Ozkan Celik, Nuray Ucar*, Seniz Ertugrul

Istanbul Technical University
Department of Mechanical Engineering,
*Department of Textile Engineering
Inonu Caddesi, No: 87, Gumussuyu 34437,
Istanbul, Turkey
Tel: +90 212 293 13 00
celiko@itu.edu.tr
ucarnu@itu.edu.tr
seniz@itu.edu.tr

Determination of Spirality in Knitted Fabrics by Image Analyses

Abstract
Spirality is a problem in knitted fabrics, especially in the apparel industry. Even though aspects of spirality have been studied in the literature, no papers have appeared which explicitly determine the angle of spirality in knitted fabrics. Therefore, the goal of this study is to develop an algorithm to determine the angle of spirality using image analyses. The proposed algorithm has yielded fast and accurate results.

Key words: *spirality, knitted fabrics, image analyses.*

Introduction

It is necessary that the wale on the knitted fabric be perpendicular to the course. However, the wales are not always perpendicular to the course and skew to the right or left, forming a spirality angle as seen in Figure 1 [1, 3]. This creates a serious problem, especially in the apparel industry.

The spirality problem has been investigated by several researchers [1-5]. Araujo and Smith [1, 2] studied the effect of machine, yarn and fabric properties on the fabric spirality. They determined that spirality depends on machine cut, feed density, machine rotation direction, loop shape, yarn twist value (twist liveliness) and yarn twist direction. They suggested using S-twist yarns in machines rotating counterclockwise and Z-twist yarn in machines rotating clockwise. Plied yarns, plating techniques and yarns with different twist directions can be used to solve or reduce this problem. They also presented an empirical model to predict fabric spirality on the fabric. Tao et.al.[3, 4], developed a yarn modification process on rotor-spun and friction-Spun DREF III yarn to eliminate the spirality problem. They concluded that modifying a rotor-spun yarn greatly reduces spirality and improves the fabric handle. However, they also stated that modifying rotor-spun degraded yarn tensile strength, burst strength and fabric pilling. On the other hand, modified friction-spun DREF III yarn reduces yarn snarling and fabric spirality. This modification process has resulted in higher yarn hairiness, fabric weight reduction, an increase in air resistance and reductions in thermal conductivity, yarn tenacity and elongation percentage at break. Banerjee & Alaiban [5] have also worked on the spirality problem. They explained that the full relaxation process may decrease or increase spirality, depending on whether the tightness factor of fabric is greater or less than 14.0.

The measurements of spirality on these studies have been carried out by the conventional method. The conventional measuring method takes time, and also depends on human measuring precision. Therefore, in this study, a fast, accurate and objective method has been developed to measure spirality in fabrics by using image analysis techniques which can also be implemented on-line. In the literature, there are several studies to measure the weft and warp yarn placement on woven fabrics by using image analysis techniques [6-9]. Kang et.al. [6] analysed several fabric qualities such as count, cloth cover, fabric thickness, fabric weight, yarn crimp and the orthogonality of the yarn intersecting angle on woven fabric by image processing. They have used the grey values of the minimum points of an average profile in the x and y direction to determine the orthogonality of the yarn intersecting angle. Ravandi & Toriumi [8] measured woven fabric characteristics such as directionality, the density of yarns protruding from the fabric body and yarn spacing, by using an angular Fourier Power spectrum and an/its autocorrelation function for plain weave cotton fabric. Xu [9] applied Fast Fourier Transformation (FFT) on woven fabric

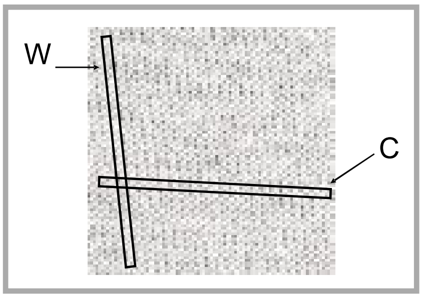

***Figure 1.** A wale and a course on a knitted fabric.*

images to identify weave pattern , fabric count and yarn skewness. Harwood et.al. [7] also studied the measurement of the straightness of the weft threads on the back of a woven carpet by analysing the intensity of the signal obtained from a CCD line scan camera and point sensors. Chen et.al. [10] studied the detection and classification of defects on woven fabrics using the Fourier transform. In their study, they determined the actual x and y axes of the spectra, because the wefts and warps of the samples are in different directions from that of the x and y axes of the CCD camera. They drew straight lines passing through the centre and having 1^{o} increments. Then, they added the intensity of the power spectrum at every point along each line, until the line with the maximum sum was reached.

All the studies mentioned above focused on the measurement of several woven fabric properties such as weft and warp yarn placement, fabric count, weave pattern, woven fabric skewness, etc. Although several methods have been used to determine skewness on woven fabrics, no study is available in the literature which specifically determines the spirality of knitted fabrics. In general, image analyses of knitted fabrics involve difficulties due to the loop structures and yarn hairiness, compared to woven fabrics consisting of neat warp and weft yarns. Therefore, determining the spirality angle of knitted fabrics using image analyses is quite a challenging problem.

Methods

The cotton-plain-knitted fabric samples used in this study have been prepared as 3×3 cm squares. Images of the samples have been acquired via a scanner and stored as greyscale images of 256×256-pixel resolution. The 256×256-pixel sized images obtained by cropping correspond to a square area smaller than 3×3 cm. Each pixel in the images has a value between 0 and 255, 0 being black and 255 being white. No image filtering has been used.

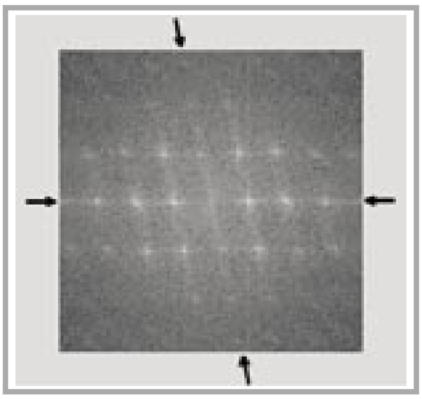

Figure 2. Logarithmic spectrum. Arrows indicate the lines in the horizontal and vertical directions passing through the most evident peaks and intersecting in the centre.

The proposed method is based on image-processing techniques, specifically the Fast Fourier Transform, for obtaining the directions of the wale and the course in order to measure the angle of spirality.

The first step in the algorithm is to apply the Fast Fourier Transform (FFT) to a two-dimensional discrete function, i.e. the image [9, 10, 11]. By doing so, a power spectrum of the image has been obtained. It is more convenient to observe the power spectrum in terms of logarithmic spectrum [11]. The logarithmic spectrum of a sample fabric image can be seen in Figure 2. The distribution of the peaks in the logarithmic spectrum is related to the direction of wales and courses. The spirality angle can be calculated using this information.

The most visible peaks (white regions) lie in the horizontal direction carrying the information about the periodicity of the wales. Similarly, the most visible peaks which lie in the vertical direction carry the information about the periodicity of the courses. Thus, the lines in the horizontal and vertical directions passing through the most visible peaks and intersecting in the centre have to be determined to lead us to the angle of spirality. Thresholding is applied to pixels of the logarithmic spectrum image so that pixels with intensity values below 128 (in the range of 0-255) are set to 0. This thresholding operation made the most visible peaks more dominant, and prevented false detection of direction. The values of pixels located on a line which passes through the centre peak were summed up by rotating the line in order to find the line with the maximum summation value. The line with maximum summation value represents the direction of the course or the wale.

Table 1. t-test results for 10 sample groups.

Sample Group	Measured spirality angle*	Calculated spirality angle*	t-test**	Significance ***
1	11.0	10.4	1.40	Insignificant
2	16.9	16.1	2.75	Insignificant for 99% con.lev. Significant for 95% con.lev
3	12.5	12.8	0.89	Insignificant
4	12.3	11.2	3.97	Significant
5	6.5	6.7	0.43	Insignificant
6	12.5	12.3	0.37	Insignificant
7	12.0	11.1	2.12	Insignificant for 99% con.lev. Significant for 95% con.lev
8	16.1	16.2	0.29	Insignificant
9	11.5	10.3	3.08	Significant
10	The algorithm has determined a false direction for the wale.			

* Mean value of ten measurements
** t=1.83 for 95% confidence level and t=2.82 for 99% confidence level
*** For 95% confidence level

Results

10 different plain knitted fabrics with varying fabric properties are used to form 10 groups of data, and 10 samples are prepared for each group. Firstly, the spirality of the fabrics are measured manually [3]. Then, images of all samples are processed with the spirality angle calculating algorithm written in Matlab. The t-test is applied to see the significance of the difference between the measured and calculated spirality angles. The results of the t-test are given in Table 1.

As seen from Table 1, the differences between the calculated and measured spirality angles are not generally greater than one degree. Among 10 sample groups, only 2 groups display significant differences in t-test, and only the last sample group caused incorrect direction detection.

Conclusion

It can be said that the algorithm is quite satisfactory in determining the angle of spirality in knitted fabrics for 7 groups of fabrics out of 10. In samples with significant differences according to the t-test, the means of measured and calculated spirality angles still differ by about 1.2 degrees. Therefore this algorithm, which is simple, fast, and objective, can be very useful in determining the spirality angle during both laboratory work and manufacturing. Only group 10 appears as a serious problem for the programme, and requires further study.

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The 60th Anniversary of the Textile Research Institute (IW) in Łódź, Poland

The two-day celebration began on September 12, 2005 at the New Theatre in Łódź with a ceremonial meeting which was attended by invited guests, as well as former and present employees of the Institute. The official part of the meeting was opened by Jolanta Mamenas, the managing director of the Institute, who presented the Institute's foundation and history, its main achievements, and the outstanding researchers who have worked there since its foundation. Many congratulatory addresses followed, including from Stefan Krajewski, the Voivode of Łódź (provincial governor of the Łódź region), Marek Bartosik, the Ministry of Scientific Research and Information Technology, Prof. Jan Krysiński, the Rector of the Technical University of Łódź, Prof. Tadeusz Więckowski, the Rector of the Technical University of Wrocław, Prof. Tadeusz Kulik, the Rector of the Technical University of Warsaw, Prof. Janusz Szosland, the Honorary Chairman of the Polish Textile Association, Prof. Eckhard Schollmeyer, Prof. Henrik Wenzel, Prof. Marc van Parys, Dr. Victoria Vlasenko, and Dr Tatyana Chibisova, representatives of the Deutsches Textilforschungscentrum Nord-West e.V, Krefeld (Germany), the Technical University of Denmark; the Technical University of Ghent and UNITEX (Belgium), the Kiev National University of Technology and Design, Kiev (Ukraine), and the Nonwovens Research Institute, Serpukhov (Russia) respectively, and Prof. Izabella Krucińska, the Dean of the Faculty of Textile Engineering and Marketing, Technical University of Łódź.

Jadwiga Sójka-Ledakowicz Ph. D., Eng., the Institute's vice director responsible for scientific research, was awarded the Gold Cross of Merit, and Bogna Goetzendorf-Grabowska Ph. D. Eng., & Halina Królikowska M. Sc. Eng. –were awarded the Silver Cross of Merit; and 28 former & present employees were awarded congratulation letters.

The official part of the meeting was followed by the comedy '*Mayday*' written by Ray Cooney, and by a dinner-party. The second day of the Anniversary celebration took place at the

International Scientific Symposium 'New Vision of Textile Industry and Economic Needs'

at the Dobieszków Conference Hall. The following lectures were presented:

- **'Nanotechnology to Functionalisation of Textile Materials'** by *Prof. Eckhardt Schollmeyer, DTNW, Krefeld, Germany.*
- **'Perspectives for Material Engineering at the Beginning of the 21st Century'** by *Prof. Krzysztof J. Kurzydłowski, Technical University of Warsaw.*
- **'Biotechnology in the Textile Industry'** by *Dr Jadwiga Sójka-Ledakowicz, Textile Research Institute, Łódź .*
- **'Our Engineering Is Your Change to Innovations'** by *Prof. Mark van Parys, I. Garez, M.Eng., A. Deraeve, M.Eng., Technical University of Gent, Belgium.*
- **'Microporous Polyurethane Membranes as a Basic Component of Multilayer High-tech Composite'** by *Prof. Stefan Brzeziński, IIMW, Łódź.*
- **'Current Multifunctional Multiplayer Textiles: Unlimited Possibilities of Their Application'** by *Dr Victoria Vlasenko, EKMA, Kiev, Ukraine.*
- **'Research and Innovation in Textile Industry: the Role of Technological Centres'** by *Dr Jan Laperre, Centexbel, Ghent, Belgium.*
- **'Textile Dyes: Past, Present and Future'** by *Prof. Wojciech Czajkowski, Technical University of Łódź.*
- **'Savings of Water and Energy by Process Integration in Polyester Dyeing: Latest Achievements and Perspectives'** by *Prof. Henrik Wenzel Christensen, IPU, Lyngby, Denmark.*
- **'Modern Methods of High Quality Yarn Production'** by *Prof. Tadeusz Jackowski, Dr Danuta Cyniak, Dr Jerzy Czekalski, Technical University of Łódź.*

An open-air party ended the anniversary celebrations.

TEXTILE RESEARCH INSTITUTE
Brzezińska 5/15, 92-103 Łódź, Poland
Tel. (director) (+48 42) 616-31-00
Fax (+48 42) 679-26-38
e-mail: info@mail.iw.lodz.pl http://www.iw.lodz.pl