Analysis of Characterization Indexes for Worsted Fabrics Type Using Correlation Method as a Statistical Tool

LILIANA ROZEMARIE MANEA[1], LILIANA HRISTIAN[1]*, MARIA MAGDALENA OSTAFE[1], LAURA LILIANA APOSTOL[1], ION SANDU[2,3]*

[1] Gheorghe Asachi Technical University, Faculty of Textile Leather and Industrial Management, 28 Mangeron Blvd., 700050, Iasi, Romania

[2] Romanian Inventors Forum, 3 Sf. Petru Movila Str., 700089, Iasi, Romania

[3] Alexandru Ioan Cuza University of Iasi, ARHEOINVEST Interdisciplinary Platform, 22 Carol I Blvd., 700506, Iasi, Romania

The paper proposes an indicator for analyzing the fabrics structure and a manner of calculation thereof, reflecting the warpand weft yarns volume in a weave repeat, being useful in designing fabrics and filling some information about the characteristics and fabric properties, including also their behavior at their various demands. This indicator was called volumetric filling factor as it reflects the real state of the internal structure of the fabric, according to the type of bonding. The elements that characterize the internal structure of the fabrics are defined by the basic structural parameters, fineness, density of yarns and the weave, that determines the mutual position of the yarns of those two systems, yarns positional stability, distribution of the yarns on the parts of the fabric, the dominant of the bundle points binding regarding warp or weft effect. In this study for analysis of volumetric filling coefficient that characterizes the worsted fabrics type, it was used the correlation method/graphic method.Correlation curve allows determining both bond existence, shape, direction, intensity, and the absence of link between variables.

Keywords: volumetric filling coefficient, fabrics, elastomeric yarns, bond type, correlation method

The fabrics made from worsted yarn are customized by the structural and aspect characteristics and physico-mechanical properties that meet a particular field of use.

Among the basic parameters of the fabric: the finesse of the yarns, technological density and the bond which defines the internal structure of the fabric, there are the interdependence and interaction correlations, influencing each other, so by modifying one of them we may occur by default the change of others, thus establishing a new balance and correlation of which results a new fabric with another structure and technical characteristics.

The research and design field, where among certain actions and measures the theory cannot establish any relationship, the correlation method is one of the techniques that can fill this gap by processing experimental data [1-3]. First correlation method involves an experimental research of variation of those measures. The first stage consists in gathering experimental data and plotting the variation of those quantities [2-5].

The graph obtained suggests the type of adjustment that can be used. The essence of the concept of correlation, that of simultaneous variation of the values of two variables, provides a basis of a mutual *prediction* between those variables [4-7].

Analysis and correlation method may facilitate the management process from the point of view of fairness decisions and timeliness of decisions [6-9].

Correlation method is used to analyze the links, which manifests dependencies between most mass phenomena in real life [7-11]. In this way, the statistical indicators can summarize and present synthetic links between two statistical characteristics (for bivariate data) or more features (for multivariate data) [8-13].

Correlation will show how strong is the link, dependency between variables, while regression will help in explaining and predicting a factor based on the value of another (others) which, obviously, will reduce uncertainty regarding important but random phenomena [9-15] .

Correlation involves finding the analytical function which describes the statistical relationship between the studied variables. It is defined as interdependence between the various phenomena or characteristics expressed in numbers (quantitative) or words (qualitative) manifested in biological or economic phenomena [11-16]

By comparing the variation of the factorial characteristics with that of resulting characteristics can be approximated: the bonding character, the direction and intensity of it [16-18]. The graphic method is called the *clouds points* method, it is the choice of analytical function for regression and correlation [18-20].

Experimental part

Materials and methods

We have taken for study by six articles from five groups of combed wool fabrics, with different compositions, representing the number of individuals, according to table 1.

In the realization of the fabrics from the groups A, B and D were used Siorospun yarns, with aspect of doubled yarn, produced by passing on the ring spinning frame two strands through a modified drawing frame, then they are twisted together and are wrapped on a package/cops; these are also called Jaspe or double roving yarn.

At the fabrics from group C, the weft yarns are elastomer with filament core and the coating also obtained through Sirospun procedure by simultaneously delivering in the drawing frame the roving and the filament core. The two components get together before the delivery roller, such that a structure with filament core coated with the fiber sequence is formed by simultaneous twisting. By using two rovings that will be drawn apart, and a filament core at one of the sequences, a double yarn is obtained made of a spun yarn and a cored yarn. Most polymers and

* email: hristianlili@yahoo.com; ion.sandu@uaic.ro

Group	Article code	Type of bonding	Composition	Technological density	
				Pu (yarns/10cm)	Pb (yarns/10cm)
A	A1	D2/2	100% wool	280	255
	A2	D2/1		250	225
	A3	plain		200	180
	A4	crepe		225	260
B	B1	plain	55%Pes+45% wool	220	235
	B2	D2/2		240	280
	B3	crepe		250	260
	B4	D2/1		270	260
C	C1	D2/1	43%Pes+52% wool + 5% Dorlastan	330	260
	C2	plain		205	255
	C3	D2/2		300	220
	C4	D2/1		335	280
D	D1	D2/1	60%Pes+40%Celo	270	280
	D2	D1/12/11/5		200	240
	D3	plain		245	370
	D4	crepe		210	285

Table 1
THE CODES OF THE ARTICLES

elastomers used for industrial and commercial applications are composites which contain solid fillers [19-23].

The algorithm for calculating the volumetric filling coefficient

In the literature, there is a similar indicator named the degree of coverage which means the ratio between the area of the plane projection of the warp and weft yarn systems, at a length given density and the total area of that fabric.

Because coverage of the two systems of yarns according to Math definition depends on the diameter of the yarns and technological density of these two yarn systems, we proposed to use the volumetric filler coefficient that includes other elements for characterizing the internal structure for each type of bond.

The DEX-Explanatory Dictionary of the Romanian language, the concepts like coefficient, volumetric filling, are explained as follows: coefficient is a relative measure expressing the ratio of two indicators, showing how many units of the indicator reported per one unit of the indicator taken as the basis for reporting; volume-which refers to determining the volume of a body (thread/yarn and fabric); filling - to hold, cover an area.

Volumetric filling factor is the ratio between the volume of the yarn in a weave repeat and the ratio of weave repeat volume:

$$Cvu = \frac{Vfu + Vfb}{V} = \frac{\pi\frac{du^2}{4}Lu + \pi\frac{db^2}{4}Lb}{Lru.Lrb.g_t} \qquad (1)$$

where:

V - weave repeat volume, (mm^3);

Vfu ; Vfb - warp and weft yarn volume, (mm^3);

du ; db - warp and weft yarn diameter, (mm);

Lu ; Lb - warp and weft yarn lenght in a weave repeat, (mm);

Lru ; Lrb - weave repeat lenght on warp and welf directions, (mm);

g_t - the thickness of the fabric, (mm).

Always this coefficient has a subunit value because the volume of warp and weft yarns is less than the weave repeat total ratio, which constitutes an expression of the filling capacity and compactness: the more values are close to unity, the more the fabric has a greater compactness.

Most fabrics are formed in the phases between F_{III}-F_{VII} depending on the density unbalanced index so that all fabrics where Pb > Pu is formed in a upper stage than the V th-phase.

The yarn length included in a weave repeat depends on: the structure phase (measured by wave heights), curl frequency and type of bonding.

The length of the warp yarn contained in a weave repeat is calculated like this:

$$Lu = t_u l_{tu} + \frac{100}{Pb}(Rb - t_u) = t_u\sqrt{l_b^2 + h_u^2} + \frac{100}{Pb}(Rb - t_u) \qquad (2)$$

Weft length contained in a weave repeat is calculated like this:

$$Lb = t_b l_{tb} + \frac{100}{Pu}(Ru - t_b) = t_b\sqrt{l_u^2 + h_b^2} + \frac{100}{Pu}(Ru - t_b) \qquad (3)$$

where:

Ru – it is the size of the warp ratio, expressed as number of yarns / ratio;

Rb - it is the size of the weft ratio, expressed as number of yarns /ratio;

t_u - number of passes of the warp yarn through the weft threads in a weave repeat;

t_b - number of passes of the weft yarn through the warp yarns in a weave repeat;

Pu – technological density of warp system, expressed as number of yarns /10 cm;

Pb - technological density of warp system, expressed as number of yarns /10 cm;

l_{tu} - length of warp yarn segment in the transition through the opposite system yarns;

l_{tb} - length of weft yarn segment in the transition through the opposite system yarns;

l_u - the geometric density of the warp yarn system, in mm;

l_b - the geometric density of the weft yarn system, in mm;

h_u – the wave height of the system of warp yarns, in mm;

h_b - the wave height of the system of weft yarns, in mm;

l_{tu} and l_{tb} segment length was calculated using the method of the approximate calculation using the relations: (4)

$$l_{tu} = \sqrt{l_b^2 + h_u^2} \qquad (5)$$

$$l_{tu} = \sqrt{l_b^2 + h_u^2}$$

and the wave heights using the density method, with the relations:

$$h_u = D\frac{Pu}{Pu+Pb} \quad (6)$$

$$h_b = D\frac{Pb}{Pu+Pb} \quad (7)$$

$$D = d_u + d_b$$

where:

d_u - it is the diameter of the warp yarn, in mm;

d_b - it is the diameter of the weft yarn, in mm.

The length of the bond ratio for the warp system could be calculated with the relation:

$$L_{Ru} = d_u \cdot Ru + x_b \cdot t_b \quad (8)$$

$$L_{Rb} = d_b \cdot Ru + x_u \cdot t_u \quad (9)$$

where:

x_b; x_u - it is the minimum distance measured horizontally between two consecutive warp or weft yarns through a yarn of opposite system passes and it is calculated with the relations:

$$x_u = l_u - d_u \quad (10)$$

$$x_b = l_b - d_b \quad (11)$$

$$l_u = D\cos\beta \quad (12)$$

$$l_b = D\cos\alpha \quad (13)$$

where:

α, β - they are curling angles depend on the phase when it is made the fabric and they are determined by relations:

$$\cos\beta = \frac{\sqrt{D^2 - h_u^2}}{D} \quad (14)$$

$$\cos\alpha = \frac{\sqrt{D^2 - h_b^2}}{D} \quad (15)$$

Results and discussions

Based on the algorithm we have determined the volumetric coefficient for kinds of fabrics studied whose values are presented in table 1.

Analysis of this type of characterization of the worsted fabrics was performed using the method of correlation/ graphical method and the estimation of the parameters model was performed by Excel.

By analyzing the results, it is possible to formulate practical conclusions regarding the dependence between the Cvu and elements characterizing for the internal structure of the fabrics as follows:

- the graph correlation between the coefficient of volumetric filling (Cvu) and length of the weave repeat for the weft system (Lrb), shown in figure 1, highlights the nature and intensity of this bond;

- after the distribution of the corresponding points for these 16 pairs of individual values of the volume coefficient and the length of weave repeat for the weft system results that between these two characteristics there is a very strong indirect conexion R = 0.8028 and R^2 = 0.6445 ($0.75 \leq 0.8028 \leq 1$). The equation of regression line for this studied correlation is :

$$Y = -8.1412X + 3.325 \Leftrightarrow Cvu = -8.1412Lrb + 3.325.$$

Table 1

THE VALUES INVOLVED IN CALCULATING VOLUMETRIC COEFFICIENT

Article Code	Ru	Rb	tu	tb	cosb	cosa	hu	hb	D	lu	lb	Lu	Lb
A1	4	4	2	2	0.879	0.852	0.240	0.264	0.504	0.392	0.357	1.575	1.730
A2	3	3	2	2	0.881	0.850	0.239	0.265	0.504	0.444	0.400	1.332	1.480
A3	2	2	2	2	0.881	0.850	0.227	0.252	0.480	0.556	0.500	1.098	1.220
A4	12	12	8	8	0.844	0.886	0.266	0.231	0.497	0.385	0.444	5.923	5.126
B1	2	2	2	2	0.856	0.875	0.219	0.205	0.424	0.426	0.455	1.009	0.945
B2	4	4	2	2	0.843	0.887	0.245	0.210	0.456	0.357	0.417	1.800	1.543
B3	12	12	8	8	0.860	0.872	0.232	0.223	0.456	0.385	0.400	5.301	5.097
B4	3	3	2	2	0.871	0.861	0.216	0.224	0.440	0.385	0.370	1.228	1.275
C1	3	3	2	2	0.898	0.829	0.178	0.226	0.404	0.385	0.303	1.006	1.277
C2	2	2	2	2	0.832	0.895	0.235	0.189	0.424	0.392	0.488	1.083	0.871
C3	3	3	2	2	0.906	0.817	0.191	0.261	0.452	0.455	0.333	1.102	1.503
C4	4	4	2	2	0.890	0.839	0.187	0.224	0.411	0.357	0.299	1.302	1.558
D1	3	3	2	2	0.861	0.871	0.203	0.196	0.398	0.357	0.370	1.215	1.171
D3	2	2	2	2	0.838	0.891	0.217	0.181	0.398	0.417	0.500	1.090	0.909
D4	11	11	6	6	0.799	0.917	0.248	0.164	0.411	0.270	0.408	4.905	3.248
D5	12	12	8	8	0.818	0.906	0.254	0.187	0.442	0.351	0.476	6.224	4.586

(CONTINUATION Table 1)

Article Code	Lru	Lrb	Dcosb	Dcosa	xu	xb	Vfu	Vfb	Vrap	gt	Cvu
A1	1.432	1.322	0.443	0.430	0.180	0.189	0.086	0.079	1.227	0.648	0.134
A2	1.167	1.083	0.444	0.429	0.180	0.188	0.073	0.067	0.684	0.5414	0.204
A3	0.850	0.810	0.422	0.408	0.174	0.177	0.053	0.051	0.257	0.3726	0.407
A4	4.516	4.350	0.420	0.440	0.171	0.192	0.287	0.248	7.043	0.8676	0.031
B1	0.743	0.727	0.363	0.371	0.151	0.159	0.036	0.033	0.173	0.3204	0.399
B2	1.264	1.224	0.384	0.404	0.156	0.176	0.073	0.063	0.704	0.4548	0.194
B3	4.090	4.048	0.392	0.397	0.164	0.169	0.216	0.208	8.867	0.5356	0.048
B4	1.017	0.948	0.383	0.379	0.156	0.167	0.050	0.045	0.400	0.4156	0.238
C1	0.960	0.837	0.362	0.335	0.143	0.151	0.038	0.034	0.387	0.4812	0.186
C2	0.760	0.706	0.353	0.380	0.141	0.168	0.038	0.031	0.199	0.3704	0.347
C3	0.974	1.037	0.410	0.369	0.182	0.145	0.045	0.059	0.553	0.5482	0.188
C4	1.185	1.061	0.366	0.345	0.147	0.153	0.049	0.045	0.600	0.4774	0.157
D1	0.893	0.885	0.343	0.347	0.144	0.148	0.038	0.036	0.281	0.3558	0.264
D3	0.710	0.668	0.334	0.355	0.135	0.156	0.034	0.028	0.159	0.3354	0.392
D4	3.293	3.000	0.329	0.377	0.123	0.172	0.163	0.108	6.115	0.6190	0.044
D5	4.085	3.774	0.361	0.400	0.140	0.179	0.239	0.176	8.466	0.5490	0.049

- The probability that the model is correct is relatively high, about 80%, this conclusion may be expressed based on the values determined by R testing, using Excel - squared (0.8028) and Adjusted R-squared (0.6445).

Validity of the model is confirmed by the values of regression tests F_{calc} = 102.8433 higher than the tabulated F_{tabel} = 2.4034, considered to be the basis for comparison in analyzing the validity of econometric models and the risk degree almost zero (reflected by the value of Prob test F-statistic).

- The high value of the constant term shows that the influence of unspecified factors in this model on the evolution of resultatives variable (Cvu) is significant, which leads us to conclude that the used model (even it is correct) can be developed to ensure better outcomes for characterization of the fabrics.

- To check the significance of the correlation coefficient is applied t test (Student), by calculating the variable t_{calc} = 4.087 and it is compared with critical value, from the table. If we choose a 95% and 15 degrees of freedom (scope), t_{tabel} = 1.753.

Because $|t_{calc}| > |t_{tabel}|$, $|4.087| > |1.753|$ we can say that the hypothesis of significance correlation is checked and between the studied variables there is a significant connection, so the $R_{Y/X}$ coefficient is statistically significant and analysis model is correctly specified.

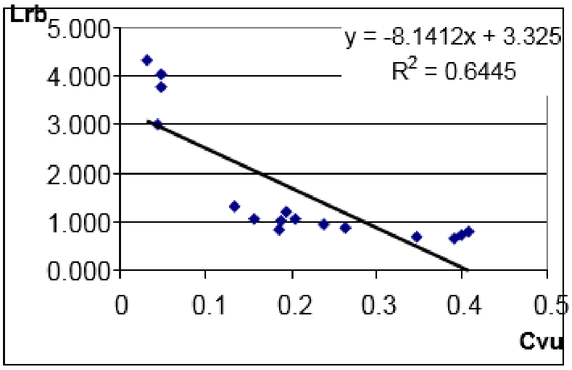

Fig. 1. Chart correlation between volumetric filling coefficient (Cvu) and the length ratio of bond for the wefy system (Lrb)

Correlation method was applied for the other elements for characterizing the internal structure of fabrics that can influence the volumetric filling coefficient, from which we can conclude the following issues:

- from the Graph correlation between the coefficient of volumetric filling (Cvu) and fabric thickness (g_t), shown in figure 2, it appears that the two characteristics are linked very strong indirectly, R = 0.8239 and R^2 = 0.6789 (0.750.82391). The equation of regression line for this studied correlation is:

$$Y = -0.9021X + 0.6783 \quad Cvu = -0.9021g_t + 0.6783$$

The probability that the model is correct is relatively high, about 68%, this conclusion may be expressed based on the values determined by R testing, using Excel - squared (0.6789) and Adjusted R-squared (0.6560).

Validity of the model is confirmed by the values of regression tests F_{calc} = 1.1986 higher than the tabulated F_{tabel} = 0.3651, considered to be the basis for comparison in analyzing the validity of econometric models and the risk degree almost zero (reflected by the value of Prob test F-statistic).

Constant value from regression equation reflects the fact that there are,in the model, other unspecified factors which influence the volumetric filling coefficient.

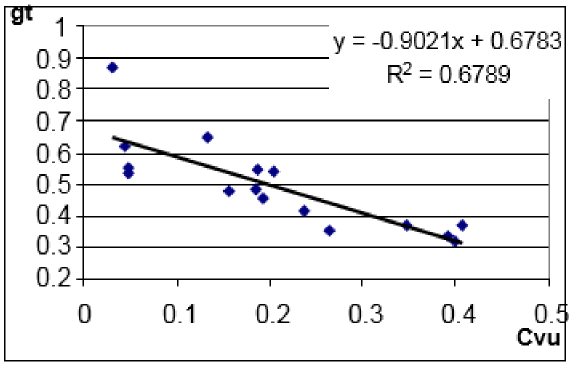

Fig. 2. Chart correlation between volumetric filling coefficient (Cvu) and the fabric thickness (g_t)

To check the significance of the correlation coefficient is applied t test (Student), by calculating the variable t_{calc} = 4.4496 and it is compared with critical value, found in the table. With a 95% probability and 15 degrees of freedom (scope), $t_{tabel.}$ 1.753. Because $|t_{calc}| > |t_{tabel}|$, $|4.4496| > |1.753|$ we can say that the hypothesis of significance correlation is checked and between the studied variables there is a significant connection, so the $R_{Y/X}$ coefficient is statistically significant and analysis model is correctly specified.

Based on the values shown in table 1, we did the chart the development of volumetric filling coefficient for all groups of fabrics.

Analysis of the values and graphical representations leads to the following observation:

For sorts of Group A fabrics (fig. 3),

- the highest values of the volumetric filling coefficient were obtained at balanced and unbalanced fabrics for smoothness and density of plain weave, which have the lowest technological density in both. The warp and weft and also the smallest thickness, for example: Art. A3 (Cvu = 0.4068 with $Nm_u Nm_b$, Pb > Pu), plain weave, with average floating F = 1;

- minimum values of the volumetric filling coefficient were obtained at crepe fabrics eg Art. A4 Cvu = 0.0314, with Nm_u = Nm_b, Pu>Pb with crepe connection, with average floating F = 1.5;

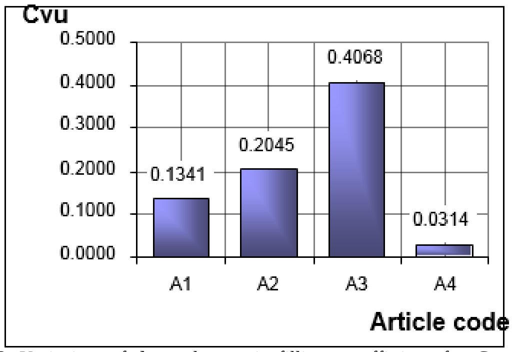

Fig. 3. Variation of the volumetric filling coefficient for Group A fabrics

For sorts of Group B fabrics (fig. 4),

- the biggest values for the volumetric filling coefficient were obtained from plain weave fabrics as the fabrics of Group A. For example: art. B1 (Cvu = 0.399 with Nm_u = Nm_b = 60/2, Pu > Pb), plain weave, with an average floating F = 1;

- the lowest values for the volumetric filling coefficient were obtained from crepe weave fabrics for example: Art. B3, (Cvu = 0.048, with Nm_u = Nm_b = 52/2, Pu > Pb), crepe weave, with an average floating F = 1.5;

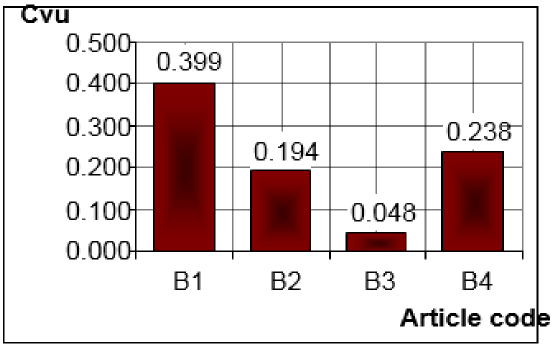

Fig. 4. Variation of volumetric filling coefficient for the Group B fabrics

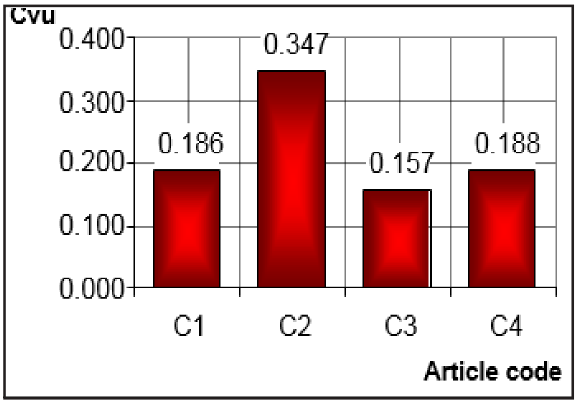

Fig. 5. Variation of the volumetric filling coefficient for Group C fabrics

For sorts of Group C fabrics (fig. 5),

- the highest value of the volumetric filling coefficient was obtained as in case of the fabrics from Group A and Group B at plain woven fabric, for example: Art. C2 (Cvu = 0.347 with $Nm_u = Nm_b$ = 60/2, Pbu > Pu, plain weave);

-the lowest volumetric filling coefficient was obtained for Art. C3 (Cvu = 0.157, $Nm_u Nm_b$, Pb > Pu, with Dweave);

For sorts of Group D fabrics (fig. 6),

- the highest values of the volumetric filling coefficient were obtained at the plain woven fabric, which have the lowest technological density, in both, the warp and weft and also the smallest thickness, eg Art. D3 (Cvu = 0.392 with $Nm_u = Nm_b$, Pu > Pb), plain weave, with an average floating F = 1;

- the minimum of the volumetric filling coefficient were obtained from twill fabrics and crepe woven example: art. D2 (Cvu = 0.044, with $Nm_u = Nm_b$=60/2, Pu > Pb, with Dbond) and Article D4 (Cvu = 0.049, $Nm_u = Nm_b$, Pu > Pb) with touch crepe, with an average floating F = 1.5;

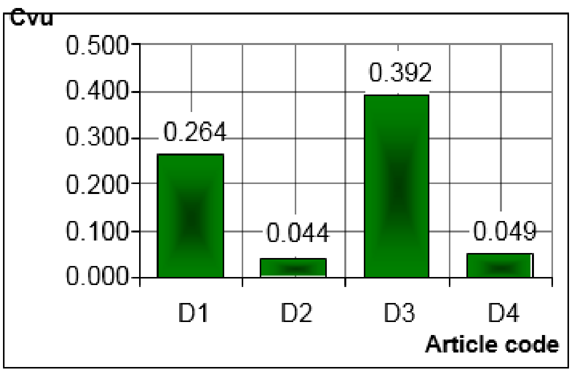

Fig. 6. Variation of volumetric filling coefficient for Group D fabrics

Conclusions

The plain woven fabrics are characterized by the highest values of the volumetric filling coefficient; this is justified by the fact that the evolution of the two yarn systems ensures a good positional stability, wire to wire, these having a curling maximum frequency.

Unbalanced fabrics to finesse and density, which are related to the largest flotation, are characterized by the lowest values of the volumetric filling coefficient.

The ultimate goal of the analysis of these indices for characterizing the fabrics is to establish the influence of structure parameters on the surface characteristics so that it can be correctly defined the most appreciated item from the studied range, ensuring an excellent performance both in technological processes, and the use processes, in accordance with destination.

References

1. KARPINSKA, J., SOKOL, A., ROZKO, M., Analytical Letters, **42,** no. 8, 2009, p. 1203.
2. ROMAN STAN, F., Romanian Statistical Review, **8**, 2013, p. 44.
3. RADOIU, S., Rev. Chim. (Bucharest), **59**, no. 3, 2008, p. 351.
4. ISAIC-MANIU, A., MITRUT, C., VOINEAGU, V., Stat. for Business Manag., Ec. Publishing House, Bucharest, 2005.
5. MANEA, L.R., NECHITA, E., DANU, M.C., AGOP, M., J. Comput. Theor. Nanosci. **12,** 2015, p. 4693.
6. HRISTIAN, L., SANDU, A.V., MANEA, L.R., TULBURE, E.A., EARAR, K., Rev. Chim. (Bucharest), **66**, no. 3, 2015, p. 342.
7. MARK, L., BERENSON, D., LEVINE, M., TIMOTHY, C., KREHBIEL, Basic Business statistics: concepts and applications, twelfth edition, Pearson, 2012.
8. DINÇ, E., BALEANU, D., Rev. Chim. (Bucharest), **56**, no. 9, 2005, p. 937.
9. MANEA, L.R., SCARLET, R., LEON, A.L., SANDU, I., Rev. Chim. (Bucharest), **66,** no. 5, 2015, p. 640.
10. POPESCU, V., MANEA, L.R., AMARIEI, N., Mat. Plast., **46**, no. 1, 2009, p. 95.
11. HRISTIAN, L., BORDEIANU, D.L., IUREA, P., SANDU, I., EARAR, K., Mat. Plast., **51**, no. 4, 2014, p. 405.
12. DINÇ, E., BALEANU, D., TOKAR, F., Rev. Chim. (Bucharest), **53**, no. 4, 2008, p. 303.
13. EARAR, K., MATEI, M.N., SANDU, A.V., HRISTIAN, L., BEJINARIU, C., SANDU, I.G., Mat. Plast., **52**, no. 1, 2015, p. 98.
14. DINÇ, E., KANBUR, M., Die Pharmazie, **59**, no. 9, 2004, p. 700.
15. ERTURK, S, CETIN, S.M., ATMACA, S., J. of Pharm. and Biomed. Anal., **33**, no. 3, 2003, p. 505
16. NEJNERU, C., NICUTA, A., CONSTANTIN, B., MANEA, L.R., TEODORESCU, M., AGOP, M., Journal of Applied Mathematics, **13**, 2013, p. 7056.
17. ABD, E.L, KAWY, M., E.L., GINDY, A.E., HEGAZY, M., SHOKRY, E.S., Journal of Applied Sciences Reserach, **6**, no. 8, 2010, p. 918.
18. FANGZHOU, Y., COQUERY, J., LE CAO, K.A., BMC Bioinformatics, **13,** 2012, p. 24.
19. BRUSCO, J.M, Computational Statistics & Data Analysis, **77**, 2014, p. 38.
20. ZHIQIANG, G.E, Control Engineering Practice, **31**, 2014, p. 9.
21. BECKER, C.M., GABBARDO, A.D., WYPYCH, F., AMICO, S.C., Composites: Part A, **42**, 2011, p. 196.
22. HU, H., LIU, Y., WANG, Q., ZHAO, J., LIANG, Y., Mater. Lett., **65**, 2011, p. 2582
23. WANG, J., CHEN, Y., Appl. Polym. Sci. **111**, 2009, p. 658.

Manuscript received: 8.09.2015