

Jihong Liu,
Zhengxin Li,
Yuzheng Lu,
*Hongxia Jiang

Creative Digital Media Research Center,
School of Textile and Garment,
Jiangnan University
Lihu Road 1800, Wuxi, Jiangsu, China
E-mail: liujihongt@hotmial.com

* Faculty of Textile Science and Technology,
Shinshu University,
Tokita 1, Ueda, Nagano
E-mail: jianghongxiatex@hotmial.com

Visualisation and Determination of the Geometrical Parameters of Slub Yarn

Abstract

This paper presents an analytical method of determining slub yarn geometrical parameters based on a 2D visualisation image of a slub yarn. The method can be used to adjust the slub yarn mechanism by comparing experimental results with the setting used. Geometrical size data of slub yarn are acquired by DAQ (Data Acquisition Card), and expressed as voltage signals. The dynamic threshold method is used to separate the base and slub parts, and the geometrical parameters of each part can be acquired through analysis of the new curve. The slub length can be plotted against the distance between slubs to give a 2D visualisation of any pattern in the periodicity. Characteristic lengths and spacing can be estimated from the plot. According to the experimental results, the slub length is longer and the slub distance shorter than the values set for the mechanism of the spinning frame.

Key words: slub yarn, geometrical parameter, determination, visualisation, signal.

mass decrease and the repetition pattern of the slub yarn. A kind of device (Jiangnan University: ZJ-V) was developed to produce slub yarn, and the parameters can be adjusted manually in the device. But when a specimen of slub yarn is given, it is difficult to obtain the parameters that can be used in the device. Therefore, determination of the parameters is a very important process in the analysis and manufacture of slub yarn fabric.

A practical method for determination of the slub yarn parameters of a specimen is to count slub parameters based on the yarn black boards. However, the measurement results do not coincide with the setting of the slub yarn mechanism. In fact, the difference between the measurement results and the setting of the results differ by various causes, including the production process. Therefore, some processes should be provided to eliminate the difference. Judgment of the repetition pattern of the slub yarn is a difficult process in terms of recognition. The repetition pattern of the slub yarn cannot be obtained through a frequency domain method. The parameters of slub yarn are listed in a table, and the statistical method is provided to analyse the repetition pattern. Therefore the practical method demands special skills of the workers. The repetition pattern of slub yarn is calculated after checking the the initial length of the yarn. As well as being quite complicated and time-consuming, when using the measurement method it is easy to make a mistake, and an accurate repetition pattern cannot be found without testing for a long time. Such a problem is known to be critical and has not yet been efficiently and effectively solved. More recently, the Uster® tester 5 [13]

and Liu et al. [14] have provided easier and more accurate assessment tools, supplying a full picture of slub yarn characteristics. The tools include a scatter plot, slub classification matrix, histogram, slub sequence diagrams, bar charts, spectrogram and impressive 3D displays, all of which offer the capability of analysing slub yarn. The application report [15] of the Uster Tester 5 pointed out that the slubs measured do not coincide with the settings of the slub yarn mechanism of the spinning machine. As mentioned by Uster, the resulting slub yarn depends on the settings of the spinning machine, the raw material, the yarn guiding elements, etc. However, there is little literal and theoretical explanation about data processing, and there has yet been no determination of the repetition pattern of slub yarn nor of the setting of the slub yarn mechanism to coincide with the specimen.

This paper outlines an analysing process for slub yarn parameters and an auxiliary method of acquiring parameters from the specimen to set the slub yarn mechanism based on a 2D visualisation image of the parameters of the slub yarn and comparison of the experimental results with the setting parameters. The slub length and distance were selected as an example, and the methods of visualisation and determination were analysed. Slub yarn geometrical parameters are transferred to a 2D visual image to analyse the parameters, which are identified by observing the image. Utilising the method, operators can confirm the parameters approximately, and then they can accurately measure the slub and distance by pulse according to the type of slub yarn. Therefore the method can partially substitute the traditional method and increase efficiency.

Introduction

Slub yarn is a kind of fancy yarn, and fabrics woven from it acquire special aesthetic properties through slub effects formed by variation in the linear density of slub-yarn [1]. Fancy yarn has been researched recently. Kwasniak [2 - 4] presented the application of a pressurised-air method for the manufacture of fancy yarns on standard rotor-spinning machines. Pouresfandiari [5] proposed and discussed a new method of producing loop fancy yarns. Wang et al. [6] researched property parameters of slub yarn. Richard [7] used an Uster Tester to evaluate the quality of slub yarn. Liu et al. [8, 9] presented a rapid and accurate approach for automatic detection of slub in fabric images using Gabor filters. Therefore it is widely used in a variety of garments and decorative fabrics. The special aesthetic characteristics of slub yarn fabric are determined by the apparent parameters of the yarn, as fancy yarns have a special structure property [10 - 12]. The parameters include the slub length, slub distance, mass increase or

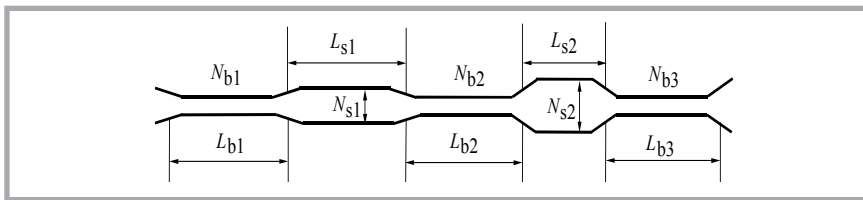


Figure 1. Geometrical parameters of a slub-yarn.

Table 1. Repetition pattern of specimens for three types of slub yarn.

Type	Setting parameters		Repetition pattern	Periodicity
	Slub length	Slub distance		
Periodic slub	$L_{s1}, L_{s2}, L_{s3}, \dots$	$L_{b1}, L_{b2}, L_{b3}, \dots$	$L_{b1}, L_{s1}, L_{b2}, L_{s2}, L_{b3}, L_{s3}, \dots, L_{b1}, L_{s1}, L_{b2}, L_{s2}, L_{b3}, L_{s3}$	Yes
Random proportion slub	$L_{s1}, L_{s2}, L_{s3}, \dots$	$L_{b1}, L_{b2}, L_{b3}, \dots$	L_{b1} or L_{b2} or L_{b3}, L_{s1} or L_{s2} or L_{s3}, \dots	No
Random slub	L_{s1}, L_{s2}	L_{b1}, L_{b2}	$L_b \in (L_{b1}, L_{b2}), L_s \in (L_{s1}, L_{s2}), \dots$	No

Slub yarn structure and signal characteristic

Structure

A simpler structure of slub yarn can be described as follows: slub yarn is composed of two parts: the base part and the slub part. The appearance is influenced by the length and linear density of each constituent part. Figure 1 indicates the geometrical parameters of the two parts. The boundary of the base part and slub part are defined as half of the height of the trapezoid of the slub part. The length of the slub is defined as the length between the start and finish of the slub part. The distance of the slub is defined as the length from the end of a previous slub to the start of the subsequent one. Where L_{bi} is the length of the base yarn, N_{bi} is the linear density of the base yarn, L_{si} is the length of the slub with linear density N_{si} ($i = 1, 2, 3, \dots$). The repetition pattern of the slub yarn is determined by the range of the parameters: slub length, slub distance and mass increase. We will introduce how to determine the repetition

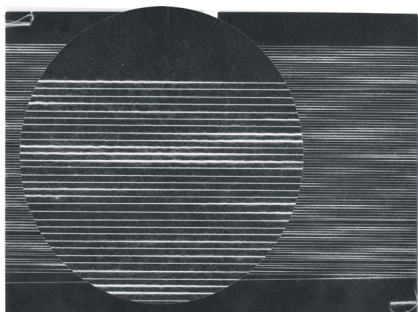


Figure 2. Snapshot of a slub yarn wound on a blackboard.

pattern. Figure 2 shows a snapshot of a slub yarn wound on a blackboard. In the Figure, convenient for observing a part of a slub, the yarn (base yarn count: 18.2 tex, slub amplitude: 250%) was first spun. Then the yarn was wound on the blackboard; after that a photo was taken of the blackboard. The circle part is an enlarged part of the blackboard.

Characteristic of slub yarns signal

Although there are still problems in calculating the repetition pattern of slub yarn, there are three main kinds of slub yarn, as shown in Table 1, differentiated by the repetition pattern as indicated by the definition of the slub yarn mechanism ZJ-V. They are periodic slub, random proportion slub and random slub. Periodic slub yarn has a cycle in its parameter setting, which means there are repeats of the slub length and slub distance according to the ranking of parameters. The parameters can be obtained after establishing an adequate length of the slub yarn. Random proportion slub is when the parameters in a certain series of data are chosen randomly, while random slub yarn parameters are chosen from a setting range of data; these two kinds of slub yarn are the main ones manufactured, the parameters of which can be acquired after checking more lengths of yarn.

Slub yarn is produced on a spinning frame with a slub yarn controller installed. Yarn unevenness is inevitable during the manufacture. The unevenness will form noise in the signal of the slub yarn.

Determination processing

Yarn preparation

In order to acquire accurate geometrical parameters of slub yarn, a specimen yarn of adequate length should be prepared. The slub length and distance can be easily obtained after checking a few meters of the yarn; however, the repetition pattern of the slub yarn needs more yarn. At least 1000 m of specimen yarns were prepared for the determination process in the measurements.

Data acquisition

A capacitance – type sensor is prepared to check the specimen yarn, through which the range of yarn line density produces a change in the output voltage. The capacitance – type sensor on an Uster tester (Zellweger Uster Ltd.: U1-M0-B) is used to transfer the line density of the slub yarn to voltage, and data of the voltage signal can be obtained based on a DAQ card. As the voltage is proportional to the line density of the yarn, the curve of the line density of the slub yarn specimen can be acquired through multiplying it by a coefficient.

Data processing

The curve of the slub yarn line density is interrupted by some noise rising from the yarn manufacture, which is unavoidable. Therefore some data processing should be carried out to reduce the noise. Three steps are necessary before parameter analysis.

Dynamic threshold

The following process is to separate the slub part from the base part, and the dynamic threshold is established to set the boundary. The curve of slub yarn is not even; the average voltage of 20 metres of slub yarn is calculated as the threshold substituting half of the height of the trapezoid of the slub part. The voltage of the yarn part exceeding the threshold is related to the slub part, while the other part is related to the base yarn part. Slub yarn can be separated into two parts: the slub part and the base yarn part, and the pulse wave signal is used to describe the two parts.

Condition filtration

Some peak values of the base part are more than the dynamic threshold because of the unevenness of the base yarn. Condition filtration is utilised to eliminate these peak values. During the

manufacture of slub yarn, the smallest slub length is more than 25 millimeters. In this research, 25 mm is selected as the condition filtration threshold. All the slub length acquired from a curve shorter than 25 millimeters is considered as the base part, and a pulse curve can be obtained after condition filtration. In future practical application it is better to allow the user to select the condition filtration threshold.

Visualisation and determination of parameters

The parameters of the slub yarn are expressed by the final curve. The pulse length is related to the slub length, and the pulse distance is related to the slub distance. The parameters of the slub yarn are obtained after checking at least 400 meters of yarn. The repetition pattern of the slub yarn can be obtained from the data. Plot the parameters in an image using the length of the slub as the x-axis, and the distance of the slub as the y-axis. Observe the final image and get a repetition pattern.

Thus, the procedure of data processing is deduced as follows.

Table 2. Periodic slub yarn (specimen 1).

Slub length, mm	Slub amplitude, %	Slub distance, mm	Repetition pattern
30	200	250	30, 250, 70, 200, 50, 150, 30, 250, 70, 200, 50, 150
70	200	200	
50	200	150	

Table 3. Random proportion slub yarn (specimen 2).

Slub length, mm	Slub amplitude, %	Slub distance, mm	Repetition pattern
30	200	150	30 or 50 or 70, 150 or 200 or 250, ...
50	200	200	
70	200	250	

Table 4. Random slub yarn (specimen 3).

Slub length, mm	Slub amplitude, %	Slub distance, mm	Repetition pattern
30	200	150	$L_b \in (30, 70), L_s \in (150, 250),$...
70	200	250	

- Step 1: Initialise data array y_s [0, 400000] using double type, and plot the source line.
- Step 2: Lowpass filter utilising the rectangle window function, giving y_f [0, 400000], then plot the line.
- Step 3: Cal the average y_a of y_f [0, 20000];
- Step 4: Cal z_s [0, 400000], if $y_f(i) > y_a$ or $y_f(i) = y_a$, $z_s(i) = 0.5$, if $y_f(i) < y_a$, $z_s(i) = 0$;
- Step 5: Initialise L, D; $L_s[]$, $D_s[]$;
- Step 6: if $z_s(i-1) = 0$, $z_s(i) = 0.5$, L = 0, $D_s[] = D$; if $z_s(i-1) = 0.5$, $z_s(i) = 0.5$, increment L; if $z_s(i-1) = 0.5$, $z_s(i) = 0$, D = 0, $L_s[] = L$; if $z_s(i-1) = 0$, $z_s(i) = 0$, increment D;
- Step 7: if $L_s[j] < 25$, $D_s[k] = D_s[k-1] + D_s[k] + D_s[k+1]$, plot the pulse signal.

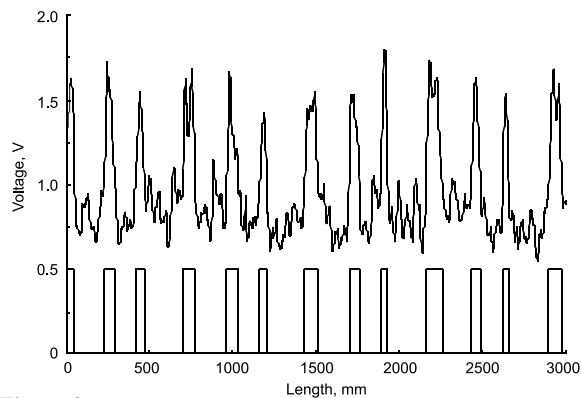


Figure 3.

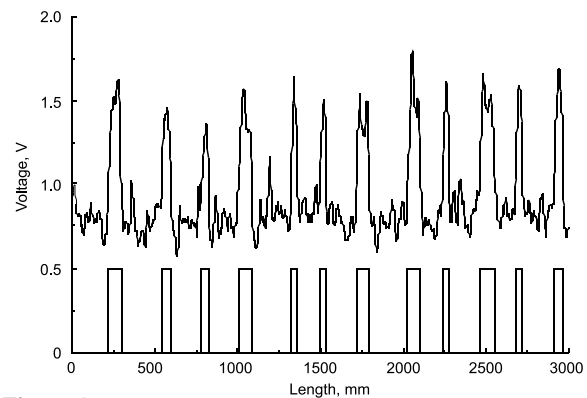


Figure 4.

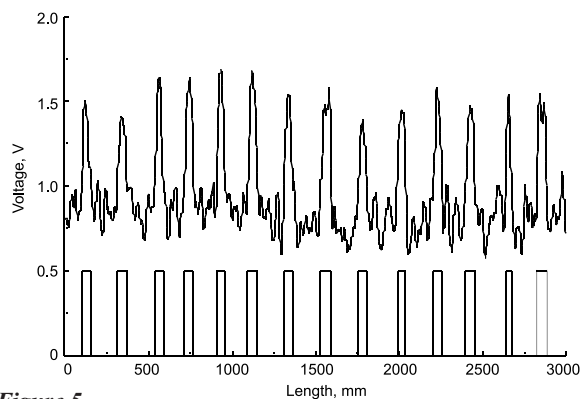


Figure 5.

Figure 3. Pulse wave signal of periodic slub yarn.

Figure 4. Pulse wave signal of random proportion slub yarn.

Figure 5. Pulse wave signal of random slub yarn.

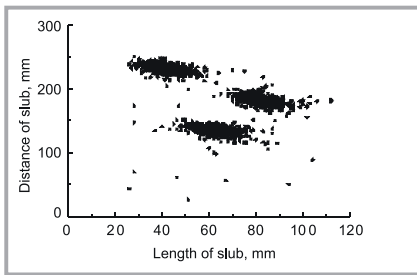


Figure 6. 2D image of periodic slub yarn.

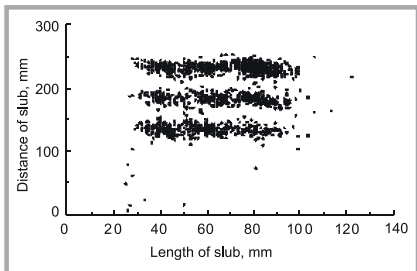


Figure 7. 2D image of random proportion slub yarn.

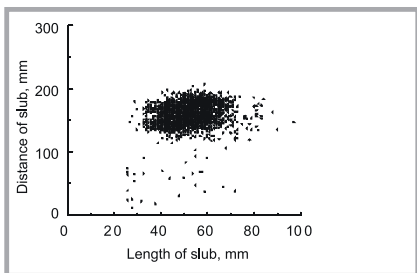


Figure 8. 2D image of random slub yarn.

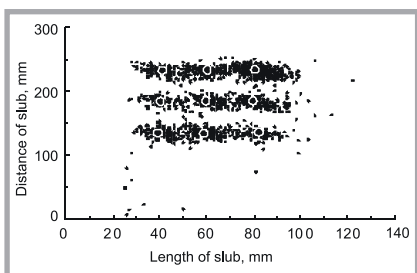


Figure 9. Nine areas of random proportion slub yarn.

Experimental

Specimen preparation

Utilising a slub yarn controller, developed by Jiangnan University, we prepared a slub yarn specimen. In the controller slub yarn can be divided into three categories according to the repetition pattern, which is the most difficult parameter determination process. Each specimen of slub yarn was at least 1000 m. All the specimen yarns were spun from the same roving with the same base

yarn count, 18.2 tex; The parameters of the three kinds of slub yarn are listed in **Tables 2 to 4** (see page 33). Although there is little practical application for the periodic slub yarn listed in **Table 2**, periodic slub yarn is a typical example in our experiment. The specimen used had the same slub amplitude, 200%, in order to omit the influence.

Data acquisition

The capacitance-type sensor on an Uster tester (Slot: 4, Test yarn speed: 400 m/min) was used to check the line density of the slub yarn, and data of the voltage signal were obtained based on the DAQ card after checking 400 m of the specimen yarn. Because the slub amplitude was 200% and the base yarn count 18.2 tex, the average count of the whole yarn was more than the base yarn count. In the experiment, 28 tex was selected as the measurement parameter of the count in the software to prevent the data exceeding the maximum of the measurement. The value of the voltage is proportional to the line density of the yarn in the same cross section.

Data processing

Curves of the specimen yarns were ranged into pulse wave signals after the dynamic threshold and condition filtration. Sample parts of the pulse wave and voltage signals of the specimen are shown in **Figures 3 to 5** simultaneously (see page 33). The figure shows only 3000 mm of the yarn. The arrange voltage was about 0.5 V to 2.0 V and that of the thresholds 1.0 V. We can state that the base and slub parts are uneven.

Parameters acquisition

A program, created using the Borland C Builder language, was used to count the slub parameters from the pulse wave signal. The results of the slub parameters were used to plot a 2D image, as shown in **Figures 6 to 8**.

In **Figure 6** the points are clustered into three areas. The x and y coordinates of each centre express the length and distance of the slub. The lengths are 45 mm, 65 mm, 85 mm, while the distances are 135 mm, 185 mm, 235 mm. According to the pulse data, the results can be confirmed and listed in **Table 5**.

There is a difference between the setting parameters and results measured. In fact, during the manufacture of slub yarn,

Table 5. Results of periodic slub yarn.

Slub length, mm	Slub distance, mm
45	235
65	135
85	185

the slub length is extended by a length of about 15 mm because of the production process. The length is determined by the parameters of the ring spinning machine. Therefore the slub distance is smaller, while the slub length is bigger than the setting value. In the determination process, parameters acquired from the pulse wave signal should be compared with the slub parameters using manufacturing experience. If the results are confirmed, the repetition pattern of the specimen can be obtained.

The results of random proportion slub yarn (**Figure 7**) have nine area centres, circled in **Figure 9**. The number of points in each area is unequal. In the same way the length of the slub is extended to a length of about 10 mm, and the distance of the slub is shortened by a length of about 10 mm.

There is only one area in **Figure 8**. These points are distributed from 45 mm to 85 mm along the x-axis, and from 135 mm to 235 mm along the y-axis. The distribution is uneven in the figure. Utilising the method, operators can confirm the parameters approximately and then accurately measure the slub and distance according the type of slub yarn.

Conclusions

In this research, a method of determining the main geometrical parameters of slub yarn based on a visualised image, including the length and distance of the slub, is described. This method is more robust than the traditional method of establishing slub parameters based on yarn black boards. In particular, these parameters can be acquired by three steps: eliminating the noise signal by lowpass filtration; separating the slub part signal to build a pulse signal using the dynamic threshold; and confirming the parameters by observing the 2D image and pulse signal. Comparison of experiments determining the parameters of the specimen by adjusting the slub yarn mechanism was accomplished, and the results show that the method can obtain reliable results,

since it directly measures the slub yarn signal and does not require modification of standard measurement apparatus.



Acknowledgment

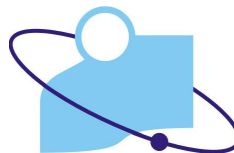
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Information:

Textile Research Institute (IW), Brzezińska 5/15, 92-103 Łódź, Poland,
fax: +4842 6792638

Contact persons:

Katarzyna Grzywacz tel. (+4842) 6163 195, e-mail: grzywacz@iw.lodz.pl
Joanna Koprowska tel (+4842) 6163 116, e-mail: koprowska@iw.lodz.pl