Research Article

Developing Sustainable Methods for Softener and Fixing Agent Application in HT Dyeing Machines

Perinur KOPTUR TASAN[1*], Özlem DEMİR GÜNENÇ[2], Şaban YUMRU[3], Esra GELGEÇ[4], Sultan ARAS ELİBÜYÜK[5], Mustafa ÇÖREKCİOĞLU[6]

[1*]Ozanteks Tekstil San ve Tic. A. Ş. Ar-Ge Merkezi, Denizli, Türkiye (ORCID: 0000-0001-9052-1763), perinur.koptur@ozanteks.com.tr
[2]Ozanteks Tekstil San ve Tic. A. Ş. Ar-Ge Merkezi, Denizli, Türkiye (ORCID: 0000-0003-1505-2164), ozlem.demir@ozanteks.com.tr
[3]Ozanteks Tekstil San ve Tic. A. Ş. Ar-Ge Merkezi, Denizli, Türkiye (ORCID: 0000-0001-9102-6078), syumru@ozanteks.com.tr
[4]Ozanteks Tekstil San ve Tic. A. Ş. Ar-Ge Merkezi, Denizli, Türkiye (ORCID: 0000-0001-7999-5757), esra@ozanteks.com.tr
[5]Ozanteks Tekstil San ve Tic. A. Ş. Ar-Ge Merkezi, Denizli, Türkiye (ORCID: 0000-0002-1866-6332), saras@ozanteks.com.tr
[6]Ozanteks Tekstil San ve Tic. A. Ş. Ar-Ge Merkezi, Denizli, Türkiye (ORCID: 0000-0001-7976-6049), mcorekcioglu@ozanteks.com.tr

* Correspondence: perinur.koptur@ozanteks.com.tr; 0537 217 8417
(First received January 12, 2023 and in final form March 19, 2023)

Reference: Developing Sustainable Methods for Softener and Fixing Agent Application in HT Dyeing Machines. The European Journal of Research and Development,3(1), 129-138.

Abstract

Global warming, which is one of the problems brought by the increasing population day by day, and the rapid depletion of water resources have increased the restrictions on water use. Thus, more environmentally friendly and sustainable production processes are developed by producers and consumers. The number of studies carried out to minimize the use of raw materials in textile dyehouses is increasing day by day. The high chemical load, waste water usage rate and energy cost resulting from pretreatment, dyeing and other processes vary according to the processes used in textile factories.

Our company aims to support environmentally friendly studies that contribute to the economy in production processes. While producing in the paint shop, energy, water, chemicals, etc. It also aims to use raw material resources sparingly. In this study, the efficiency studies carried out in HT dyeing and finishing processes in the dyehouse of our company were examined. By optimizing the

post-processing performed in HT machines after dyeing, softener and fixator chemicals applied in HT machines were carried out by using double pads before drying in stenter machines after trials. Obtained results were compared with old methods. A sustainable new method has been developed without any color, fastness or touch difference between the old system and the new system.
With this new process study, our company's water, energy and chemical savings and the company's impact on the environment have been reduced, while time savings have been achieved by shortening the process time. In the test results, there was no problem in washing, color and rubbing fastness efficiency. No change was observed in the touch of the products after the application of the softener step with the impregnation method instead of shrinking. As a result of the study, while the water consumption was reduced by 20%, the process time was also reduced by 19%.

Keywords: Environmental impact, Sustainable production, HT machine, Textile Finishing Process

1. Introduction

The textile industry is one of the most important sectors for the economic development of countries all over the world. Turkey is Europe's second most important textile supplier. The textile industry is known for its intensive use of water and energy in complex production processes and high consumption of chemicals, especially in dyeing processes. The concept of sustainability began to be discussed towards the end of the 20th century as a result of the fact that unlimited human needs could not be met due to the limitedness of natural resources. On the one hand, increasing people's demand for water, energy, food and space; on the other hand, global population growth, climate change, the spread of urbanization and extreme industrial progress require water, energy, etc. caused scarcity of resources and increased concerns about the sustainability of natural resources [1]. Accordingly, as in many other sectors, there has been a search for increasing sustainability in the field of textiles.

The issue of environmentally friendly textile production plays a major role in guiding the future of the textile industry. Attention should be paid to the damage caused to the environment as a result of the raw materials used, the energy sources used, the amount of water consumed, the recycling and production of the product [2].

The manufacturing sector of textile products, especially the finishing of textile products including finishing processes, has an important place in production with the excess water consumption. The high amount of water needs are generally met from underground water sources. Raw water obtained from underground water sources is used intensively in dyeing and finishing processes and steam boilers after water softening process.

Consumption of water values; It differs according to the type of fiber used in the product, the form of the textile material, the techniques applied and the processing times [3].
In the textile sector, the most chemicals and dyestuffs are used and the most energy is spent in the finishing processes. If the raw fabrics come to the dyehouse, they are subjected to processes such as desizing, bleaching and pre-washing before dyeing. In dyeing and post-dyeing processes; repeated washings, finishing applications, etc. Large amounts of clean water are used with after-treatments such as As a result of use, a waste water load occurs. Approximately 28 billion kg/year of products are dyed in the textile sector and approximately 100-150 liters of water are generally needed for dyeing 1 kg of textile material [4].

Waste water, which is generated due to the consumption of water and chemicals in the sector, especially in textile finishing processes, has an important place in terms of both pollution load and quantity. Dyestuffs used in the dyeing of textile products, toxic and difficult to biodegrade foreign substances increase the load of dirty wastewater [5].
The manufacture of textile products is among the sectors where thermal energy and electricity consumption is intense. The finishing of textile products is provided by thermal energy, hot oil and steam used in the sub-sector. In production processes, especially in all dyeing processes, thermal energy is used intensively. In addition, it is realized with electricity consumption in all machine systems in textile companies [6].

Our company, Ozanteks Tekstil, located in Denizli, considers using resources at the highest efficiency and highest performance, at the beginning of all production operations targets. In this context, it aims to support it with environmentally friendly studies that contribute to the economy. Like other textile dyehouses, continuous improvements are made in the procedures and production processes in our dyehouse department.
In this study, the after-treatment of cotton towel products in HT machines in our enterprise was analyzed, and softener and fixator chemicals were applied to the products by using a double foulard in the impregnation method instead of the shrinking method. After the trials, the effects of the changes made on production and consumption of water, energy, etc. were determined while comparing the quality characteristics of towel products.

Application; generally, in chemical finishing processes, it is the process of transferring the treatment solution containing chemical substances to the textile product properly. The main purpose of the chemical application is to ensure the rapid and intense

interaction of the textile product with the chemical substance and to achieve a smooth substance transfer on it. In other words, application is a basic finishing step for chemical finishing processes. In the application process, a chemical substance is transferred to the fabric, and this transfer process is usually done with an aqueous solution of that substance [7].

Main application methods;

- Exhaust
- Impregnation
- Vacuum application

The symbol machine of the exhaust method is HT. Characteristics of the exhaust method;

- Working with long liquor ratio
- Long application time
- The affinity of the chemicals used
- In general, working in batches and ropes [7]

In the exhaust method, the application process is long. Because it takes time for most of the chemicals in the liquor to be properly absorbed by the fibers. For this reason, according to the exhaust method, the affinities of the chemicals used in the study should have an affinity for the fibers that make up that fabric. In our business, the pulling process is done on HT machines.

Figure 1. HT Machine

Impregnation method is the textile product is impregnated with a solution containing chemical substances. Excess of the liquor in the impregnated fabric is removed by passing between the rollers at the exit of the vat and returns to the impregnation trough. Thus, together with the liquor transferred to the fabric, the chemical substances are transferred

to the fabric properly. In the impregnation method, there are working methods from dry to wet and wet to wet. According to the impregnation method, the general features of the application are the opposite of the extraction method;

- Low liquor ratio
- It is necessary to work with non-affinity substances or using a dosing pump
- In general, it is worked uninterrupted and open width. The classic machine of the impregnation machine is the foulard

In this application method, the impregnation time is very short. However, this time should not fall below 4 seconds. In other words, the fabric should be given a sufficient minimum time for the air in the fabric to come out during the impregnation and take its place by the liquor. Otherwise, a proper application will not be possible [8,9,10].

The purpose of applying the softener chemical to textile products is to improve the touch of the products. The touch of the fabric is the feeling we perceive when we touch the fabric by hand due to the effect of the raw material feature, thickness, softness, knitting and the finishing processes applied to the fabric. Generally, fabrics are required to be soft, plump, draped and lively.

2. Materials and Methods

Experiences were made using 100% cotton towel. The dyeing processes of the towels were carried out on HT machines in Ozanteks Tekstil dyehouse. Stenter machines were also used in the drying and impregnation processes of towel products. Each step in the dyeing and finishing processes, where the most water and energy consumption in HT machines, is analyzed and evaluated.

Process development and renewal is a system that takes a process and repeats trials. The tests made on the samples made during the trials; color measurement with spectrophotometer device, color fastness to washing (ISO 105-C06), determination of color fastness to rubbing (TS EN ISO 105-E04) and hydrophility tests were carried out according to ATCC 79 standards. Washing fastness was done in Gyrowash machine and dry-wet rubbing fastness was done with crockmeter device.

3. Result

As a result of the trials, optimizations were made in the dyeing post-processing and finishing processes of cotton terry products. In the old method; while the fixator and softener chemicals are applied to the products in the last step in HT machines and drying

processes are started, in the new method, fixator and softener chemicals are not applied in HT machines, but by using double foulard before drying and by impregnation method in stenter machines.

While the dyeing and finishing processes of towel products in the facility consisted of 9 steps after dyeing in HT machines, it was reduced to 6 steps with optimizations after experiments (Figure 3 and 4).

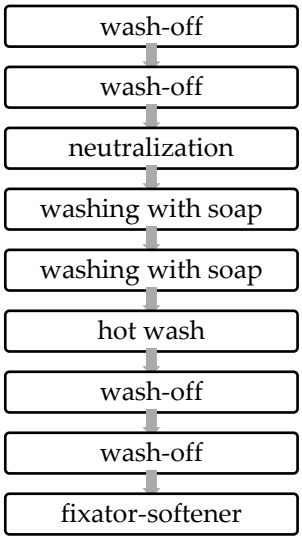

Figure 3. After dyeing on HT machines (standard method)

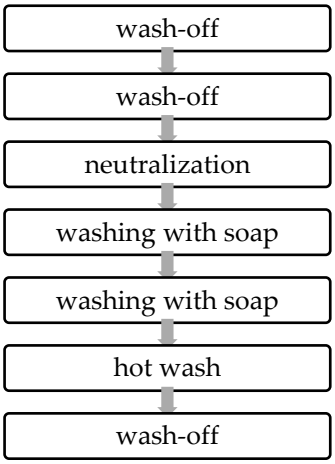

Figure 4. After dyeing on HT machines (new method)

The color measurements, fastness tests and hydrophilicity test results required to compare the quality of towel products produced with the new method, which are carried out simultaneously with the standard method, are given below.

Table 1: Washing and rubbing fastness results

	(ISO 105-C06) Washing fastness							
			Wool	**Acrylic**	**Polyester**	**Nylon**	**Cotton**	**Acetate**
%100 Cotton towel	1	Standard	5	5	5	5	4	5
	2	New	5	5	5	5	4	5
	(TS EN ISO 105-X12) Color fastness to rubbing							
			Wet rubbing fastness			**Dry rubbing fastness**		
%100 Cotton towel	1	Eski	4			5		
	2	Yeni	4			5		

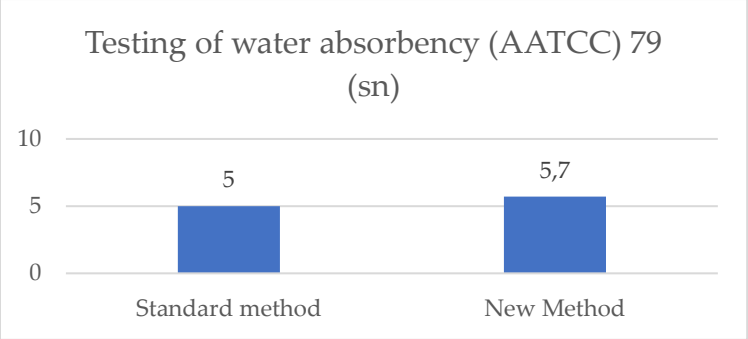

Figure 5. Hydrophilicity test results

Yellowness and redness values are given in Figure 6.

Table 2. Color measurement results

	L*	a*	b*	C*	h	dE*
standard method	33.39	56.75	6.11	57.08	6.15	
new method	33.62	56.21	5.18	56.45	5.27	1.08

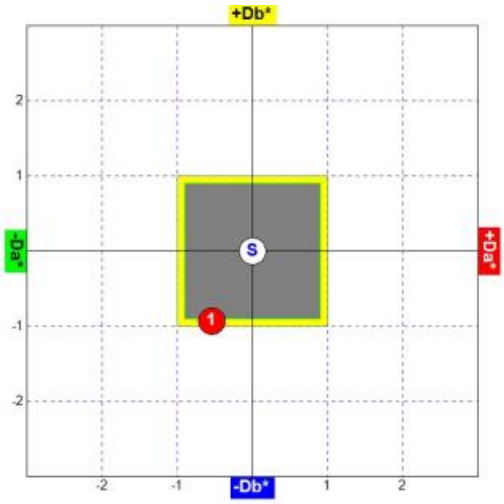

Figure 6. Color comparison results of towel products

The comparison of the process times of the new process and the standard method after the studies is given in the table.

Table 3. Comparison of savings made in the standard process and the new process

	Standart Process	**New Process**
Towel dyeing and post treatment time	8 hour	6,5 hour

4. Discussion and Conclusion

In this study, by keeping sustainability in the foreground, improvement attempts were made in the post-processing of HT machines in our enterprise. In the standard process, since the post-processing of cotton towel after dyeing is carried out by exhaust, it takes a long time and causes high water consumption. For this reason, it has been ensured that some steps are removed from the after-treatment and the fixator-softener chemicals are applied to the products with the impregnation process. In order for the application process to be more successful, the products were passed through two different foulard with different pressures before proceeding to the drying step. Excess water on the product was removed by passing it through the first foulard, and in the second foulard, it was treated with a liquor consisting of softener and fixator chemicals. While the purpose of using the fixator is to improve the fastness values by providing the fixation of the dyestuffs to the products, the purpose of using the softeners is to improve the touch

of the products. For this reason, after the trials, the conformity of the products to the quality standards was tested.

When Table 1 is examined, there is no difference in the fastness values of the products after the new process.

Especially in towel products, the hydrophilicity value is a very important criterion. For this reason, when the hydrophilicity tests performed after the trials were examined, no adverse events were encountered (Figure 5).

It is desired that the color values of the products should not be different in order to ensure the continuity of the new trials made in the orders that are produced regularly in the enterprise. For this reason, color comparisons were made by making color measurements on the products after the trials.

When Figure 6 is examined, the point indicated by S shows the redness-yellowness value of the towel product produced with the standard process, while the number 1 shows the color values of the towel produced with the new process. The presence of both colors in and around the yellow area is acceptable.

When the test results after the studies were evaluated, it was observed that it was possible to continue production with the new process and no quality problems were experienced. In post-processing after dyeing in HT machines, 20% water consumption is reduced and the process time is shortened by 19%. Production capacity has been increased by shortening the time.

5. Acknowledge

This work was supported by the Ozanteks Tekstil R&D Center with the Equity 22SO3 project number. In addition, this study supports the development of sustainable products within the scope of TÜBİTAK 2244 Industry Doctorate Program Project numbered 119C070.

References

[1] ABBAS, Shahbaz, HSIEH, Lin Han Chiang, TECHATO, Kuaanan Ve TAWEEKUN, Juntakan (2020). "Sustainable Production Using A Resource–Energy–Water Nexus For The Pakistani Textile Industry". Journal Of Cleaner Production, Sayı 271, 122633, Ss. 1-10.

[2] ÖZDEMİR, Sonnur, TEKOĞLU, Onur (2011). "Ekolojik Tekstil Ürünlerinde Kullanılan Hammaddeler". Akdeniz Sanat. Cilt 4, Sayı 8. Ss. 27-30.

[3] KAYA D. ÖZTÜRK H., H., 2014 .Sanayide Enerji Yönetimi Ve Enerji Verimliliği, Umut Tepe Yayınları, Kocaeli.

[4] Textile Machinery 3, (2010), Www.Dyecoo.Com/Pdfs/Colourist.Pdf

[5] European Commission, (2003), Integrated Pollution Prevention And Control (IPPC) Reference Document On Best Available Techniques For The Textile Industry. EC IPPC Bureau, 747s., Seville, Spain

[6] E. Öztürk, (2014), Tekstil Sektöründe Entegre Kirlilik Önleme Ve Kontrolü Ve Temiz Üretim Uygulamaları,, Isparta: Süleyman Demirel Üniversitesi, Fen Bilimleri Enstitüsü, Doktora Tezi.

[7] Koca, M. (2006). Mavi Reaktif Boyanın (Reaktif Mavi 221) Örülmüş Pamuklu Kumaşa Uygulanmasında Değişik Parametrelerin Renk Verimine Etkilerinin Incelenmesi. *Gazi Üniversitesi Yüksek Lisans Tezi, Ankara*.

[8] Yakartepe Z., Ünal A., Yakartepe M., (2005) ,"Büyük Tekstil Terbiye Ansiklopedisi", T.K.A.M Tekstil & Konfeksiyon Araştırma Merkezi Yayınları, 3:234-246.

[9] Tarakçıoğlu I., (1979),"Tekstil Terbiyesi Ve Makinaları Cilt-1", Ege. Üniv. Tekstil Fakültesi Tekstil Kimyası Ve Terbiyesi Bölümü Yayınları, 65-78.

[10] Çoban S., (1999) ,"Genel Tekstil Terbiyesi Ve Bitim İşlemleri", Ege. Üniv. Tekstil Ve Konfeksiyon Araştırma-Uygulama Merkezi Yayınları, 51-62.