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ESTIMATION OF QUALITY LEVEL BASED ON QUALITY INDICATORS

PUSTIANU Monica, POPA Alexandru, BARBU Ionel, FOGORASI Magdalena, BUCEVSCHI Adina

Aurel Vlaicu University, Faculty of Engineering, AIITT Department, Revoluției,77, 310130, Arad, Romania,
E-Mail: pustianumonica@yahoo.com

Corresponding author: Barbu, Ionel, E-mail: ionelbarbu@yahoo.com

Abstract: *Calimetry is a vast field of research, with applications in the textile field. It deals with both compliance and comparative measurements.This paper presents a comparative study of quality estimation based on integral indicators, two variants of fabrics made of a mixture of threads of 45% cotton and 55% polyester, intended for outerwear. For determining the integral indicators, an additive calculation method was used, based on synthetic indicators of the groups of characteristics (structural, mechanical, functional).By comparing the values of the integral (complex) indicators obtained for the two fabric variants, we could evaluate the best variant that corresponds to its destination in terms of the structural, mechanical and functional solutions adopted.To determine the integral indicators, an additive calculation method was used, based on synthetic indicators of the characteristics groups (structural, mechanical, functional).Synthetic indicators are the indicators of the subgroups and groups of characteristics and are obtained by following the steps below: determination of the degree of importance of the representative characteristic, adoption of the scale of assessment, reporting to the same assessment scale, determination of the value of synthetic quality indicators. Integral indicators calculated by statistical-mathematical analysis, express the level of product quality. They can be calculated both by methods based on synthetic indicators of feature groups and by methods based on simple indicators, using additive or multiplicative calculation methods.*

Key words: *Calimetry, integral and synthetic indicators, quality level of fabrics.*

1. INTRODUCTION

Calimetry is an interdisciplinary science dealing with the study of quality level estimation using technical, analytical or sociological measurement methods and resulting in the calculation of quality indicators.[1]

The measurement methods are applied on samples extracted by sampling, from batches of raw materials, semi-finished products, finished products, etc.

The estimation of the quality level is based on the statistical processing and interpretation of the data obtained from the evaluation of the quality characteristics.[2], [3], [4],[6].

Integral (complex) indicators calculated by statistical-mathematical analysis, express the level of product quality. They can be calculated both by methods based on synthetic indicators of feature groups and by methods based on simple indicators, using additive or multiplicative calculation methods.[1]

By comparing the integral indicators, it can be estimated for the best variant in terms of the solutions adopted.

2. RESULTS AND DISCUSSIONS

For this study, two variants of 45% cotton and 55% polyester yarn blend fabrics were used, with the same structure, but with other adopted values of structural, mechanical and functional characteristics, intended for outerwear.

To determine the integral indicators, an additive calculation method was used, based on synthetic indicators of the characteristics groups (structural, mechanical, functional).

Synthetic indicators are the indicators of the subgroups and groups of characteristics and are obtained by following the steps below:

- Determination of the degree of importance of the representative characteristic,
- Adoption of the scale of assessment,
- Reporting to the same assessment scale,
- Determination of the value of synthetic quality indicators.

2.1 Determination of the degree of importance of the representative characteristic

Determination of a synthetic indicator is based on a series of quality characteristics and requires their hierarchy through the coefficient of importance [1],[5].

For this study, the following groups of quality characteristics were adopted according to the destination of the article, presented in Table 1.

Table 1. *Adopted quality characteristics*

No.	Structural characteristics	Mechanical characteristics	Functional characteristics
1.	fabric width – l [cm]	Breaking load in warp- Su [kg f]	Wrinkle recovery angle to warp [0]
2.	specific mass – M [g / m]	Weft breaking load -Sb [kg f]	Wrinkle recovery angle in the weft [^{0}]
3.	Density in the warp – Du [yarns / 10 cm]	Elongation at break in the warp- Au [mm]	Humidity [%]
4.	Weft density – Db [yarn / 10 cm]	Elongation at break in the weft- Au [mm]	Wash fastness [notes]
5.		Resistance to splice [N]	Ironing fastness [Notes]
6.			Crocking fastness [notes]
7.			Fastness to perspiration [notes]

Tissue samples were taken and the following intervals of variation of the values of each characteristic were obtained. The preferred direction of variation of these characteristics (ascending ↑ or descending ↓) presented in Table 2 was also established.

Table 2. *Intervals and variation of the characteristics adopted*

No.	**Characteristics groups**	**Characteristic**	**Value variation of the values**	**Preferably sense of variation**
1.	Structural characteristics	fabric width - l [cm]	147-156	↑
		specific mass - M [g / m]	350 - 400	↓
		Warp setting - Du [yarn / 10 cm]	150-220	↓
		weft spacing - Db [yarn / 10 cm]	150-220	↓
2.	Mechanical characteristics	Warp breaking load Su [kg f]	50-100	↑
		Weft breaking load Sb [kg f]	40-100	↑
		elongation at break in the warp [mm]	10-50	↑
		elongation at break in the weft Au [mm]	10-50	↑
		Resistance to splice [N]	25-50	↑
3.	Functional characteristics	Wrinkle recovery angle to warp [0]	90-180	↑
		Wrinkle recovery angle to weft [^{0}]	90-180	↑
		Humidity [%]	1-10	↑
		Wash fastness [notes]	1-5	↑
		Ironing fastness [Notes]	1-5	↑
		Crocking fastness [notes]	1-5	↑
		Fastness to perspiration [notes]	1-5	↑

Measures were carried out on the two variants of fabrics and the values obtained for the characteristics are shown in Table 3.

Table 3. *Values of the characteristics obtained for each variant of fabric*

No.	**Characteristics groups**	**Characteristic**	**Variant V1**	**Variant V2**
1.	Structural characteristics	fabric width - l [cm]	149	152
		specific mass - M [g / m]	387	360
		Warp setting - Du [yarn / 10 cm]	205	196
		weft spacing - Db [yarn / 10 cm]	201	180
2.	Mechanical characteristics	Breaking load in warp Su [kg f]	89	60
		Weft breaking load Sb [kg f]	85	45
		Elongation at break in the warp Au [mm]	39	23
		Elongation at break in the weft Au [mm]	37	20
		Resistance to splice [N]	26	30
3.	Functional characteristics	Wrinkle recovery angle to warp [0]	154	140

		Wrinkle recovery angle in the weft [^{0}]	158	130
		Humidity [%]	3,5	5,5
		Wash fastness [notes]	5/5/5	4/4/4
		Ironing fastness [Notes]	5/5	4/4
		Crocking fastness [notes]	5/5	4/4
		Fastness to perspiration [notes]	5/5/5	4/4

The matrix method was used for calculating the importance coefficients of characteristics. The square matrices built with the chosen characteristics are presented in Tables 4,5,6.

Table 4. *The square matrix for structural characteristics*

Ci / Cj	C1 (l)	C2 (M)	C3 (Du)	C4 (Db)	$\sum_i n_{ij}$
C1 (l)	1	0	1	0	2
C2 (M)	1	1	1	1	4
C3 (Du)	0	0	1	1	2
C4 (Db)	1	0	1	1	3
$\sum_j n_{ij}$	3	1	4	3	$\sum_i\sum_j n_{ij} = 11$

Table 5*. The square matrix for Mechanical characteristics*

Ci / Cj	C1 (Su)	C2 (Sb)	C3 (Au)	C4 (Ab)	C5 (Rs)	$\sum_i n_{ij}$
C1 (Su)	1	1	0	0	1	3
C2 (Sb)	0	1	0	0	1	2
C3 (Au)	1	1	1	1	1	5
C4 (Ab)	1	1	0	1	1	4
C5 (Rs)	0	0	0	0	1	1
$\sum_j n_{ij}$	3	4	1	2	5	$\sum_i\sum_j n_{ij} = 15$

Table 6. *The square matrix for Functional characteristics*

Ci / Cj	C1 (Șu)	C2 (Șb)	C3 (U)	C4 (Rs)	C5 (Rc)	C6 (Rt)	C7 (Rf)	$\sum_i n_{ij}$
C1 (Șu)	1	0	1	1	1	1	1	6
C2 (Șb)	1	1	1	1	1	1	1	7
C3 (U)	0	0	1	1	1	1	1	5
C4 (Rs)	0	0	0	1	0	0	0	1
C5 (Rc)	0	0	0	1	1	0	0	2
C6 (Rt)	0	0	0	1	1	1	0	3
C7 (Rf)	0	0	0	1	1	1	1	4
$\sum_j n_{ij}$	2	1	3	7	6	5	4	$\sum_i\sum_j n_{ij} = 28$

Values of importance coefficients obtained with Equation 1, are presented in Table 7.

$$\alpha_i = \frac{\sum_i n_{ij}}{\sum_i \sum_j n_{ij}} \quad \textbf{(1)}$$

Table 7. *Calculated importance coefficients*

No.	Characteristics groups	Importance coefficient α_i	Values	Hierarchy of characteristics
1.	Structural characteristics	α1	0.27	C3>C1≥C4>C2
		α2	0.09	
		α3	0.36	
		α4	0.27	
2.	Mechanical characteristics	α1	0.2	C5>C2>C1>C4>C3
		α2	0.26	
		α3	0.06	
		α4	0.13	
		α5	0.33	
3.	Functional characteristics	α1	0.071	C4>C5>C6>C7>C3>C1>C2
		α2	0.035	
		α3	0.107	
		α4	0.25	
		α5	0.214	
		α6	0.17	
		α7	0.14	

From the analysis and comparison of the values of the importance coefficients, these characteristics can be ranked and it is clear which is the most important characteristic for each group of characteristics.

2.2. Adopt the scale of assessment of quality characteristics and reporting to the same assessment scale of all the characteristics adopted,

The values were reported on a scale of (0-10) and the following values presented in Table 8 were obtained.

Table 8. *Nj scores given to the characteristics adopted on the scale (0-10), for each fabric variant*

No.	Characteristics groups	Characteristic	Score n_j	Variant V1	Variant V2
1.	Structural characteristics	fabric width - l [cm]	n_1	2.22	5.55
		specific mass - M [g / m]	n_2	2.6	8
		Density in the warp - Du [yarns / 10 cm]	n_3	2.14	3.4
		Weft density - Db [yarn / 10 cm]	n_4	2.71	5.71
2.	Mechanical characteristics	Breaking load in warp Su [kg f]	n_1	7.8	2
		Weft breaking load Sb [kg f]	n_2	7.5	0.83
		Elongation at break in the warp Au [mm]	n_3	7.25	3.25
		Elongation at break in the weft Au [mm]	n_4	6.75	2.5

		Resistance to splice [N]	n_5	0.4	2
3.	Functional characteristics	Wrinkle recovery angle to warp [0]	n_1	7.1	5.5
		Wrinkle recovery angle in the weft [^{0}]	n_2	7.5	4.4
		Humidity [%]	n_3	2.7	5
		Wash fastness [notes]	n_4	10	7.5
		Ironing fastness [Notes]	n_5	10	7.5
		Crocking fastness [notes]	n_6	10	7.5
		Fastness to perspiration [notes]	n_7	10	7.5

2.3. The calculation of the synthetic indicators of the adopted characteristics was made with the relationship:

$$I_c = \frac{N_p}{N_{p\max}} \quad \textbf{(2)}$$

Where:
N_P - The average score obtained for the quality features adopted
N_{pmax} - The maximum score for the scoring system

$$N_p = \sum_i \alpha_i \cdot n_i \quad \textbf{(3)}$$

Where:
α_i- the values of the coefficients of importance of the characteristics
n_i – the score granted to the quality characteristics adopted

The values of the mean scores and the values of the synthetic indicators calculated are shown in Table 9.

Table 9. *Average score values and values of synthetic indicators calculated*

No.	Characteristics groups	Variants	Average score	Max score	Synthetic indicator
1.	Structural characteristics	V1	2.32	10	I_{c1} =0.232
		V2	4.97	10	I_{c2} = 0.497
2.	Mechanical characteristics	V1	4.94	10	I_{c1} = 0.494
		V2	1.79	10	I_{c2} = 0.179
3.	Functional characteristics	V1	8.794	10	I_{c1} = 0.879
		V2	6.879	10	I_{c1} = 0.687

For the calculation of the integral indicators, the additive method was used based on the synthetic indicators, of the characteristics groups, which involves in addition to these indicators and the application of a calculation relationship containing these indicators and the level of importance of each synthetic indicator. That is why the level of importance for these indicators has been established by the matrix method.

The square matrices built with these synthetic indicators are shown in Table 10.

Table 10. *Quadratic matrix for synthetic indicators*

Ci / Cj	C1 (Structural characteristics indicator)	C2 (Mechanical characteristics indicator)	C3 (Functional characteristics indicator)	$\sum_i n_{ij}$
C1 (Structural characteristics indicator)	1	0	0	1
C2 (Mechanical characteristics indicator)	1	1	1	3
C3 (Functional characteristics indicator)	1	0	1	2
$\sum_j n_{ij}$	3	1	2	$\sum_i \sum_j n_{ij} = 6$

Values of importance coefficients obtained with Equation 4, are presented in Table 11

$$\alpha_i = \frac{\sum_i n_{ij}}{\sum_i \sum_j n_{ij}} \quad (4)$$

Table 11. *Importance coefficients of the calculated synthetic indicators*

No.	Synthetic indicator	Synthetic indicator values		Importance coefficient α_i	Values
		Variant V1	Variant V2		
1.	Structural characteristics indicator	0.232	0.497	α1	0.5
2.	Mechanical characteristics indicator	0.494	0.179	α2	0.16
3.	Functional characteristics indicator	0.879	0.687	α3	0.33

The following relationship was used for calculating the integral indicator (5) Aad the values obtained are shown in Table 12.

$$N_I = \sum_i \alpha_i \cdot N_i \quad (5)$$

Where:

N_I - the level of the integral indicator
α_i - the values of the importance coefficients of the synthetic indicator

N_i - Synthetic indicator level

***Table 12**. The values of the integral indicators obtained by the additive method*

No.	Variant	Integral indicators
1.	V1	0.485
2.	V2	0.502

3. CONCLUSIONS

Comprehensive product quality indicators can express the level of quality of these products

By comparing the values of the integral (complex) indicators obtained for the two fabric variants, it results that the V2 variant corresponds better to its destination in terms of the structural, mechanical and functional solutions adopted.

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