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Simple Approach For Cost Effective Reuse Of Water In Pretreatements Of Cotton

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Abstract : The raw material used in greatest quantity in virtually every stage of textile wet processing is water; which is now becoming a scarce commodity worldwide. Rising costs for fresh water, waste water treatment and energy, force the textile industry to research and develop new processes and equipments in order to conserve water and energy. Thus all research efforts in the field of wet processing of textiles are directed towards shortening and simplification of the processing sequence or reusing the water. In this study, an attempt is made to carry out the pre-treatment processes in an ecologically and economically optimal way by simply reusing the baths of each separate pre-treatment process like desizing, scouring and bleaching by standing bath method without further replenishment of water or chemicals but maintaining the Material to liquor ratio (MLR) by adjusting the size of fabric material accordingly. The reuse of the same bath in each process was done until the results obtained were acceptable for further processing.

Keywords: Water; Energy; Wet processing; Pre-treatment process; Standing bath method.

1.Introduction

Water is a vital natural reserve for sustaining life and environment, which is always thought to be available in abundance and free gift of nature[1]. Nowadays water scarcity is becoming a global concern. Due to increase in industrialisation, the water quality and quantity both are now on the verge of getting depleted.

Textile sector is one of the high water consuming industries and disposes a large quantity of effluent in the environment. According to USEPA (United States Environment Protection Agency) a unit producing 20,000 lb / day of fabric consume 36000 litres of water[2]. There is need to implement cost-effective practices for the use of water in textile industries. It has been estimated that 3.5 % of the total cost of running the industry is required for water utilization in textile industry[3].

Textiles are manufactured to perform a variety of functions. They are produced by using a variety of fibres, dyes, chemicals and auxiliaries, resulting in a complex waste or effluent. Textile waste occurs in a variety of forms throughout the production process[4]. The water requirement varies from mill to mill depending on the process sequence they follow. The longer the processing sequences, the higher will be the quantity of water required[5].

The high consumption of water and energy for textile wet-processing sector emphasize the urge for improvement of process i.e. to adopt cost effective practices to reduce the use of scarce resources like water and energy[3,6]. There should be a cut down in the chemical usage wherever possible and recycling of wastewater before releasing it into the environment[7]. The water quality has to be maintained as per the requirements as the quality of water affects the quality of textiles[8].

The effluent from wet processing sector, if discharged without proper treatments, is harmful to the environment. On an average about one million litres of effluent is discharged per day by an average sized textile mill having a daily production of 8000 kg[9]. Thus wastewater recycling can be seen as the solution to meet the growing demand for good quality water if there is increase in the water scarcity and pollution[10].

The aim of this research was to develop a process which would minimise the load on the effluent treatment plant by reusing the water in the wet processing sector. In accordance with this, the work was carried out to reuse each pre-treatment bath i.e. desizing, scouring and bleaching separately by standing bath method without replenishment of chemicals and water but altering the weight of substrate to maintain the required MLR. The fabric properties after each reuse of bath were evaluated.

Thus efforts were made towards reusing the pre-treatment bath to not only reduce the water intake and minimise the intermediate washings but also to minimise the intake of chemicals wherever possible to make existing process, ‘more sustainable’ and ‘environment friendly process.

2. Materials and Methods

2.1 Materials

100 % greige cotton fabric with a plain weave having count of 40 and weight 85 g/m^2 with a size content of 12 % procured from Tata mills, Mumbai.

The chemicals used were, Hydrochloric acid, Wetting agent (Turkey Red Oil), Sodium hydroxide, Sodium carbonate, Hydrogen peroxide, Sodium silicate (peroxide stabiliser), acetic acid supplied by S.D. Fine chemicals of LR grade.

2.2 Experimental methods

2.2.1 Conventional method

Acid Desizing Process

Initially weighed grey cotton woven fabric is treated with 2% HCl and 1% wetting agent at a temperature of 50-60°C for 2 hrs with a material to liquor ratio (MLR) of 1:30 by exhaust bath technique. After this the sample is given cold wash followed by hot wash and neutralized with dilute alkali and dried and again weighed.

Enzyme desizing process

Initially weighed grey cotton woven fabric is treated with 2 % (o.w.f.) amylase enzyme, 1% wetting agent at a temperature of 60°C for 2 hrs with MLR of 1:40. After this the sample is given cold wash followed by hot wash and dried and weighed.

Alkali desizing process

Initially weighed grey cotton woven fabric is treated with 0.24 moles/lit NaOH at a temperature of 100°C for 1 hr at MLR of 1:30. After this the sample is given cold wash followed by hot wash and dried and weighed.

Oxidative desizing process

Initiallly weighed grey cotton woven fabric is treated with 5gpl H_2O_2 ,2-5gpl Sodium silicate at a temperature of 80°C for 1 hr at MLR of 1:30. After this the sample is given cold wash followed by hot wash and dried and weighed and further weight loss is calculated.

Scouring Process

Initially weighed desized cotton woven fabric is treated with 10 gpl NaOH, 5 gpl sodium carbonate, and 2 gpl wetting agent at boil for 2 – 3 hours at MLR of 1:30. After this the sample is given cold wash followed by a hot wash and dried and weighed and weight loss is calculated.

Hydrogen peroxide bleaching process

Initially weighed desized and scoured cotton woven fabric is treated with 5 gpl H_2O_2,2-5 gpl Sodium silicate and 2-5 gpl Na_2CO_3 at a temperature of 80-85°C for 1 hr at a MLR of 1:30. Residual peroxide present on the fabric was removed by using 0.25% o.w.f. peroxide stabiliser at 85 °C for 15 minutes. After this the sample is given cold wash followed by a hot wash and is neutralized by using acetic acid. The fabric is dried and Whiteness Index is measured to ensure complete decolourization of coloured impurities.

2.2.2 Modified methods

In one method, water consumption is reduced by reusing the same bath of the pre-treatment process by using standing bath technique repeatedly without further addition of chemicals or water but maintaining the MLR by adjusting the size of fabric material till a stage comes where the fabric properties were unacceptable for further processing.

In another method, the fabric from the last reused bath of acid desizing was cut into four parts and was taken for scouring process where the bath was reused four times with the four parts of fabric used at each stage. Then the fabric from the fourth scouring bath was cut into four parts and was used for the bleaching bath where this bath was also reused four times.

3. Testing and Analysis

Testing of starch size on the fabric is done by using Tegewa Scale.

Absorbency test is performed using AATCC Test Method 79-2000, details of this method are given in AATCC Technical Manual Vol.75 Edition 2000.

Sinking time test AATCC 17-2005 was modified for being used for fabric instead of yarn and used as indicative test for evaluating absorbency.

The Hunter Whiteness index of the samples is measured using a Datacolor Spectraflash SF300 spectrophotometer.

4. Results and discussion

The Table – 1 shows various methods of desizing and the reuse of separate baths along with the fabric weight loss and Tegewa rating. An effort was made to reuse the baths of acid desizing and enzymatic desizing 4 times whereas the baths of alkaline and oxidative desizing were reused 3 times. It can be seen that as the bath gets reused, the weight loss and Tegewa rating gets reduced. Amongst all methods, acid desizing method gives best results with the initial fabric weight loss of 10.3 %.

Table 1: Reuse of various desizing baths

Sr. No.	Fabric samples	Weight loss (%)	Tegewa rating
	Untreated (grey)	--	2
1.	Acid desizing (Fresh)	10.3	6
	1st reuse of bath	9.3	5
	2nd reuse of bath	8	5
	3rd reuse of bath	6.6	4
	4th reuse of bath	4.8	3
2.	Enzymatic desizing (Fresh)	7.6	5
	1st reuse of bath	7	5
	2nd reuse of bath	6.3	4
	3rd reuse of bath	5.4	4
	4th reuse of bath	3.8	3
3.	Oxidative desizing (Fresh)	6.8	5
	1st reuse of bath	5.4	4
	2nd reuse of bath	4.7	4
	3rd reuse of bath	3.4	3
4.	Alkaline desizing (Fresh)	7	5
	1st reuse of bath	6.4	4
	2nd reuse of bath	5.6	4
	3rd reuse of bath	3.6	3

Table 2: Reuse of bath during alkaline scouring process

Sr.no.	Fabric Samples	Wt. loss (%)	Absorbency (sec.)	Sinking time (sec.)
1	Desized fabric	--	3 – 4 min	>10 min
2	Fresh Treatment Bath	6.8	< 3	3 – 4
3	First reuse of bath	5.7	< 3	3 – 4
4	Second reuse of bath	5	< 3	3 – 4
5	Third reuse of bath	4.4	< 3	3 – 4
6	Fourth reuse of bath	2.2	< 3	3 – 4

Table 3 Reuse of bath during H_2O_2 bleaching process

Sr.no.	Fabric Samples	WI	YI	BI
1	Grey fabric	20.324	31.155	49.825
2	Desized Fabric	37.837	18.857	55.979
3	Scoured fabric	49.345	13.183	62.469
4	Fresh Treatment Bath	71.459	0.209	73.135
5	First reuse of bath	71.508	1.29	73.043
6	Second reuse of bath	70.495	1.803	72.653
7	Third reuse of bath	70.665	1.62	72.617
8	Fourth reuse of bath	70.379	1.251	72.318
9	Fifth reuse of bath	68.068	2.84	71.206
10	Sixth reuse of bath	64.53	4.406	69.486

WI – Whiteness Index
YI – Yellowness index
BI – Brightness index

The Table – 2 elaborates the results of reuse of scouring bath without replenishment of chemicals or water in terms of weight loss and absorbency. The fabric used for scouring process was acid desized by the earlier mentioned recipe. This bath was reused four times. After a certain stage, the oils, fats and waxes accumulate in the scouring bath and there is depletion in the available alkali, reducing the effectiveness of the scouring process. Even after reusing the bath four times the sinking time remained similar as in the first use of scouring bath i.e. 3 – 4 seconds and the absorbency of the fabrics remained less than 3 seconds but the weight loss went on reducing with every reuse of the bath. This shows that there has been efficient removal of waxes and oily matters from the fabric. As such further reuse was not possible as the left over bath was distinctly accumulated with removed impurities and also visual inspection showed that the motes removal is insufficient.

As the bleaching bath gets reused, the whiteness index and the brightness index of the fabric decreases whereas the yellowness index increases as seen from Table – 3. Even after reusing the bath six times, the whiteness index of the fabric was satisfactory i.e. around 65. Thus it can be seen that even after reusing the bath as it is, the colouring matter from the fabric was removed and a satisfactory whiteness index was obtained. As the hydrogen peroxide concentration in general recipe from the literature in alkaline medium is present in excess to the amount of targeted chromophoric groups and susceptible keratin functionality, only 15 – 25 % of the peroxide in the bleach bath is actually consumed during bleaching. Thus the bleaching bath can be reused several times which in addition to saving water and decreasing effluent load, will also give handsome saving on costly chemicals used in the bleaching bath and following peroxide killing treatment [11].

Table 4 Reuse of scouring bath by using fabric from last reused desizing bath

Sr. No	Fabric Samples	Absorbency (sec)
1	Fresh bath	< 3
2	First reuse of the bath	< 3
3	Second reuse of the bath	< 3
4	Third reuse of the bath	< 3

The fabric from the last reused bath of acid desizing (i.e. from the four times reused bath) was cut into four pieces and taken for alkaline scouring where the scouring bath was reused number of times with each fabric part that was cut before was added. Here also no replenishment of water and chemicals was made. Table – 4 shows the absorbency of each fabric after its treatment in the repetitive scouring bath. Even after reusing the bath, the absorbency remained unaltered.

Table 5 Reuse of bleaching bath by using fabric from last reused scouring bath

Sr. No	Fabric Samples	WI	YI	BI
1	Fresh bath	67.98	3.66	71.83
2	First reuse of the bath	65.27	4.56	69.53
3	Second reuse of the bath	66.88	4.53	71.68
4	Third reuse of the bath	66.52	3.79	70.68

The fabric from the last reused bath of scouring (i.e. from the four times reused bath) was again cut into four pieces and taken for peroxide bleaching, where the bleaching bath was reused number of times with each fabric part that was cut before was added. Table – 4 shows the whiteness index, yellowness index and brightness index of each fabric after its treatment in the repetitive bleaching bath.

It can thus be noted that the fabric from even the last reused bath (i.e. four times) of acid desizing can be effectively taken further for scouring and scoured sample of last reused bath can be bleached in last reused bleaching bath without drastically affecting/altering the properties for further processing.

5.Conclusion

Reduction of waste at the source can be the preferred strategy instead of the traditional method of ‘end of pipe waste treatment’. Also traditional technologies to treat textile wastewater which include various combinations of biological, physical, and chemical methods require high capital and operating costs. Thus efforts are to be made to adopt integrated approach to treat and recycle water in the industry.

The results of the simple approach as implemented indicate that the separate pre-treatment baths can be reused for number of times without replenishing the water and chemicals. Also the fabric properties were satisfactory. This will have a significant influence on saving the water and chemicals. Moreover if purification of this scanty leftover bath is done there and there it will have potential to avoid complicated effluent treatment processes as required today.

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