Research Article

Investigation of One Bath Dyeing Processes of PES/CO Mixed Towel Products and Investigation of Test Results

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Abstract

In recent years, restrictions on water use have increased due to the increase in population, global warming, rapid pollution and depletion of water resources. All over the world, not only warnings but also laws are issued and more environmentally friendly and sustainable production processes are developed. Our company is one of the well-established bathrobe and towel manufacturers and exporters in Denizli. As a result of the environmental policies adopted in 2014, environmentally friendly and harmonious production processes are implemented.

The method normally used for dyeing PES/CO mixed towel products; first dyeing of the polyester part under HT conditions, reductive washing followed by dyeing of the cotton part with reactive dyestuff. Although disperse dyes require acidic environment and HT conditions, dyeing processes must be done in two separate baths because reactive dyestuffs are fixed in alkaline environment. It is stated in the literature that one-bath, one-step dyeing is possible by using disperse dyestuffs resistant to alkaline environment or by using reactive dyestuffs that can be fixed in acidic-neutral environment. In the light of the information

obtained, one-bath dyeing of PES/CO mixed towel fabrics, which will be a new process for our processing, has been carried out. With the study, the time, chemical, energy and water values consumed in this new process were examined and studies were carried out for the most ideal use. Since the study is a sustainable dyeing process, all dyeing steps have been reviewed. The most important criterion is the improvement of the water and energy consumption steps spent in the whole process for dyeing in the one-bath dyeing step. With this improvement, there is no difference in color and fastness between the old system and the new system. Research and experimental studies on this subject are also summarized in this paper.
With this new process study, our company's water, energy and chemical savings, the company's impact on the environment and the waste water load have been reduced. In this way, our company's carbon footprint has been reduced and a more sustainable production process has been implemented. In the test results, there was no problem in washing, color and rubbing fastness efficiency. It is thought that the publications to be made with the results obtained can give ideas to the dyehouse businesses in Denizli and other provinces and develop new R&D ideas for improvements.

Keywords: *PES/CO, Blended yarn dyeing, Water consumption, Environmental impact, Sustainable production.*

1. Introduction

Polyester is a synthetic fiber obtained from polyethylene terephthalate, a derivative of the petroleum industry, by soft spinning. Cotton is a vegetable fiber. When polyester/cotton blends are mixed in certain ratios such as 67/33, 65/35 or 50/50, blends with various superior properties are obtained with the contribution of the advantageous aspects of both fibers. Polyester is the most produced synthetic fiber among synthetic fibers in our country and in the world. Polyester fibers, like other synthetic fiber types, are produced from polymers obtained by synthesis. The polymer substances that make up the structure of synthetic fibers are not found in nature, but are obtained from the fractional distillation of petroleum or coal. The appropriate polymer materials obtained are turned into synthetic fibers by spinning methods (5).
Polyester fibers are difficult to dye. In general, these difficulties arise from the following factors (1, 3):

• Since polyester fibers have high fiber crystallization, crystalline regions are high and amorphous regions that allow dyestuff diffusion are less,

• Absence of hydrophilic groups in their structures due to their high hydrophobic character,

• Due to its high hydrophobicity, it has a very low moisture absorption rate of 0.4%,

• The absence of functional groups that can form chemical bonds with the dyestuff in the structure of polyester fibers,

• Large molecule dyestuffs cannot easily penetrate polyester fibers due to their tight crystalline structure.

Fibers are not suitable for dyeing with hydrophilic dyes due to their hydrophobic character, and with dyes attached to the fibers by electrostatic attraction forces or covalent bonds due to the absence of functional groups. It is used in dyeing polyester because it does not contain a disperse dyestuff-chemically active group that can form chemical bonds with the fibers due to its hydrophobic feature (2, 4, 5).

Disperse dyestuff is a water-insoluble dyestuff. With the addition of water at the required rate, it is dispersed in suspension in water (heterogeneous mixture of substances suspended without dissolving in water) (3, 4).

Cotton fiber is also called cellulose-based fiber because it contains 80-90% cellulose in its cellulose. The dyestuffs used in the dyeing of cotton are dyestuffs that are related to the fiber and can bond with the fiber (4, 6).

Perhaps the most water and energy consumption among the branches of industry is in the textile industry. In the Turkish textile industry, between 20 and 230 m3 of water is consumed per 1 ton of textile fabric (5). In addition to high water consumption, the textile industry draws attention with its high consumption of chemicals (auxiliary chemicals, dyes, etc.). The high chemical load resulting from pretreatment, dyeing and other processes varies according to the processes used in textile factories, and the total amount of chemicals used in textiles can vary between 10% and 100% by weight of the textile product produced (2).

In recent years, restrictions on water use have increased due to the increase in population, global warming, and rapid pollution and depletion of water resources (4). All over the world, not only warnings but also laws are issued and more environmentally friendly and sustainable production processes are developed.

Ozanteks Tekstil is one of Denizli's well-established bathrobe, towel manufacturer and exporter companies. As a result of the environmental policies adopted in 2014, environmentally friendly and harmonious production processes are implemented. Paint shop; It consists of parts dyeing, pad-batch dyeing, HT dyeing and coil dyeing sections, and with the help of the automatic chemical dosing system used, the appropriate use of chemicals can be ensured.

The method normally applied in dyeing PES/CO mixtures is first dyeing the polyester part under HT conditions, then dyeing the cotton part with reactive dyestuff after reducing washing. Although disperse dyes require acidic environment and HT conditions, dyeing processes must be done in two separate baths because reactive dyestuffs are fixed in alkaline environment. It is stated in the literature that one-bath, one-step dyeing is possible by using disperse dyestuffs that are resistant to alkaline environment or by using reactive dyestuffs that can be fixed in acidic-neutral environment (4, 6).

With the study, it is planned to carry out studies for the most ideal use by examining the time, chemical, energy and water values consumed in the process of dyeing cotton / polyester towel fabrics in one step. The most important of these studies is the improvement of the water and energy consumption steps spent in the whole process for dyeing in the one-bath dyeing step. It is aimed to carry out research and experimental studies on this subject.

2. Materials and Methods

In the trials, fabrics in weaving were produced by using 20/1 ring cotton on one side, 150 D/288 microfiber PES on the other side, and textured PES yarn with a ground weave of 150 D/48F. To see color reception, different colors are chosen for both faces. Blue Shade will be used for the cotton surface and Red EC2G will be used for the polyester surface. Tube dyeing machine with 12 capacity for dyeing experiments, color measurement with spectrophotometer device, color fastness to washing from color fastness tests (ISO 105-C06), and determination of color fastness to rubbing (TS EN ISO 105-X12), Testing of water absorbency (AATCC) 79/ EN ISO 14697 standards will be used. Washing fastness will be done in Gyrowash machine and dry-wet rubbing fastness will be done with crockmeter device.

In these trials, which will be carried out within the scope of the laboratory trial, the fabrics were weave in our factory. For dyeing, the samples were prepared for 10 gr tube dyeings. First, the standard procedure was applied. As a result of the normal process, normal and reductive washings were made. At the same time, samples were prepared for the staining experiment. The charging steps, which took 11 steps in double dyeing, which is the standard procedure, were examined for simultaneous dyeing. For simultaneous dyeing, the processing steps, namely the charging steps, have been reduced. Thus, the temperature difference was adjusted and the dyeing time was evaluated. After dyeing, washing was done reductively. Fastness evaluations and hydrophilicity evaluations were made. In addition, a Spectrophotometer device was used for color yield. Rubbing fastness evaluations were made with gray scale.

3. Results

As a result of the experiments, the cotton side of the samples was dyed blue and the polyester side was dyed red. Each sample was subjected to 2 different washings, normal and reductive, at the end of the process. The standard process is normal and reductive washing, the dyeing trial performed at the same time is process 1 as a result of normal washing, and the simultaneous dyeing trial is process 2 as a result of reductive washing. The fastness results of the experiments are given in Table 1.

Table 1: Washing fastness results

Washing fastness (ISO 105-C06)						
	Wool	**Acrylic**	**Polyester**	**Nylon**	**Cotton**	**Acetate**
S. Process N.Washing	4	4	4-5	4	4	4-5
S. Process N.Washing	4	4-5	4-5	4	4	4-5
Process 1	3-4	4	4	3-4	3-4	4
Process 2	3-4	4	4	4	4	4

Standard process and newly applied simultaneously dyeing process 1 and process 2 washing fastness results gave results close to the operating criteria, and their rubbing fastness was checked. Dry and wet rubbing fastnesses are given in Table 2.

Table 2: Rubbing fastness results

Color fastness to rubbing (TS EN ISO 105-X12)		
	Wet rubbing fastness	**Dry rubbing fastness**
S. Process N.Washing	4-5	5
S. Process N.Washing	5	5
Process 1	3-4	4
Process 2	4	4-5

Two different standards, EN ISO 14697 and AATCC79, were applied to determine hydrophilicity. Hydrophility test results are given in Table 3.

Table 3. Hydrophility results

Hydrophility results		
	Water absorption (AATCC 79) sec	**Water absorption (EN ISO 14697) sec**
S. Process N.Washing	2,2	8
S. Process N.Washing	1,6	6
Process 1	2,5	12
Process 2	1,8	10

The color comparison values of the measurement results made with the spectrophotometer device are given in Table 4.

Table 4. Color measurement results

	L*	a*	b*	C*	h	dE*	
standard process	0,27	0,26	0,55	0,58	0,20	0	1,5
new process	0,58	0,54	-0,89	0,75	0,38	0,67	1,5

Yellowness and redness values are given in Figure 1, saturation values are given in Figure 2 and dE* (total color difference) values are given in Figure 3.

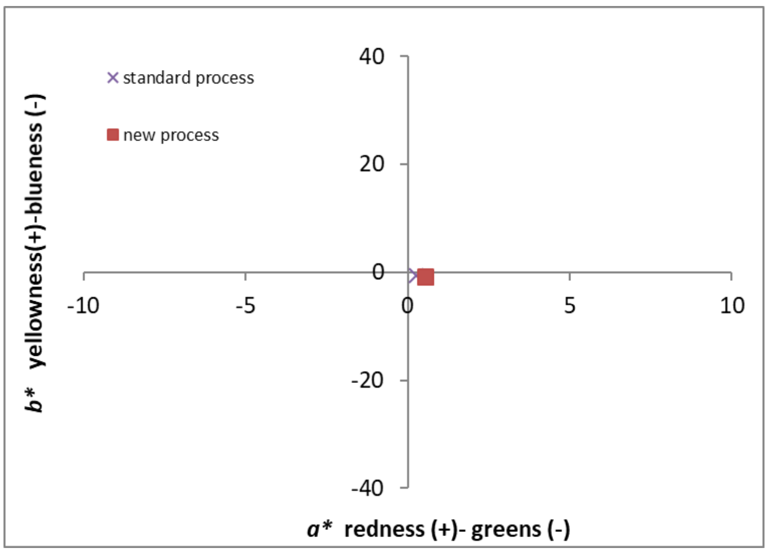

Figure 1. a (redness- b*(yellowness) values*

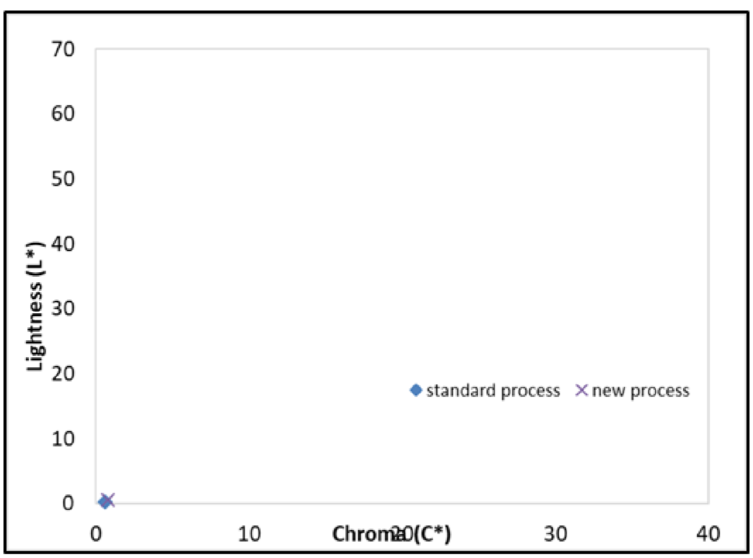

Figure 2. L (lightness-darkness)- C*(saturation) values*

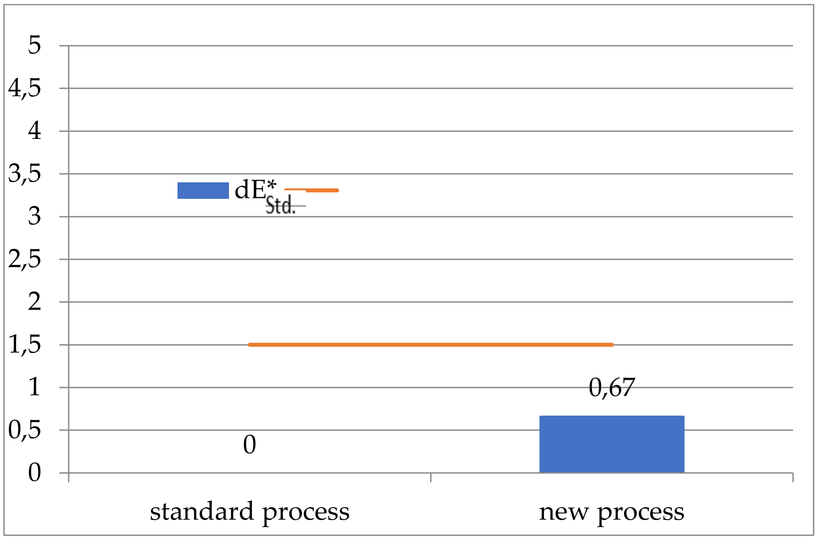

Figure 3. dE ((total color difference) values*

Color measurements were also made, standard and new process color values were compared.

4. Discussion and Conclusion

In the evaluation of the test results after the improvement of the process steps performed in the dyeing process of cotton polyester products after the trials and the application of the new dyeing process at the same time;

When the yellowness (a*)-redness (b*) graphs (figure 2), lightness-darkness (L*)-chroma (C*) (figure 3) graphs related to the results of the spectrophotometer color fastness tests regarding color fastnesses are examined, it is seen that all data are very close to each other. This shows that there is no difference between the colors.

When the dE* (total color difference) values (Figure 4) are examined, if the color difference tolerance values (output variables) of Ozanteks Tekstil are repeated, all values are expected to be within this tolerance range (<1.5). When the old process and new process color values were compared, it was below this value. In other words, dyeing at the same time did not affect the values much.

When the results of washing and rubbing fastness in table 1 and table 2 are examined, it is seen that all data are very close to each other. The wet and dry rubbing fastnesses of the products are 3 and above and these values are commercially acceptable, but it has been seen that it needs improvement. In addition, the gradual removal of rinsing in the process showed that the fastness problem could be eliminated in other trials.

Considering the hydrophilicity test results, both standards showed acceptable values for the new process.

As a result of this laboratory trial, the water, chemical and energy savings to be obtained in the operational trials with the new process will reduce the waste water load and energy use given by the dyehouse to the environment. And thus contributing to the prevention of the rapid depletion of limited water and energy resources. It is foreseen to achieve long-term gains by making effective use of raw materials and in terms of cost. Thus, it will also contribute to the target of reducing carbon emissions of our business. As a result of the study, the continuity of its sustainability was also ensured. It is aimed to move on to the next stage, the business trials.

5. Acknowledge

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