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RESEARCH ARTICLE

Eco-Friendly Knit Garments Washing Implementation and Its Impact

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ABSTRACT

Environment pollution is one of the major threats to today's world and researchers say most of the pollution comes from the washing industry. So, the study aims to find out an alternative way to the existing chemical wash process of the washing industry to save the environment. To conduct this study, one knit washing factory has been selected that has eco-friendly wash facilities. The eco-friendly wash process samples have been developed and finally show the comparison in respect of time, per day production and test result to the conventional chemical wash processes along with the impact of production cost on the garment. For all eco-friendly process, it has been found that water consumptions are too less in comparison with conventional process potentials which is partially related to Sustainable Development Goals 13 (Climate Action). This study might help to find out a new era of doing washed knitted product business without polluting the environment.

Keywords: Eco-friendly; Water consumption; Production time; Production cost

1. Introduction

The quality and various chemical and mechanical treatments on ready-made garments offer different fashionable visual effects on their surfaces. One of the latest fashion trends is the worn look or fad look for casual wear which has become very popular among the young generation. In most cases, this worn look is applied to garments made of denim fabric but now it's also applied to knit garments in a

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wider range [1].

The eco-friendly wash process represents sustainable textiles processing methods that create not only eco-friendly finished products but also do not hinder the surpass ambiance and the environment by polluting the air and water with emissions of harmful gases and discharge of wastewater.

Now the whole world is fully aware of environmental pollution by the emission of gases and effluent discharges from polluting industries such as textile industries [2]. To reduce and save the earth from the pollution of industries, there comes into existence of stipulated norms and standards for the finished goods and the way of operation [3]. All over the world, almost all countries have created certain rules and regulations for importing and exporting processed textile products. This study shows the adverse impact of various textile finishing processes on the environment and implements new innovative concepts of sustainable knit garments washing process to create a pollution-free environment. Nowadays different brand buyers are also demanding a product with eco-friendly manufacturing processes as customers are also more conscious of environmental pollution [4]. Mainly different washes like garment dye with acid washes, sandblasting, oil wash, stone wash, tie-dye, dip dye, etc. be done on denim products but nowadays customers are demanding to have these wash effects on knit products like t-shirts, joggers, sweat-shirt, shorts, etc. For this reason, knit composite factories are increasing their washing unit strength focusing on the customer's demand but they are not adopting an eco-friendly washing process at the same time. As a result, huge environmental pollution has occurred from these hazardous washing chemicals. The study should focus on this eco-friendly washing process to make a pollution-free healthy environment for the next generation.

Research objectives

(i) To implement alternate eco-friendly wash processes to get a pollution-free environment which is the demand of today's world.

(ii) To know the impacts of eco-friendly washing process on production cost, production time, per day production, water consumption, and test-related issues.

2. Literature review

Garment washing is a technology that is applied to bring a fad look, comfort and designs to garments and is usually done on solid-dyed garments. Ali A. et al. focused on eco-friendly garments washing and showed how an eco-friendly wash process can be applied to achieve the fading effect on denim garments dyed with natural indigo dye [1]. Xie, K. et al. focused on the dyeing properties of cellulose fabrics using micelle dyeing with a low liquor ratio discussed by color yields (K/S), color differences (ΔE), exhaustion (E), fixation (F) and reactivity (R) of three reactive dyes [5]. Mamun Kabir, S. M. et al. discussed low liquor ratio dyeing afforded superior dyeing compared to traditional dyeing, attributed to the anti-agglomeration effects of the former, which also had no negative influence on the fastness of the dye [6]. Cheung, H. F. et al. showed how cotton fabric can be dyed at a low liquor ratio (material to liquor ratio = 1:5) [7]. Matthews, J. has focused on the development of determining optimum parameters for laser processing materials [8]. Sarker et al. have focused on the change of physical properties due to the application of different dry washing processes for imparting the desired effect on denim garments [9]. After analyzing different journals, it can be reiterated that different experiments have been done to find out an alternate eco-friendly way of garment fading technology by applying laser and ozone wash but it was done on denim products not on knit products. Similarly, the garment-destroying effect is also achieved on denim products by using a laser ray. The concept of developing another trendy wash effect like dip dye and tie dye effects on knit products with laser wash and ozone wash respectively is quite new and no previous research was done in this area. Although several studies have been done on garment dyeing at a low material-to-liquor ratio of up to 1:5 the concept of garment dyeing with a 1:2 liquor ratio is extremely new and this study will show the outcome.

Kit batik dyeing process: It's a sustainable garment-dyeing process that is done on a special machine. It's the replacement of the normal garment-dyeing process but it's a sustainable process as here garments are dyed at a very low liquor ratio that is 1:2. So ultimately for the whole process water consumption is very less.

Ozone wash: It is modern technology and is used to change color after washing. Normal washing requires water, chemicals, time and mechanical action to wash but ozone wash changes all those objects in wet washing and saves power and resources. It uses oxygen gas and makes ozone gas for the process. Bleaching of denim garments is done in a washing machine with ozone dissolved in water.

Laser dip dye process: The dip dye effect is very popular and trendy nowadays. This dip dye effect can be developed by an eco-friendly laser machine. The process includes firstly spray washes on the scoured garment without water (pigment mix with special binder) then line dry by hanging the garments on the hangers for around 30 minutes and placing one piece of garment into the laser machine, lastly putting the design into the computer and complete laser wash [10].

3. Methodology

A knit garment factory named GMS Composite Knitting Industry Ltd. in Bangladesh has been selected which has eco-friendly wash facilities and then closely works with the factory concerned persons to identify hazardous chemicals that are being used in the chemical wash process. Samples have been developed by using three eco-friendly wash processes named laser wash, ozone wash and kit batik process. The garment dip dye effect has been developed by using laser wash. Garment dyeing is the most common trend which is done in washing units where a huge amount of water is used normally material liquor ratio is 1:10 but applying an eco-friendly wash process named kit batik process can reduce a huge amount of water as the material liquor ratio used in this process is only 1:2. In this study a comparison of different garment wash effects developed by both conventional chemical wash and eco-friendly wash process has been shown.

For sample development, a fixed fabric composition has been selected that is 100% cotton single jersey with 150 GSM and 100% cotton terry fabric with 230 GSM.

Data are collected like production time, temperature, per day production and water consumption for both conventional chemical wash process and eco-friendly wash process and showed a comparison. Besides this, a comparative analysis of production costs for the chemical wash process and eco-friendly wash process also has been given and finally shows the cost impact on the garment for both conventional chemical and eco-friendly wash processes.

4. Results and discussion

4.1 Garment dyeing and kit batik process

In the current garment-dyeing process, a 1:10 (material: liquor) ratio is used and in the kit batik process, a 1:2 (material: liquor) ratio is used to prepare dyed products for comparison.

In **Table 1**, it has been found that less time is required for the kit batik garment-dyeing process compared to the conventional garment-dyeing process and per day production is higher in the kit batik process compared to the conventional garment-dyeing process.

Table 1. Comparison of production time and production per day (conventional garment-dyeing process and kit batik process).

Type	Conventional garment dye	kit batik process
Total time	Around 480 minutes	Around 110 minutes
Production	1800 pieces/day/machine Assuming loading per batch per machine is 600 pieces. Per day total batch is 3.	2080 pieces/day/ machine Assuming loading per batch per machine is 160 pieces. Per day total batch is 13.

In **Table 2**, it has been found that less water is consumed for the kit batik garment-dyeing process compared to the conventional garment-dyeing process.

In **Table 3**, it has been found that in two process-

es, the sample has passed all test parameters. **Table 4** shows the production (wash) cost of conventional garment dyeing. **Table 5** shows the production (wash) cost of the kit batik process.

Table 2. Total water consumption (conventional garment-dyeing process and kit batik process).

Type	Conventional garment-dyeing process	Kit batik process
Total water consumption	2.5 liter/piece	0.5 liter/ piece

Table 3. Test result comparison (conventional garment-dyeing process and kit batik process).

Type	Conventional garment dyeing	Kit batik process
After 5 time wash appearance	pass	pass
Color fastness to water	pass	pass
Colorfastness to dry rub	pass	pass
Color fastness to wet rub	pass	pass
Colorfastness to saliva	pass	pass
Colorfastness to perspiration	pass	pass
Colorfastness to light	pass	pass

Production (wash) cost comparison for the conventional garment-dyeing process and kit batik process is shown in the following figure.

In **Figure 1**, it has been found that the production cost is too less for the kit batik garment-dyeing process compare to the conventional garment-dyeing process.

4.2 Ozone wash

The faded or worn-out look on the garment is done by different chemical wash processes like acid wash or snow wash or bleach wash. This worn-out or faded effect can be brought by eco-friendly wash processes like ozone wash. The ozone fading effect is not the same as an acid wash as it is well known that every wash effect is unique and it's non-comparable but the main purpose is achieved which is to bring a faded or worn-out look. Acid wash and ozone wash samples are prepared for comparison.

In **Table 6**, it has been found that less time is required for the acid wash process compared to the ozone wash dyeing process and per day production is higher in the acid wash process compared to the ozone wash process.

In **Table 7**, it has been found that less water is consumed for the ozone wash process compared to the acid wash process.

In **Table 8**, it has been found that in two processes, the sample has passed in all test parameters except in acid wash, color fastness to wet rubbing and color fastness to light. **Table 9** shows the production cost of acid wash. **Table 10** shows the production cost of ozone wash.

Table 4. Production (wash) cost of conventional garment-dyeing.

Chemical name	Chemical price/kg	Chemical consumption for 1 piece garment	Chemical cost for 1 piece garment
Reactive dyes (red)	$10	15 gm	$0.15
Detergent	$2.50	9 gm	$0.02
Acetic acid	$0.40	2.7 gm	$0.00
OSR (chemical)	$1.80	18 gm	$0.03
Glauber salt	$0.22	700 gm	$0.15
Soda ash	$0.27	175 gm	$0.05
Leveling agent	$1.44	9 gm	$0.01
Anti-creasing agent	$1.10	9 gm	$0.01
Softener	$1.60	18 gm	$0.03
Silicon	$3	9 gm	$0.03
			Total cost = $0.48

Table 5. Production (wash) cost of the kit batik process.

Chemical name	Chemical price/kg	Chemical consumption for 1 piece garment	Chemical cost for 1 piece garment
Reactive dyes (red)	$10	12.500 gm	$0.125
Detergent	$2.50	8.750 gm	$0.02
Acetic acid	$0.40	2.650 gm	$0.00
OSR	$1.80	17.500 gm	$0.03
Glauber salt	$0.22	20 gm	$0.00
Soda ash	$0.27	5 gm	$0.00
Caustic soda	$0.37	0.250 gm	$0.00
Soaping agent	$1.30	17.500 gm	$0.02
Softener	$1.60	17.500 gm	$0.03
Silicon	$3	8.750 gm	$0.03
			Total cost = $0.26

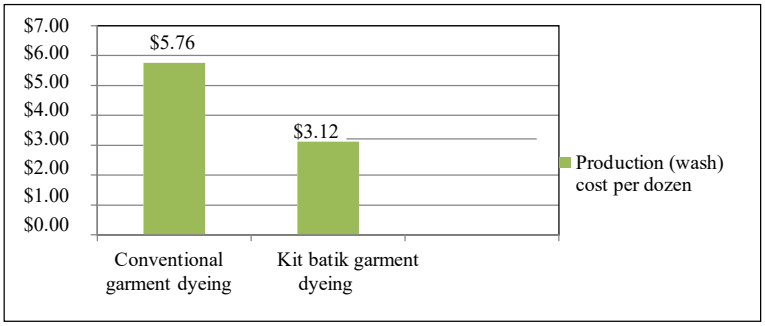

Figure 1. Production cost comparison (conventional garment-dyeing process and kit batik process).

Table 6. Comparison of total time and production (acid wash and ozone wash).

Type	Acid wash	Ozone wash
Total time in minute	120	150
Production (per day per machine)	1200 piece (assuming loading 100 pieces/batch/machine)	270 pieces (assuming loading 30 pieces/batch/machine)

Table 7. Total water consumption (acid wash and ozone wash).

Type	Acid wash	Ozone wash
Total water consumption	7.5 liter/piece	5.5 liter/piece

Table 8. Test result comparison (acid wash and ozone wash).

Type	Acid wash	Ozone wash
After 5 time wash appearance	4	4
Colorfastness to water	4	4
Colorfastness to dry rub	4	4
Colorfastness to wet rub	For dark colors comes 2 instead of requirement 3	3
Colorfastness to saliva	4	4
Colorfastness to perspiration	4	4
Color fastness to light	For light color comes 2-3 instead of 4	4

Table 9. Production cost of acid wash.

Acid wash (garment dye + acid wash)					
Chemical name	**Chemical price/kg**		**Chemical consumption for 1 piece garment**		**Chemical cost for 1 piece garment**
Garment dye					
Dischargeable reactive dyes (Navy)	$37		15 gm		$0.56
Detergent	$2.50		9 gm		$0.02
Acetic acid	$0.40		2.7 gm		$0.00
OSR	$1.80		18 gm		$0.03
Glaubar salt	$0.22		700 gm		$0.15
Soda ash	$0.27		175 gm		$0.05
Leveling agent	$1.44		9 gm		$0.01
Anti-creasing agent	$1.10		9 gm		$0.01
Softener	$1.60		18 gm		$0.03
Silicon	$3		9 gm		$0.03
Acid wash					
Chemical name	**Chemical price/kg**		**Chemical consumption for 1 piece garment**		**Chemical cost for 1 piece garment**
$KMNO_4$	$22.25	0.550 gm	$0.01	0.550 gm	$0.01
H_3PO_4	$17.50	0.550 gm	$0.01	0.550 gm	$0.01
Reducing agent	$4	13.5 gm	$0.05	13.5 gm	$0.05
Softener	$1.60	13.5 gm	$0.02	13.5 gm	$0.02
Silicon	$3	6.75 gm	$0.02	6.75 gm	$0.02
					Total cost = $1.0

Table 10. Production cost of ozone wash.

Ozone wash (garment dye + ozone wash)			
Chemical name	**Chemical price/kg**	**Chemical consumption for 01-piece garment**	**Chemical cost for 01-piece garment**
Garment dye			
Dischargeable reactive dyes (navy)	$37	15 gm	$0.56
Detergent	$2.50	9 gm	$0.02
Acetic acid	$0.40	2.7 gm	$0.00
OSR	$1.80	18 gm	$0.03
Glauber salt	$0.22	700 gm	$0.15
Soda ash	$0.27	175 gm	$0.05
Leveling agent	$1.44	9 gm	$0.01
Anti-creasing agent	$1.10	9 gm	$0.01
Softener	$1.60	18 gm	$0.03
Silicon	$3	9 gm	$0.03
Ozone wash			
Reducing agent	$4	17 gm	$0.07
Detergent	$2.50	8.5 gm	$0.02
Acetic acid	$0.40	2.5 gm	$0.00
OSR	$1.80	17 gm	$0.03
Softener	$1.60	17 gm	$0.03
Silicon	$3	8.5 gm	$0.03
			Total cost = $1.07

Production cost comparison for the acid wash process and ozone wash process is shown in the following figure.

In **Figure 2**, it has been found that the production cost is too less for the acid wash process compare to the ozone wash process.

4.3 Laser wash

Using laser dip dye allows for this dip dye effect to be achieved without polluting the environment as well a huge amount of water can be saved. The effect developed by laser dip dye is unique and has a different look than chemical dip dye which could be a new version of the usual dip dye effect and could be a new market promotion. The garment dip dye effect has been developed by using chemical and laser wash respectively for comparison.

In **Table 11**, it has been found that laser dip dye consumes more time than chemical dip dye as only one-piece garment can be placed in the machine at a time. Production of laser dip dye is less than chemical dip dye.

In **Table 12**, it has been found that less water is consumed for laser dip dye compared to chemical dip dye.

In **Table 13**, it has been found that in two processes, the sample has passed all test parameters except in chemical dip dye and color fastness to light. **Table 14** shows the production cost of chemical dip dye. **Table 15** shows the production cost of laser dip dye.

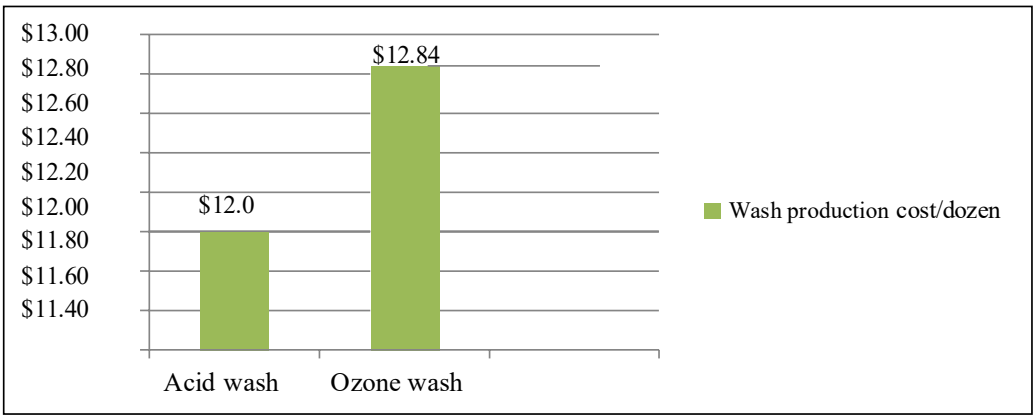

Figure 2. Production cost comparison (acid wash and ozone wash).

Table 11. Comparison of time and production (chemical dip dye and laser dip dye).

Type	Chemical dip dye	Laser dip dye
Total time	Around 110 minutes (for 1 batch = 220 pieces)	Around 4 minutes for one piece of garment
Production	Per day total of 6 batches, so production per day per machine is 1320 pieces.	360 pieces (per day per machine)

Table 12. Total water consumption (chemical dip dye and laser dip dye).

Type	Chemical dip dye	Laser dip dye
Total water consumption	13.64 liter/piece	5 liter/piece

Table 13. Test result comparison (chemical dip dye and laser dip dye).

Type	Chemical dip dye	Laser dip dye
After 5 time wash appearance	4	3-4
Colorfastness to water	4	4
Colorfastness to dry rub	4	4
Colorfastness to wet rub	3	3
Colorfastness to saliva	4	4
Colorfastness to perspiration	4	4
Colorfastness to light	For light color results 2-3 instead of 4	4

Table 14. Production cost of chemical dip dye.

Chemical dip dye			
Chemical name	**Chemical price/kg**	**Chemical consumption for 1 piece garments**	**Chemical cost for 1 piece garment**
Reactive dyes (navy)	$9	33.330 gm	$0.30
Detergent	$2.50	10 gm	$0.03
Acetic acid	$0.40	3 gm	$0.00
OSR (chemical)	$1.80	20 gm	$0.04
Softener	$1.60	20 gm	$0.03
Silicon	$3	10 gm	$0.03
Leveling agent	$1.44	16.670 gm	$0.02
Glauber salt	$0.22	1000 gm	$0.22
Soda ash	$0.27	250 gm	$0.07
Soaping agent	$1.30	10 gm	$0.01
Fixing agent	$4.20	10 gm	$0.04
			Total cost = $0.79

Table 15. Production cost of laser dip dye.

Laser dip dye			
Chemical name	**Chemical price/kg**	**Chemical consumption for 1 piece garments**	**Chemical cost for 1 piece garment**
Pigment (navy)	$22	7.5 gm	$0.165
Binder	$8.27	17.5 gm	$0.144725
Soaping agent	$1.30	10 gm	$0.01
Softener	$1.60	10 gm	$0.02
Silicon	$3	5 gm	$0.02
			Total cost = $0.36

Production cost comparison for chemical dip dye and laser dip dye is shown in the following figure.

In **Figure 3**, it has been found that the production cost is too less for laser dip dye compare to chemical dip dye. The summary of findings of all processes is given in **Tables 16-18**.

In the above discussion, it has been found that the kit batik process, ozone wash process and laser dip dye process consumed less water than conventional garment dyeing, acid wash, and chemical dip dyeing process which is partially related to Sustainable Development Goals 13 (climate action).

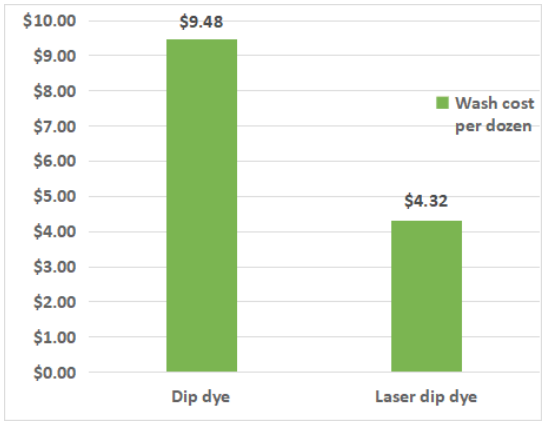

Figure 3. Production cost comparison (chemical dip dye and laser dip dye).

Table 16. Findings (kit batik process and conventional garment-dyeing process).

Findings (kit batik process and conventional garment-dyeing process)	
Sample shade	The sample shade developed by the kit batik garment-dyeing process is good compared to conventional garment-dyeing shade.
Liquor ratio	In conventional garment dyeing, liquor ratio is 1:10 whereas in the kit batik process, it is 1:2 liquor ratio.
Total time in minute	Less time is required for the kit batik garment-dyeing process compared to the conventional garment-dyeing process.
Production (per day per machine)	Production is higher in the kit batik process compared to the conventional garment-dyeing process.
Water consumption	A huge amount of water can be saved by implementing the kit batik process. If the conventional garment dyeing process is used it can produce 1800 pieces garments by using 4500-liter water per day whereas in the kit batik process it can produce 2080 pieces garments per day by using only 1040 liter water.
Test result	In the kit batik process, the sample is passed in all test parameters.
The production cost impact on garment free on board(FOB) price	From the experiment, it has been seen that for kit batik process cost impact on garment FOB price is 22 cents less than conventional garment dyeing. But practically the kit batik dye process price is more than the conventional garment dye process due to kit batik machine depreciation cost, maintenance cost, and labor cost.

Table 17. Findings (ozone wash and acid wash).

Findings (ozone wash and acid wash)	
Total time in minute	Ozone wash needs more time to complete the whole process than acid wash.
Production (per day per machine)	Production per day of ozone wash is less than acid wash.
Water consumption	In the ozone wash process, no water is needed, the fading effect is done by an ozone ray.
Test result	Ozone wash has no test issues whereas the acid wash sample test fails on color fastness, wet rub for dark color and color fastness to light for light color.
Production cost impact on garment FOB price	The price upcharge for applying an eco-friendly ozone wash process is 7 cents per piece. But practically this upcharge is more due to ozone machine depreciation cost, maintenance cost, and labor cost.
Usage of chemical	No chemical is used in the ozone wash process. So it doesn't have any adverse impact on human health as well as on the environment like the acid wash process.

Table 18. Findings (laser dip dye and chemical dip dye).

Findings (laser dip dye and chemical dip dye)	
Total time in minute	Laser dip dye consumes more time than chemical dip dye as only one piece garment can be placed in the machine at a time.
Production (per day per machine)	The productivity of laser dip dye is less than chemical dip dye.
Water consumption	A huge amount of water is needed for the chemical dip dye process. By implementing laser dip dye, huge amount of water per dozen is saved which is 103.63 liters.
Test result	Laser dip dye samples pass all test parameters whereas chemical dip dye sample test fails on color fastness to wet rub for dark color and color fastness to light for light color.
The production cost impact on garment FOB price	From the experiment it has been seen for laser dip dye cost impact on garment FOB price is 43 cents less than chemical dip dye. But practically laser dip dye price is more than chemical dip dye due to laser machine depreciation cost, maintenance cost, and labor cost.
Usage of chemical	No chemical is used in the laser dip dye process. So it doesn't have any adverse impact on human health as well as on the environment like the chemical dip dye process.

5. Conclusions

The implementation of eco-friendly technologies in the conventional knit washing lines ensures the vintage looks and other fashion effects on knit products with less water and without the usage of harmful chemicals. In these cases, the effluent output is reduced to a negligible amount that needs to be treated by the effluent treatment plant (EPT). It has been seen in the experiment part, the eco-friendly kit batik process is used in the replacement of the conventional garment-dyeing process, the ozone wash process is used in the replacement of the acid wash process and the laser dip dyeing process is used in the replacement of chemical dip dyeing process. For all eco-friendly process, it has been found that water consumptions are too less in comparison with conventional process which is partially related to Sustainable Development Goals 13 (climate action). In the kit batik dyeing process, production time and production cost are less than conventional process and in the laser wash process, the production costs are less but production time is higher than the conventional process. In the ozone wash process production cost and production time are higher than the conventional process. In this study, the garment's original test report can't be attached due to some confidential issues the factory can't provide the original test result sheet. The wash effect is nicely visible on full garments but due to some factory restrictions samples can't be carried out of its premises without any valid business purpose. For this reason, all the wash effect is developed on fabric panels instead of garments. In this study, it has been shown how garment faded look, dip dye effect, and garment-dyed effect is achieved in an eco-friendly process but in the chemical wash process there are many other wash effects like cold pigment dye, spray wash, and oil wash. So further comprehensive research is needed to find out an alternate eco-friendly way of doing these wash effects to make the surrounding environment pollution free.

Conflict of Interest

There is no conflict of interest.

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Appendix

1. Kit batik dyeing

Solution making:

For sample

Liquor ratio = 1:2

Total solution = 3.5 Liter Garment weights 3 kg

0.64% dyes of total solution = 22.4 gram 80 g/L glaubar salt = 280 gram

20 g/L soda ash = 70 gram 1 g/L caustic soda = 3.5 gram

For bulk

Liquor ratio = 1:2

Total solution = 80 Liter Garment weights 40 kg

0.64% dyes of total solution =

512 gm 80 g/L glaubar salt = 6400 gm

20 g/L soda ash = 1600 gm 1 g/L caustic soda = 80 gm

Process flow charts of kit batik dyeing

Load garments into the machine

⇩

Spray the solution from the nozzle to the garments

⇩

Drying

⇩

Soaping (material: liquor = 1:20)

⇩

PH control

⇩

Drying: Tumble dry (90 °C × 45 min)

2. Process flow chart of acid wash process

Garment dye with dischargeable reactive dye
Material: liquor = 1:10

⇩

Making solution
$KMNO_4$ = 5-10 g/L
H_3PO_4 = 5-10 g/L

⇩

Spraying solution onto the thermocal ball or foam or stone or sand

⇩

Mixing 5-10 minute

⇩

Put garments in the machine

⇩

Machine running

⇩

Neutralization (material: liquor = 1:20)
Reducing agent (sodium metabisulphite) = 2 g/L)

⇩

PH Control (5-5.5)

⇩

Softening (1-2 g/L), silicon (1-2 g/L) at 40 °C for 5-10 minutes

⇩

Drying: Tumble dry (90 °C × 45 min)

3. Process flow chart of ozone wash (fading)

Garment dye with dischargeable reactive dye Material: liquor = 1:2 (Kit Batik process)

⇩

Hydro extraction after garment dye (remaining 20% existing water)

⇩

Ozone washes at room temperature, time duration is 27 to 77 min depending on the wash effect

⇩

Neutralization (material: liquor = 1:20)
Reducing agent (sodium metabisulphite) = 2 g/L

⇩

PH Control

⇩

Softening (1-2 g/L), silicon (1-2 g/L) at 40 °C for 5-10 minutes

⇩

Drying: Tumble dry (90 °C × 45 minutes)

4. Process flowchart of chemical dip dye process

Hot wash (liquor ratio: M: L = 1:20)
(detergent 1 g/L + acetic acid 0.3 g/L + OSR 1 g/L at 80 °C for 40 minutes)

⇩

Hanging garments on the machine rail

⇩

Dyeing with reactive dye Liquor ratio = 1:10

⇩

Soaping M: L = 1:20

⇩

PH control (5-5.5)

⇩

Softening (1-2 g/L), silicon (1-2 g/L) at 40 °C for 5-10 minutes

⇩

Drying: Tumble dry (90 °C × 45 minutes)

5. Process flow chart of laser dip dye process

Spray washes on the scoured garment without water (pigment mix with special binder)

⇩

Line dry by hanging the garments on the hangers for around 30 minutes

⇩

Placing one piece of garment into the laser machine

⇩

Putting design into the computer

⇩

Laser wash (machine start and a laser ray is given over the placed garment)

⇩

Soaping (liquor ratio=1:20)

⇩

PH control

⇩

Drying: Tumble dry (90 °C × 45 minutes)