A Vision-Based Method For Analyzing Yarn Evenness

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Abstract: Yarn evenness is a key factor in its performance and in the properties of the material produced from the yarn. The presence of defects in a yarn will result in the deterioration in the quality and usability of the yarn. While many methods are available to ascertain the yarn evenness many of them are tedious and dependent on the operator for its results, while others, though less subjective and of high speed, are prohibitively expensive. This paper outlines a method which uses a cost-effective image capture device and image processing algorithms to process the captured images, generate a diameter variation plot and analyse the same to count the number of thick and thin places in the yarn.

Index Terms: diameter variation plot, evenness testing, image processing, thick places, thin places, yarn diameter, yarn evenness.

1 INTRODUCTION

Yarns are an important material in the textile manufacturing process. Yarns may form the immediate raw material for the manufacture of fabric, sewing threads, cables and other products. Yarn without defects helps to create a fabric of good quality. During the manufacturing of fabric yarn must pass certain elements of machines continuously without any disturbance to the motion. In knitting yarn will be dragged by needles, while in weaving yarn will go through heald wires and reed. The parts of the respective machines are very sensitive to the variations in yarn evenness. Thus the evenness of yarn plays a crucial role in the textile manufacturing process. Yarn evenness, which may be broadly defined as the variation in the linear density or thickness of the yarn, can be considered as a basic, but essential property because it can affect all the other properties of yarn and the fabric formed from it. The irregularity of the yarn can lead to breakages during spinning, winding, knitting and weaving processes. In addition, yarn irregularity will often result in variations in other properties such as the yarn count, twist and strength. If uneven yarn became part of the fabric, it will result in visible faults on the fabric surface, as well as compromising performance properties such as the strength of the fabric. Defects such as streaks, stripes, barre effect or other visual groupings which develop in the cloth will lead to uneven dyeing and finishing of the fabric. Ultimately the unevenness of yarns will seriously influence the quality of the material. Especially in natural staple yarns it is virtually impossible to have fibres without variations in thickness. In addition, processing constraints make it practically impossible to manufacture perfectly even yarn. Thus knowledge of the evenness of the yarn is essential in determining the quality and resultant suitability of a yarn for a particular end-use. When it comes to the testing of evenness of the yarns, the USTER yarn evenness tester is one of the popular machines used to check the evenness of the yarn. While the newly developed testers give comprehensive details of yarn defects, there are several drawback and limitations in getting accurate details of the yarn profile from these testers.

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2 EXISTING METHODS FOR EVENNESS TESTING

2.1 History

One of the earliest publications on the study of yarn evenness was by Martindale as early as 1945 [1], where he introduced the basic concepts and discussed different ways of describing yarn evenness. This served as a basis for the study of yarn evenness, and over the years many methods have been devised based on the derived understanding of yarn evenness to measure the same. One of the earliest and simplest methods is to cut the yarn into set lengths and weigh each length, and then calculating the mean and variation of the weights of each length. This method, while simple and cheap, is tedious, as a very large number of readings are required in order to get a reliable result. There should also be a foolproof way to cut the yarn to ensure that all lengths are equal, which is easier said than done. Another way of evaluating yarn evenness is by visual evaluation. A common method is to wrap the yarn on a tapered blackboard, and then evaluate them under light to provide a grading. Again, while being relatively simple, the method has some inherent challenges, such as the need to obtain even-spaced wrapping, and the subjective nature of visual evaluation. ASTM provides a set of photographic standards for spun yarn [2].

2.2 Current Methods

The USTER evenness tester is used widely in the technical world for yarn evenness testing. This method uses the change of capacitance is used as its working principle. The yarn is fed through two capacitance plates at a certain speed, with several capacitance plates available to be selected according to the count of the yarn. When the yarn enters in to the capacitor region with a certain speed, the capacitance of the polar plates will increase, and the change of the capacitance is analogous to the actual volume of the yarns in the polar plate. Thick places, thin places, neps and the CV% of the yarn will be indicated according to the capacity variation. [3] While the Uster Tester has many advantages of measuring the evenness of the yarn and providing a variety of additional information, the capacitance of the plates may be affected by atmospheric conditions and by variations in the blend, thus resulting in erroneous readings. In addition, Li et al [4] point out that it is not suitable for on-line measurement, neither can it directly provide the characteristics of the yarn structure. Mahmoudi and Oxenham came up with an electro mechanical yarn thickness tester [5]. After being deposited on a yarn accumulator, the yarn is drawn between two vertically mounted measuring rollers and a pair of take-up rollers. This method uses a stepper motor to provide an accurate interval length of yarn between tests. It also provides information about the effect of compression. However this method is subject to wear and tear, and is more suitable for the measurement of sliver thickness. The CTT (Constant Tension Transport) Yarn Performance Tester was developed by Dairong Zhang and Ling Cheng [6]. This uses a CCD camera, a CTT yarn supply system photoelectric components. While the factors affecting the Uster tester will not affect this tester, electromagnetic disturbances may cause errors in the readings. Li et al [4], have proposed an image processing based system where a photoelectric method comprising an image acquisition system, a computer processing system, and an USTER evenness tester is used. It is claimed that this system has a strong correlation to the results of the USTER tester, while being superior as it is not affected by the quality of the yarn. Image processing techniques have also been used to assess the slub yarns in the industry. Slub yarns are wrapped around a black cardboard using a YG381 yarn evenness tester. Then images of the yarn will be scanned by a high resolution scanner. Then the images will be analysed using image processing toolbox and the small objects such as hairiness and dust of the yarns will be deleted from the image in order to enhance the image quality. Then the slubs will be separated from the base yarn according to the mean diameter [7]. This method, while having similarities to the method proposed in this paper, is restricted to detecting slubs, whereas the proposed method looks at other defects as well.

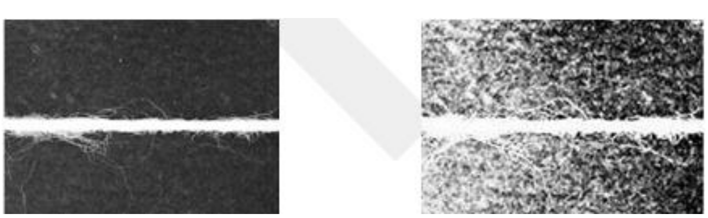
3 Proposed Method

3.1 Selection of an Appropriate Image capturing Device

A number of different digital cameras were considered and images taken with them analysed. However it was found that the zooming capabilities of these devices were a limiting factor to obtaining images of the required quality. The captured image could not be satisfactorily scaled and analysed. In addition the frame capture rate in the digital cameras was comparatively low. For this reason a digital microscope with 200x zooming capability and a frame capture rate of 30 frames per second was used. The device used was portable and could be interfaced via a USB port to the computer.

3.2 Image Processing of Captured Images

Histogram equalization and the use of different thresholding levels were tried out in order to correct the image and extract its contours.



(a) (b)

Fig. 1- *(a) Image of yarn on black background (b)Resultant image after histogram equalization*

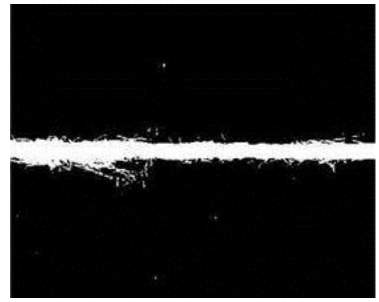


Fig. 2 *– After thresholding at 0.5658*

Different filtration methods were tried out, and it was found that median filtration used with averaging filters gave the best results. Average filtration served to remove the excess hairiness of the yarn.

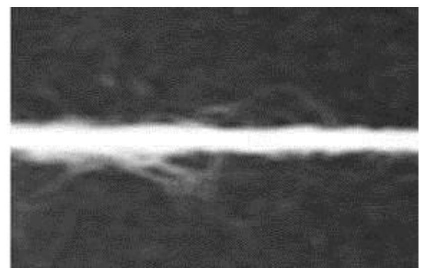


Fig. 3 *– After filtration*

In the next stage the image intensity was adjusted to facilitate further processing.

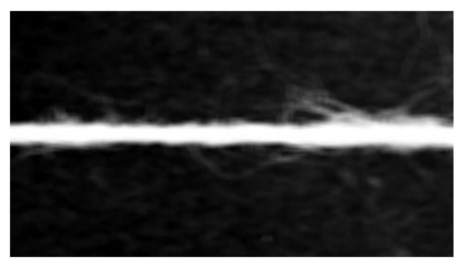


Fig. 4 *– Contrast adjusted image*

In the next step a threshold value was calculated for the contrast adjusted image, and using a threshold value of 0.4765 the binary image in Fig. 5 was generated.

Fig. 5 *– Binary image generated after thresholding at 0.4765*

Finally morphological operations were carried out to remove small distortions or noise less than the defined amount of pixels, resulting in Fig. 6.

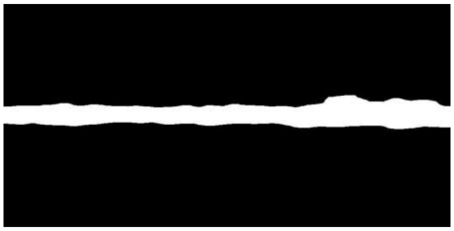


Fig. 6 *– Cleaned image after morphological operations.*

3.3 Analysis of Images

The images obtained from the length of yarn being analysed using Matlab. Fig 7(a) shows the processed image of a yarn and Fig 7(b) the equivalent diameter variation plot.

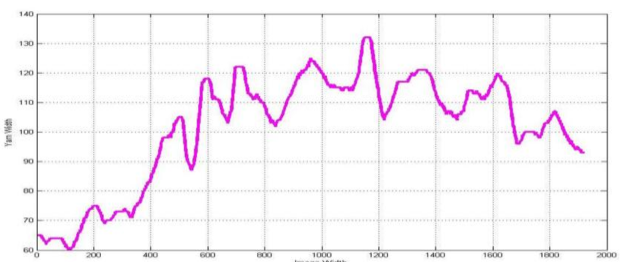


Fig. 7 *(a) – Processed yarn image*

Fig. 7 *(b) – Matlab-generated diameter variation plot*

The calibration calculation was done as follows: an image was taken from the image capturing device using a similar zooming level used to capture the images of yarn. Then a Matlab program was used to convert the image taken to binary image. Then the number of pixels was counted and plotted to a graph. Finally the average number of pixels was calculated in order to obtain an accurate result. The calculations made identified that

1 pixel = 0.005119 mm

The above relationship was used to identify the range for acceptable thickness for a yarn, and thick and thin places were identified accordingly. An example is show in Fig. 8.

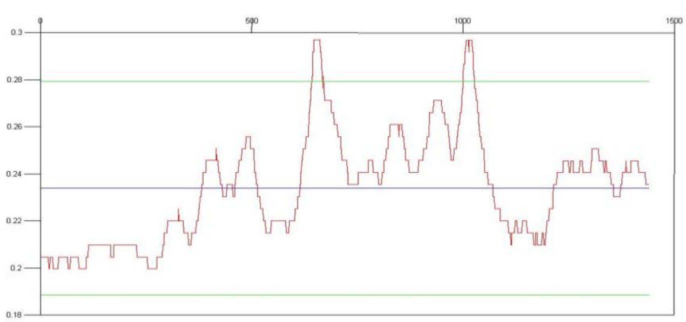


Fig 8 *– Matlab plot of the diameter variation of an image of the yarn*

In the above figure the acceptable thickness range in pixel values lies between 0.1886 cm and 0.2794 cm. Thus the above plot shows two thick places. These results were found to tally with the results as examined under a projection microscope.

4 Conclusion

The method was found to be a cost-effective one to accurately identify thick and thin places in yarn by processing images captured from stationary yarn. It would be desirable if the program can be modified to capture images from movi, ng yarn and process the same to identify the defects in the same. The method worked well for white yarns, but showed varied results for coloured yarns. This also needs to be addressed in future work. Finally, this method will be even more effective if it can incorporate a way to identify slubs and neps.

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