiler feedwater. This will reduce the make-up of water required for the plant. The amount of effluent from the process also gets reduced.

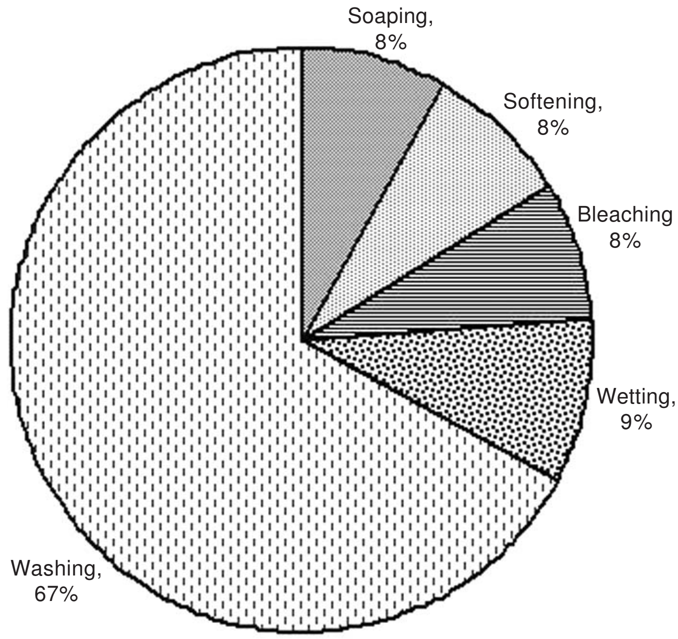

Figure 3 Water use balance

5. Use of efficient machinery and process helps to use low M:L ratio in the process and therefore water requirement will be considerably reduced.

Reduction in Wastewater Volume

Though by reduction in volume of water, the gross pollution load does not get reduced, but the handling of smaller volume of concentrated effluent is quite economical. This can be achieved by following steps.

- Reducing the number of washings in the preceding washing operation
- Recycling less contaminated water in the preceding washing operation
- Using countercurrent washing wherever possible
- Use of standing bath in dyeing
- Use of low material-liquor ratio system

Washing and Rinsing

These are the most common operations in textile processing. Many processes involve washing and rinsing stages and therefore optimization of these processes can conserve significant amounts of water. The washing and rinsing requires about 70% – 75% more water than the other stages like bleaching and dyeing. Several typical washing and rinsing processes include

- drop and fill batch washing
- overflow batch washing
- continuous washing

Based on the system and equipment it is possible to adopt an appropriate process so that water use can be controlled. Moreover, in many type of operations, washwater can be reused for cleaning purposes. In printing, cleanup activities can be performed with used washwater including screen and squeeze cleaning, collar strip, cleanup equipment and facilitates cleaning. A typical preparation department may also reuse washwater as follows:

- Reuse scour rinses for desizing
- Reuse merceriser washwater for scouring
- Reuse bleach washwater for desizing
- Reuse water-jet loom washwater for desizing
- Recycle kier drains to saturator.

Improvement in Quality of Water

The source of water used in some of these industries is borewell and this water contains large amount of TDS. The TDS has gone sometimes upto 5000 ppm. The raw water TDS characteristics is shown in Table 1.

Table 1 shows that water after treatment is also not free from TDS. In fact, in some units it was observed that treated water contain more TDS than feed water indicating that TDS got increased in the system due to addition of chemicals and also due to malfunctioning of the softeners. Most of the units are using softeners which is not sufficient for water treatment due to increased TDS in borewell water. Thus quality of soft water used in operation is not as per the required standard. In some units, it has been mentioned that softeners have not undergone any maintenance like cleaning for considerable period of time and it is likely that resins or chemicals have been fouled. Hence a continuous check on treated water quality is essential to maintain efficient processing (dyeing operation) at a later stage.

It was also observed that hard water with high TDS led to poor performance in processing with inferior quality end product[1]. Hard water does not yield clean dye solution and also affect the performance of various chemicals and auxiliaries employed in processing. In addition to this, acidic and alkaline textile aids would be reacting with water itself with little reaction during processing[2]. Due to this fact, for a number of times the matching and desired quality for the processed goods could not be assured. In fact this can be understood from the percentage of right first time (RFT) of the product. Further reprocessing also uses the quality deficient water leading to further complication. This also leads to more washing and rinsing.

Table 1 Characteristics of raw water TDS

Units	Total Dissolved Solids (TDS), ppm	
	Before water treatment	After water treatment
1	940	780
2	1000	1100
3	1840	640
4	710	840
5	3780	2190
6	340	140

Further analysis has also indicated that treated water provide better quality in the form of better fastness to washing[3]. The cost of treating water is negligible compared to the cost of reprocessing and savings achieved. So efficient water treatment is essential to achieve better water quality, which in turn will improve the dyeing efficiency. The treatment methods have been classified as physical, chemical and biological. Physical treatment includes coagulation, flocculation and adsorption while chemical treatment includes oxidation, catalytic oxidation and reduction and biological treatment includes aerobic and anaerobic processes. Based on the quality of raw water, the treatment method has to be chosen and sometimes it may be necessary to follow a combination of treatments. Some of the common treatment techniques are listed below.

- Lime-soda process
- Ion-exchange process
- Advanced membrane filtration techniques like micro-filtration, ultra filtration, nano-filtration and reverse osmosis.
- Advanced oxidation technologies
- Ultraviolet radiation

The selection and application of these techniques can be based on techno-economics of these processes.

Steam Utilisation

It is observed that in winches, steam is used directly and in soft-flow, steam is used indirectly. In the direct use of steam, pressure of steam is higher than liquid head in the winch and considerable steam escapes. This escape of steam is estimated to be around 85% – 90%. Thus the treated water is wasted to the same extent. The extent of water wastage in a series of winches is considerable. Further, direct injection of steam into winch leads to dilution of the dye liquor and also causes non-uniform temperature in the bath. Thus in the winch, the temperature varies widely from 80 °C – 95 °C and its temperature distribution is given in Figure 4, which indicates a non-uniform temperature distribution.

This wide variation leads to poor and low dyeing efficiency. This leads to a low percentage of RFT in product, which again results in reprocessing of the remaining products.

Similarly in the soft-flow machines, steam is used indirectly in a separate heat exchanger and the condensate from this heat is not recovered properly. Further malfunctioning of the traps leads to leakage of live steam. Thus live steam and condensate escapes into the drain without any recovery. By proper heating arrangement and maintenance of traps, it is possible to recover pure condensate to an extent of 80%. This can be used for boiler feed water or process water. Thus water treatment cost will come down drastically by this recovery.

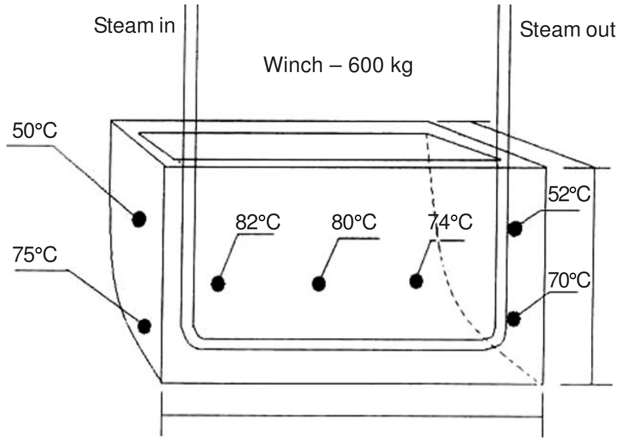

Figure 4 Temperature distribution (spatial) in a winch system

Type of Process or Machine

Different types of processing machinery use different amount of water, particularly in relation to bath ratio in dyeing process. Water consumption of a batch processing machine depends on its bath ratio and also on mechanical factors such as agitation and mixing, bath and fabric turnover rate (called contact), turbulence and other mechanical considerations as well as physical flow characteristics involved in washing operations. All these factors affect washing efficiency. Low bath ratio dyeing equipment conserves water and achieves higher fixation efficiency. Table 2 shows the water consumption by different unit processes.

GOOD HOUSE KEEPING PRACTICES

Working practices can greatly influence utilization of water. Sloppy chemical handling and poor housekeeping can result in excessive cleanup. Poor scheduling and mix planning also may require excessive cleanup that leads to unnecessary cleaning of equipment like machines and mix-tanks. Leaks and spills should be reported and repaired promptly. Equipment maintenance is essential. Inappropriate work practices waste significant amount of water. Good procedures and training are important. When operations are controlled manually, an operations audit checklist is helpful for operator reference, training and retraining.

Table 2 Requirement of water at different stages for 100 kg hosiery fabric processing

Processing stages		Liquor ratio	Water consumption, l
Preparation	Wetting agent (0.5%)	----	----
	Caustic soda (3.0%)	----	----
	Peroxide (3.0%)	----	----
	Water ratio	1:12	1200
Washing	Water ratio	1:12	1200
	Water ratio	1:12	1200
Neutralization	HCl (4.0%)	----	----
	Water ratio	1:12	1200
Washing	Water ratio	1:12	1200
	Water ratio	1:12	1200
	Water ratio	1:12	1200
Dye bath	Reactive dyes (3.0%)	----	----
	Water ratio	1:12	1200
Washing	Water ratio	1:12	1200
	Water ratio	1:12	1200
Neutralization	HCl (7%)	----	----
	Water ratio	1:12	1200
Washing	Water ratio	1:12	1200
	Water ratio	1:12	1200
Soaping	Water ratio	1:12	1200
Washing	Water ratio	1:12	1200
Finishing	Water ratio	1:12	1200
Total requirement of water		=	19 200 l

In one case example, a knitting mill experienced excessive usage of water on winch machines. A study of operating practices revealed that each operator was filling the machines to a different level. Some operators filled the machines to a ¾th of the depth while others filled upto its full depth.

Also the amount of water used for washing varied. Some operators used half-bath, *ie*, repeatedly draining half of dye bath and then refilling it. Without training and without specific training procedure, operators were left to determine water use on their own. Cleaning operation contributes to large amount of water use and as such this needs to be monitored.

Machinery should be inspected and improved wherever possible to facilitate cleaning and use of water can be reduced by using displacers that lower the chemical requirements for pH control as well as lower the use water. Similarly by adopting process changes like pad-batch dyeing techniques, it is possible to reduce water use by more than 90%.

CONCLUSION

Therefore, it is possible to reduce water consumption by careful auditing and identifying the wastages and reasons thereof. By appropriate remedial measures like proper quality and quantity control, proper treatment techniques, proper choice of manufacturing process or machinery, it is possible to save water to an extent of at least 40-50%. Tirupur has a large number of knitwear industry and these units are meeting their water needs both from local sources and also from far off places at a higher cost. At present water treatment for processing is not considered as a major requirement and this trend has to be changed in order to achieve efficient water utilization and also improve the quality of the product.

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REFERENCES

1. H G Prabhu, *et al*. 'Study of TDS in Textile Wet Processing.' *The Textile Industry and Trade Journal*, January – February 2002, p 40.

2. Y V V Satyanarayana. 'Total Water Management in Cotton Textile Industry.' *Textile Magazine*, August 2004, p 49.

3. G S Nadiger, *et al*. 'Role of Water Quality in Chemical Processing of Textiles.' *Asian Textile Journal*, p 69.