ESTIMATION AND PREDICTION OF LONG SCUTCHED FLAX SPINNING ABILITY

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ABSTRACT

This article describes the developed information system of quality control of long scutched flax fiber, based on modern technology of development of network applications. The system is implemented in the production process of RUPTE "Orsha Linen Mill", which is the largest enterprise in the Republic of Belarus in terms of volume of flax fiber processing. The information system collects data on the physical and mechanical properties of flax fiber and its products and provides basis for estimation of flax spinning ability by methods of mathematical statistics. Information system allows the following:

- operatively implement quality control of flax fiber delivered to the linen mill;
- prepare different kinds of statistical reports in real time mode;
- predict the physical and mechanical properties of the products produced by processing long scutched flax fiber.

The article discusses the developed methodology of comparative analysis, which allows to resolve disputes about the quality of the flax fiber between suppliers and linen mill, and introduces the concept of individual quality functions for each of the controlled properties.

Keywords: quality control, long scutched flax, spinning ability, quality indicator

INTRODUCTION

In today's rapidly changing requirements of world market for the production of textile enterprises, a modern manufacturing technology as well as information systems for analysis and control of product quality should be used. "Orsha Linen Mill" is the largest enterprise in the Republic of Belarus and Eastern Europe in terms of volume of flax fiber processing. It integrates technological processes from flax fiber to finished linen textiles. Flax fiber to the "Orsha Linen Mill" comes from more than 50 suppliers of the Republic of Belarus and other countries. The spinning ability of flax fiber is an indicator, which characterizes its quality and allows predicting the properties of linen yarn that can be produced from it. The input control laboratory measures numerical values of physical and mechanical properties of flax fiber: breaking load, flexibility, length, color, etc. Existing methods allow to estimate spinning ability of flax by comparing the values of physical and mechanical properties with standard values. Due to the changing climatic conditions, cultivation of new varieties of flax, using of new types of fertilizers, the probability distribution of the physical and mechanical properties of flax fiber is changing and, as a result, the existing methods for estimating the ability of spinning lose their accuracy. To improve the control efficiency and to improve the quality of yarn produced at the "Orsha Linen Mill", the authors developed and implemented computer information system of quality control of processed flax. The information system collects data on the physical and mechanical properties of flax fiber and its products and provides basis for estimation of flax spinning ability by methods of mathematical statistics.

Figure 1 shows the scheme of information system of quality control.

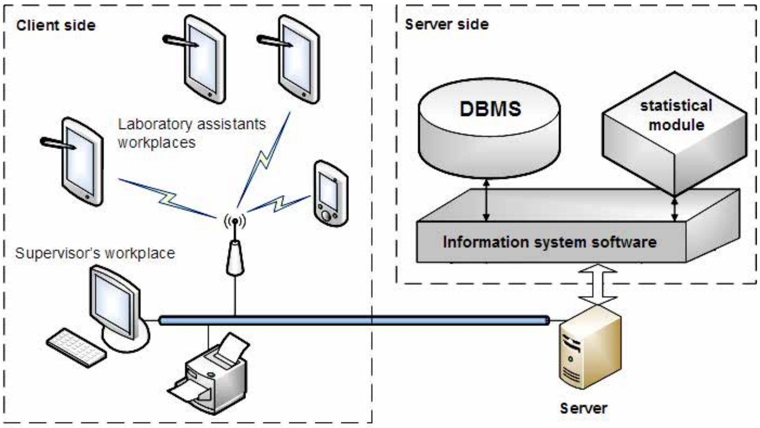

Fig. 1

Information system of quality control (Dyagilev 2016) is based on modern technology of development of network applications: web-oriented languages – PHP, JavaScript, CSS; Debian Linux server operating system; Apache web-server; MySQL database management system. For statistical processing of data and generation of graphical representation used functional programming language R (R Core Team 2016), which allows to use all the variety of modern statistical methods for the analysis of accumulated data. Using web-based technologies makes it easy to organize access to the capabilities of the information system with various devices, such as PCs, tablets, smartphones, etc. For example, to enhance mobility, workplaces are equipped with portable touch-input devices, providing access to all of the information system via a wireless Wi-Fi technology.

MATERIALS AND EXPERIMENTAL METHODS

In Belarus, there are normative documents (STB1195 2008), according to which a quality indicator of long scutched flax fiber (its spinning ability) is measured in units called "nomer". To assess the nomer following physical and mechanical properties are investigated: breaking load, flexibility, handful length, color group, content of shive, defects of fibers, humidity.

Figure 2 shows the graphical dependences of the average, minimum and maximum values of the breaking load, handful length, flexibility, color group of long scutched flax grown in Belarus in 2015 on nomer.

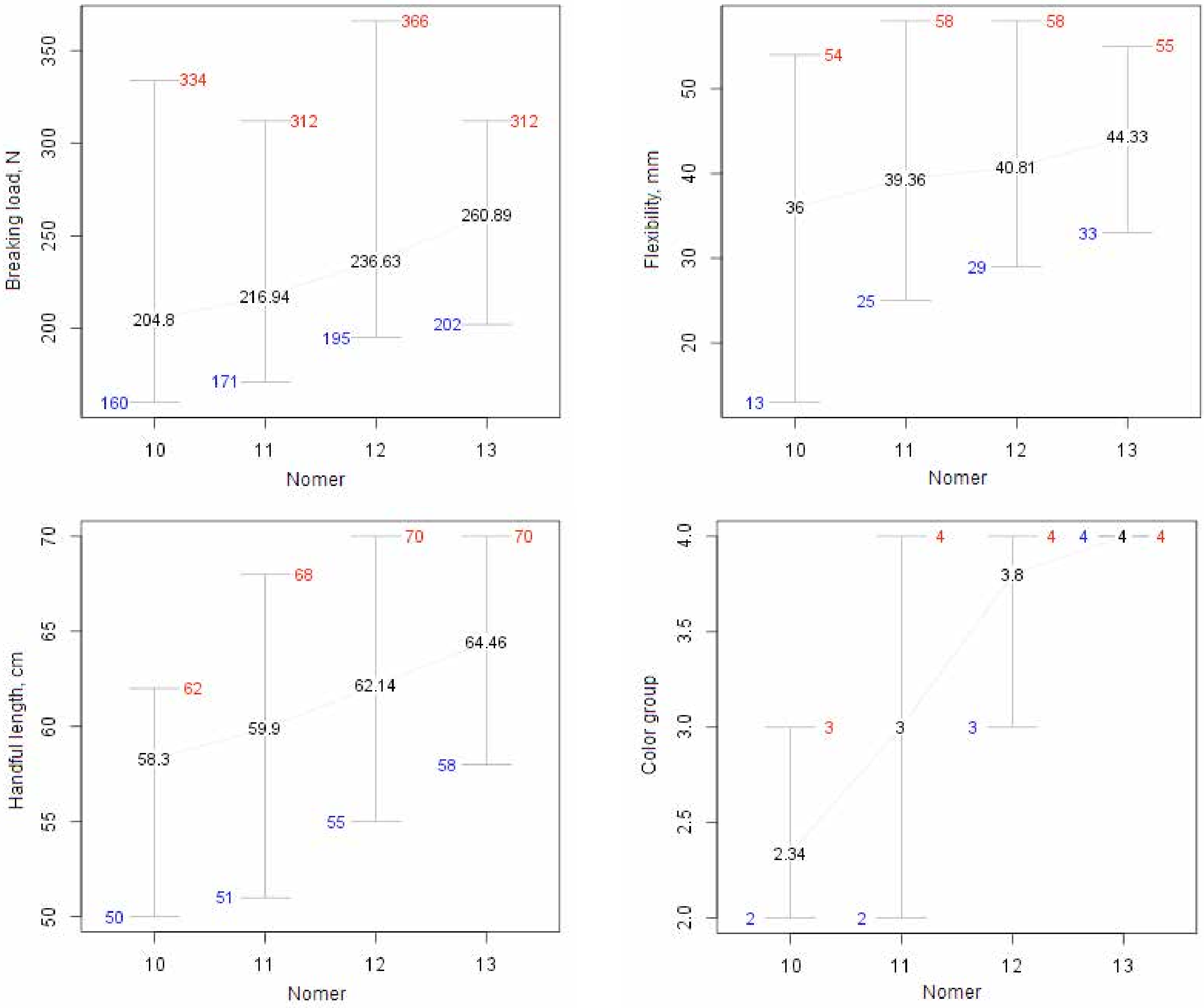

Fig. 2

As Figure 2 shows the average values of the breaking load, flexibility, handful length and color group of long scutched flax fiber tend to increase alongside with increasing nomer. Intervals between the minimum and maximum values within the same quality indicator increase with the volume of batches (Dyagilev 2014).

Figure 3 shows the distribution of the volume of batch depending on the quality indicator of long scutched flax fiber grown in Belarus in 2015.

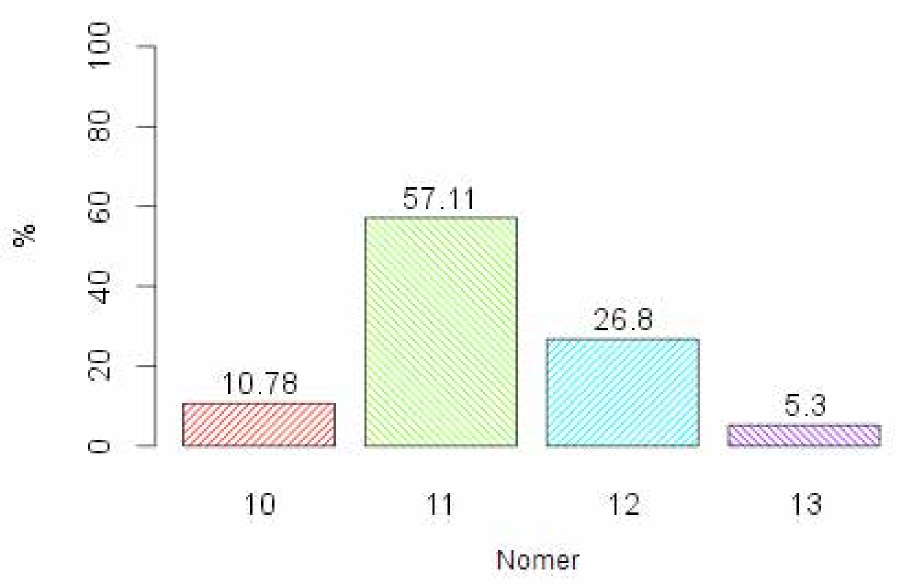

Fig. 3

As Figure 3 shows there is the prevalence of nomer #11 in the total volume of batches of flax fiber. The share of flax fibers of nomer #13 is less than 6 percent, flax fiber of nomer #14 and higher was not delivered by Belarusian flax plants.

Often, in case of complaints, it is impossible to give a clear answer why the properties of the fiber do not match the nomer declared by the supplier. If the quality of flax fiber does not match the declared nomer, the supplier can either accept the instrumentally defined nomer or withdraw the batch of fiber to resorting. In the latter case, it is necessary to know which properties need to be improved. For this purpose, the method of comparative estimation of physical and mechanical properties of flax fiber, based on the statistical apparatus of survival analysis was developed. In the informational system of quality control, a comparative analysis module was implemented based on the developed methodology, and the concept of individual quality functions was introduced for each of the controlled properties. To determine the relative position of the value of the selected property of the test sample to a set of values of all the examined samples the following function is used (Dyagilev 2015):

$$S(x) = 1 - CDF(x) = \int_{x}^{\infty} PDF(t)dt \approx \sum_{i: x_i \geq x} p_i = \frac{1}{n} \cdot k_{x_i \geq x}, \qquad (1)$$

where x – the value of property of a single test sample; $CDF(x)$ – the cumulative distribution function; $PDF(t)$ – the probability density function; p_i – the probability associated with the value that satisfies the condition $x_i \geq x$; n – the number of tested samples; k – the number of samples that satisfy the condition $x_i \geq x$.

Function (1) shows what percentage of test samples has values of selected properties of the same or better than the value in the test sample. This function can be used for those properties, which have large values more preferable than smaller ones, for example: breaking load, handful length, flexibility.

Figure 4 shows graphs of individual quality functions (1) for breaking load and flexibility of long scutched flax fiber, which has quality indicator (nomer) equal to #12 and grown in 2014. Property values of one of the batches of long scutched flax grown in 2015 are displayed on the graphs.

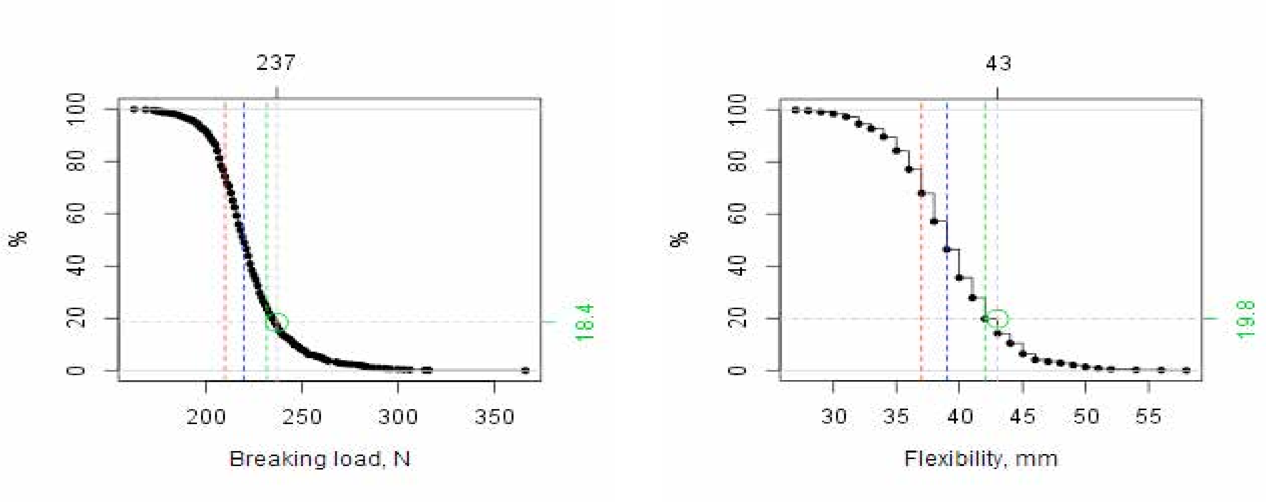

Fig. 4

Figure 4 shows that the value of the breaking load of test sample equals to 237 N. According to the graph, 18.4% of the batches of flax fiber, which have instrumentally confirmed quality indicator of #12, have a value of the breaking load not less than that of the sample. Additionally Figure 4 shows that the value of the flexibility of test sample equals to 43 mm. According to the graph, 19.8% of the batches of flax fiber, which have instrumentally confirmed quality indicator of #12, have a value of the flexibility not less than that of the sample.

For properties, which have smaller values more preferable than large ones, such as content of shive, the coefficient of variation for breaking load, used cumulative distribution function:

$$CDF(x) = \int_{-\infty}^{x} PDF(t)dt \approx \sum_{i: x_i \leq x} p_i = \frac{1}{n} \cdot k_{x_i \leq x}. \qquad (2)$$

Figure 6 shows graphs of individual quality functions (2) for coefficient of variation for breaking load and coefficient of variation for flexibility of long scutched flax fiber, which has quality indicator equal to #12 and grown in 2014. Property values of one of the parties of long scutched flax grown in 2015 are displayed on the graphs.

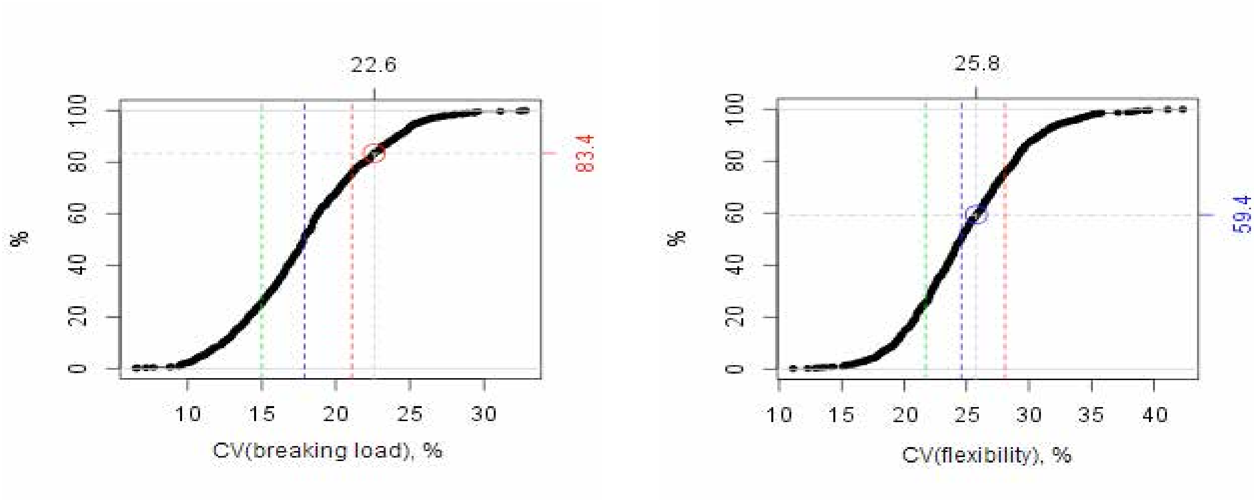

Fig. 6

Figure 6 shows that the value of the coefficient of variation for breaking load of test sample is 22.6%. According to the graph, 83.4% of the batches of flax fiber, which have instrumentally confirmed quality indicator of #12, have a value of the coefficient of variation for breaking load not greater than that of the sample. Additionally Figure 6 shows that the value of the coefficient of variation for flexibility of test sample is 25.8%. According to the graph, 59.4% of the batches of flax fiber, which have instrumentally confirmed quality indicator of #12, have a value of the coefficient of variation for flexibility not greater than that of the sample.

Figures 2-6 are made directly by the information system of quality control in the production environment of "Orsha Linen Mill".

Using the data accumulated in the information system of quality control of long scutched flax fiber and using methods of computer simulation modeling, algorithms to predict spinning capacity more accurately than methods approved by the applicable regulatory documents were developed and implemented.

The use of statistical methods and modern information technologies allows for prediction of spinning ability to rely on the data of flax control carding of current year harvest as well as the previous years.

RESULTS

Information system of quality control of long scutched flax fiber is developed and implemented in the production process of RUPTE "Orsha Linen Mill". The information system allows:

operatively implement quality control of flax fiber delivered to the linen mill;

prepare different kinds of statistical reports in real time mode;

predict the physical and mechanical properties of the products produced by processing long scutched flax fiber;

operatively and argumentatively resolve disputes about the quality of the flax fiber between suppliers and a linen mill.

CONCLUSIONS

The use of modern information technology and statistical methods can improve quality and reduce costs in the manufacture of textile materials. In the nearest perspective, all the technological transition from the production of flax fiber to manufacture of the finished product should be controlled by a single information system of quality control that will allow to use all available reserves to improve quality, reduce costs, increase the speed of development and production of new assortment of textile products.

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