Application of Laser Slit Beam to Characterize Yarn Irregularity

You Huh[1], Jong S. Kim[1], Do W. Kwack [1], and M.W. Suh[2]

[1] Department of Mechanical and Industrial Systems Engineering, College of Advanced Technology, Kyunghee University, Yongin, Gyunggi-Do, 449-701, Korea.

[2] Department of TATM, College of Textiles, NCSU, Raleigh, North Carolina 27695, USA.

Abstract

The surface evenness and texture of textile products are closely related with the irregularity of yarn thickness which has an important role to influence the quality and the process efficiency. For measuring yarn thickness the capacitive method is known to dominate the market, delivering results that are in a close relation with the mechanical properties of yarn, while the optical method offers information that seems related rather with the apparent quality of yarn.
If a thin light beam is applied for the opto-electrical measurement, it is very possible that this method can provide us with important information which is not obtainable from the capacitive type measurement.
This paper reports the results of a study about the yarn thickness and its variation on the basis of a new measurement system using a laser slit beam. Analysis of the new system confirms that we can extract new information on the yarn irregularity ranging into much short wavelengths. Even the visual shade created by the yarn doubling and twisting can be measured and represented well. Depending on the yarn types, the thickness measurements show their own characteristics.

Introduction

In general there are two ways to represent the yarn thickness ; i.e., in terms of the mass per unit length and the diameter of yarn cross-section. The mass per unit length (linear density) is closely related with the mechanical properties of yarn, while the diameter of yarn cross-section with the apparent quality of the products [1]. Among many methods for measuring the yarn thickness the capacitive method, as well known, dominates the market because it outputs the results relating to the mechanical properties that play important roles for process efficiency. But from the point of view of apparent textile quality the optical method outweighs the capacitive one, because it measures the yarn diameter that is more closely related with the apparent textile quality than the linear density of yarn is.
Therefore in this research we try to obtain some basic information on the apparent thickness irregularity, especially in the range of the short-term wavelength that almost has been unknown but seems to play an important role to the visual textile quality. We developed a new measuring system that operates on a slit beam of which the source is laser and are going to introduce for short the new measuring system that is applied to 3 types of specimens, that is, a single yarn, a two-plied yarn, and a three-plied yarn to show the extent to which this method can measure the yarn thickness and to represent the short-term characteristics of yarn irregularity.

Measuring System

A new system to measure the yarn thickness operates on the basis of the laser scanning [2], but the light source generates a laser slit beam. The system consists of 3 parts; the laser slit beam generating system with the sensor head, the yarn feeding device and speed control system, the measuring procedure controller and data analysis system, including the data transformation.
The beam is a visible semiconductor laser of 670 nm in wavelength. The scanning rate is 1200 cycles per second. A specimen is placed between the transmitter and the receiver.

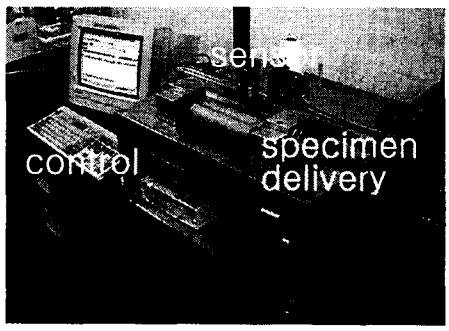

Fig. 1 The new measuring system

The sensor consisting of a CCD array collects data on the width of the specimen shadow through an optical lens and outputs a signal.
Yarn feeding is driven by a servomotor connected to a personal computer that is equipped with appropriate software programs for monitoring and controlling the total measuring procedure, including signal processing. Fig.1 shows the new measuring system.

Experimental

As human eyes have different visual sensitivity to the yarn surface, we selected 3 different types of yarn as specimen, i.e., a single yarn, a two-plied yarn, and a 3-plied yarn to characterize the yarn irregularity in short term range. Fig.2 shows the specimens. The single yarn has a round surface, but the two-plied yarn has rather a ribbon like shape that makes the twist effect out. The three-plied yarn has a triangular configuration of yarn cross-section and the twist effects get weakened visually. The specifications of the specimens are given in Table 1.

Table 1. Specifications of the specimens

Yarn type	material	TPM	Fineness (tex)	CV(%) of thickness
Single yarn	cotton	472	42.4	22.38
Two-plied yarn	rayon	318	173.2	12.35
Three-plied yarn	cotton	700	60.6	17.62

The sampling time interval is fixed as 5msec. and specimen feeding speed as 1.19m/min. The output signal is then transferred to the computer by a data acquisition software program and processed and analyzed further. The calibration procedure showed a very good linearity of the new measuring device, which is not brought up here, though.

Results

In Fig.2 is given a signal obtained from the experiment.

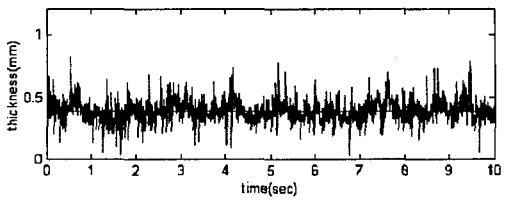

Fig. 2 A signal obtained from a single yarn

From the measured data the mean and variation of yarn diameter are calculated. The measuring signal delivered almost invariant values of apparent yarn thickness and its variance depending on types of yarn. The single yarn has a diameter of 0.39mm, the two-plied yarn 0.66mm, and the three plied yarn 0.45mm in average. The standard deviation of diameter for the single yarn is 0.087mm, for the two-plied was 0.78mm, for the three-plied 0.80 respectively.
The characteristics of yarn thickness irregularity can be quantified in detail by representing the irregular components in forms of correlation function with length argument, so called "correlogram". Fig.3 shows the correlograms of the 3 types of yarn.

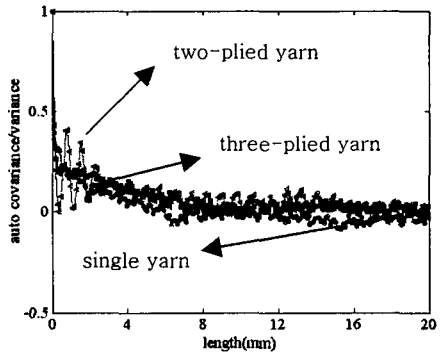

Fig. 3 Correlograms of yarn thickness for different types of yarn

This result reveals the fact that irregularities of the single and three-plied yarns can be characterized as the simply decreasing cross-section correlation, while the two-plied yarn as a correlation with a decaying oscillation. As a whole, irregularity of yarn can be characterized using the correlograms that show different shapes according to the type of yarn.

Conclusions

In this research we tried to apply a new measuring system to get the information on the characteristics of yarn irregularity. Results of the study show that the new measuring method can provide us with the short-term irregularity that can be characterized by means of correlogram. The 3 kinds of yarn have different irregularity traits.

References

1. Harrison, B.W., (1986), Textile Progress -Yarn Evenness, **14**, 3/4, 22
2. Soell, W., (1990), Information Gain through Optoelectronic Measurement of the Two-Dimensionally Determined Yarn Diameter, Melliand International, 80, E124-E130