COMPARATIVE ASPECTS CONCERNING METHODS USED TO DETERMINE COTTON FIBERS STRENGTH PER DENIER

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Abstract: *This work has shown to you a study about the determination of tensile strenght by three methods of stress, using the four varieties of the cotton fibers: Russian 2A, Russian 1A, Sudanese Baracat 5x5, Pakistani SLM (Medium IV). The methods of the tensile stress used in this study are: the method of requesting of a bundle containing all categories of fibers from the sample, using the DS-3M dynamometer; the the method of application of flat bundles of fibers containing fibers previously sorted by length classes using the mechanical fibrometer and then subjected to tensile strength determination on the dynamometer DS-3M; the method of application of the three fiber bundles corresponding to the class with the highest fiber content.*
From the comparative analysis of these three methods of stress,we can find that the index for assessing the tensile strength, called the toughness mode, obtained by the third method, combining the advantages of the first method and eliminating the disadvantages of the second, can be an optimal index to express it. From the experimental results and the graphical representations as the distribution diagram of the cotton fiber length, depending on their mass,we can find that the fiber mass belonged to the classes with the highest fiber content is about 35-55% of the total mass of the sample, an enough approximation for the tenacity, the toughness mode, to be expressed, using a coefficient ,named the average tenacity, measured by the disclosed methods .
The third proposed method has a double productivity of conventional methods, it reduces the time required for all determinations by 55%, it is not required the counting of the fibers per a milligram and also, it is possible to determine the mode length of the fibers at the same time /with the tenacity.

Key words: *tensile strength, fiber length, cotton, average tenacity, stress methods*

1. INTRODUCTION

Tensile strength of cotton fibers is important at various stages of processing such as ginning, spinning and weaving. Inferior tensile properties lead to poor fiber length distribution, increased short fiber content, poor yarn quality, lower fabric appearance and low productivity. Studies on the relationships between cotton fiber quality measurements and physical properties of ring spun yarn revealed that longer and stronger cotton fibers can be spun into finer yarns [1], [2].

An untwisted fibre stream has a certain tensile strength thanks to the cohesion of fibres. The cohesion of fibres which form the stream is a characteristic feature of these fibres. The value of cohesion is influenced by the kind of fibre materials, by the fibre slenderness and the surface properties of the fibres [3], [4].

Despite all the competition from their artifi cial counterparts, cotton is still the best-selling fi ber material in the world, and mostly in the textile industries [5], [6].

Cotton fiber quality parameters – It is a set of dimensional and mechanical properties of cotton fibers (such as length, maturity, strength, and fineness) which defines the market value of a bale of cotton [7].

2. EXPERIMENTAL PART

2.1. Materials and Methods

Study was conducted on these sorts of cotton: Russian 2A, Russian 1A, Sudanese Baracat 5x5, Pakistani SLM (Medium IV), whose characteristics are shown in Table 1.

Table 1: *Physico-mechanical characteristics of fibers*

Cotton type	Spinner length, [mm]	Fibers count [mtex]	Pressley index	Impurities with tweezers [mg]
Russian 2A	31/32	161	86177	3,7
Russian 1A	31/32	143	90327	3,5
Sudanese Baracat 5x5	33/34	130	96900	5,3
Pakistani SLM (Medium IV)	29/30	169	97220	10,18

Among the methods used to determine the breaking strength of the cotton fibers, the following were used in the present work:

- The method of stressing a bundle that contains all the categories of fibers from the sample, using a DS-3M dynamometer, method that permits to compute the mean breaking force of a fiber by means of the relation:

$$P_{[cN/\rho b]} = \frac{Q[cN]}{m[mg]\cdot n_f \cdot 0{,}675} \tag{1}$$

with: Q is the breaking load, [cN];
m- the fiber mass [mg];
n_f -number of fibers from 1 mg;
non-simultaneity factor (of 0.675) due to asynchronous breaking of the sample fibers.

- The method of stressing some flat fibers bundles that contain fibers previously sorted in classes according to their length by means of a mechanical fiber-meter, then determining the breaking load on DS-3M dynamometer, thus determining the breaking load corresponding to fibers from each length class, as well as the mean strength per denier of the cotton fibers from the analyzed batch.
- The method of stressing only three fiber bundles corresponding to the classes with the highest fibers content.

This last method represents a direct consequence of the possibility to sort the fibers in classes according to their length by means of the mechanical fiber-meter. It is simple, much more operative and implies the determination of breaking load on DS-3M dynamometer [8], [9].

The classes with the highest fibers content (Fig.1) are identified from the sample sorted in length classes.

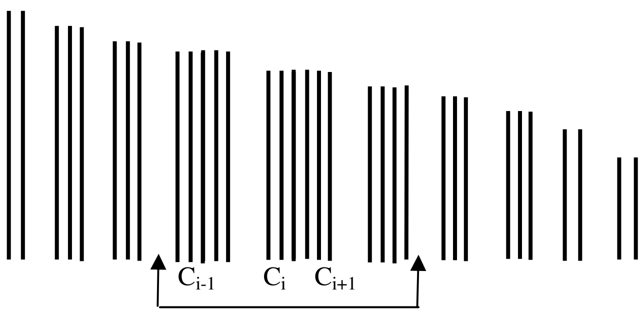

Fig. 1: *Sample sorted in length classes*

Supposing that the class C_i is the class corresponding to the **mod** length, the breaking load will be determined for the fibers from the classes C_{i-1}, C_i and C_{i+1}.

Each bundle is weighted at torsion balance. As the length of the fibers from the respective classes is known, the yarn count and mean strength corresponding to the 3 fibers classes are determined.

2.2. RESULTS AND DISCUSSIONS

The mean values of the breaking load per fiber (P_i) and fiber strength τ[cN/tex].
The formula used for calculation is:

$$\tau[\text{cN/tex}] = \text{P[cN/fibra]} \cdot \frac{1}{T_{tf}} \tag{2}$$

with: T_{tf} – fiber count [tex]. The results are shown in Table 2.

Table 2: *The mean values of the breaking load per fiber and fiber's tenacity*

Cotton type	P[cN/fibra]	T_{tf} [tex]	τ [cN/tex]
Russian cotton 1A	2.7	0.143	19.3
Sudanese cotton Baracat 5x5	2.6	0.130	20.02
Pakistanis cotton SLM (M. IV)	2.2	0.169	12.78
Russian cotton 2A	2.71	0.161	16.7

The determination of cotton fibers breaking load through bundle method by means of DS-3M dynamometer implies theoretically the realization of a 3 mg sample that contains all the types of fibers from the batch in the same proportion in which they exist in the entire fibrous mass (total batch). Yet, practically, when forming the bundle, due to the 10 combings of the fibers' bundle ends, the doer has the tendency to eliminate the short fibers, which results in errors related to bundle mass and fibers' strength.

During samples stressing at a null spacing between dynamometer clamps, the fibers with the length smaller than half the bundle length will not participate in the stress, the breaking load being taken up by the long fibers with higher strength per denier, such that the obtained value will exceed the real average. Given the fact that the determinations are carried out with DS-3M dynamometer, in the calculation of the breaking load P [cN/fiber], the relationship, will intervene a non-simultaneity factor (of 0.675) due to asynchronous breaking of the sample fibers.

This factor is influenced by the doer, namely by fiber combing manner, hand perspiration and the fastening of dynamometer clamps. Its utilization prevents getting an erroneous value as compared to the real value. From the curves of mass distribution in terms of cotton fibers length (Fig. 2, Fig. 3, Fig. 4), it was noticed that the mass of the fibers from the classes including the highest fibers content represents about 35÷55% of the total mass of the sample, a sufficient approximation for the mod strength to be expressed by means of a mean strength measured through the presented methods.

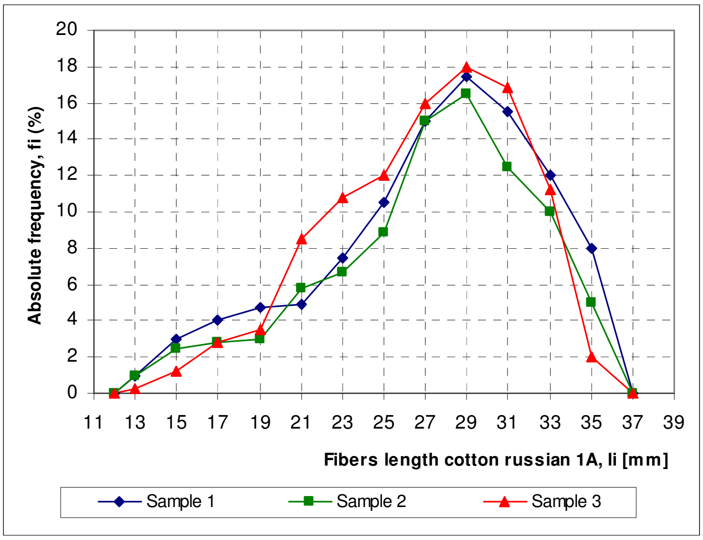

Fig.2: *Curves of mass distribution in terms of cotton Russian 1A fibers length*

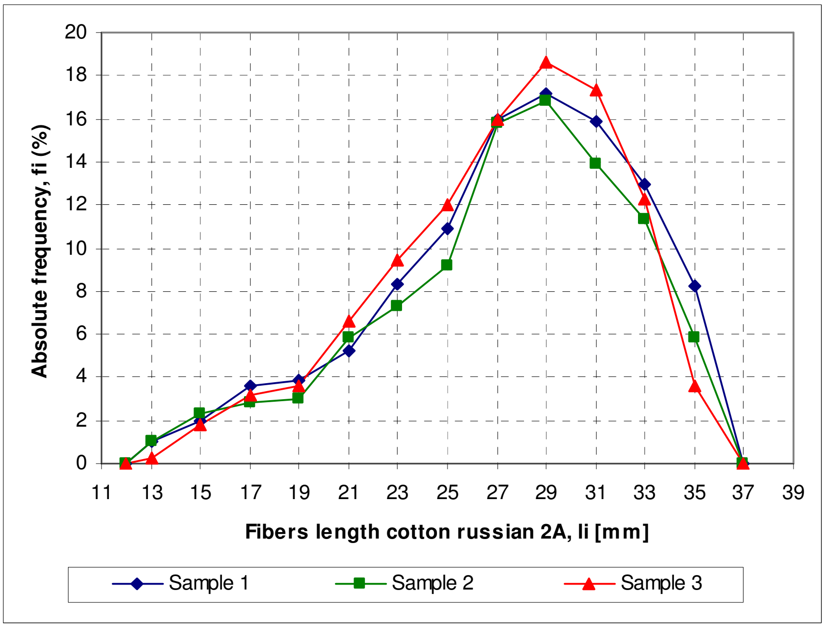

Fig. 3: *Curves of mass distribution in terms of cotton Russian 2A fibers length*

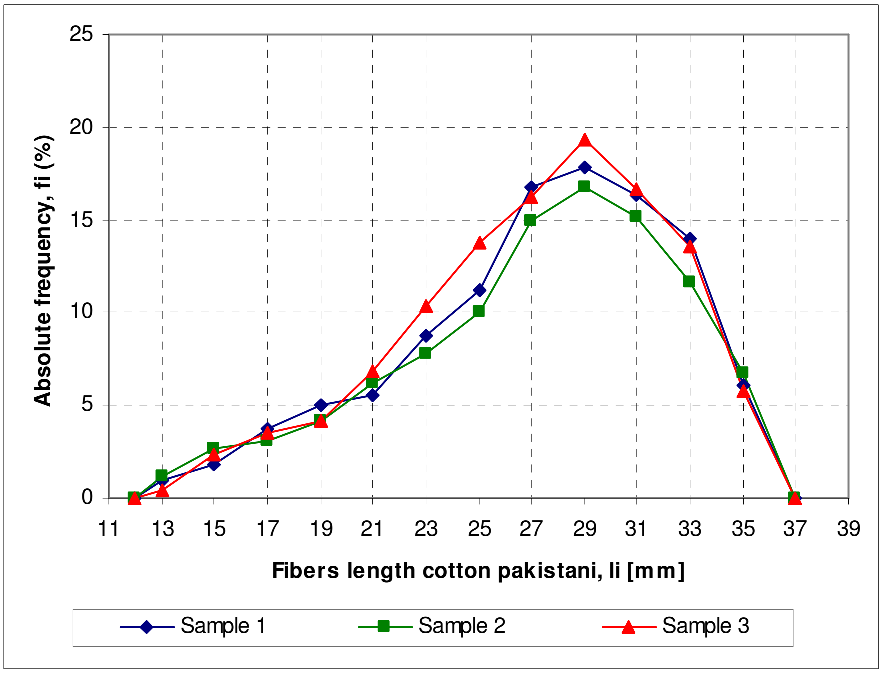

Fig. 4: *Curves of mass distribution in terms of cotton pakistani fibers length*

One can notice an increasing variation of the strength with fiber length within the same sample. By determining the strength through the flat bundle method, from reasons already mentioned at the theoretical premises of method applications, the obtained value will have a certain deviation from the real value. The curves show certain non-uniformity due to various factors of influence (lack of breaking simultaneity, sample clamping mode, hands humidity). Since the mod strength was found as the value of/between a mean strength obtained by completely sorting up the sample in classes, and that obtained with DS-3M, combining the advantages of the first method and eliminating the shortcomings of the second one, it can represent an optimum index of its expression (Fig. 5).

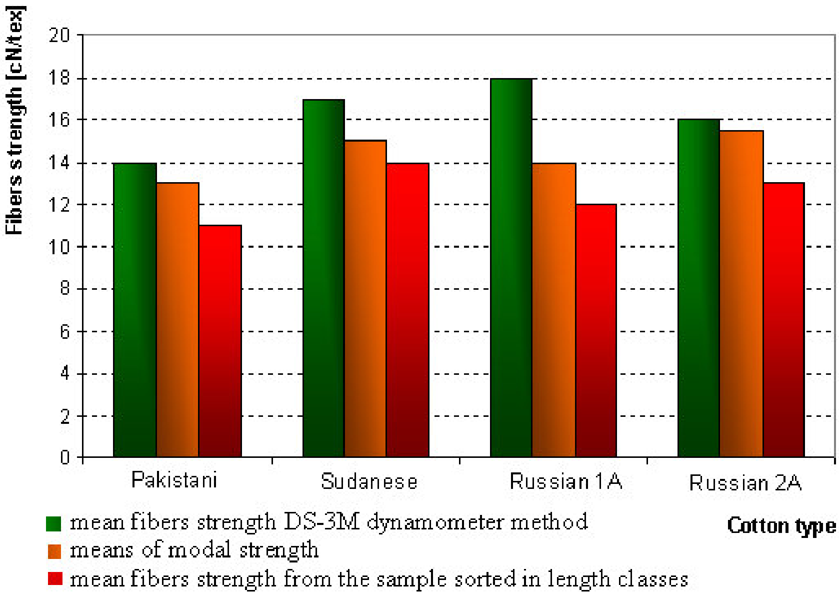

Fig. 5: *Variation mean fibers strength from the methods used to determine the breaking strength of the cotton fibers*

Table 3: *Values of breaking load through bundle method by means of DS-3M dynamometer*

Cotton type	T_{mtex}	n_f/mg		Breaking load Q									
				1	2	3	4	5	6	7	8	9	10
Russian 1A	143	252	Sample mass	3,1	3,7	3,7	3,4	3,2	3,0	3,0	3,0	3,0	3,0
			Q	1444	1800	1780	1760	1520	1404	1498	1579	1215	1579
			P[cN/f_b]	2,7	2,8	2,8	3,0	2,7	2,7	2,75	3,0	2,3	3,0
Sudanese Baracat 5x5	130	234	Sample mass	3,1	3,7	3,7	3,4	3,2	3,0	3,0	3,0	3,0	3,0
			Q	1404	1500	1400	1560	1441	1269	1228	1093	1295	1336
			P[cN/f_b]	2,3	2,78	2,7	2,9	2,7	2,6	2,5	2,2	2,5	2,7
Pakistani	169	247	Sample mass	2,5	2,5	2,7	2,8	3,0	3,0	3,0	3,0	3,0	3,0
			Q	999	1039	985,5	945	1296	1134	1026	999	1228	1242
			P[cN/f_b]	2,3	2,4	2,1	2,02	2,59	2,26	2,05	1,99	2,4	2,5
Russian 2A	161	245	Sample mass	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0	3,0
			Q	1336	1336	1255	1201	1552	1404	985	1296	1606	1066
			P[cN/f_b]	2,69	2,69	2,52	2,4	3,1	2,8	1,9	2,6	3,2	2,1

We carried out10 determinations for each sample. The utilized calculus formula (1)

3. CONCLUSIONS

- The representation of cotton fibers length variation reveals the existence of 3 classes that contain about 33 ÷ 55% of the total sample mass, offering the possibility to express the mean fibers strength by means of modal strength corresponding to these classes (Fig. 1).
- One can notice an increasing variation of the strength with fiber length within the same sample. By determining the strength through the flat bundle method, the obtained value will have a certain deviation from the real value. The curves show certain non-uniformity due to various factors of influence (lack of breaking simultaneity, sample clamping mode, hands humidity) (Fig. 2, Fig. 3, Fig. 4).
- Since the mod strength was found as the value of/between a mean strength obtained by completely sorting up the sample in classes, and that obtained with DS-3M, combining the advantages of the first method and eliminating the shortcomings of the second one, it can represent an optimum index of its expression (Fig. 5).

- The method presents a good reproducibility. It was verified on four types of cotton, the values obtained for mod strength within the same cotton type for all the variants being close to each other.
- Method efficiency. The method efficiency is twice the efficiency of the classical methods, which reduces the determinations time by 55%.
- The effort of the operator who carries out the determinations is reduced (it is not necessary to count the number of the fibers from 1 mg).
- There is the possibility to simultaneously determine the fiber mod length and the strength.

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