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A frugal way of reusing wastewater in textile pre-treatment process

Rachana Harane, Ravindra Adivarekar*

Department of Fibres and Textile Processing Technology, Institute of Chemical Technology (ICT), Matunga, Mumbai 400019, Maharashtra, India

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ABSTRACT

A grey fabric undergoes pre-treatment processes like desizing, scouring and bleaching before it gets dyed and requires a huge amount of chemicals and water. Scouring and bleaching of fabric is done by using alkali and oxidising agent respectively; and wastewater will contain the unexhausted chemicals from both the processes. Efforts have been made to utilise these unexhausted chemicals to desize a new grey fabric. The study is also extended to check the effect of filtration (90–0.2 μm) for reuse of wastewater on fabric properties such as Tegewa rating, absorbency and whiteness Index. The results show that, there is an improvement in the fabric properties as compared to conventional process after reusing the wastewater; they also exhibit comparable dyeing and fastness properties when further dyed with CBFIX Navy Blue HER and CBFIX Yellow HE6G. The economical impact of the process is about 50% and 19% reduction in intake of fresh water and chemicals respectively; and an overall saving of 40% on the processing cost of the fabric.

1. Introduction

The Indian Textile Industry contributes about 5% to the gross domestic product (GDP), 11% of the country's export earnings and 14% to overall Index of Industrial Production- IIP [1], but it also threatens the environment through water pollution, soil pollution, air pollution, etc. The textile industry requires water at almost every step of processing and it releases a wide variety of dyes and chemicals which generates a high quantity of hazardous wastewater and due to stringent regulations, the cost of water treatment is also increasing. The Indian textile industries are facing the problem of water scarcity which results in increasing fresh water cost. In order to address this issue, it is prudent to reuse wastewater and adopt clean technologies to consume less water and chemicals which result in generation of less waste [2,3].

The literature survey exposed that a lot of work has been done on investigating the effectiveness and feasibility of new advanced technologies that promise good performance in the end of pipe treatment. These technologies include, membrane filtration technology [4,5], adsorption [6–9], coagulation [10,11], biological processes [12–14], enzymatic treatments [15–18], and all advance oxidation processes (Ozone based, UV based, US based, cavitation and Fenton's reagents etc.) All these technologies are focused on removal of unwanted chemicals by physical separation or degradation to CO_2 and water which results in loss of potential chemical associated with it and the energy require to treat it. Now-a-days, one time use of water has become a luxury that can no longer be afforded. Water once used for domestic and industrial purposes still contains a natural resource that can be renovated and reused. It is thus important to understand the potential of waste water along with the chemicals for its reuse and recycle prospects. Few researchers have understood the potential of water and chemicals and they have tried to reuse it by partial or complete treatment without compromising the quality of fabric properties. Table 1 gives a brief description of various such research works carried out keeping in mind the segregation of streams and reuse principle in mind.

In textile processing, scouring is done by alkali followed by bleaching using oxidizing agent whereas desizing is possible by both alkali and oxidizing agent. In any wet processing, there is never complete utilization of the process chemicals onto the fabric, some amount gets back into the wastewater. Thus in the current work, scouring and bleaching wastewaters containing the unexhausted chemicals were segregated and reused as a desizing bath with and without prior treatment and also excluding addition of any extra chemicals. The wastewaters were filtered with varying pore size from 90 μm to 0.2 μm and were reused. The fabric performance properties and dyeing properties of all the samples were compared with standard fabric.

Theoretical comparison of proposed reused method with the conventional method has been done and it shows about 50% reduction in intake of fresh water, 19% reduction in usage of

* Corresponding author.
E-mail addresses: rachana.harane@gmail.com (R. Harane), rv.adivarekar@ictmumbai.edu.in (R. Adivarekar).

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Table 1
Comparison of research works.

Proposed processes	Treatments given	Advantages	Reference
Segregating streams like wool scouring, desizing and dyeing and reusing them	Ultrafiltration, reverse osmosis, ion exchange, evaporation, coagulation, adsorption	Water Saving	[19]
Segregating 20 streams from knit fabric processing, 4 were taken for reuse	Partial ozonation	Water saving	[20]
Segregating streams from cotton finishing processes and finding potential for their reuse	Filtering, airing, pH regulation and ion exchange	Water saving	[21]
6 different types of rinsing wastewaters were segregated for their reuse. The 'before dyeing rinse' of knitted cotton fabric was reused for scouring-bleaching with addition of required chemicals	No treatment	Water saving	[3]
Segregation of scouring and bleaching process streams from woven cotton fabric processing for their possible reuse in desizing without addition of any chemicals	No treatment	Fresh water, chemicals and heat energy savings	This work

chemicals and an overall saving of 40% on the processing cost of the fabric.

2. Methods

2.1. Materials

A 100% grey cotton plain woven fabric having a yarn count of 40 and a weight of 112 g m^{-2} was procured from Tata mills, Mumbai.

Various filter media were used,

Sintered glass filter, Borosil, Mumbai, India (40–90 μm)

Whatman filter paper 4, Qualitative, UK (20–25 μm)

Whatman filter paper 43, UK (16 μm)

Whatman filter paper 1, UK (11 μm)

Whatman filter paper 2, UK (8 μm)

Whatman filter paper 3, UK (6 μm)

Whatman filter paper 42, UK (2.5 μm)

Disposable nylon syringe filter, Axiva Scichem Biotech, Delhi, India (0.45 μm)

Disposable nylon syringe filter, Axiva Scichem Biotech, Delhi, India (0.2 μm)

The chemicals used were wetting agent, sodium hydroxide, sodium carbonate, hydrogen peroxide, sodium silicate, glacial acetic acid, potassium iodide, potassium permanganate, sulphuric acid, phenolphthalein and phenol red indicators are AR grade and supplied by S.D. Fine chemicals, Mumbai, India. Amylase enzyme was procured from Rossari biotech Ltd., Mumbai, India. The ECE detergent was obtained from AATCC. The reactive dyes (Yellow HE6G and Navy Blue HER) were supplied by Colorband India Pvt. Ltd., Mumbai.

2.2. Conventional method

Grey fabric was desized, scoured and bleached in separate baths as per the literature [22–24]. Desizing of cotton fabric was carried out using amylase enzyme 1 g L^{-1} and wetting agent 0.5 g L^{-1} at 50–60 °C for 2 h with a material to liquor ratio (MLR) of 1:20. After desizing, a cold wash was given for 5 min followed by a hot wash at boil for 10 min with a material to liquor ratio 1:50 at each washing steps. The scouring of the desized fabric was carried out in a bath containing 5 g L^{-1} NaOH and 0.5 g L^{-1} wetting agent at boil for 2 h, at a material to liquor ratio of 1:30. After scouring, a cold wash was given for 5 min followed by a hot wash at boil for 10 min with a material to liquor ratio 1:50 at each washing steps. The desized and scoured fabric was eventually bleached at 80–85 °C for 1 h in a bath containing 3 g L^{-1} H_2O_2, 2 g L^{-1} sodium silicate, 0.5 g L^{-1} NaOH and 0.5 g L^{-1} wetting agent at a material to liquor ratio of 1:30. After bleaching, the fabrics undergone a cold wash for 5 min hot wash at boil for 10 min followed by neutralisation for 10 min and a cold rinse for 10 min.

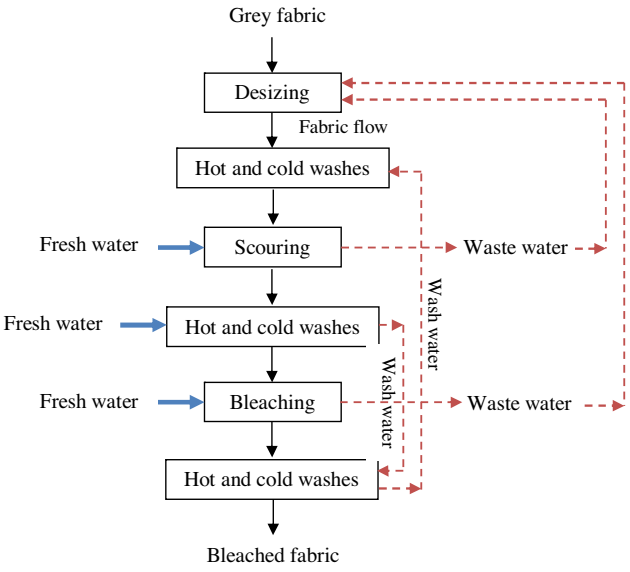

Fig. 1. Reuse of scouring and bleaching wastewater for desizing a grey fabric.

2.3. Novel method of reusing wastewater

In the reuse method (Fig. 1), scouring and bleaching was carried out by using fresh water as per the conventional method. The unexhausted alkali and oxidising agent in the scouring and bleaching wastewater respectively were reused to desize a new grey fabric. Trials were also taken by filtering them through filters of varied pore sizes and then reusing it for desizing. The hypothesis behind filtration is to remove the residual complexes formed during the scouring and bleaching processes and further improving the desizing quality of grey fabric. The grey fabric was subjected to desizing in scouring, bleaching and combined scouring- bleaching wastewater for 1 h at 80–85 °C with MLR of 1:30. The cold wash and hot wash bath after scouring were reused to wash fabric after bleaching and desizing.

The flow chart displays the fabric flow, fresh water flow and the novel reuse method where the wastewater from scouring and bleaching processes is reused in desizing.

2.4. Testing and analysis

2.4.1. Testing of fabrics

2.4.1.1. Testing of desized fabric. Desizing efficiency is checked by iodine drop test (Tegewa test). Starch gives violet colouration with iodine; this principle can be used to check the amount of starch remaining after desizing. A small sample of desized fabric was cut and immersed in a beaker containing potassium iodide and iodine solution for 1 min. The sample was then rinsed thoroughly with