TMMOB Tekstil Mühendisleri Odası
UCTEA Chamber of Textile Engineers
Tekstil ve Mühendis
Journal of Textiles and Engineer

Yıl (Year) : 2017/3
Cilt (Vol) : 24
Sayı (No) : 107

Araştırma Makalesi / Research Article

COMPARISON OF COLOR VALUES OF PACKAGES WOUND FROM DIFFERENT SPUN YARNS

Halil ÖZDEMİR*[1]
R.Tuğrul OĞULATA[2]
[1]Osmaniye Korkut Ata Üniversitesi, OMYO, Tekstil Teknolojisi Programı, Osmaniye, Türkiye.
[2]Çukurova Üniversitesi, Mühendislik Mimarlık Fakültesi, Tekstil Mühendisliği Bölümü, Adana, Türkiye.

Gönderilme Tarihi / Received: 08.03.2017
Kabul Tarihi / Accepted: 18.09.2017

***ABSTRACT*:** In this study, effects of different yarn structures and properties, produced with ring, compact, open-end rotor and vortex spinning systems, on the color efficiency of package dyeing were investigated. For this purpose, 100% combed ring, compact, open-end and vortex yarns with different yarn counts which were used from the same raw material blend were produced and wound on perforated plastic dye tubes (cones) according to the principle of loose winding (package density; 370 g/dm^3). The bobbins were dyed with reactive dye for three different dyebath concentrations in the universal package dyeing machine. CIELab (L^*, a^*, b^*, c^* and h) values, color differences (ΔE) and color strength (K/S) values of dyed yarns were measured by the spectrophotometer. In conclusion, it was determined that vortex and rotor spun yarns could have darker shades with respect to ring and compact spun yarns.

***Key Words*:** Spinning Systems, Yarn Number, Color Measurement, Color Strength (K/S), Color Difference.

FARKLI EĞİRME SİSTEMLERİYLE ÜRETİLMİŞ BOBİNLERİN RENK DEĞERLERİNİN KARŞILAŞTIRILMASI

***ÖZET*:** Bu çalışmada, ring, kompakt, rotor ve hava jetli (vortex) eğirme sistemleriyle üretilmiş ipliklerin farklı yapı ve özelliklerinin bobin boyamada renk verimliliği üzerine etkileri araştırılmıştır. Bu amaçla, aynı harman kullanılarak, farklı iplik numaralarında %100 penye ring, kompakt, rotor ve vortex iplikler üretilmiş ve 370 gr/dm^3 bobin yoğunluğunda, yumuşak sarım prensibine göre delikli plastik boyama patronlarına sarılmıştır. Bobinler bobin boyama makinesinde üç farklı konsantrasyonda reaktif boyarmadde ile boyanmıştır. Boyama sonrası renk değerleri (L^*, a^*, b^*, c^* ve h), renk farklılıkları (ΔE) ve boyama kuvveti (K/S) değerleri spektrofotometre kullanılarak ölçülmüştür. Sonuç olarak, aynı şartlar altında vortex ve rotor ipliklerinin ring ve kompakt ipliklere göre daha koyu renkte boyanabileceği belirlenmiştir.

***Anahtar Kelimeler*:** Eğirme sistemleri, İplik numarası, Renk ölçümü, Boyama kuvveti (K/S), Renk farkı

**** Sorumlu Yazar/Corresponding Author:*** *halilozdemir@osmaniye.edu.tr*
DOI: *10.7216/1300759920172410703, www.tekstilvemuhendis.org.tr*

1. INTRODUCTION

Package dyeing has accelerated for last years by the increase of demand for colored and patterned fabrics. Because, yarn-dyed fabrics can use different areas such as jacquard or dobby fabrics, woven and knit. In addition, fastness of yarn-dyed fabrics can better than other fabrics which are dyed with different dyeing methods. Package dyeing in textile finishing is more preferred comparing to other yarn dyeing methods because of advanced capacity of production and easy application of subsequent processes. On the other hand, solving the problems that might appear during dying is very difficult. The package will not have good uniformity of colour as far as the internal, centre and external parts of dyed bobbins are concerned because of the deformity of yarn. Nevertheless, levelness and faulty dyeing may occur because of poor yarn properties, insufficient machinery and equipment, wrong selection for yarn dye tubes, non uniform package density and winding profile, using of wrong dye, auxiliaries, process and dyer or personnel errors [1].

Raw material properties and processing conditions, preparation stages, machine parameters and the spinning method have considerable effects on the yarn properties [2]. Color of products is most important in textile finishing industry. It's believed that yarn properties such as yarn regularity, hairiness and bulkiness affecting yarn count and spinning systems are significantly influenced by both the dyeing behavior and color values (K/S, L*, a*, b*, C*) [3]. With respect to the spinning method, vortex and rotor spun yarns have higher dyeability than both ring and compact spun yarns. This difference is due to the fact that the yarns are considered to the yield more open structures [4]. There are several claimed advantages of vortex spinning system such as "ring-like" structure, low hairiness, reduced fabric pilling, better abrasion resistance, higher moisture absorption, better color fastness and fast drying characteristics [5]. In spite of the high spinning speed, the structure of the vortex spun yarn is similar to ring spun yarns [6].

There are studies comparing compact yarn structure with ring spun yarns, and greater evenness of structure and reduced hairiness of compact yarn is well known [7]. Göktepe and Çeken reported that there is significant color difference between the fabrics of ring and compact spun yarns and fabrics of compact yarns have darker shades, even though they were dyed in the same bath [8]. In the investigation by Kretzschmar et al., 100% cotton yarns produced from the same cotton blend were spun according to compact and ring spinning principles using two different yarn counts and twisting factors. The results show that color efficiencies of knitted fabrics produced from compact yarns were found to be slightly higher in comparison with fabrics knitted with ring yarns. However, these differences were statistically unimportant [9]. Becerir and Ömeroğlu examined color values of cotton fabric knitted from ring and compact spun yarns. The result showed that increasing yarn number increased C* and K/S values, and decreased L* values. Different from the other scientific researches, fabrics knitted from ring-spun yarns were appear darker and more saturated in color and It was emphasized that yarn hairiness, type, and count, together with the bulky structure of knitted fabrics, played a very important role in light reflectance [10].

In this paper, the combed cotton package yarns produced in ring, compact, open-end rotor, MVS systems were dyed with a reactive dyestuff in mill condition. The dyeabilities (whiteness, color values and efficiency) and color differences were evaluated and discussed in relationship between to the spinning method and dyeing.

2. MATERIAL and METHOD

In this study, 100 % combed cotton package yarns with different linear densities (Ne; 26/1, 30/1 and 36/1) produced by Ring, Compact, OE-rotor and MVS spinning methods from the same lot of Indian cotton fibers were dyed with at three different dye concentrations (0,2%, 1,5% and 4%) in mill conditions. Two replications are carried out for each package in the study. These yarns were manufactured with combed process because vortex yarn could not be produced with carding process efficiently. This case is necessary for reliable results at the color comparison. The combed process is very important for yarn quality properties and fiber arrangement. Besides it can be said that these parameters affect the dyeability of yarns directly. The fiber properties of the cotton used for producing the yarn are shown in Table 1. Cotton bale was tested on High Volume Instrument (HVI; four replications for micronaire, four for color, and ten for fiber length and strength) and on Advanced Fiber Information System (AFIS; three replications of 3000 fibers each) [1].

Table 1. Main fiber properties (HVI and AFIS measurement on raw cotton)

Fiber properties	**Average Value**
HVI	
Micronaire	4.1
Upper half mean length (UHML, mm)	30.1
Length uniformity (%)	82.9
Strenght (g/tex)	32.7
Elongation (%)	5.64
SFI (%)	6.4
Reflectance degree (R_d)	80.1 (extra bright)
Yellowness (+b)	7.6 (white)
Color-Grade (C-G)	31-1 (white cotton)
AFIS	
Neps (cnt/gr)	146
Seed coat nep (SCN, cnt/gr)	23
Short fibers content by weight (SFC_w,%)	9
Upper quartile length by weight (UQL_w,mm)	30.6
Maturity ratio (MR)	0.90
Dust (cnt/gr)	576
Trash (cnt/gr)	57

For all yarns, raw cotton fibers were opened, cleaned, carded (Rieter 60), drawn (Rieter SBD 15) and combed (Rieter E 30 and E 7/5). Ring yarns were spun on Rieter G30 spinning machine after the second drawing (Rieter RSBD 35) and roving (Rieter F5). Compact yarns were spun on Zinser 351 C^3 spinning machine after the second drawing (Rieter RSBD 35) and roving (Zinser 670). Open-end rotor yarns were spun directly from second passage sliver (Rieter RSBD 35), whereas the second passage sliver was subjected to a third drawing (I. Rieter SBD 15, II. Rieter SBD 15, III. Rieter RSBD 35) for MVS yarns. Rotor yarns were produced on Schlofhorst Autocoro SE 11 OERS yarn machine and MVS 851 vortex spinning machine was used to produce the vortex yarns. All yarns were spun with a suitable twist factor for knitted fabrics. The views of yarn surface spun with different spinning processes are shown Figure 1. Data describing the process setting and conditions for cotton spinning are listed in Table 2. Packages with different yarn counts were wound to perforated plastic dye tubes (cones) according to principle of loose winding (package density; 370 gr/L) for soft dye packages under the mill conditions [1].

After loose winding, cotton packages were pretreated and dyed in the same Universal Package Dyeing Machine (Krantz), to eliminate any variations during these processes. Table 3 and Figure 2 show the auxiliaries and dyeing diagrams used in the pre-treatment and dyeing processes.

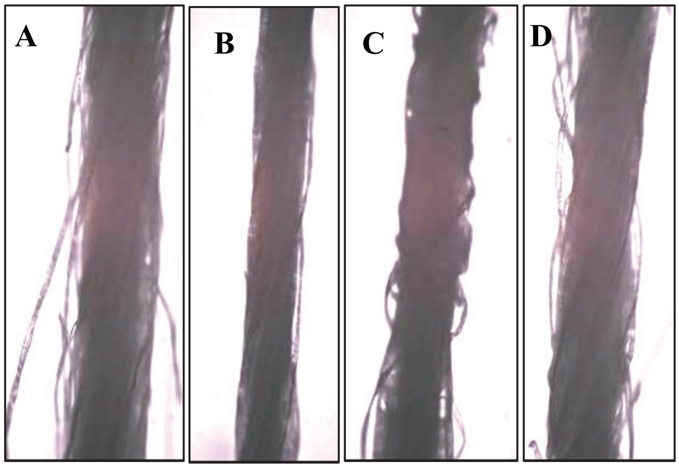

Figure 1. The views of yarn surfaces for Ne 30; A-Ring, B-Compact, C-OERS, D-MVS (40x)

Table 2. Data of process conditions for cotton spinning

Item no.	RING			COMPACT		
	Ne 26/1	Ne 30/1	Ne 36/1	Ne 26/1	Ne 30/1	Ne 36/1
Delivery speed (m/min)	19.28	18.36	16.81	25.8	23.3	21.6
Total draft	33.6	38.9	46.9	31.5	36.3	43.5
Roving no (Ne)	0,80			0,85		
Spindle speed (rpm)	15000	15000	15500	17500		
Coefficient of twist	3.9	3.8	3.9	3.37	3.47	3.42
Ring diameter (mm)	40			40		
	OERS			MVS		
	Ne 26/1	Ne 30/1	Ne 36/1	Ne 26/1	Ne 30/1	Ne 36/1
Delivery speed (m/min)	128.3	125.8	116.8	340	340	320
Total draft	210	238.7	280	140	163	168
Sliver weight (ktex)	4.54			3.5		
Rotor speed (rpm)	95000	100000	102000	-----	-----	-----
Rotor	T231	T533	T231	-----	-----	-----
Novel	KN4			-----	-----	-----
Combing speed (rpm)	9600	9200	9600	-----	-----	-----
Combing roller	B174N	B174DN	B174N	-----	-----	-----
Nozzle type	-----	-----	-----	70d/4j		
Needle holder	-----	-----	-----	2p130dL7 (9.3)		
Spindle diameter	-----	-----	-----	1.2		
Air pressure (bar)	-----	-----	-----	4.5		
Gauge	-----	-----	-----	36-36-49/36-36-44.5		

Table 3. Pre-treatment and dyeing processes conditions

Pre-treatment		***Reactive Dyeing***		***Washing and Softening***	
Hydrogen peroxide	2.2 g/L	Reactive Blau CA	0.2 %	Acetic acid	0.5 g/L
NaOH	2.5cc/L	Reactive Blau CA	1.5 %	Soap washing I(1.5 %,4 %)	0.17 g/L
Stabilizer	0.8 g/L	Reactive Blau CA	4 %	Soap washing II (4 %)	0.17 g/L
Wetting agent	1.1 g/L	Wetting agent	1 g/L	Acetic acid (for pH)	0.6 g/L
Acetic acid	0.5 g/L	Salt (0.2 %,1.5 %,4 %)	10,35,50 (g/L)	Softening agent I	1.2 g/L
Anti-peroxide enzy.	0.4 g/L	Soda	10 g/L	Softening agent II	1.6 g/L
Liquor ratio	1/10	Liquor ratio	1/10		

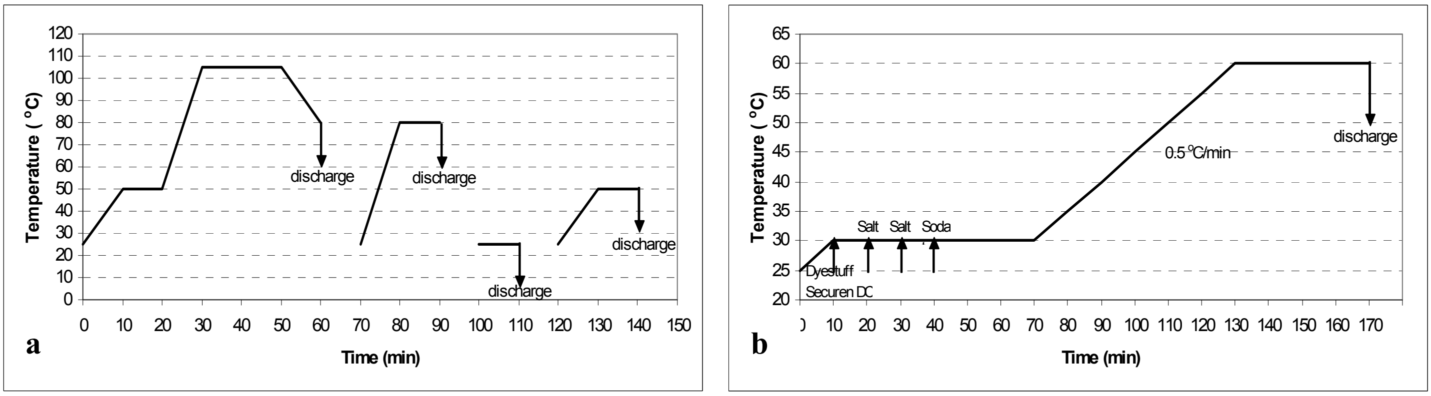

Figure 2. a) Pre-treatment, b) Dyeing diagrams [1]

Afterwards, dyed packages were dehydrated with a centrifugal hydro-extractor (1550 rpm, 6 min) and dried with a high frequency drier (conveyor belt speed; 3,5m/h). For color measurements on a spectrophotometer, dyed yarns were knitted on a laboratory-type sample circular knitting machine according the single jersey type (Figure 3). The technical properties of knitting machine are given in Table 4. [1].

Figure 3. Samples of knitted fabrics dyed with different concentrations (0,2%, 1,5% and 4%)

Table 4. The technical properties of knitting machine

Cylinder diameter	$3^{1/2}$ inc
Speed	400 rpm max.
Gauge	18
Knit type	Plain knitted fabrics (single jersey)

The color values of dyed packages were measured on a Minolta CM 3600 D model spectrophotometer coupled to a PC between 400-700 nm under $D_{65}/10^o$ illuminant. Percent reflectance values at the wavelength of maximum absorption (630nm) were recorded. K/S (Color Strength) values were obtained from Kubelka Munk equation;

$$K/S = (1-R)^2/2R \quad (1)$$

Where K is a constant associated with the light absorption of the fabric, predominantly determined bye dyestuff, S is the constant associated with the light scattering of the fabric, determined only bye the textile material, and R is the reflectance of the dyed fabric measured at the wavelength of maximum light absorption.

The CIELAB formula is used to assess small color differences and is recommended for use by DIN 6174. The colour difference is determined using a colour difference formula from the colorimetric measures L*, a*, b* which result from the CIE tristimulus values X, Y, Z. The L*-value indicates the position on the light/dark axis in the L*,a*, b* system, the a*-value gives the position on the red/green axis and the b*-value the position on the yellow/blue axis. According to DIN 6174, the ΔE^*_{ab} color difference is calculated as follows:

$$\Delta E^*_{ab} = [(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2]^{1/2} \quad (2)$$

In this study, according to “CIE, degrees of whiteness formula”, whiteness index values of fabrics were calculated as follows:

$$W= Y+800(x_n+x)-1700(y_n-y) \quad (3)$$

Where W is the CIE whiteness index, Y is the brightness of sample, x and y are the standard color values, x_n and y_n are the chromaticity co-ordinates of light source [11-12].

Color measurement results of dyed packages were evaluated and interpreted statistically. SPSS 11.5 for Windows, a statistics program for use on a PC was used for the statistical analyses. The differences between the groups for which the significance values were less than 0.05 were interpreted as statistically important.

3. RESULTS AND DISCUSSION

3.1. Whiteness Degree Results

CIE whiteness index values (WI) of package samples applied pre-treatment process are shown in Table 5. Table 5 reveals that whiteness values of the fabric knitted from air-vortex spun yarns having lower hairiness values are higher than fabric knitted from ring and compact spun yarn having a real twist. Besides, it is seen that the yarn number don't affect on whiteness values. We took a pre-treatment fabric samples, consisting of ring spun yarns, as the reference sample. Color difference (ΔE*) values of undyed yarn samples are shown in Table 6. Color difference (ΔE*) values greater than 1.0 indicate significant color difference compare to the reference sample. Table 6 indicates that there are usually significant color differences among the systems and reference ring samples are darker than the others.

3.2. Color Values and Color Difference Results

Effect of yarn count, spinning system and dye concentration on the Lightness (L^*) value is shown in Figure 4. The increase in the dye concentration brings about a decrease in L* values. It is shown that fabrics knitted from air-vortex spun yarns have the lowest L* values (the darkest color appearance) for both three dye concentration and three yarn numbers. Fabrics knitted from O.E. rotor spun yarns, have also lower L* values (darker color appearance) than fabrics produced from ring and compact spun yarn having Ne 26/1 and Ne 30/1 yarn numbers.

Effect of yarn count, spinning system and dye concentration on the color strength (K/S) value is shown in Figure 5. The increase in the dye concentration brings about an increase in K/S values. It is shown that fabrics knitted from air-vortex spun yarns have the highest K/S values for both three dye concentration and three yarn numbers. Fabrics knitted from O.E. rotor spun yarns have also higher K/S values than fabrics produced from ring and compact spun yarns.

The relationship between the spinning system, yarn count, dye concentration and color difference values is shown in Figure 6. At this comparison, ring based fabric was accepted as reference. Figure 6 indicates that there are significant color differences among ring and vortex spinning systems whereas there are rarely significant color differences for the other comparisons. Vortex yarns can be dyed darker than other yarns since there are several claimed advantages of vortex spinning system such as low hairiness, higher moisture absorption and bulkiness, more open structure and untwisted core fibers.

Table 5. Whiteness index values of ring, compact, o.e. rotor and vortex yarns (CIE, WI)

Yarn Number (Ne)	Whiteness Index Values (WI)			
	Ring	O.E. Rotor	Compact	Vortex
Ne 26/1	71,77	73,81	71,31	**74,64**
Ne 36/1	69,75	73,96	71,99	**74,26**

Table 6. Color difference values of undyed yarn samples

Standard		Samples	Color Difference (ΔE 1976)	Descriptions
Ring	Ne 26/1	Compact Ne 26/1	*0,5*	The standard has a deep color. The sample is more intense, red and yellow color appearance than standard
		O.E. Rotor Ne 26/1	***1,31***	The standard has a deep color. The sample is more intense, green and yellow color appearance than standard
		Vortex Ne 26/1	***1,41***	The standard has a deep color. The sample is more intense, green and yellow color appearance than standard
	Ne 36/1	Compact Ne 36/1	***1,54***	The standard has a deep color. The sample is more intense, green and yellow color appearance than standard
		O.E. Rotor Ne 36/1	***1,43***	The standard has a deep color. The sample is poorer, red and blue color appearance than standard
		Vortex Ne 36/1	**2,74**	The standard has a deep color. The sample is more intense, green and yellow color appearance than standard

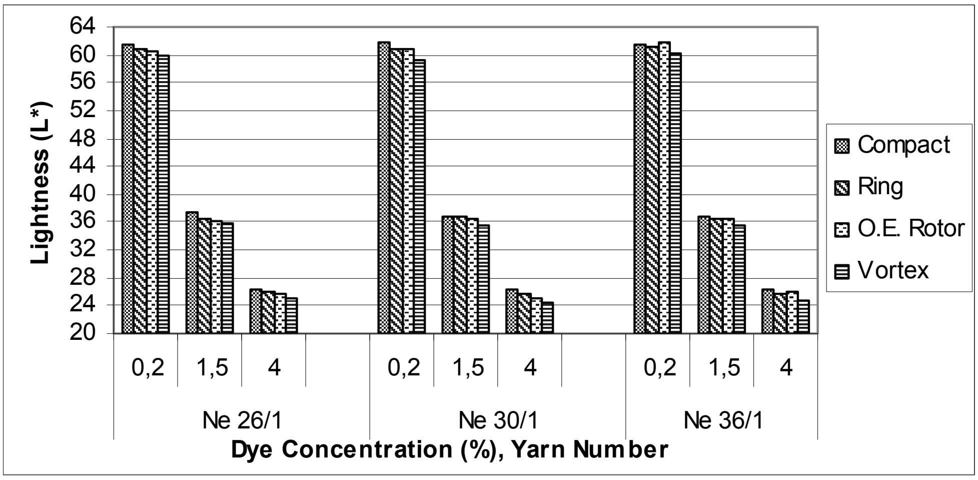

Figure 4. Comparing of lightness (L*) values

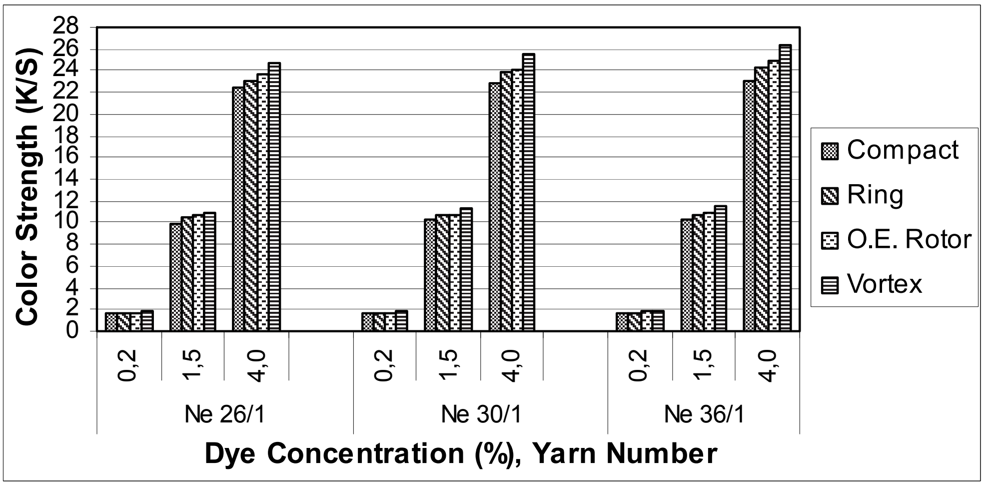

Figure 5. Comparing of color strength (K/S) values

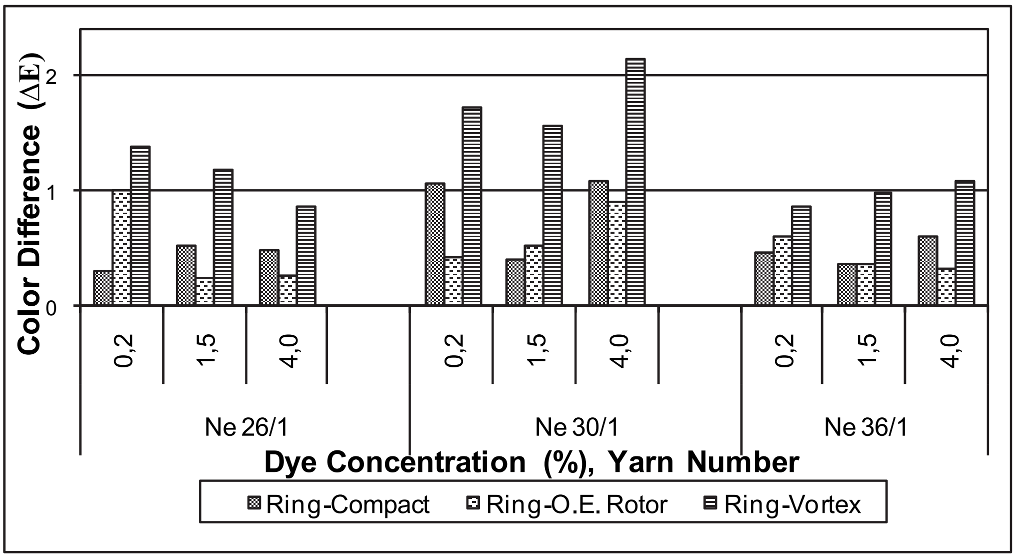

Figure 6. Change in color difference value for different spinning system when yarn count and dye concentration are increased

3.3. Statistical Analysis

In this study, it was performed an analysis of statistical (Paired Sample "t" Test) to compare of K/S values of dyed fabrics producing with different spinning systems. Results of statistical analysis are given in Table VII. Table VII reveals that there are significant differences between spinning systems. When "t" values are analyzed in the table, it is seen that the effect of vortex spinning systems is significant. Eventually, vortex yarns can be dyed darker color shades at the low, middle and high dye concentrations.

4. CONCLUSIONS

It has been said that the presence of color requires three things: a source of illumination, an object to interact with the light which comes from this source and a human eye to observe the effect which results. If surface of fabric change because of the yarn properties (hairiness, evenness, bulkiness and fiber arrangement), fabric structure, type of weave, finishing treatments; furthermore, color values of fabrics will change. For example, it can bring about increase of light absorption and decrease of light reflection because of hairy yarn or fabric producing with this yarn. Dyed ring yarns can be darker than compact yarns. However, the fiber arrangement affecting from the spinning system is other important parameter for dyeability. Vortex yarns having parallel core fiber, high bulkiness and absorbing capacity can be darker than conventional yarn having real twisted structure.

It known that decreasing the package density brings about an increase manufacture cost, however, increase dyeing efficiency and decrease dyeing defaults such as color difference in the internal, centre and external parts of dyed bobbins.

The aim of this study was to analyze the effects of spinning system and yarn count on the package dyeing. In this study, effects of different yarn structures and properties, produced with ring, compact, open-end rotor and vortex spinning systems, on the color efficiency of package dyeing were investigated. Although the yarns were wound on perforated plastic dye tubes (cones) according to principle of loose winding at fixed package density (370 g/L), package hardness values (Shore A) of vortex yarns measuring on the textile hardness tester were given lower results compared to ring, rotor and compact spun yarns. Consequently, liquor flow and circulation in the packages winding vortex yarns are more uniform and effective than the other packages. In addition to this, dyeing problems such as dyeing unevenness and color differences can be prevented with using vortex yarns.

Table 7. Paired sample "t" test for dyeing samples

Samples		Mean	Std. deviation	t	Sig. (2-tailed)
0.2 % (owf)	R-C	0.093	0.022	10.583	0.000**
	R-O	-0.012	0.042	-0.678	0.528
	R-V	-0.115	0.016	-17.14	0.000**
	C-O	-0.105	0.038	-6.801	0.001**
	C-V	-0.208	0.020	-25.00	0.000**
	O-V	-0.103	0.040	-6.276	0.002**
1.5 % (owf)	R-C	0.425	0.129	8.044	0.000**
	R-O	-0.207	0.074	-6.872	0.001**
	R-V	-0.633	0.214	-7.234	0.001**
	C-O	-0.632	0.086	-17.823	0.000**
	C-V	-1.058	0.099	-26.006	0.000**
	O-V	-0.427	0.170	-6.147	0.002**
4.0 % (owf)	R-C	0.990	0.315	7.689	0.001**
	R-O	-0.440	0.308	-3.492	0.017*
	R-V	-1.685	0.245	-16.807	0.000*
	C-O	-1.430	0.374	-9.351	0.000**
	C-V	-2.675	0.489	-13.408	0.000**
	O-V	-1.245	0.282	-10.793	0.000**

R: Ring, C: Compact, O: Open-end Rotor, V: Vortex, *; significant at α=0.05, **: significant at α=0.01

REFERENCES

1. Özdemir, H., (2009), *Farklı İplik Üretim Sistemleri ile Eğrilmiş İpliklerin Fiziksel Özellikleri ve Bobin Boyama Performansının İncelenmesi (An Investigation of The Physical Properties and Dyeing Performance of Yarn Produced by Using Different Spinning Systems),* University of Çukurova, Institute of Natural and Applied Sciences, Department of Textile Engineering, PhD Thesis, TURKEY, (in Turkish).
2. Üreyen M. E. and Kadoğlu H., (2006), *Regressional Estimation of Ring Cotton Yarn Properties from HVI Fiber Properties*, Textile Research Journal, Vol. 76, Issue 5, pp. 360-366.
3. Becerir B., Ömeroglu S., (2007), *Comparison of Color Values of Plain Cotton Fabrics Knitted From Ring and Compact Spun Yarns*, AATCC Review, Vol. 7, Issue 7, pp. 41-46.
4. Micheal M. N., Dyab W. A., (2001), *Effect of Spinning Method and Knitting Type on Dyeability and Fading Kinetics*, AATCC Review, March, Vol. 1, Issue 3, pp. 53-56.
5. Basal G., Oxenham W., (2006), *Effect of Some Process Parameters on the Structure and Properties of Vortex Spun Yarn*, Textile Research Journal, Vol. 76, Issue 6, pp. 492-499.
6. Örtlek H. G., Şener M., and Ülkü S., (2004), *Production Cost Analysis of MVS Yarns and Comparison with the Conventional Spinning Systems*, Tekstil Teknoloji (International Textile Technology Magazine), Vol. 9, Issue 98, pp. 82-93.
7. Göktepe F., Yılmaz D., Göktepe O., (2006), *A Comparison of Compact Yarn Properties Produced on Different Systems*, Textile Research Journal, Vol. 76, Issue 3, pp. 226-234.
8. Çeken F., Göktepe F., (2005), *Comparison of The Properties of Knitted Fibres Produced Bye Conventional and Compact Ring-Spun Yarns*, Fibres & Textiles in Eastern Europe, Vol. 13, Issue 1 (49), pp. 47-50.
9. Kretzschmar S. at al., (2007), *The Comparison of Cotton Knitted Fabric Properties Made of Compact and Conventional Ring Yarns Before and after the Dyeing Process*, Textile Research Journal, Vol. 77, Issue 4, pp. 233-241.
10. Becerir B., Ömeroglu S., (2007), *Comparison of Color Values of Plain Cotton Fabrics Knitted From Ring and Compact Spun Yarns*, AATCC Review, Vol. 7, Issue 7, pp. 41-46.
11. İskender M. A., Becerir B., and Koruyucu A., (2005), *Carrier Dyeing of Different Energy Level Disperse Dyes on Polyester Fabric*, Textile Research Journal, Vol. 75, Issue 6, pp. 462-465.
12. Rouette H. K., *Encyclopedia of Textile Finishing*, Woodhead Publishing, 2001