

A STUDY OF SELVEDGE WASTE LENGTH IN RAPIER WEAVING BY IMAGE ANALYSIS TECHNIQUE

KANCALI DOKUMA MAKİNASINDA KENAR TELEFİ UZUNLUĞUNUN GÖRÜNTÜ ANALİZ TEKNİĞİYLE İNCELENMESİ

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ABSTRACT

One of the most important constraints of shuttleless weaving machines is the necessity to form a false selvedge at both sides. The nature of selvedge formation in a rapier loom is analysed, and the variation in the length of weft yarn waste is measured by image analysis technique. The behaviour of weft yarn gripper at the entry into and exit from the shed are analysed by a high speed camera. The length of the trailing end of weft yarn is manually measured and digital image analysis technique is also used for the measurements. High speed film images are processed to measure the waste length of the weft and also the gap between the edge of the fabric and auxiliary warp yarns. An Image processing software is used for 2D measuring by sub pixel edge detection on the subsequent still image frames of high speed film. The measurements by image processing are found to be very close to the actual values, and it proves to be advantageous especially in case of stretch weft yarns.

Keywords: Selvedge, weft waste, rapier weaving, image processing, FFT algorithm.

ÖZET

Özet: Mekiksiz dokuma makinalarının en önemli kısıtlarından biri her iki tarafta yalancı kenar oluşturma ihtiyacıdır. Kancalı bir dokuma makinasında kenar oluşum süreci ve atkı kenar telefî analiz edilerek, atkı iplik telefî uzunluğundaki değişim görüntü analiz tekniğiyle ölçülmüştür. Atkı kavrayıcı kancanın ağızlığına giriş ve ağızlıktan çıkış anındaki davranışı yüksek hızlı kamera ile görüntülenerek, elde edilen görüntülerden ardışık resimler üzerinde imge işleme yazılımı kullanılarak 2 boyutlu ara piksel kenar sezim işlemi yapılmıştır. Görüntü analiziyle yapılan ölçüm sonuçlarının, gerçek değerlere çok yakın olduğu ve özellikle esnek atkı ipliklerinin ölçümünde kolaylık sağladığı görülmüştür.

Anahtar Kelimeler: Kumaş kenarı, atkı telefî, kancalı dokuma, görüntü işleme, FFT algoritması.

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Introduction

With the introduction of shuttleless weaving techniques in the last century, a new era of high speed weaving was launched. Over the last 40 years, shuttleless looms have been dominant in most segments of woven fabric production. Shuttleless looms are, however, unable to produce real selvedge, while a strong selvedge is created automatically at conventional shuttle looms since the weft which is inserted is practically endless and this results in the formation of a strong and continuous selvedge. This shortcoming is due to the natural phenomena of this weaving technique and overcome by the formation of false

selvedges. Whether it is real or false, a firm and strong selvedge is extremely important when producing woven fabrics, and also in their subsequent treatment. Therefore selvedge formation is essential and almost compulsory and it carried out on both sides of the cloth despite of certain constraints. Shuttleless machines are, therefore, equipped with a false selvedge mechanism.

The formation of a false selvedge, on the other hand, generates wastes in weft and warp yarns. The length of presented weft yarn needs to be slightly greater than the width of woven cloth so as to result in certain wastes as seen in Fig. 1. The ideal way is to present just long enough

pick length with a minimum number of auxiliary warps to carry out any specific selvedge making operation. The length of this extra weft yarn may be 7–9 cm at each side, accounting to as much as 9–10 % wastes.

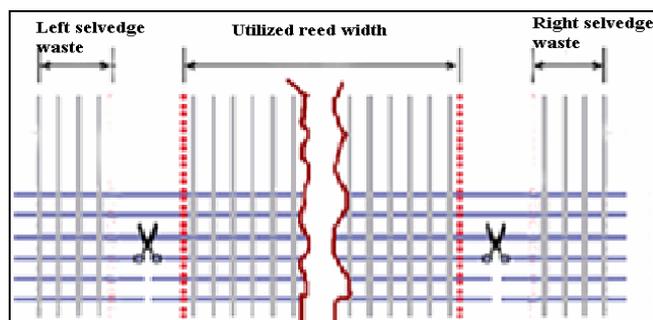


Fig. 1. Schematic view of selvedge formation on a shuttleless loom.

False selvedge is in fact a solid waste and is not useable in any other process of the unit hence increases the cost of woven fabric. Selvedge waste is always a critical problem of weavers because it directly contributes to the cost of fabric. It has been more critical with narrowing profit margins, especially when weaving expensive weft yarns. Thanks to the standardization and optimization work carried out within the frame of a project, the waste lengths are significantly reduced to 5-6 cm. The aim of this work is to determine the length of weft yarn waste and carry out this measurement by means of image processing technique.

There are very few studies concerning selvedge forming or avoiding weft wastes in weaving. A study by Jurasz [1], analyses the shuttleless weaving machines in terms of false selvedge. It is reported that the selvedge wastes could be as much 4-8% of total yarn consumption. Another work made by Kovacevic [2], makes comments about the effect of warp tension on selvedge fringes and fabric structure. Clear disruptions in cloth selvedge and fabric quality problems are observed when the warp tension is off the standard value. Lower warp tension makes selvedge fringes shorter than usual and also results in wider fabric width. These conditions increase the warp breakages and stoppage period. New techniques and machine settings for reduction of selvedge waste are discussed in two other works [3, 4].

Image processing technology has been widely utilized in textile manufacturing and inspections, including texture evaluation and examination of textile-surface characteristics. Computerized image capture and image analysis offer promising applications very rapid, accurate, and objective measurements of a wide range of textile-material properties. A measurement technique for fiber-crimp curvature, based on light microscopy and image analysis, was outlined by Swan and Mahar [5]. Image analysis and fractal geometry are used to define the three-dimensional structure of filament-crimping in another paper [6]. The diameter and twist angle of cotton yarns and jute-blended yarns were also assessed by an image analysis technique in another study [7]. Another study [8] investigated porosity values of filament woven fabric in relation to theoretically calculated values by image analysis. A recent study [9] has investigated the formation of periodical defects for several feeding configurations and the use of a false-twisting device by using high-frequency video. The coverage of core yarns

produced is evaluated using an objective method based on a Fast Fourier Transform (FFT) algorithm.

Materials and Methods

The work is carried out at rigid rapier weaving machine running in a large scale integrated woollen mill. The weaving loom is equipped with leno selvedge apparatus at both sides. The measurements are made during weaving of a plain cloth with wool / polyester (45/55) blend yarn count Nm 80/2 as warp and weft. Trials with stretch weft yarn with a count of Nm 80/2 (wool/ polyester/ elastane "44 dTex") are also carried out. The occurrence of selvedge waste at rapier loom is investigated by means of high speed camera. The entrance and exit of rapier head with tips of weft yarn, at the right hand side of the loom, are examined at consecutive weaving cycle as seen in Fig. 2. The films are taken by an Olympus i-Speed TR high speed camera with the speed of 2000 frames per second. The successive still pictures containing the movement of the rapier head with trailing weft at the exit of shed are examined and extracted separately. The loom running at 415 rpm needs approximately 0.15 second for each weaving cycle. That means a full weaving cycle covers around 500 frames of the high speed film, thus giving roughly 15-16 frames for the exit of the rapier head. The geometry and length of weft yarn trailing off the gripper head is examined by the Halcon 11.0 image processing software. The manual measurements are carried out by measuring the length of trailing weft waste caught by the auxiliary warp ends. The weft wastes are removed and stretched out on a metal ruler to read the precise length in cm.

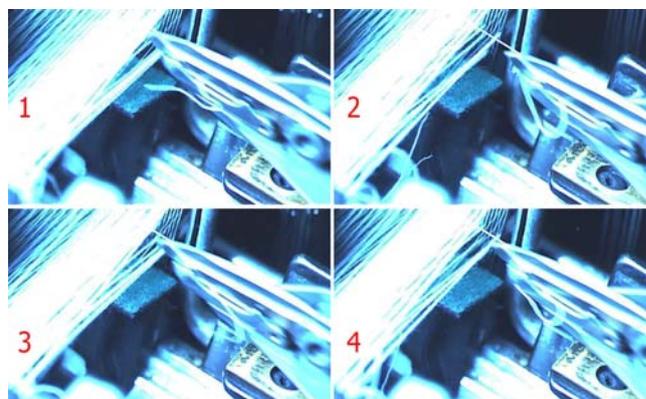


Fig. 2. Consecutive image frames corresponding to the exit of the rapier head.

Experimental Work and Results

Prior to the image analysing, some preparations are carried out. In order to obtain the correct measurements of the weft waste, the appropriate film squares are detected among the high speed film frames covering the extent of the rapier exit. The five successive loom cycles are investigated. Pre-processing is necessary to generate a binary images of each image frame which are to be used for calculations. In order to get the proper image containing the whole length of the weft waste, at first it would be convenient to select a particular region of interest. This region is chosen manually by the right camera position and assuming that the movement of yarn and rapier head shall be clearly visual within this position.

In this particular problem, it would be wise to use the knowledge of motion since the gripper in the video is moving. The gripper with the weft can be seen at left, and the gripper without the weft can be seen at right in Fig. 3. Therefore, background foreground subtraction method seems perfect in the solution of this problem. In order to implement this particular technique, the function of Sum of Absolute Differences (SAD) has been utilized after changing the color space from RGB to grey scale [10].

Since color space of the images (RGB) are transformed into grey scale, frames at time t_i could be represented as, where x and y are the coordinates of the pixels. Therefore, SAD is formulized by eq.1;

$$d_{ij}(x, y) = \sum_w |f(x_w, y_w, t_i) - f(x_w, y_w, t_j)| \quad (1)$$

Where; w represents the window, t_i and t_j are used to denote different time, represents all the pixel coordinates inside the window, and x, y are the center coordinates of the window. All the centroid points are calculated with the same formula by sliding the window from right to left and top to bottom which is called convolution in signal processing. The maximum number which this difference may have, is used to normalize SAD, that is $window_size * 255$ since the images are 8-bit. In our case, $window_size$ is 15^2 which means a square window with 15 pixel as an edge length. Therefore new formula will become;

$$norm\ d_{ij}(x, y) = \frac{1}{window\ size * 255} \sum_w |f(x_w, y_w, t_i) - f(x_w, y_w, t_j)| \quad (2)$$

$$motion\ mask(x, y) = \begin{cases} 1, & \alpha < norm\ d_{ij}(x, y) < \beta \\ 0, & otherwise \end{cases} \quad (3)$$

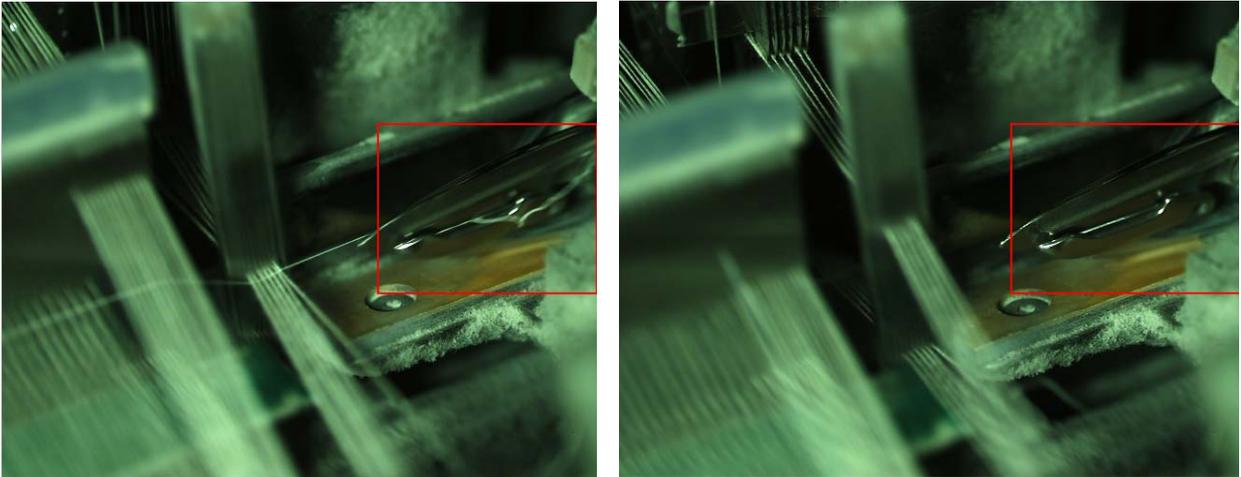


Fig 3. Figure on the left is the frame 40, and frame 210 is on the left and red rectangle represents the region of interest in both situation, with weft (left) and without weft (right).

$$total\ length = \begin{cases} add\ 1, & if\ x_{i+a, j+b} = 1\ and\ a * b = 0 \\ add\ \sqrt{2}, & if\ x_{i+a, j+b} = 1\ and\ a * b \neq 0 \end{cases} \quad (4)$$

Motion mask is generated by using double thresholding that can be written as;

Whereand β are the threshold parameters that have been adjusted for this situation, and chosen as 0.07 and 0.18, respectively, in order to eliminate undesirable motion that is considered as a noise.

The motion mask is created by using SAD which can be seen in Fig. 4. After that, connected component analysis has been made by using 8-connected neighbourhood that generates blobs with different labels. Some blobs may be filtered out if it is not desired. Consequently, elimination of undesirable noise is achieved, by using a threshold to the area of the blobs. Thanks to this analysis, smaller connected regions are eliminated.

Finally, motion mask needs to be thinned in order to manage the calculation of its exact length. Therefore, a specific thinning algorithm is implemented [11]. Even if there are still some noise in the last processed image, it has not been taken into account because of its small length. As a result, thinned image is used to calculate the length of the weft simply by counting the pixel either 1 or according to Pythagorean Theorem. Thinned image is a matrix containing zeros and ones. Therefore, assume that x_{ij} is a pixel that has a value of 1, and the decision of counting as 1 or $\sqrt{2}$ will be given by using

Where $a, b \in \{-1, 0, 1\}$ since a set of 8 neighbourhood is used. All pixels in the thinned image are counted with the same principle. Total length is the summation of distances between two pixels that has a value of 1. In accordance with the rules above, those distances can be either 1 or. In order to calculate total length, thinned image is convolved with a kernel, i.e.

$$\text{kernel} = \begin{bmatrix} \sqrt{2} & 1 & \sqrt{2} \\ 1 & 0 & 1 \\ \sqrt{2} & 1 & \sqrt{2} \end{bmatrix}$$

$$\text{Convolved}_{image}(x, y) = \sum_{n=1}^N \sum_{m=1}^M \text{thinned}_{image}(n, m) * \text{kernel}(x - n, y - m)$$

Where n and m represents the coordinates of the image, N and M are the size of the thinned image. In addition, Convolved image has the same size of the thinned image. Then,

$$\text{total length} = \frac{1}{2} * \sum_{n=1}^N \sum_{m=1}^M \text{Convolved}_{image}(n, m) * \delta(n, m)$$

$$\text{with } \delta(n, m) = \begin{cases} 1, & \text{if } \text{thinned}_{image}(n, m) = 1 \\ 0, & \text{otherwise} \end{cases}$$

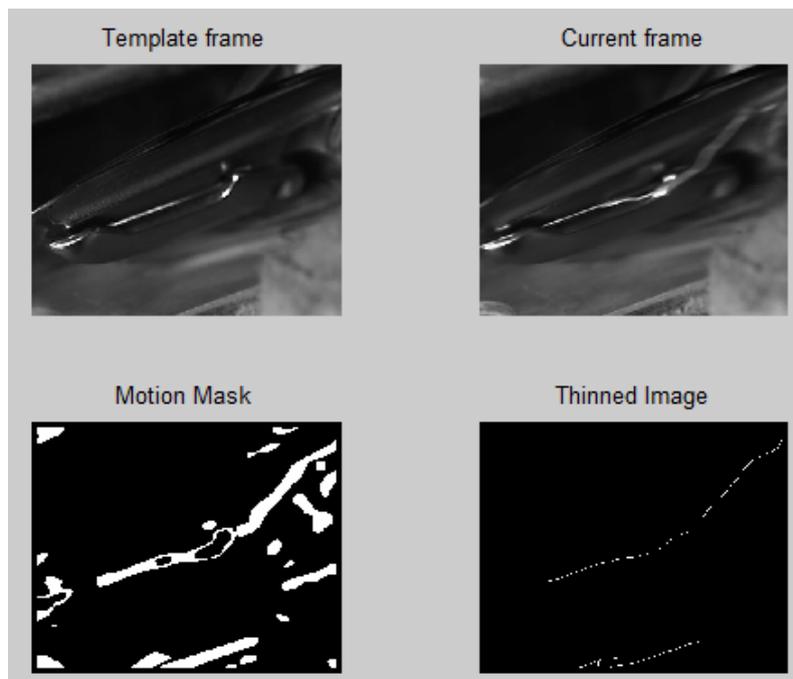


Fig 4. Template frame (background image), and current frame are in the top of the figure. Motion mask (in the bottom left). Thinned image (in the bottom right).

Finally, the length of a weft waste is calculated as 7.056 cm for the first pick which is presented in the Fig 4, whereas the actual length of that yarn waste is manually measured as 7.15 cm. This implementation will be adapted to real-time processing in future, and obtaining a template frame and a current frame could be determined automatically for further progress.

This procedure is also applied for further images obtained from the successive weaving cycles. The length of the four consecutive weft wastes are calculated as 7.09, 7.13, 7.07 and 7.32 cm. The comparison of the actual values with these calculated values are given in Fig. 5.

These values belong to the wastes occurred at the right hand side of the loom with regular non stretch weft yarns. The values at the left side are comparatively lower. There appears a small variation in actual measurements of weft lengths and it is mostly due to the weft tension variation during picking. Instant variation in the release timing of gripper head has also limited effect on the weft waste length. The results of calculation with image analysing technique using FFT algorithm reflects this variation and the results well confirm with actual values.

In the case of using stretch weft yarns, the waste length goes higher as much as 9-10 cm, and the variation between successive picks also becomes higher as expected. The calculation of stretch weft waste length by the image analysing is also achieved with almost similar deviations. It proves to be more advantageous with stretch yarns because of the difficulties in the actual measurement of the length of stretch weft wastes.

In this paper, a common technique of image analyses is applied to calculate weft yarn waste occurring during weaving. According to the performance comparison, it is

evident that this technique can detect the possible waste length and could possibly be utilized for better performance.

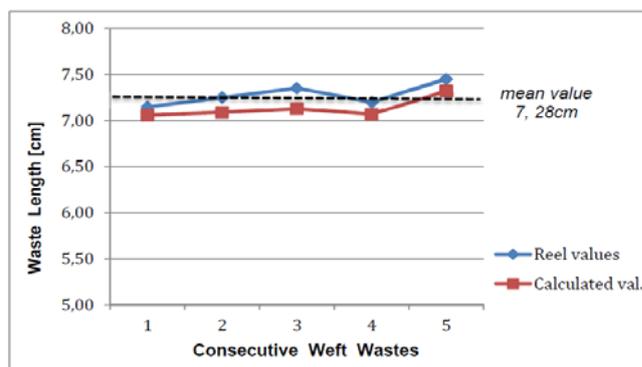


Fig 5. Comparison of actual and calculated length of the weft waste for the 5 successive picks

CONCLUSIONS

The avoidance of selvage waste is very important from both the production cost and sustainable textile production points of view. The mean value of the weft yarn waste is measured as 7.28 cm at the right side of the loom. The measurements of the weft yarn wastes by manual and image analysing are found to be very close. The difference between the mean values is found to be 0.146 cm which is equivalent to 2 % deviation. The calculation of weft waste length by image analysing appears to be a satisfactory and acceptable method. It is especially advantageous in handling of stretch weft yarn.

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