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Analysis of Regulatory Quality Indicators of Cotton Fiber

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ABSTRACT: The appropriate equations and graphs for changing the values of cotton fiber properties, and the law of changing the values of the properties of index value are examined in this article. Significance index values and maximum absolute error values were calculated based on the type, quality, and characteristics of the fiber, and the staple length used to determine the type of fiber. A simple equation according to the analysis of the empirical expressions existing for determining the length of staples has been developed by article authors. This equation is proved to be consistent with the law of mathematical statistics to evaluate the parameters of commonly accepted indicators. The mathematical model of cotton fiber staple length estimation was improved and the squared deviation of the length along with the average fiber length was obtained.

KEYWORDS: cotton, fiber, quality, grade, class, length groups, *modal length, duration,* dynamic.

I. INTRODUCTION

It is well known that the main characteristics of cotton fiber are its length, shear strength and the value of micronaire. In addition, other properties of the fiber directly affect the quality of the yarn. Considering this, different countries value cotton fiber differently. This is probably why cotton is classified in different ways by technological properties. Many studies have identified and evaluated the interconnectedness of the properties of fiber and yarn. Assessing the quality of the thread is more complicated than planning and accounting for its quantity, because product quality is associated with a number of indicators and factors. It is important to identify changes in the quality of cotton fiber by varieties as a result of comparing quality indicators based on various regulatory documents. To do this, it is important to study the variety of classification of cotton fiber. The most widespread classifications of cotton fiber are made in the USA, Great Britain, Uzbekistan and in Russia, which differ from each other by the presence of quality indicators and gradation of the quality of cotton fiber. This is primarily due to the development of equipment and test methods for assessing the quality of cotton fiber and differences in quality standards.

The basis of the quality system of cotton fiber is laid down by the British, and it is accepted in the world's largest cotton producing regions - America, India, Egypt, where fiber is divided into classes and quality levels. Figure 1 below shows the description of cotton fiber in the English Middling system [1].

ISSN: 2350-0328
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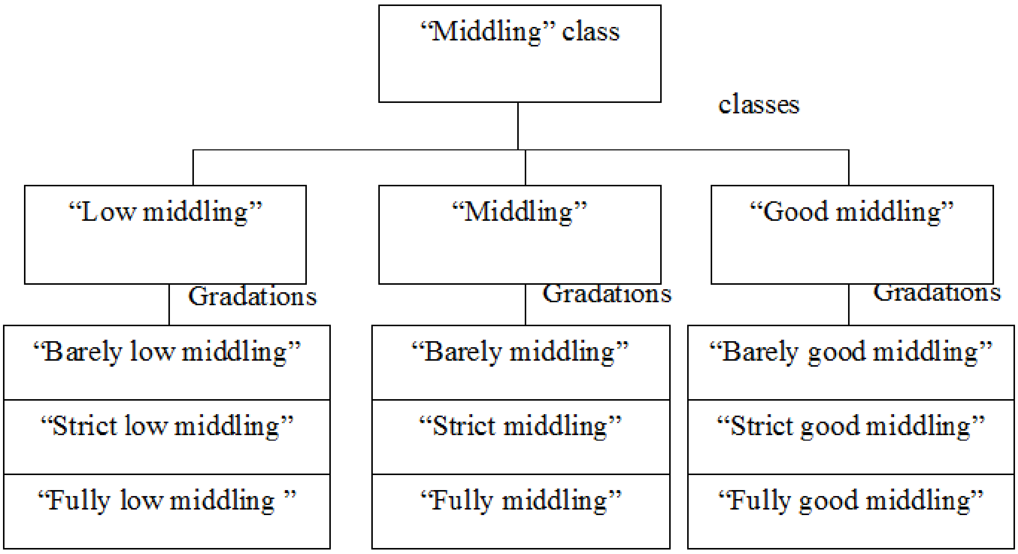

Figure 1. Classification of the quality of cotton fiber in the English system

II. METHODOLOGY

In 1981, HVI (High Volume Institution) became known to all cotton fiber producers. In 1990, the National Cotton Marketing Advisory Committee, which consisted of farmers, exporters, cotton processors, and warehouse owners, recommended to use HVI system included the US pricing program to all of the upland cotton. [2]

In addition to the HVI systems around the world of demons and quality indicators: the process of staple length and micronaire, and fiber impurities to determine the amount and color of the shirt, which the classer system is also used to assess the quality of the fiber.

The following indicators are taken into account in the calculation and calculations of the average fiber cotton of Upland type: UzDSt 604-2016.

Without denying the possibility of improving each classification of cotton fiber, it should be noted that this path is very complex and requires that all states (especially, cotton producers) historically have their own classification. Based on the foregoing, it is necessary to classify the quality of cotton fiber in such a way that it is "universal" for each cotton producer [3,4]. According to the analysis, such a classification of cotton fiber can be quantified; properties of cotton fiber can be evaluated separately and reduced to the total number.

An analysis of the quality classifications of cotton fiber shows that they are characterized by a level scheme and are classified by unrelated quality groups. For example, according to standard [5] cotton fiber type, grade and class, length groups, stiffness and durability have international standards (Table 1).

The advantages of such cotton fiber characterization systems are: ease of use and flexibility, the ability to limit the number of fiber quality indicators is sufficient to cover them.

Table 1.
International standards of cotton fiber quality characteristics

Consistency of fiber properties (parameters) by quality level			
Length group	Sort	Rigidity	Character of hardness
1.Length (staple length, high average length)	1.Color (coefficient of reflection, yellowness level) 2. Impurities (average share of non fiber impurities)	1. Thinness and ripeness (micronaire)	1. Hardness (comparable tensile strength)

To analyze some absolute normative indicators of the quality of cotton fiber, we move on to dimensionless indicators that show the dynamics of decline in the quality of a variety, type, and class at different quality levels. If it is impossible to imagine the main indicators of quality in functional relationships using mathematical models, we can use the complex average value [6]:

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 11 , November 2019

Average mathematic value

$$K = \sum_{i=1}^{n} q_i a_i \quad (1)$$

Average geometric value

$$K = \prod_{i=1}^{n} q_i^{a_i} \quad (2)$$

Average harmonic value

$$K = \frac{1}{\sum_{i=1}^{n} \frac{a_i}{q_i}} \quad (3)$$

Average square value

$$K = \sqrt{\sum_{i=1}^{n} q_i^2 a_i} \quad (4)$$

here α_i–product particular quality indicator i – significance coefficient $\sum_{i=1}^{n} a_i = 1$

. n – number of separate indicators;

q_i - i– individual quality indicators index.

Individual quality indicators indexes define as affirmative (i) and negative (c) as follows:

$$q_i^u = \frac{\|x_i\|}{\|x_{\min}\|} \langle 1, \qquad q_i^u = \frac{\|x_{\min}\|}{\|x_i\|} \langle 1 \quad (5)$$

here $||x_i||$-is i- regulatory value of quality indicator;

$||x_{max(min)}||$- - highest (lowest) regulatory value of quality indicator

In practice, the quantitative estimation of the coefficients of the primary quality indicators (sorting operation) is often based on expert evaluation [7].

In this case, we use the mathematical expression (4). Using standard values of the first type, first grade, top class cotton fiber according to the [5] standard, the corresponding linear equations are obtained from the values obtained in the plane of different coordinates {x, u}:

$$\left.\begin{aligned} y_1 &= 0{,}986 - 0{,}037x_1 \\ y_2 &= 1{,}050 - 0{,}036x_1 \\ y_3 &= 1{,}028 - 0{,}050x_1 \\ y_4 &= 1{,}100 - 0{,}125x_2 \\ y_5 &= 1{,}140 - 0{,}158x_3 \end{aligned}\right\} \quad (6)$$

where y_1, y_2, y_3,y_4, y_5 are indicators corresponding to: relative tensile strength, length of staples, linear density, ripening coefficient, percentage of impurities and defects;

x_1, x_2, x_3- fiber quality, respectively: by type, sort and class.

Mistakes which computational functions against the theory were found during the study. The calculation results for fiber type, sort and class are given in Tables 2 .... 4 and shown in the histograms in Figure 2. Also, the maximum values of absolute errors were separately shown in the tables.

Table-2
The primary indicators of the quality of cotton fiber types of normative document [O'zDSt 604: 2016] calculated based on the normative value of the data Indexes

Designations		Quality indicators value index by types								
Cod.	real.	1a	1б	1	2	3	4	5	6	7
y_1	q_{Py}	1,00	0,97	0,94	0,89	0,83	0,72	0,68	0,67	0,65
$(y_1)_{theoretic}$	$(q_{Py})_{theoretic}$	0,95	0,91	0,88	0,84	0,80	0,76	0,72	0,69	0,65
$\|\Delta y_1\|$	$\|\Delta q_{Py}\|$	0,05	0,06	0,06	0,05	0,03	0,04	0,04	0, 02	0,00
y_2	q_{lu}	1,00	0,98	0,95	0,93	0,88	0,83	0,78	0,75	0,73
$(y_2)_{theoretic}$	$(q_{lu})_{theoretic}$	1,01	0,98	0,94	0,90	0,87	0,83	0,79	0,75	0,72
$\|\Delta y_2\|$	$\|\Delta q_{lu}\|$	0,01	0,00	0,01	0,03	0,01	0,00	0,01	0,00	0,01
y_3	q_T	1,00	0,93	0,87	0,83	0,76	0,69	0,66	0,63	0,60
$(y_3)_{theoretic}$	$(q_T)_{theoretic}$	1,03	0,93	0,88	0,83	0,78	0,73	0,68	0,63	0,58
$\|\Delta y_3\|$	$\|\Delta q_T\|$	0,03	0,00	0,01	0,00	0,02	0,04	0,02	0,00	0,02

Table -3
Regulatory value indexes of main quality of cotton fiber by grades obtained according regulations in normative document [UzDSt 604:2016]

Designation		Quality indicators value index by types				
code.	real.	I	II	III	IV	V
y_4	q_{k3}	1,00	0,85	0,70	0,60	0,5
$(y_4)_{theoret}$	$(q_{k3})_{theoretic}$	0,98	0,85	0,72	0,60	0,48
$\|\Delta y_4\|$	$\|\Delta q_{k3}\|$	0,02	0,00	0,02	0,00	0,02

ISSN: 2350-0328
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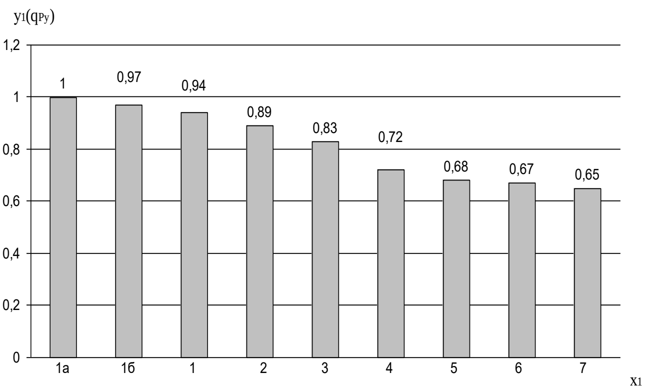
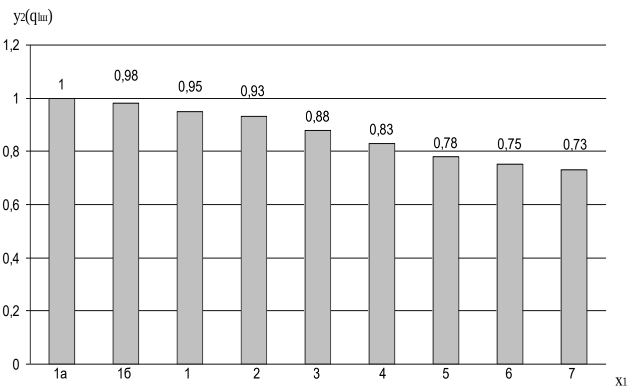
Vol. 6, Issue 11 , November 2019

Table -4
Regulatory value indexes of main quality of cotton fiber by classes obtained according regulations in normative document [O'zDSt 604:2016]

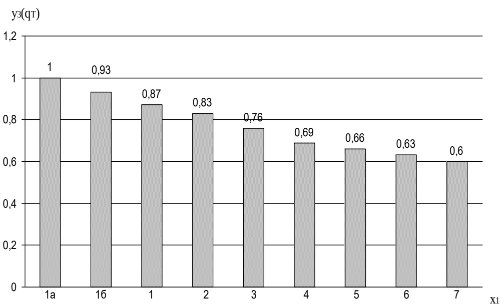
Designation		Quality indicators value index by classes				
code.	real	extra	good	average	usual	dirty
y_5	$q_з$	1,00	0,80	0,67	0,50	0,36
$(y_5)_{theoretic}$	$(q_з)_{theoretic}$	0,98	0,82	0,67	0,51	0,35
$\|\Delta y_5\|$	$\|\Delta q_з\|$	0,02	0,02	0,00	0,01	0,01



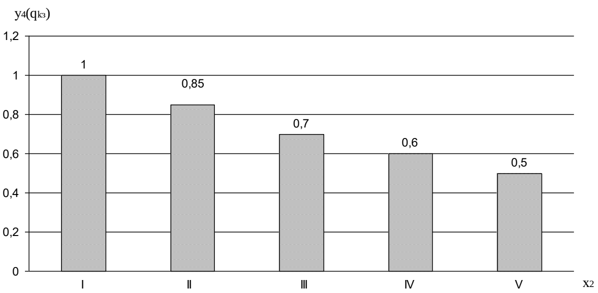
a) Relative tensile strength changing histogram of fiber type



b) Staple length changing histogram of fiber type



c) Linear density changing histogram of fiber type



d) Histogram of fiber grade changing by ripeness

Figure 2.

Figure 2.2 Changes in specific values of cotton fiber in accordance with specifications [8] are determined by relative tensile strength (a), staple length (b), linear density (c) and ripening coefficient (d).

Thus, changes in the properties of cotton fibers were studied on the basis of the corresponding equations and diagrams, and the pattern of changes in the properties was established. The highest values of calculation values and regulatory value index as well as absolute error values were determined according to the indicators of significant fiber type, grade and class. Also staple length of fiber considered as the main characteristics of fiber length and is used to determine the type of cotton fiber [5].In addition, staple length is used as a key indicator in various yarn manufacturing processes. The distances between the extension pairs are adjusted according to the length of the bracket. For example, in technical applications [8, 9, and 10] accordingly on piloting machines:

$$R_{1-2}=l_ш+6....8mm, \qquad R_{3-4}=l_ш+8....10mm$$

In this case, the number of expansion pairs 1, 2, 3, 4.

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According to the standard measurement method [11], the length of the staples can be found by the following expression:

$$l_{ш} = l_{м} + \frac{\sum_{j=k+1}^{n} icm_j}{m + \sum_{j=k+1}^{n} m_j} \qquad (7)$$

here, lm-modal length, mm;
k- is serial number of longer fibers' group;
n- is the serial number of the last group of longer fibers;
i- is the difference between longer than modal length and the serial number of modal fiber group;
m_j – is the mass of fibers in the group j*;*
c- is difference between in the length of the fiber adjacent to each other;
*m *- short fiber mass from modal length fibers, mg*

There are other empirical expressions for determining the length of the bracket [9]. As a result of their analysis, the following equation is given:

$$l_{ш} = al_{м} + b, \qquad (8)$$

here a, b are coefficients.

The study [12] considers a = 1,02 and b = 2,6, a = 1,1 and b = 0,0. In expressions (7) and (8), the modal length and various values in the coefficients *a* and *b* are used as basic characteristics.

From the point of view of metrology, we see the value of the variability of both lengths of the fiber group — modal length l_m and $\bar{l}$ average length [1]. To do this, we first investigated the distribution of the mean absolute error of the modal length over p, that is:

$$\left|\Delta(l_{м})_p\right| = (l_{м})_p - \overline{l_{м}} \qquad (9)$$

So like this, the ratio of the absolute error $\Delta\overline{l_p}$ of the average length to the total mean $\bar{\bar{l}}$ is:

$$\left|\Delta\overline{l_p}\right| = \overline{l_p} - \bar{\bar{l}} \qquad (10)$$

In addition, the variability of the characteristics of the length of the group of fibers within the distribution of longer fibers, namely:

$$\left|\Delta L_p\right| = L_p - \overline{L} \qquad (11)$$

Here, $L_p = \frac{\sum_{j=k+n}^{n} l_j}{n-k} - l_{м}$

One of the objectives is using from medium fiber Namangan-77 selective type of 5th type 2nd sort cotton fiber in order to manage the sorting in the research.

In that, the length of the fiber mixture is performed according to the method of distribution groups [5]. The required fiber length parameters are calculated in 5 repetitions and summarized in table 5.

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 11 , November 2019

Table 5
Quantitative values of cotton fiber descriptions for different distribution laws

Fiber length descriptions	p- values for distribution, mm					
	1	2	3	4	5	average
$l_м$	29,2	27,2	27,4	27,7	27,9	27,9
$\left\|\Delta l_м\right\|$	1,3	0,7	0,5	0,2	0,0	
$\bar{l}$	25,4	24,6	25,6	25,9	25,9	25,5
$\left\|\Delta \bar{l}\right\|$	0,1	0,9	0,1	0,4	0,4	
$\frac{\sum_{j=k+n}^{n} l_j}{n-k} - l_м$	5,8	5,8	6,6	6,3	6,1,	6,1
$\left\|\Delta\left(\frac{\sum_{j=k+n}^{n} l_j}{n-k} - l_м\right)\right\|$	0,3	0,3	0,5	0,2	0,0	
σ_l	8,4	8,7	8,7	8,6	8,5	8,6
$\left\|\Delta \sigma_l\right\|$	0,2	0,1	0,1	0,0	0,1	
$l_ш$	33,1	30,4	32,2	32,5	32,9	32,2
$\left\|\Delta \bar{l}_ш\right\|$	0,9	1,8	0,0	0,3	0,7	
$\bar{l} + \sigma_l$	33,8	33,3	34,3	34,5	34,4	34,06
$\left\|\Delta(\bar{l} + \sigma_l)\right\|$	0,26	0,76	0,24	0,44	0,34	

Analysis of Table 5 shows that the following expression is authenticity for cotton fiber:

$$\left|\Delta l_м\right|_{\max} \rangle \left|\Delta \bar{l}\right|_{\max} = 1{,}3 \rangle 0{,}9 мм \quad (12)$$

Further analysis of the results in Table 5 demonstrated the following interrelation:

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Vol. 6, Issue 11 , November 2019

$$\left|\Delta\left(\frac{\sum_{j=k+n}^{n} l_j}{n-k} - l_м\right)\right|_{\max} \rangle \left|\Delta\sigma_l\right|_{\max} = 0{,}5 \rangle 0{,}2\,мм \tag{13}$$

here, σ_l *is the average squared deviation of length.*

Thus, for simplicity of calculation and achieving high accuracy, in contrast to the normative document [8], it is recommended to use the following formula to determine the length of the staple fiber:

$$l_ш = \bar{l} + \sigma_l \tag{14}$$

This expression is consistent with the law of mathematical statistics to evaluate the parameters of generally accepted indicators.

Thus, the mathematical model of cotton fiber staple length estimation is improved, which takes into account the quadratic deviation of the length along with the average fiber length.

III. CONCLUSION

As a result of the studying and analyzing of the sources, different classifications are learned about using cotton fiber quality on applying in world practice.

In the considered classifications of cotton fiber, quality schemes are constructed and a rational classification is proposed that allows to increase the range of conventional fiber properties and ensure their evenly distribution over the group of properties. Normative values of separate properties of cotton fiber have been studied on the basis of UzDSt 604: 2016, the individual properties index has been determined and the dynamics of decline in quality characteristics of fiber properties by type, sort and class. Equations have been obtained, which allow adjusting the normative values of the individual quality characteristics of cotton fiber.

Metrological analysis of the existing expressions for determining the length of staple of a group of cotton fibers of different lengths has been carried out and a formula for determining the length of staple fibers, which is close to the normal distribution law was developed.

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