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HVI in implementation of internet technologies for providing quality of textile articles

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Abstract. A computerized flow of unified information on textile raw material is able to reach the world commodity exchanges within the shortest possible time, actively influence promotion of new products to the market and price-formation processes owing to implementation of Internet technologies. Cotton of new breeds of cotton plant and fiber of a new breed of textile hemp has been used for investigation. The comparative assessment of fiber has been performed using the methods of national standards UzRST (GOST) and computerized Spinlab HVI 900. The national standards of cotton quality are informative, but labor-intensive and related to equipment, which is not computerized. The assessment of quality fiber of cotton plant breeds and the hemp ones testifies to the fact that Spinlab HVI 900 characterizes peculiarities of different fibers. The availability of the unified HVI technology integrated into Internet is of crucial significance for a possibility of assessing the new product in the criteria of widespread raw material, and not only a cotton one. The investigations of hemp fiber have demonstrated that the raw material features UHML length comparable with fine-fibrous cotton (36.8–37.4 mm) with uniformity along the length of Un up to 77.6. The strength of such fiber is high — up to 43.5. It is evident for the consumers of different countries that the hemp fiber is suitable for blended spinning with cotton using the widespread cotton-processing equipment. The fiber quality information in digitized form can be promptly transmitted and analyzed globally for production and commercial purposes. It increases the capabilities of qualitative assessment of some fiber examples with the prospects of dynamic provision of information from the unit laboratory to the world market through implementation of Internet technologies.

1. Introduction
Cotton is a very popular raw material on the market due to its high consumer qualities [1, 2]. However, the potent development of petro chemistry in expanding the range of textile raw materials with low prime cost during sharp drop of oil prices has determined an increase of share of the range of textile articles made of synthetic fibers. Low-cost products occupy an increasing market share in many countries of the world and squeeze natural fiber products amid a decline in the purchasing power of the population. A reduction of share of cotton articles on the world market from 39% to 26.5% has been observed over a period since 2008 [3].

The world cotton crop areas have increased from 30 million in 2008 to 37 million in 2012, but amounted to 29.8 million ha in the season of 2017/18. Beginning from the season of 2015/16 by the end
of 2017/18 the world production output of cotton has increased by 9 million kips (227 kg) and reached 102 million. However, the consumption of cotton fibers in the world from the season of 2011/12 until now has been on the rise — from million. to 108 million kips. At that, the world per capita cotton consumption has grown since 1998 from 3.12 kg to 3.26 kg and its maximum consumption was registered in the season of 2007 — nearly 4 kg [1].

The processes reflecting commercial and economic trends in the world cotton industry are closely related with global economics and follow the global changes in it and dynamics of the exchange rates of the main reserve currencies of the world. Cotton, the same as oil, as the most important raw material for global economics, features the long-standing stock reserves and overstocking phenomena. A two-fold increase of cotton stock-in-trade has taken place in the world since the season of 2009/10 to the season of 2017/18. The favorable seasonal agro meteorological conditions of cotton cultivation and harvesting in the countries of the world cotton belt over this period have contributed to this apart from the other factors. A certain decrease of cotton stock-in-trade is predicted in 2018 due to an expected restoration of cotton fiber consumption in the world and a continuing trend of cotton price decrease.

The positive dynamics of the exchange rate of US dollar and a decreasing rate of the main ‘raw-material’ currencies in the countries of cotton production and processing over the said timeframe have supported profitability of cotton fiber production in a number of cotton-growing countries. So, for instance, the price has grown from 200 AU$ to 230 AU$ per kg since 2009 to 2015 in Australia as the leading ‘cotton-growing’ country of the world in spite of a two-fold volatility of Australian dollar. Besides, a further local growth is predicted in 2018 [3].

The manufacturing countries of cotton and other fibers [4] tend to overcome the obstacles in assessing quality of textile feedstock being produced and materials sold on the world market. This tendency brings about a commonality of the used standards and methods of cotton testing, which are gradually becoming international.

One of the conditions of successful selling of cotton fibers on the International exchanges is the provision of as much information as possible on the quality of supplied batches in the unified indices [5]. The majority of countries producing cotton fiber changes over from the obsolete national methods of testing properties to the universal methods used in the international practices. The use of the new methods of assessment with preservation of an old national system of cotton fiber classification brings an additional profit to its producers, which emerges due to a reduced number of claims due to poor quality and the increased price index numbers at the stock exchanges. Many countries of the world, such as Egypt, China, Pakistan, Australia, Uzbekistan and other have accomplished a change over to the international assessment of quality of cotton fiber produced thereby [6].

The textile industry of Russia as the buyer of cotton raw material on the international market continues to use the standards and methods of assessing quality of cotton fiber adopted earlier [6, 7]. A repeated assessment of cotton quality is required during conversion of the acquired raw material to articles, adjustment of production process and selection of bales into charges for blending despite the fact that the acquired batches are already provided with information thereof in the accompanying documents [8]. It can be explained by the fact that significant quality deviation may be encountered inside of the supplied batches. In order to preclude claims on this issue, the cotton manufacturing countries change over to bale-by-bale cotton fiber quality assessment. Such an assessment remains to be inaccessible for the domestic raw-material laboratories owing to high labor intensity and duration of tests adopted in the existing standards [6].

Both the domestic textile industry and other production facilities located in many world centers of processing cotton produced in different world countries of the ‘cotton belt’ into yarns and finished textile articles need the expansion of online availability of information on the complex of its properties in the indices adopted on the world market [9, 10].

The computer flow of information on the quality of produced cotton and other raw materials are capable of approaching the world commodity exchanges, actively influence the processes of price-formation for textile raw materials within the shortest possible time due to implementation of Internet technologies [11, 12]. The information on quality and quantity of the raw materials promptly produced
and supplied to the buyers of textile raw materials will be available for work planning at the local textile production facilities all over the world in significant distances from the places of cotton production proper and its stock and depot storage. It contributes to a significant increase of operational efficiency not only of producers of raw materials proper, but of the textile and spinning industry, substantiated reduction of produce prime cost and overhead expenses and increasing quality of the manufactured textile articles [13, 14].

2. Purpose of investigations
Implementation of investigation of physical and mechanical and geometric parameters of types of traditional textile raw materials by means of the methods of national standards widely used earlier (UzRST and GOST) and HVI methods for comparing operative capabilities of the methods, revealing and demonstration of the efficient and dynamic use of Internet capabilities for acquisition and assessment of information about raw materials and transfer of the acquired parameters from an analytical laboratory to the places of industrial processing.

3. Material and methods
Cotton differently dyed fiber of new Russian breeds of medium-fiber cotton plants has been used for laboratory analysis: Abolin TsFN, Voitenok FRT, Kumbazik Maron, Tutum and fibers of new breed of industrial hemp Kefenza [15, 16]. Cotton fiber has been used for a subject of investigations as the most demanded industrial raw material nowadays. Hemp fiber (common hemp) closes a list of industrially produced plant textile fibers of Russia. However, it is produced in the RF in sufficient quantities being attractive in terms of a number of physical and mechanical indicators and yielding capacity. The comparative assessment of fiber has been performed using the methods of UzRST (GOST) and HVI 900 [6].

The following climatic conditions have been provided in the course of testing by means of the methods of UzRST (GOST): air temperature in the room — +22°C; air relative humidity — 63–65%. Regulatory documentation for test methods: UzRST 614 ‘Cotton fiber. Sampling methods’; UzRST 619 ‘Methods of determining specific tensile strength’; UzRST 620 ‘Methods of determining linear density’; UzRST 633 ‘Methods of determining length’ GOST 3274.0 — GOST 3274.5 ‘Cotton fiber. Test methods’, TU 8112-001-05746069-96 ‘Flax cottonized fiber. Specifications’.

The investigation results have been processed by means of standard methods of mathematical statistics — dispersion analysis (ANOVA) with providing indicator of the least significant difference HCP05.

4. Results and discussion
The methods of national standards and HVI feature different duration and labor intensity. Depending on spinning method the cotton fiber parameters feature different priority grades. The length of cotton fiber is of great significance. When determining length by means of GOST method, a staple weighing 30±5 mg from the final ribbon was laid with fibers graded by the length groups (up to 20 and 16 mm). The modal, staple and average weight-length in millimeters with a measure of inaccuracy up to 0.1 mm, as well as content of short fibers up to 20 and 16 mm in staple, coefficient of variation by the length in percents with a measure of inaccuracy up to 0.1% have been calculated according to GOST formulae. Proceeding from the measurement results the indicators of staple weight-length varied from 25.8 mm to 39.3 mm with the samples of fibers from different cotton brands. The modal weight-length varied from 23.0 mm to 36.4 with length variation in the range of 28.6–33.9 (table 1). However, an average weight-length with the same fiber samples has assumed values from 19.6 mm to 30.6. The test results demonstrate that one fiber sample could be characterized by quantitatively different length indicators.

The national standards assess the fiber fineness, which characterizes its cross dimensions. Cotton fiber is one of the thinnest textile fibers. The experiments have shown that the longer is the fiber, the thinner it is. It is possible to produce a thin, even and strong yarn from mature and thin fiber since
Interestingly more thin fibers than thick ones get settled in the yarn transverse section. In order to make such analyses much time and manual labor is required. The fiber fineness is determined in the national standards by an indicative measure of fineness — a metric number, which is calculated as a ratio of fiber length to its weight and shows a number of length units accounted for the weight unit. We can take it that this indicator most impersonally characterizes the fiber fineness, since the thinner is the fiber; the higher is its number. However, it is rather labor-consuming to get this indicator.

**Table 1.** Physical and mechanical indicators of cotton samples of new cotton plant breeds according to GOST 3274.0 – 3274.5.

| Breeds   | Weight-length, mm | Coefficient, % | Breaking tenacity, gf/tex | Linear density, mtex | Fiber number |
|----------|-------------------|----------------|--------------------------|----------------------|--------------|
| Tyamin  | 36.5              | 28.5           | 38.5                     | 135                  | 7407         |
| Kumbazik Maron | 25.5              | 30.7           | 25.8                     | 215                  | 4674         |
| Tutum   | 23.1              | 30.9           | 24.1                     | 292                  | 3437         |
| Voitenok FRT | 27.1              | 30.2           | 27.1                     | 201                  | 5010         |
| Abolin TsFN | 30.1              | 33.8           | 25.4                     | 191                  | 5273         |
| NSR05   | 2.3               | 3.1            | —                        | —                    | —            |

A differential weighing system is used in a number of national standards instead of the metric numbering system when determining the fiber number. For instance, denier is a weight of 9,000 meters of fiber in grams. Tex (millitex) used in UzRST and GOST is a weight of 1,000 meters of fiber in grams. Grex unit, which is the weight of 10,000 meters of fiber in grams, was also used in a number of measurements.

The breaking tenacity and the linear density have been determined manually. 2 staples weighing 17–20 mg each from a ribbon had been laid at the staple layer instrument, which were combed later by means of a large-toothed comb with 10 spikes/cm and used spreader to spread fibers longer than 20 mm on the object carriers. The fibers were counted later on the projection-type fibers counter. The counted fibers have been collected into staples as wide as 2–3 mm to be joined into one common staple with the least number of fibers of 500. The breaking tenacity of cotton fiber in mtex, and the breaking tenacity in gf/tex have been calculated according to GOST formulae. The fiber number of the investigated fiber samples varied with different cotton plant breeds from 3436 (Tutum variety) to 7404 (Tyamin variety). The breaking tenacity varied from 24.0 gf/tex (Tutum) to 38.5 (Tyamin variety) (table 1). The coefficient of cotton maturity determination according to GOST has also been rather labor-consuming.

Thus, the used national standards of methods for determining the cotton fiber quality are quite informative, but they involve the manual labor and a great number of different equipment, which is not computerized and has no access to Internet.

In case of selling cotton fiber on the international market its quality has been traditionally assessed also by means of a classer method — with respect to external view, color and length [6]. One of the factors that has greatly influenced the intensity of HVI technologies development in the 90s was the increased use of rotor spinning machines in the world textile industry. The fiber strength has become the most important factor for these machines in the course of fabrication of sturdy yarn. The assessment of this strength has not been possible using traditional classer method. HVI system measures and calculates the following cotton fiber quality indicators and its state by its color and contamination level.

A micronair indicator, Mic, is the characteristic of fineness and maturity of cotton fiber being determined by the porosity of fiber sample.
An upper average length, Uhml, is the average length of the longest fibers making a half of the sample under test by weight, which is expressed in inches or mm. A staple length is the fiber length, which is determined by the classifier visually with respect to a staple of parallel fibers laid thereby manually and expressed as 1/32 of an inch. An index of uniformity by length, Unf, is the characteristic being determined by the ratio of fibers average length to the upper average length expressed as a percentage. An index of short fibers, SFI, is the share of short fibers in a sample featuring length less than 0.5 of an inch expressed in percentage.

A reflection coefficient, Rd, is the amount of light reflected by the surface of cotton fiber sample under test expressed in percentage. A yellow degree coefficient, +b, is the degree of color yellow component in a sample under test. A trash code, T, is the indicator of contamination with non-fiber impurities being determined by multiplying an area of foreign impurities by ten.

An area of foreign impurities, Trash Area, is the total area of impurity particles being determined instrumentally at HVI system in the way of scanning the surface sample expressed as a percentage of the tested sample portion area surface. A number of foreign impurities, Trash Count, is the number of individual foreign impurities in a sample featuring diameter of 0.01 inch and more. A breaking tenacity, Str, is the strength of cotton fiber expressed in HVI graduation of calibration cotton, gf/tex.

Extensibility at break, Elg, is the fiber elongation by the moment of its breakage at the dynamometer of HVI system expressed as a percentage. All calculations have been performed by means of an internal programmed microprocessor of HVI 900 system with respect to every identified sample with indicating average measurement results alongside with parallel fiber test results. The aggregate result of measuring cotton fiber indicators has been output both on paper medium in the form of printouts and in the form of files. As may be agreed upon by fiber manufacturers, suppliers and consumers the number of indicators can be either increased or decreased.

Additionally, HVI 900 system is capable of determining values of the following cotton fiber characteristics: an index of availability for spinning, SCI, which is a calculated value based on multiple regression investigations that compare the fiber properties with the yarn properties. Every equation takes into account all cotton fiber properties identified at HVI and calculates one value, which should be used for every sample under test. Presently, equations are used for calculating SCI, which make it possible to analyze the influence of quality indicators of samples from the bales of a certain batch of cotton fiber for availability thereof for spinning and potential quality of the produced yarn: index of uniformity, coefficient of uniformity, expected yarn strength (Count Strength Product — CSP). The values of expected yarn strength (CSP) are to be calculated and are based on investigating regression equations to be used for forecasting the strength of yarn made of cotton fiber of the batch being analyzed.

The indicators of quality of cotton plant fiber samples (table 1) analyzed by the methods of UzRST and GOST have been determined by Spinlab HVI 900 methods. The results are presented in the table 2. The fiber length (UHML) varied from 24.7 to 29.2. The tested fiber samples have been similarly ranged by Spinlab HVI 900, the same as in case with GOST analyses. Tutum breed features the shortest fiber. The strength of the STR fiber varied from 27.2 to 35.1 (table 2). Visually the breed of cotton plant featured quite short and strong fiber. Spinlab HVI 900 system appeared to be able to characterize this feature quite accurately. The micronair Mic 6.8 testified to the coarseness of Tutum fiber (table 2). According to classification adopted on the international market the cotton fiber of the above samples can be attributed with respect to the degree of bleaching (indicators Rd, +b, CG) to grade W — white, and to grade 1 according to classification of the Republic of Uzbekistan.
Table 2. Physical and mechanical indicators of cotton samples of new cotton plant breeds according to Spinlab HVI 900.

| Breeds     | Fiber length | Uniformity index by length | Strength | Extensibility at break | Micronair |
|------------|--------------|----------------------------|----------|------------------------|-----------|
|            | Uhm          | Un                         | Str      | El                     | Mik       |
| Kumbazik   | 28.3         | 82.5                       | 27.2     | 6.0                    | 4.9       |
| Maron      |              |                            |          |                        |           |
| Tutum      | 24.7         | 82.9                       | 35.1     | 5.5                    | 6.8       |
| Voitenok   | 29.2         | 85.8                       | 28.3     | 6.1                    | 4.1       |
| FRT        |              |                            |          |                        |           |
| Abolin     | 28.4         | 83.8                       | 29.3     | 6.0                    | 4.3       |
| TsFN       |              |                            |          |                        |           |
| NSR_05     | 2.2          | 2.0                        | 3.1      | –                      | 0.1       |

Thus, one can conclude from the above comparative analyses that Spinlab HVI 900 is quite informative and authentically characterizes specific features of the new cotton plant breeds. Information received in digitized form on electronic media can be promptly transmitted and analyzed for different purposes: production and commercial. It can significantly influence the possibilities of technological assessment of the new fiber samples with the prospects of dynamic submission of information acquired in a particular technological laboratory through implementation of Internet technologies to the world market.

Table 3 shows comparative information on the quality of hemp fibers according to indicators of Spinlab HVI 900 and TU 8112-001-05746069-96. The performed research has demonstrated that

Table 3. Physical and mechanical indicators of hemp fiber samples according to Spinlab HVI 900 and TU 8112-001-05746069-96.

| Fiber length | Index of uniformity by length | Strength | Extensibility at break | Linear density, tex | Fiber number | Average weight-length, mm |
|--------------|-------------------------------|----------|------------------------|---------------------|--------------|---------------------------|
|              | Uhm                           | Un       | Str                    | El                  | T            | N                         | Lcp                      |
| Kefenza      | 37.4<sup>a</sup>              | 77.6     | 43.5<sup>a</sup>       | 4.3                 | 3.5          | 296<sup>a</sup>           | 37.5<sup>a</sup>          |

<sup>a</sup> essentially at 5% level of significance

Hemp fibers can be assessed not only by locally used fibers analysis of TU 8112-001-05746069-96, but in the parameters of globally-adopted unified system Spinlab HVI 900 too. The availability of Internet technology widely accessible in the world is of fundamental importance for a possibility of assessing a new product in the criteria of quality unified for the cotton raw material most globally common. Proceeding from the data of table 3 it is evident for textile fiber consumers all over the world that the common hemp produced and characterized in universal parameters features quite a big length UHML comparable with the fine-fibered cotton plant equal to 36.8–37.4 with the uniformity by length Un up to 77.6. The common hemp fibers provided to the market is suitable for blended spinning with cotton utilizing widely-used cotton-processing equipment. The strength of such fiber is quite high — up to 43.5 (table 3).

5. Conclusion
The information on quality of the produced, warehoused, sold and delivered batches of cotton and other fiber acquired in HVI systems is reproducible, widely apprehensible, informative and quite mobile due to communication between fiber producers and its consumers through Internet technologies. The investigation shows that information on quality indicators of fiber of the new breeds of the average-fiber
cotton plants can be promptly represented at the international commodity exchanges. The results of conducted investigations also testify to the fact that common hemp fiber can be used as a substitute of the cotton fiber when manufacturing a number of textile articles in countries, where the cotton fiber is not produced due to climatic conditions (e.g., Western Europe), while a demand for vegetative textile raw material is rather high.

The Internet technologies are necessary for textile enterprises to solve the tasks of selecting bales into charge, which helps reduce the non-uniformity of the produced yarn on the basis of computerized solutions taking into account analysis of databases on fiber quality in every bale. The solutions can be adopted also on the basis of inherent measurements or using information accompanying a batch of the imported fiber.

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