(REFEREED RESEARCH)

EVALUATION OF CORE VISIBILITY RATIO FOR HYBRID YARNS USING IMAGE PROCESSING TECHNIQUE

HİBRİT İPLİKLERDE ÖZ GÖRÜNÜRLÜK ORANININ GÖRÜNTÜ İŞLEME TEKNİĞİ KULLANILARAK DEĞERLENDİRİLMESİ

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ABSTRACT

Aesthetic values are needed to be optimized with technical performances for hybrid yarns. In this study, a new method is proposed to determine the core visibility ratio (CVR) of the hybrid yarns. The new method is used to determine aesthetic differences of hybrid yarns manufactured by three different production methods (ring core-spun, siro core-spun, compact core-spun), and three different yarn counts (Ne 18, Ne 24, Ne 30) containing stainless steel (SS) wire and cotton fibers.

Keywords: Hybrid yarn, core visibility ratio (CVR), stainless steel (SS), image thresholding method, core-spun yarn

ÖZET

Hibrit iplikler için estetik değerlerinin teknik performansları ile optimize edilmesi gereklidir. Bu çalışmada, hibrit ipliklerde öz görünürlük oranını (CVR) belirlemek için yeni bir yöntem geliştirildi. Bu yeni yöntem, üç farklı üretim yöntemi (ring-özlü iplik, siro-özlü iplik, kompakt-özlü iplik) ve üç farklı iplik numarasında (Ne 18, Ne 24, Ne 30) paslanmaz çelik (SS) tel ve pamuk lifleri içeren hibrit ipliklerin estetik farklılıklarını belirlemek için kullanıldı.

Anahtar Kelimeler: Hibrit iplik, öz görünürlük oranı (CVR), paslanmaz çelik tel (SS), görüntü işleme metodu, özlü iplik

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INTRODUCTION

Hybrid yarns are yarn structures, which are developed to benefit from the properties of two or more different components at the same time. Combining different fibers in a structure yields yarn types that have different outstanding functional characteristics [1-9]. The production methods of hybrid yarns can be separated into four different groups as core spinning, covering, twisting and commingling method.

The production of core-spun yarns can be realized by commonly used staple spinning methods, such as ring, rotor, friction or vortex spinning with proper modifications [1-4]. Among these systems, ring core-spun method is by far the dominant method adopted by the industry. Many researchers have published several studies relating to optimize and enhance the physical and mechanical properties of core-spun yarns [10-15].

Core-spun yarns used widely in the market can be classified under three different groups by means of material content as containing PET/PA (Polyester/Polyamid)/ metal wire (Hard core), containing elasthane (Soft core) and containing PET/PA+Elasthane (Intermingled or dual-core). Core-spun yarns containing metal wire are used in fabric structures to avoid static electricity and to shield electromagnetic fields [2]. Even though core-spun yarns containing metal wire are mainly produced for technical purposes, these yarns are also expected to provide certain level of acceptable aesthetic and comfort properties [16]. Core-spun yarns have been popularly used and studies on their many properties have been carried out [9-14]. Yarns manufactured with different core spinning methods have not been compared with each other in terms of their aesthetic properties.

The aim of this study is to evaluate the aesthetic performance of different core-spun yarns containing metal wire by using image processing technique with a newly proposed approach. The application areas of image processing methods are increasing every day and usage of these methods is finding solutions for different industrial problems [17-21]. In this study, firstly a new image processing approach was designed to evaluate core visibility ratio (CVR) values of core-spun yarns based on thresholding method and then aesthetic performances of core-spun yarns manufactured by ring core-spun, siro core-spun, compact core-spun of three different yarn counts were evaluated with this approach and compared with each other so that the differences between their aesthetic performances could be considered together with their other properties.

MATERIALS AND METHOD

In this study, core-spun hybrid yarns containing stainless steel wire were produced with 3 different production methods as ring core-spun(RC), siro core-spun(SC), compact core-spun(CC) and each with 3 different yarn counts as Ne 18, Ne 24, and Ne 30 on ring spinning frame. A special apparatus was used on ring spinning frame for producing core-spun yarns. Yarn count was measured according the standard TS244 EN ISO2060 [22]. Table 1 shows the yarn codes and production methods.

Same type of fibre was used as the covering material for all yarn types which is same lot of Urfa St-1 type cotton so that comparison of the aesthetic performance of yarn samples could be done. Properties of cotton fibers were measured on the Premier ART2. Properties of cotton fibers are as: 4.59 micronaire reading, 28.93 mm UHML, uniformity index of 84.5, breaking elongation 7.32 % and 30.61 cN/tex strength. For the production of hybrid yarns, 20 micron (Nm 200) AISI 316 L type of stainless steel (SS) were used as core material. The production of conventional ring core-spun yarn samples was done on the sample ring spinning machine with the core device of Pinter Company (Figure 1a). The production of siro core-spun yarn samples was done on the sample ring spinning machine using the siro-core device of Pinter Company (Figure 1b). Additionally, in order to produce compact core-spun yarns, RoCoS compact equipments from Rotorcraft were assembled on ring spinning sample machine (Figure 1c).

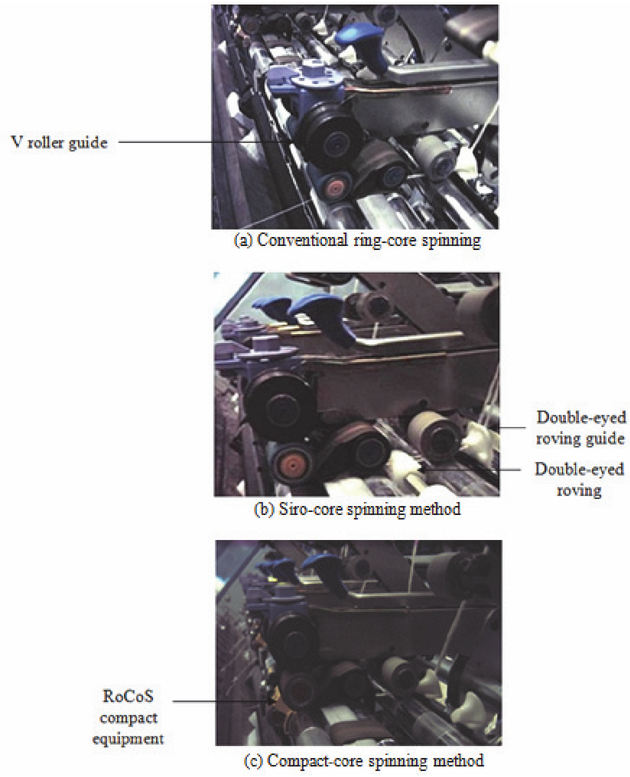

Figure 1. Production methods in this study (a) Conventional ring-core spinning. (b) Siro-core spinning method. (c) Compact-core spinning method.

All yarns were produced at 15.000 rpm spindle speed, with a total draft ratio of 28.24. Ring and compact core-yarns were manufactured from one roving of Ne 0.85 whereas siro core-spun yarns were produced from two rovings, each Ne 1.7. Siro core yarns were produced with 8 mm strand spacing. The core draft ratio of “1” and the twist coefficient (αe) of “3.7” were selected for all core-yarn samples. Sample yarns were photographed with an Olympus SZ61 stereo microscope using BABSOFT digital image processing software. The longitudinal views of the yarns manufactured with 3 different production methods and 3 different yarn counts are given in Figure 2.

Table 1. The yarn codes and production methods.

Yarn Code	Nominal Yarn Count (Ne)	Actual Yarn Count (Ne)	Production Method
18RC	18/1	18.1	Ring Core-spun
24RC	24/1	23.6	Ring Core-spun
30RC	30/1	29.8	Ring Core-spun
18CC	18/1	18.9	Compact Core-spun
24CC	24/1	24.0	Compact Core-spun
30CC	30/1	29.9	Compact Core-spun
18SC	18/1	17.9	Siro Core-spun
24SC	24/1	23.9	Siro Core-spun
30SC	30/1	29.8	Siro Core-spun

RC: Ring core-spun, SC: Siro core-spun, CC: Compact core-spun.

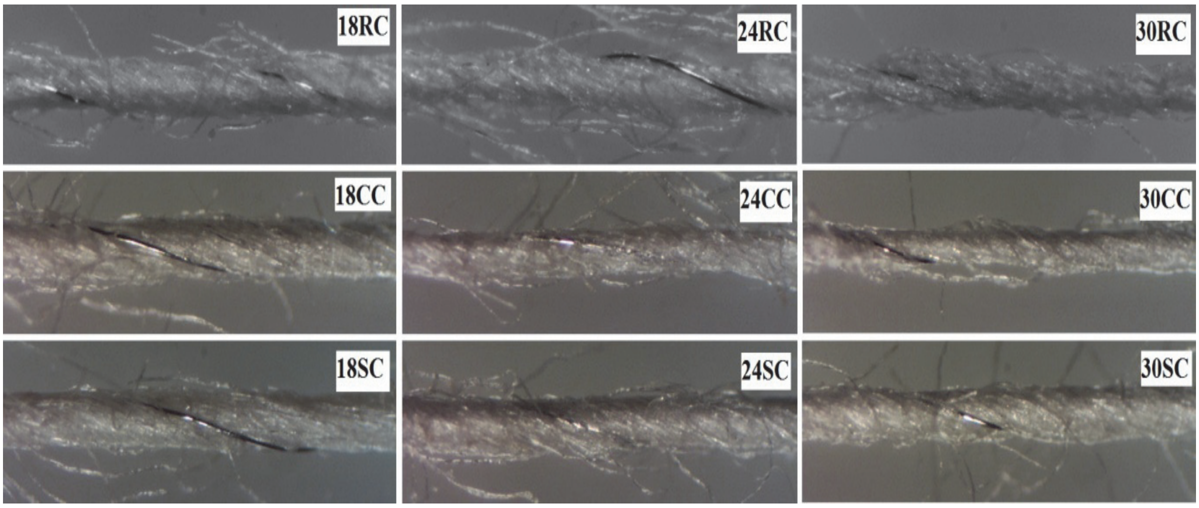

Figure 2. Longitudinal views of yarns at the magnification of 45×.

The visibility of core parts of hybrid yarns, which were produced with the different production techniques, was evaluated in the knitted fabric form. As a result of knitted fabric structure, core part of hybrid yarn, which is normally invisible, becomes visible. For this reason, plain knitted fabrics were manufactured with hybrid yarns on sample knitting machine. The images of the knitted fabrics which were manufactured with hybrid yarns are given in Figure 3.

The common metal wires used in textiles are stainless steel, silver and copper wires. Ortlek et al. used image thresholding method in CIELab space to determine the core visibility ratio of hybrid yarn containing copper wire [2]. Although CVR results for hybrid yarns containing copper wire can be achieved in CIELab space, this method cannot be used for hybrid yarns containing stainless steel wire due to bright appearance of the stainless steel wire in the image. For this reason, image thresholding method in RGB (red-green-blue) color space was used to determine the CVR of hybrid yarns containing stainless steel wire.

In order to evaluate the effect of yarn production methods and yarn counts on CVR of hybrid yarns, the image frames of each fabric samples have been acquired from five different places by using Olympus SZ61 stereo microscope. After converting the image of the fabric sample to grey level image by using MATLAB, the grayscale image frames are converted into binary form by using double thresholding. The original and the grey images of the 30RC coded sample fabric are given in Figure 4 as an example. Two threshold values were used in this study, one for light areas and one for dark areas of the grey image. Thresholding was done for each image on the grey levels of the images at 35 and 225 pixel grey level values using MATLAB software.

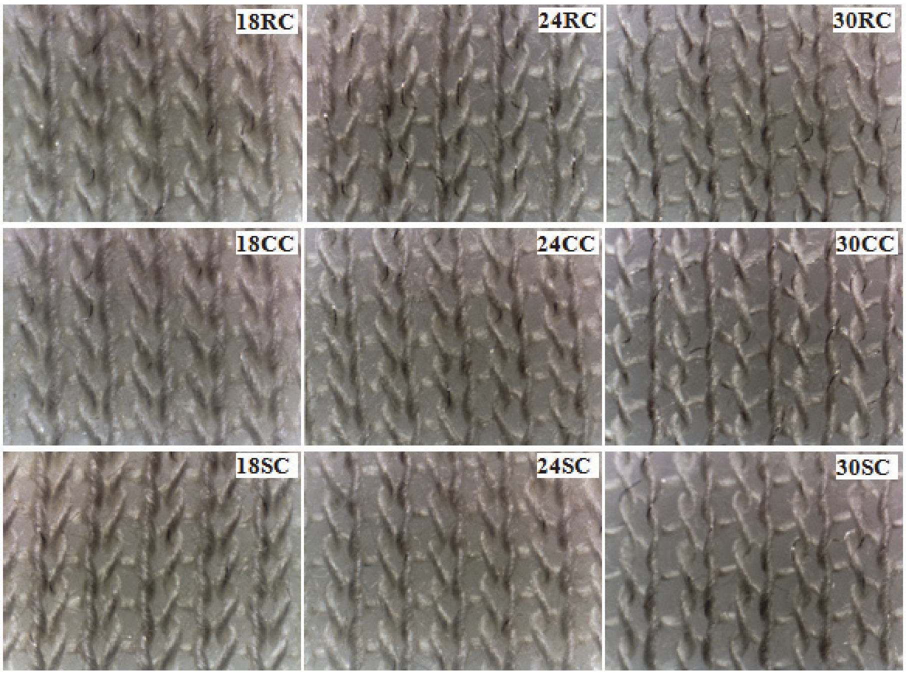

Figure 3. Images of knitted fabrics at the magnification of 45×.

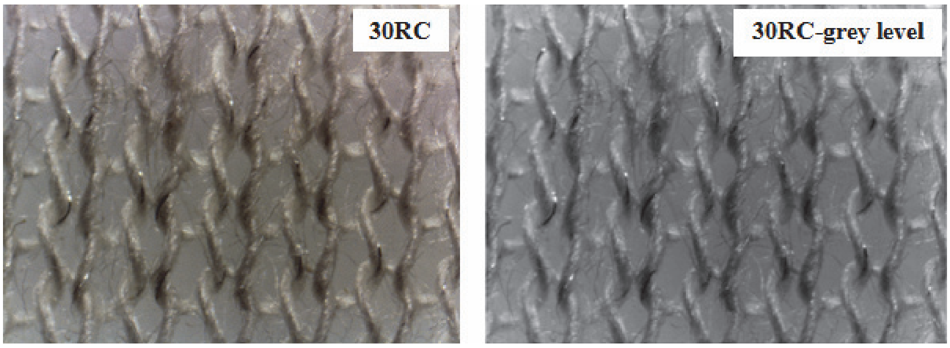

Figure 4. Original image 30RC and image of 30RC at grey level.

An image is a two dimensional function of the light and composed of pixels. Thresholding is simply locating the pixel values on the image instead of defining them according to certain values. Thus, the background of the object and the silhouette of the object can be exposed [20]. So a simple method for object segmentation from the background is to choose the thresholding (T). Otherwise, the pixel will be defined as a pixel of the background. In other words, threshold image g (x,y) can be defined as in equation (1) [21]. Here image is expressed as a function shown as f (x,y), "x" and "y" are the cartesian coordinates and the numerical value at (x,y) pixel is the gray level intensity value of the image at the corresponding pixel.

$$g(x,y)=\begin{cases}1, & if \quad f(x,y)\geq T\\ 0, & if \quad f(x,y)<T\end{cases} \qquad (1)$$

In order to determine the thresholding value for the images of the fabric samples, the gray-scale histogram of the images of the fabric samples are obtained. In this way each pixel of the image is placed in a bin corresponding to the colour intensity of that pixel and all of the pixels in each bin are then added up and displayed on the histogram of the image. The histogram of the grey level of image "30RC" is shown in Figure 5.

General information about the image can be obtained from the light-dark area values of the image histogram. When the pixel value of the image is in a certain range, this changes the property of the image. The grey tone images consist of different grey tone values. Grey value range was defined as G={0,1,2,……….255}. This means that a grey tone image can be consisting of 256 different grey tone values, in other words grey values. When the image of the 30RC fabric sample at grey level was analyzed, the metal on the fabric surface was seen close to white or black color. When the histogram of 30RC is analyzed, it can be seen that the sum of pixel values were lower than a certain value for lower pixel values (black color level) and pixel values were higher than a certain value for higher pixel values (white color level) resulting as the visible metal (core material) on the fabric surface on the image histogram. The results of the obtained images were added together for 35 and 225 threshold values to determine the core (metal) visibility on the fabric samples. The threshold values to be applied in this study was estimated by trial and error.

The ratio of core area for the total image area on the fabric image was defined as CVR. Equations (2), (3) and (4) were used to calculate the CVR values on the fabric surface.

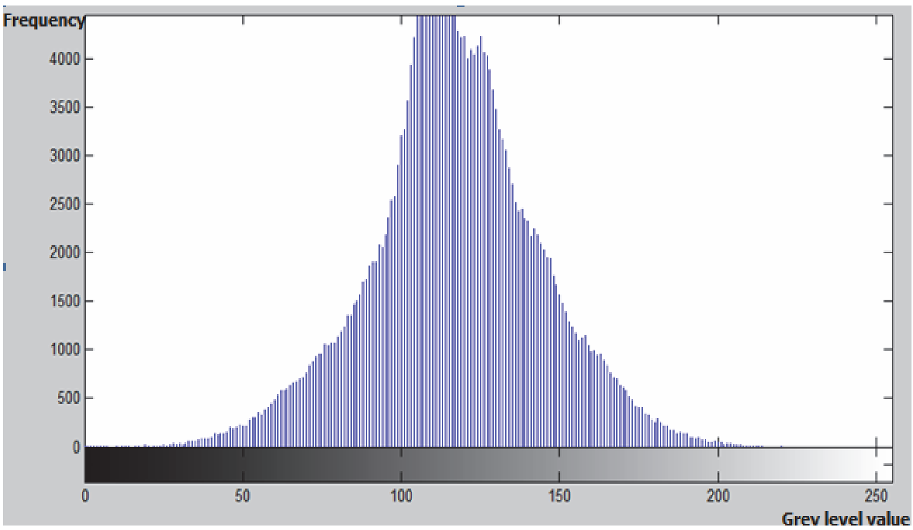

Figure 5. Image Histogram of "30RC".

Figure 6. Results of image samples (30RC) of metals after thresholding at 35, 225, (35+225) pixel values.

$$M_1(x,y) = \begin{cases} 1, & \text{If } f(x,y) \leq 35 \\ 0, & \text{If } f(x,y) > 35 \end{cases} \quad (2)$$

$$M_2(x,y) = \begin{cases} 1, & \text{If } f(x,y) \geq 225 \\ 0, & \text{If } f(x,y) < 225 \end{cases} \quad (3)$$

$$M(x,y) = M_1(x,y) + M2(x,y) \quad (4)$$

$$\text{CVR} = \frac{\sum_x^M \sum_y^N M(x,y)}{MN} \; x\,k \quad (5)$$

Here **f** defines the value of grey level image at x,y coordinates, $\mathbf{M_1(x,y)}$ defines the threshold status of grey level at 35 threshold value and $\mathbf{M_2(x,y)}$ defines the threshold status of grey level at 225 threshold value. **"MN"** shows the total pixel values on the measured fabric surface. "**k**" is constant and considered as 10^4 in this study.

In Figure 6, the image of the "30RC" coded sample fabric obtained after thresholding at 35 and 225 pixel values are given respectively and the total image where these two images are merged together.

For the start-up image with MxN dimension, the processes given in Figure 7 are done respectively for all of the samples as explained also above.

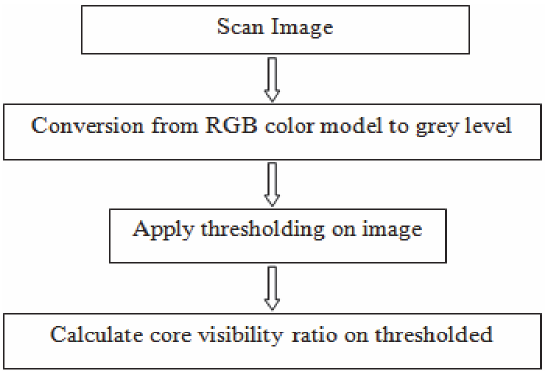

Figure 7. Used method to determine CVR of hybrid yarns on the fabric surface.

CVR of hybrid yarns obtained from the photographs of samples were also statistically analyzed with two-way repeated measurement analysis of variance (ANOVA) method. The mean differences of subgroups were also compared by Student-Newman-Keuls (SNK) test at 95 % significant level in the SPSS statistical package.

RESULTS AND DISCUSSION

The CVR value of the knitted samples for each hybrid yarn was calculated by finding the average CVR value of the 5 images of each fabric sample. The effect of the production method and the change of yarn count on the CVR values of the hybrid yarns are shown graphically in Figure 8.

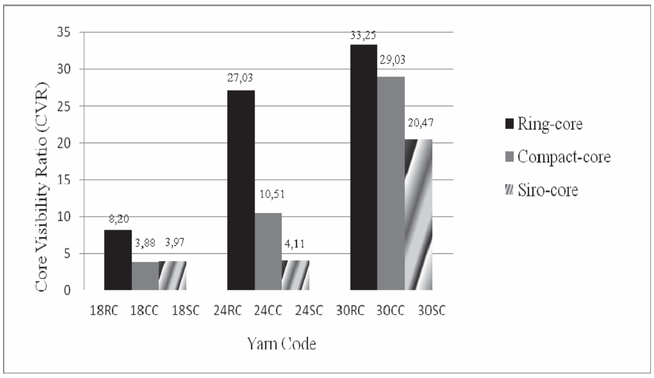

Figure 8. CVR values for different hybrid yarns.

As seen in Figure 8, it was found that the CVR values of RC method for all count levels were higher than that of the other hybrid yarns. According to Figure 8, it is seen that the CVR values of hybrid yarns containing metal wire are lower than that of Ne 18.

According to the ANOVA results, it was found that the production method (P=0,000), yarn count (P=0,000) and the intersection of these two factors (P=0,000) have statistically significant influence on the CVR values of hybrid yarns. According to the SNK test results, the difference between CVR values of RC, CC, SC production techniques were found to be statistically significant. Also the differences between CVR values of hybrid yarns at different yarn counts were found to be statistically significant (Table2).

The highest CVR value was obtained from RC production method. This was respectively followed by the CC and SC production methods as a result of modification on the ring spinning machine. This means that the fiber orientation in the yarn structure in modified ring spinning methods which are siro and compact spinning, was much better when compared with conventional ring spinning method.

Table 2. SNK table for the CVR values of the hybrid yarns.

Factor	Factor Levels	CVR
	RC	22,83 a
Production Technique	CC	14,47 b
	SC	9,52 c
	Ne18	5,35 a
Yarn Count(Ne)	Ne24	13,88 b
	Ne30	27,58 c

RC: Ring core-spun, SC: Siro core-spun, CC: Compact core-spun.

The lowest CVR value was obtained from Ne 18 yarn. This was followed by Ne 24 and Ne 30 yarn samples respectively. This can be explained by the fact that as the core-spun yarn count goes finer, core part of the yarn becomes more visible as a result of lower number of fibres in the cross-section of the yarn.

CONCLUSION

Besides the technical performance, aesthetic performance is also very important for the hybrid yarns containing stainless steel wire. In this study, firstly a new technique to determine the CVR of hybrid yarns has been developed. Then the influence of hybrid yarn production methods and yarn counts on the CVR values was evaluated.

Based on the CVR values of the core spun yarns, the best aesthetic performance in terms of hiding the stainless steel is obtained by siro core-spun method and Ne 18 count core-spun yarns. In addition, the CVR evaluation method developed in this study can also be used to determine the influence of core-spun production parameters such as feeding angle, twist, pre-draft on the appearance properties of hybrid yarns.

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