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APPRAISAL OF THE QUALITY OF FABRICS MADE OF COMBED WOOL YARNS THROUGH SYNTHETIC INDICES

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Abstract: *In order to assess the quality level, it is necessary to determine a series of indices, then to establish the reference elements on whose basis to formulate the findings and the conclusions, thus highlighting the optimum variants of fabrics. In this work have been determined the values of synthetic durability indices, setting the basis for a ranking of studied fabric variants in terms of surface characteristics. The highest weight in this work belongs to the measurement applied to an important number of quality characteristics, representative for the appraisal of durability functions specific to fabric surfaces. The selection of the representative characteristics: breaking strength, Pr (daN); mass loss due to friction stress, Δm (%); thickness diminution due to friction stress, Sg (%), breaking strain work, Ws (daN/m), fabric strength per denier, τ_t (cN/tex) and wrinkle recovering angle α (^{o}), on whose basis the durability indices were calculated, have been determined through standardized means and methods. The expertise method has been applied to assess the significance degree of the characteristics which express the analyzed products functions.*

*Quality index is the relative expression of a certain characteristic, obtained by referring it to a reference value (norm, standard or pattern). The index can be converted in marks, namely by convention the qualificative/mark «**0**» represents an inadequate product/non-quality, while the qualificative/mark «**1**» represents the high qualificative/mark level. In terms of complexity, quality indices can be simple, synthetic and global. The work sets the accent on the appraisal of quality level of the analyzed textile surface by means of synthetic indices.*

Key words: *synhtetic indices, breaking strength, wool fabrics, quality, qualificative*

1. INTRODUCTION

Quality has a complex character, which is determined by the large number of qualities or attributes which must be satisfied by the product in order to be considered as a quality product. Quality characteristics are used in order to assess or evaluate the quality. Named also quality criteria or parameters, these are quantitative and qualitative properties used to set forth the quality requirements imposed to products and/or their components [1], [2], [3]. Quality indices represent numerical expressions of the quality level of a product and they need to satisfy a series of conditions:

- to be simple, such that their calculus variant, their expression and their significance to be easily understood;
- to be pertinent, such that to provide the most accurate description of the real quality level;
- to be verifiable, i.e. to permit recalculation at any moment based on the utilized method.

Yarns quality characteristics influence the fabrics structure and properties in the processing procedures, wearing and maintenance; they motivate the prescription through standards and their testing through adequate methods [4], [5]. In order to determine the indices, it is necessary to apply appraisal methods for the quality characteristics specific to textile industry: *measurement* with a known accuracy through standardized means; *expertise*, accomplished through sensorial analysis by persons specialized in the field; *sociological*, based inquiry questionnaires address to potential users [6], [7], [8].

The basic raw material in the garment industry is represented by the fabrics which, depending on their destination, must satisfy a series of quality conditions related to the consumer, these being given by: properties which express the use value (of composition and structure, physical); properties which express durability (mechanical), properties expressing the comfort (physical, defining physiological comfort; mechanical, defining psycho- sensorial comfort) [9], [10]. Quality indices are very useful to help management companies, current conditions of globalization. Business should strive to increase the competitive advantage that will increasingly depend on the parameters of innovation, new product development, versatility, quality, cost, etc, and indices will be measured [11], [12].

2. EXPERIMENTAL PART

2.1. MATERIALS AND METHODS

The study has been performed on fabrics of combed wool -type yarns used to manufacture overdresses. Durability indices have been determined based on an experimental matrix (Table 1) which included 4 input variables: fibrous composition, weave type, warp and weft yarn counts and flotation of the two yarn systems.

Table 1: *Experimental Matrix*

Variant Code	X1	X2	X3		X4	
	Fibrous composition	Bonding	Yarn count Nm		Flotation F	
			Warp	Weft	Warp	Weft
A2	100% Wool	D2/1	40/2	24/1	1.5	1.5
A5		P 2/1	52/2	52/2	1.5	1.5
A8		D2/1	48/2	30/1	1.5	1.5
A9		crepe	48/2	30/1	1.5	1.5
A10		crepe	48/2	48/2	1.5	1.5
A15		crepe	45/2	45/2	1.5	1.5
A16		D2/1	64/2	64/2	1.5	1.5
A17		D2/1	60/2	60/2	1.5	1.5
A18		D 3/1 3/1 1/2 1/1	60/2	60/2	1.6	1.6
A19		D2/1	56/2	37/1	1.5	1.5
A21		D2/1	56/2	37/1	1.5	1.5
A22		D1/2	56/2	37/1	1.5	1.5

The basic parameters (fibre composition, linear density, technological density of the two yarn systems and weave type) have been determined for the finished fabric through classical means and standardized methods. The intersection between a warp yarn and weft yarn is called bonding point, thus the bonding contains all bonding points having a warp or weft effect along a longitudinal or transversal direction. One or more bonding points having the same effect and forming one bonding segment can exist in longitudinal or transversal direction [13]. The bonding segments with the same effect are called flotation (F). They can be warp flotation (Fwarp) when the warp yarn passes over the weft yarn and weft flotation (Fweft) when the weft yarns passes over the warp yarn. The flotation size, similar to the bonding segment, have the minimum value F=1. The following relations exist between the ration (R), number of passes (t) and mean flotation (F):

$$F_{warp}=R_{weft}/t_{warp} \quad (1)$$

$$F_{weft}=R_{warp}/t_{weft} \quad (2)$$

Stages of synthetic index calculation:

- select the representative characteristics;
- get the set of representative samples (n);
- measure the characteristics through standardized methods;
- establish preferable sense of increase/decrease of each characteristic, depending on product destination;
- refer the values for each characteristic to a unique scale [0÷1]; the ratio will give the usefulness characteristic U_i from the relation:

$$U_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \quad (3)$$

for preferable increase sense of the characteristic value (positive characteristic);

$$U_i = \frac{x_{\max} - x_i}{x_{\max} - x_{\min}} \tag{4}$$

for preferable decrease sense of characteristic value (negative characteristic) [14];

- set the hierarchy of quality characteristics in terms of significance coefficient (significance degree), computed with the relation

$$\gamma_i = \frac{100 / \sum_{j=1}^{m} R_{ij}}{\sum_{i=1}^{n} (100 / \sum_{j=1}^{m} R_{ij})} \tag{5}$$

where: R_{ij} = 1 represents the rank assigned to the characteristic considered as the most important (with maximum mark/qualificative);
R_{ij} = n represents the rank assigned to the characteristic considered as the less important (with minimum mark/qualificative);
n- number of characteristics, i= 1, …., n;
m – number of experts, j= 1,……., m.

The expertise method was used in order to establish the significance characteristic. The ranks corresponding to quality characteristics have been evaluated by an expert team consisting of six specialists in textile area (high instruction teaching staff). Based on appraisals, inquiry cards were drawn up, where the experts wrote the rank of each adopted characteristic (Table VI.4). In the polls carried out within the work, the experts have different ranks to quality characteristics.

The following relation was applied in order to check the agreement between the experts opinion:

$$W = \frac{\sum_{i=1}^{n} \left(\sum_{j=1}^{m} R_{ij} - R_{ij,n} \right)^2}{m^2 \cdot \left(n^3 - n\right)/12} \tag{6}$$

where:

$$R_{ij,n} = \frac{\sum_{i=1}^{n} \sum_{j=1}^{m} R_{ij}}{12} \tag{7}$$

In order to check the agreement between expert opinions, the χ^2 test was applied, where:

$$\chi^2 = W \cdot m(n-1) \tag{8}$$

If $\chi^2{}_{\text{calc}} > \chi^2_{\nu=n-1,\alpha=0.05}$ it follows that expert opinions agree with each other (W is significant)

For $W \geq 0.8$, the significance coefficient γ_i is determined with the relation:

$$\gamma_i = \frac{100 / \sum_{j=1}^{m} R_{ij}}{\sum_{i=1}^{n} 100 / \sum_{j=1}^{m} R_{ij}} \tag{9}$$

The characteristic hierarchy/ranking will be established based on the criterion of decreasing γ_i values. The representative values must satisfy the condition $\gamma_i > 1/n$

- calculate the synthetic index with the relation:

$$Is = \sum_{i=1}^{n} U_i \gamma_i \tag{10}$$

2.2. RESULTS AND DISCUSSIONS

In this work the synthetic durability (I_s) indices were calculated for each studied article, based on the previously presented algorithm:

- choose the representative characteristic:
  - breaking strength, Pr (daN);
  - mass loss due to friction stress, ΔM (%);
  - thickness decrease due to friction stress, Sg (%);
  - breaking strain work, Ws (daN/m);
  - fabric strength per denier, τ_t (cN/tex);
  - wrinkle recovering angle, α (^{o}).
- The mean values of the durability characteristics for the fabrics from group A (100%L) are presented in Table 2.

***Table 2:**. Mean values of durability characteristics for fabrics of A group (100%L)*

Fibrous composition	Art. Code	Pr (daN)	ΔM (%)	Sg (%)	Ws (daN/m)	τ_t (cN/tex)	α (^{o})
Gruop A 100%	A2	30.28	2.5	8.50	66.5	6.61	167.2
	A5	32.48	3.0	11.21	54.5	7.28	168
	A8	24.53	2.8	9.94	62.3	6.06	166
	A9	25.12	2.6	8.08	38.5	6.20	169
	A10	30.88	2.3	8.08	57.1	8.06	162.2
	A15	28.92	2.4	5.30	51.6	5.81	161.4
	A16	23.1	3.1	12.16	54.0	6.19	167
	A17	28.24	5.8	9.40	67.9	6.83	164.2
	A18	39.6	2.6	8.10	125.3	8.22	166.4
	A19	25.12	3.2	11.65	55.6	7.15	166.6
	A21	24.7	3.1	12.28	57.0	7.03	167.6
	A22	24.98	3.1	10.03	47.3	6.72	169
min		**23.1**	**2.3**	**5.3**	**38.5**	**5.8**	**161.4**
max		**39.6**	**5.8**	**12.3**	**125.3**	**8.2**	**169.0**

- Preferable sense of variation for durability characteristics was adopted as follows:
  - positive characteristics: Pr, Ws, τ_t and α;
  - negative characteristics: ΔM and Sg.
- Refer the obtained characteristics to a unique scale (0- 1), presented in Table 3;
- for positive characteristics: $U_i= (X_i- X_{min})/(X_{max}- X_{min})$;
- for negative characteristics: $U_i= (X_{max}- X_i)/(X_{max} – X_{min})$.
- The calculus of synthetic durability indicator for **Group A** fabrics is presented in Table 3.
- To compute the indicator (I_s), the values of durability characteristics significance degree presented in Table 4 are necessary. The durability characteristics significance degree has been evaluated through the experts' method (Table 5).

***Table 3:**. Calculus of synthetic durability index for Group A fabrics*

Fibrous composition	Art. Code	positive Pr (daN)	negative ΔM (%)	negative Sg (%)	positive Ws (daN/m)	positive τ_t (cN/tex)	positive α (^{o})	I_s
Group A 100%	A2	0.435	0.936	0.542	0.322	0.330	0.763	0.534
	A5	0.568	0.778	0.153	0.184	0.610	0.868	0.537
	A8	0.087	0.857	0.335	0.274	0.102	0.605	0.345
	A9	0.122	0.890	0.602	0.000	0.163	1.000	0.416
	A10	0.472	1.000	0.602	0.214	0.931	0.105	0.518
	A15	0.353	0.953	1.000	0.151	0.000	0.000	0.352
	A16	0.000	0.762	0.018	0.178	0.156	0.737	**0.289**
	A17	0.312	0.000	0.413	0.338	0.424	0.368	0.314
	A18	1.000	0.892	0.599	1.000	1.000	0.658	**0.880**
	A19	0.122	0.739	0.091	0.196	0.556	0.684	0.381
	A21	0.097	0.748	0.000	0.213	0.506	0.816	0.383
	A22	0.114	0.771	0.322	0.101	0.378	1.000	0.419

Table 4: *Significance degree of durability characteristics*

Significance degree	Pr (daN)	ΔM (%)	Sg (%)	Ws (daN/m)	τ_t (cN/tex)	α (°)
γ_i	0.24	0.13	0.11	0.18	0.16	0.17

The conditions of characteristics ranking (γ= 0.11 and W= 105.2) were satisfied. The position of the characteristics presented in Table 5 was established in terms of γ_i. Ranking the fabric quality level has been performed in terms of synthetic indices (Fig. 1), whence one can see that the highest level of synthetic index was obtained at the article **A18**. Therefore this article can be considered as reference article for assortments of group A fabrics.

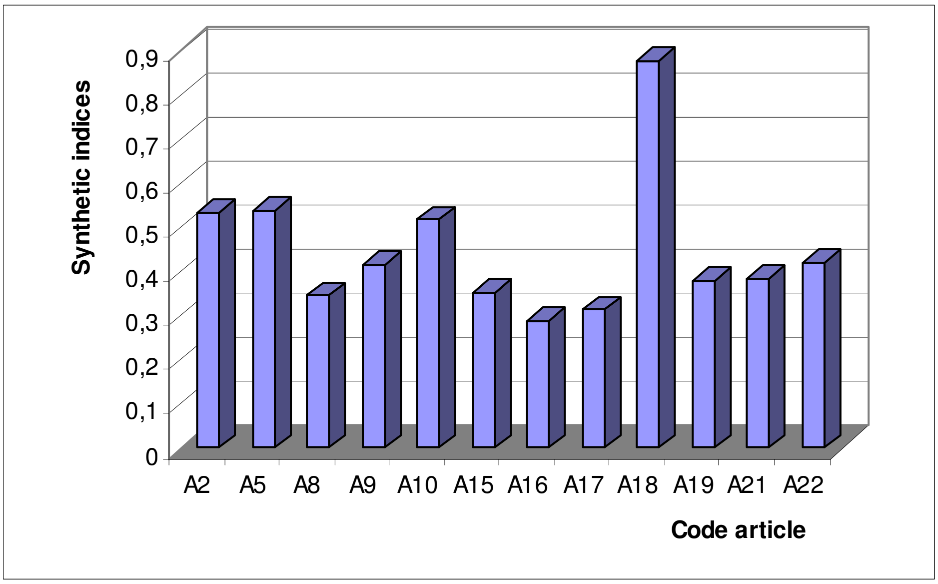

Fig. 1: *Fabrics ranking in terms of synthetic indicators*

Table 5:*. Determination of characteristics' significance degree through experts' method*

Characteristics / Experts	Pr (daN)	ΔM (%)	Sg (%)	Ws (daN/m)	τ_t (cN/tex)	α (°)	$\sum_{j=1}^{n} R_{ij}$
E1	1	5	6	2	4	3	21
E2	2	6	5	1	3	4	21
E3	2	5	6	4	1	3	21
E4	4	5	6	3	2	1	21
E5	1	3	4	5	6	2	21
E6	4	1	2	3	5	6	21
$\sum_{i=1}^{m} R_{ij}$	14	25	29	18	21	19	126
$100/\sum_{j=1}^{m} R_{ij}$	7.14	4.00	3.45	5.56	4.76	5.26	30.2
γ_{ij}	0.24	0.13	0.11	0.18	0.16	0.17	1.0
Position	1	5	6	2	4	3	21.0
$\sum_{j=1}^{m} R_{ij} - R_{ij,n}$	12544	10201	9409	11664	11025	11449	$\sum_{i=1}^{n}(\sum_{j=1}^{m} R_{ij} - R_{ij,n})^2$

3. CONCLUSIONS

This calculation mode permits to draw direct conclusions based on the values of quality indices: the closer to 1 is the index value, the better is the quality to which it refers.

The synthetic index I_s includes all the characteristics reflected in the analyzed fabric durability, as one can see from the experimental values in the case of **Group A** fabrics (100%L). Art **A18**, characterized by Nm_{warp}= Nm_{weft}= 60/2, P_{warp}= 310 yarns/10cm, P_{weft}=290 yarns/10cm, weave $D\frac{3\ \ 1\ \ 3\ \ 1}{1\ \ 1\ \ 2\ \ 1}$ with floating F= 1.6, has the highest value of the synthetic index I_s = 0.880. This is justified by the fact that within the range of analyzed assortments from **Group A**, the **Art 18** has the highest values for tensile strength, strain breaking work and fabric strength per denier, while the mass loss and thickness decrease due to friction are reduced; it also has a high crease recovering capacity.

The smallest value of the synthetic index I_s = 0.289, under the mean value of this index, was obtained at the article **Art A 16** from **Group A**, characterized by Nm_{warp} = Nm_{weft} = 64/2, Pwarp= 360 yarns/10 cm, Pweft= 240 yarns/10 cm, weave $D\frac{2}{1}/$ with floating F= 1.5, since it has the smallest tensile strength.

The present study is also revealing the differentiation,in the frame of the same item, according to technological axis, the recovery angle from creasing along weft direction is higher than the recovery angle along warp direction. When the fineness Nm_{warp} = Nm_{weft}, the recovery angle is higher along warp direction and depends on the ration between technological densities and bonding type.

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