Influence of Weave and Densities on Visual Appearance of Woven Fabrics Made From Two Colored Yarns

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ABSTRACT

The paper examines the effect of different factors, i.e. weft density, weave type and consequently agglomeration of the interlacing points of the same type, on the colour impression of a woven fabric. The experimental part is based on 60 weaved samples which differ in weave type (we used 10 different weave types in which the technical face and technical back are the same), colour of the warp (we used white and black warp) and weft density (we used yarns with densities 15, 20 and 25 yarns / cm). We measured the colour values of the woven samples. We arranged the measurements in different ways and tried to visually evaluate the effect of density, effect of weave type, also the effect of the size and shape of agglomerated interlacing points of the same type, on the colour impression of the woven fabric. The results of the colour measurements were sorted into tables and presented in graphs, which were used to find the samples within the observed groups of characteristics that showed the biggest colour differences, to calculate these colour differences and observe and explain the effect of the observed factors on the colour impression.

KEYWORDS

Colour impression of woven fabrics, weave type, agglomeration, colour values

INTRODUCTION

One of the most important property of woven fabrics is their appearance which is affected mostly by their colour impression. Colour impression depends on different elements. Multicoloured fabrics can be made through printing processes or through weaving processes with use of differently coloured yarns. In the second case visual colour impression depends on many factors as are: the thickness of yarns, their colours, the colour sequences of warp and weft yarns, the densities of warp and weft yarns and the weave, which interact and made combination of interlacing coloured yarns on the woven fabric surface [1-7]. The paper will focus on influence of densities and weave on visual impression of woven fabrics made from one coloured warp yarns and differently coloured weft yarns. In mentioned case, the mixture of used colour on the fabric surface, was obtained. Since the appearance depends on the size and shape of areas coloured with one colour, which consisted of agglomerated interlacing points of the same colour, depending of used weaves, it was trieded to researched how the weave and different weft densities influence the visual impression. For that, a colour measurements and expressed the colour differences according to colour metrics using CIE L*a*b* colour space, was used. CIE L*a*b* is the most completed and most used system for colour evaluation. Presents mathematical combination of Cartesian and Cylindrical coordinate systems. Colour is determined by the next parameters:

Figure 1. Graphical presentation of CIE L*a*b* colour space where: L* - lightness of the colour and takes the values from 0 (absolute black) to 100 (absolute white) and lays in the plain normal to axes a* and b*; a* - determine the position of colour on green- red axe taking the values from - 80 (absolute green) to + 80 (absolute red); b* determine the position of colour on blue – yellow axe taking the values of - 80 (absolute blue) to + 80 (absolute yellow).

All three parameters have in CIE L*a*b* system the physical meaning. Beside that graphical component of Cartesian coordinate system there are also two component of Cylindrical coordinate system which are: the saturation C* and hue h, values of which can be calculated from presented equation (1) and (2) from the values of a* and b*.

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \tag{1}$$

$$h = arctan(a^*/b^*) \tag{2}$$

where: C*- croma (saturation) represent the potion of pure colour component in some colour and mathematically is the distance of colour from the third (black - white) axe; h - represent the kind of colour mathematically described as an angle from green -red axe in opposite direction of watch scale.

EXPERIMENTAL

Materials

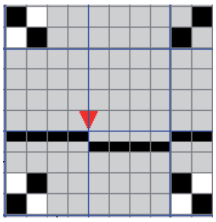
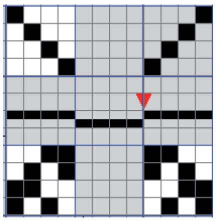
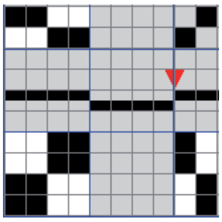
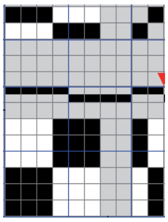
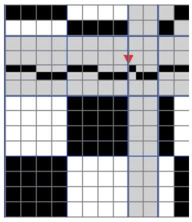
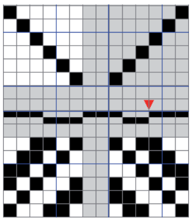
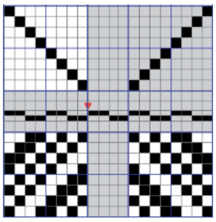
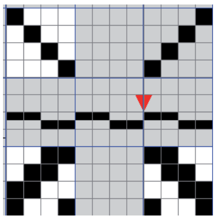
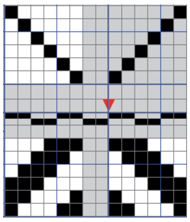
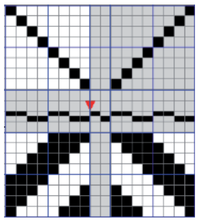
The purpose of research was to find how big is the colour difference within different weaves with the same number of differently coloured interlacing points on their surface and how big is the change with the changes of weft density. The next is to find, are there any differences among plain, and plain like weaves and twill weaves, as well as how significant those differences could be?

For this research, 60 different two coloured woven fabrics which differed in weave, density of weft and colour of warp, was weaved. 10 different weaves was chosen, in three different densities of weft and two different colours of warp. The choosen weaves are both sided weaves, which means that the number of warp and weft interlacing points on the surface and back side are equal. The samples were weaved on laboratory weaving loom equipped with electronic jacquard.

As warp, black and white coloured yarns of the same fineness (8x2 tex) was used and for weft red coloured yarns of the same fineness was used. The set density of warp on the loom was 20 ends/cm and the density of weft was 25, 20 and 15 picks/cm.

Table 1 is showes ten used weaves, made on Arach Weave computer program for simulation of woven fabrics [8].

Table 1. Graphical presentation of used weaves

Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
				
Plain	Broken T $\frac{2}{2}$	Pa $\frac{2}{2}$	Pa $\frac{3}{3}$	Pa $\frac{4}{4}$
Sample 6	Sample 7	Sample 8	Sample 9	Sample 10
				
$T\frac{1\ \ 2}{1\ \ 2}Z$	$T\frac{1\ \ 1\ \ 2}{1\ \ 1\ \ 2}Z$	$T\frac{2}{2}Z$	$T\frac{3}{3}Z$	$T\frac{4}{4}Z$

The weaves were chosen very carefully. The upper part weaves are giving checkered visual impression with increasing of floating points from 1 (in plain weave) to 4 (in eight-ends panama weave). In the lower part are the twill weaves, also with increasing of floating from combination of 1 and 2 (in six-end twill weave) to 4 (in eight-end twill weave).

METHODS

The measurements of CIE L*a*b* values of samples were made on spectrophotometer Data Color Spectra Flash SF 600Plus-CT according to standard EN ISO 105-JO1 (General principles for measurements of surface colour) [9]. Measurements were taken on the 5 different places of samples under the next condition:

- Angle of measurements 10˚,
- Geometry of measurements d/8˚,
- Standard type of illumination D65,
- Mirror reflection - ON,
- Measured values: L*, a*, b* and C* and h.

All measurements were made on the circular open area 9 mm. It was processed by measurements taking ΔE (CIE L*, a*, b* unit for assessment of color difference) to validate color differences among samples using equations:

$$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} \quad (3)$$

where:

$$\Delta L^* = L^*_{sample} - L^*_{standard} \quad (4)$$

$$\Delta a^* = a^*_{sample} - a^*_{standard} \quad (5)$$

$$\Delta b^* = b^*_{sample} - b^*_{standard} \quad (6)$$

RESULTS AND DISCUSSIONS

For summarizing the results, Figures 4 and 5 were used, which graphically represent the measured results. The average color difference for every group of samples with the same density was calculated and than compered the color differences of sample with white and black warp.

To assess the colour differences among samples in the same constructional group of samples, as standard value it was chosen the sample with the highest number of interlacing points – in both cases with black or white warp, it was sample with the warp density of 20 ends/cm and wet density 25 picks/cm (Table 2). Than, measured differences was evaluated. In Table 2 are showen measured values of L*, a* and b*, calculated values of h and C* and ΔE^*_{ab} compared to standard sample with white color warp. In Table 3 are presented the same values regarding samples with black color warp.

Table 2. Measured values of L*, a* and b*, calculated values of h and C* and ΔE^*_{ab} compared to standard sample with white warp color

Sample	Weave	Density (yarns/cm)	L*	a*	b*	C*	h °	**ΔE^*_{ab}**
1	Plain	15	60.52	24.98	-0.40	24.98	359.07	10.066
2	Broken twill 2/2	15	60.78	25.22	-0.36	25.22	359.17	10.079
3	Panama 4/4	15	62.22	24.45	-1.23	24.49	357.13	11.885
4	Panama 6/6	15	61.35	24.60	-0.62	24.61	358.56	10.953
5	Panama 8/8	15	63.21	22.81	-1.51	22.86	356.22	13.681
6	Twill 1/1/2/2	15	61.25	24.49	-0.80	24.51	358.14	11.020
7	Twill 1/1/1/1/2/2	15	60.36	25.47	-0.44	25.47	359.02	9.665
8	Twill 2/2	15	61.54	24.24	-0.70	24.25	358.35	11.339
9	Twill 3/3	15	61.35	24.18	-0.93	24.20	357.80	11.333
10	Twill 4/4	15	61.70	23.64	-0.68	23.65	358.36	11.828
1	Plain	20	56.51	28.21	1.48	28.25	3.00	4.625
2	Broken twill 2/2	20	55.43	29.39	2.08	29.47	4.04	2.923
3	Panama 4/4	20	57.34	27.62	1.24	27.65	2.58	5.634
4	Panama 6/6	20	58.25	26.54	0.48	26.54	1.03	7.229
5	Panama 8/8	20	57.06	27.32	0.56	27.32	1.17	5.960
6	Twill 1/1/2/2	20	55.90	29.20	1.79	29.25	3.51	3.460
7	Twill 1/1/1/1/2/2	20	54.91	29.98	2.44	30.08	4.65	2.058
8	Twill 2/2	20	56.28	28.60	1.65	28.64	3.30	4.150

9	Twill 3/3	20	56.07	28.90	1.75	28.95	3.47	3.778
10	Twill 4/4	20	55.56	29.04	2.07	29.11	4.08	3.249
1	Plain	25	53.75	31.41	3.36	31.59	6.11	0 / standard
2	Broken twill 2/2	25	52.11	33.12	4.26	33.39	7.34	2.535
3	Panama 4/4	25	54.00	31.18	3.59	31.39	6.58	0.410
4	Panama 6/6	25	55.06	29.54	2.56	29.65	4.96	2.419
5	Panama 8/8	25	54.37	30.20	2.55	30.31	4.83	1.583
6	Twill 1/1/2/2	25	52.88	32.13	3.66	32.34	6.49	1.169
7	Twill 1/1/1/1/2/2	25	52.45	32.65	4.04	32.89	7.06	1.921
8	Twill 2/2	25	53.13	31.95	3.70	32.16	6.60	0.890
9	Twill 3/3	25	53.30	31.35	3.34	31.53	6.07	0.454
10	Twill 4/4	25	53.37	31.41	3.22	31.58	5.84	0.405

Table 3. Measured values of L*, a* and b*, calculated values of h and C* and ΔE^*_{ab} compared to standard sample with white black color

	Sample	Density (yarns/cm)	L*	a*	b*	C*	H °	**ΔE^*_{ab}**
1	Plain	15	26.29	23.47	4.95	23.99	11.90	9.816
2	Broken twill 2/2	15	26.73	25.23	5.65	25.86	12.62	7.961
3	Panama 4/4	15	27.14	25.72	6.01	26.42	13.15	7.247
4	Panama 6/6	15	26.59	25.06	5.72	25.70	12.86	8.150
5	Panama 8/8	15	28.17	28.00	7.00	28.86	14.03	4.625
6	Twill 1/1/2/2	15	26.24	23.94	5.21	24.50	12.27	9.379
7	Twill 1/1/1/1/2/2	15	26.39	24.32	5.30	24.89	12.29	8.969
8	Twill 2/2	15	25.89	23.43	4.97	23.95	11.98	10.041
9	Twill 3/3	15	26.53	24.36	5.39	24.94	12.47	8.838
10	Twill 4/4	15	26.23	24.85	5.63	25.48	12.77	8.539
1	Plain	20	29.02	29.20	7.30	30.10	14.03	3.130
2	Broken twill 2/2	20	28.40	27.38	6.42	28.12	13.20	5.142
3	Panama 4/4	20	29.54	30.48	8.02	31.52	14.74	1.780
4	Panama 6/6	20	29.78	30.61	8.19	31.69	14.98	1.509
5	Panama 8/8	20	29.74	30.60	8.05	31.64	14.74	1.546
6	Twill 1/1/2/2	20	28.59	28.70	7.09	29.56	13.88	3.822
7	Twill 1/1/1/1/2/2	20	28.98	28.92	7.20	29.80	13.98	3.389
8	Twill 2/2	20	28.31	27.79	6.69	28.58	13.53	4.785
9	Twill 3/3	20	28.28	28.57	7.13	29.44	14.02	4.106
10	Twill 4/4	20	28.23	28.95	7.31	29.86	14.18	3.841
1	Plain	25	31.01	31.48	8.10	32.50	14.44	0 / standard
2	Broken twill 2/2	25	31.49	33.17	9.00	34.37	15.18	1.974
3	Panama 4/4	25	31.40	33.36	9.28	34.62	15.54	2.254
4	Panama 6/6	25	31.50	33.93	9.57	35.26	15.76	2.899

5	Panama 8/8	25	31.72	34.84	10.03	36.25	16.06	3.939
6	Twill 1/1/2/2	25	30.74	31.86	8.34	32.93	14.67	0.524
7	Twill 1/1/1/1/2/2	25	31.22	32.49	8.61	33.61	14.85	1.151
8	Twill 2/2	25	31.15	32.40	8.67	33.54	14.98	1.091
9	Twill 3/3	25	30.49	32.19	8.67	33.34	15.07	1.049
10	Twill 4/4	25	30.88	32.80	9.04	34.03	15.41	1.626

The results presented in Tables 2 and 3 are also shown in Figures 2 and 3. It can be easily visualized how the changes of densities and weaves affect color impression.

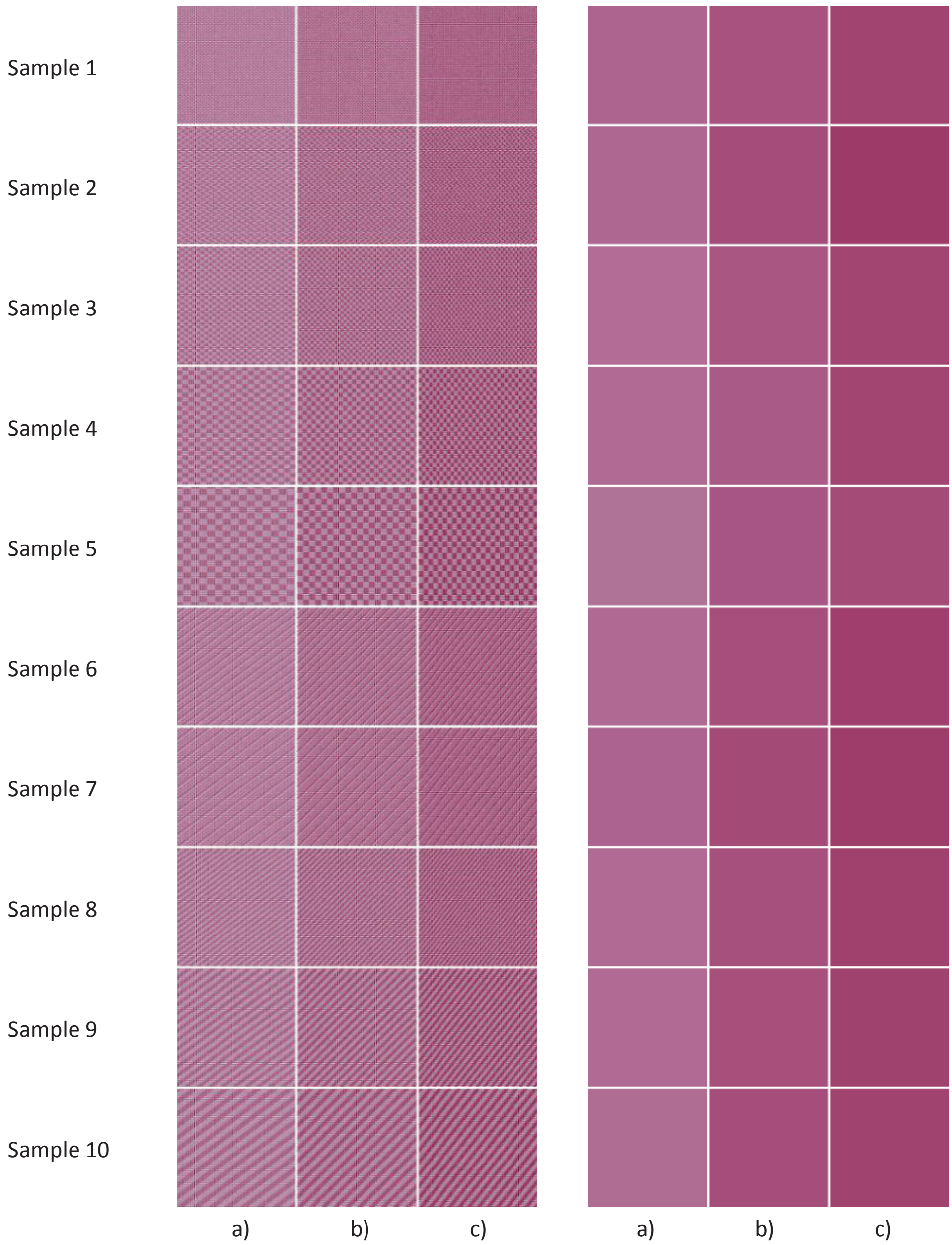


Figure 2. Left: Simulation of all 10 weaves (from 1 to 10) with white color warp, in densities of weft: a) 15 picks/cm; b) 20 picks/cm and c) 25 picks/cm.
Right: measured values of colour impressions from the woven fabrics in the same order

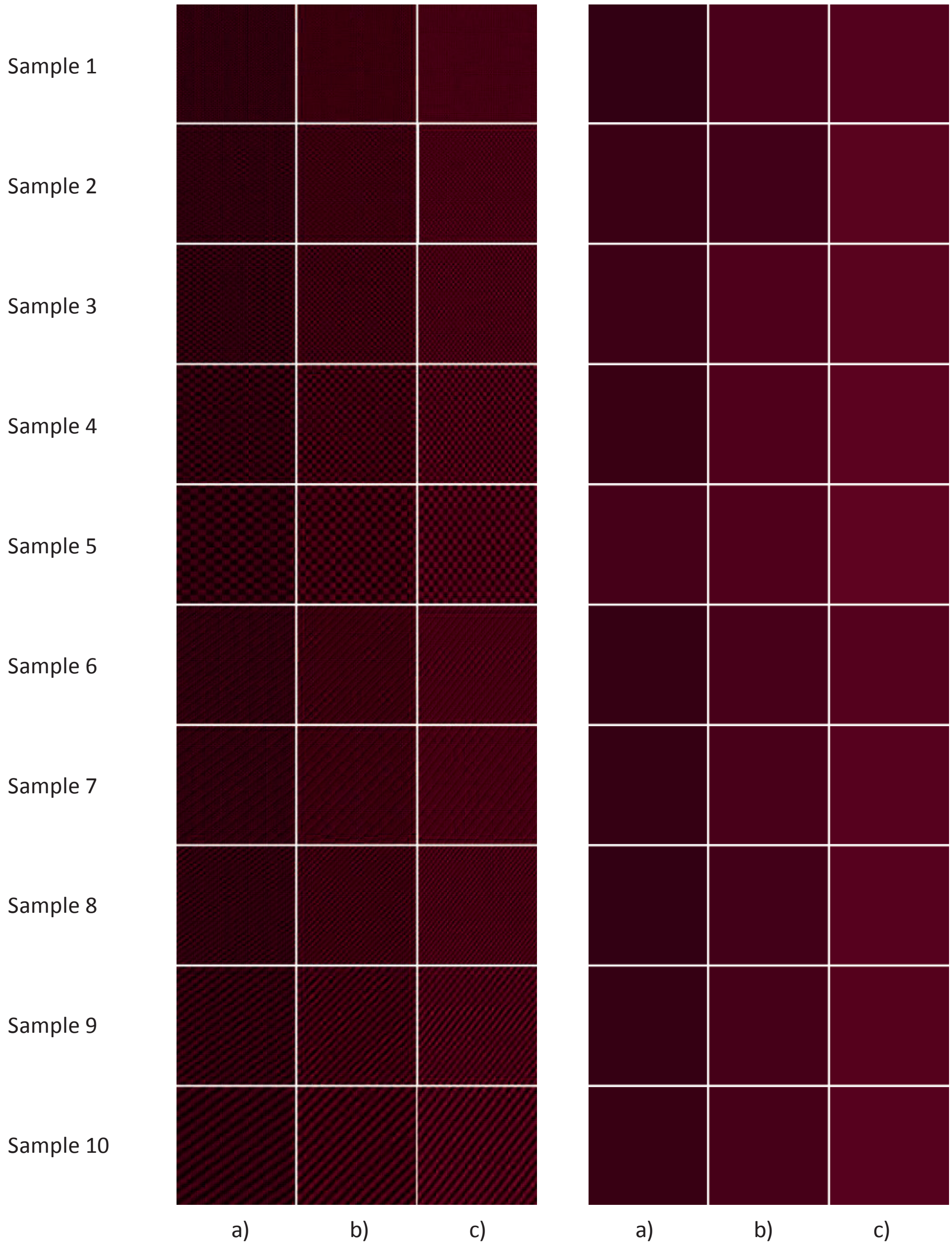


Figure 3. Left: Simulation of all 10 weaves (from 1 to 10) with black color warp, in densities of weft: a) 15 picks/cm; b) 20 picks/cm and c) 25 picks/cm.
Right: measured values of colour impressions from the woven fabrics in the same order

For samples with white color warp yarns the average values of the most dence fabrics (25 yarns/cm) is about 1.0 ΔE^*_{ab} over the standard (which is the same construction in plain weave), the fabrics with weft density 20 yarns/cm has average values for about 4.5 ΔE^*_{ab} and the fabrics with weft density of 15 yarns/cm has average values of about 11 ΔE^*_{ab}. It proves that average changing of color difference for about 3.5 ΔE^*_{ab} is caused by changing (diminishing) of weft density for 5 picks/cm and for 10 ΔE^*_{ab} with changing of next 5 picks/cm. This means that if the color tone of the finished fabric, woven from the defined thread colors and certain fabric structural parameters, is not satisfactory, this can be influenced by changing the thread density, which will result in the achievement of a desired color tone.

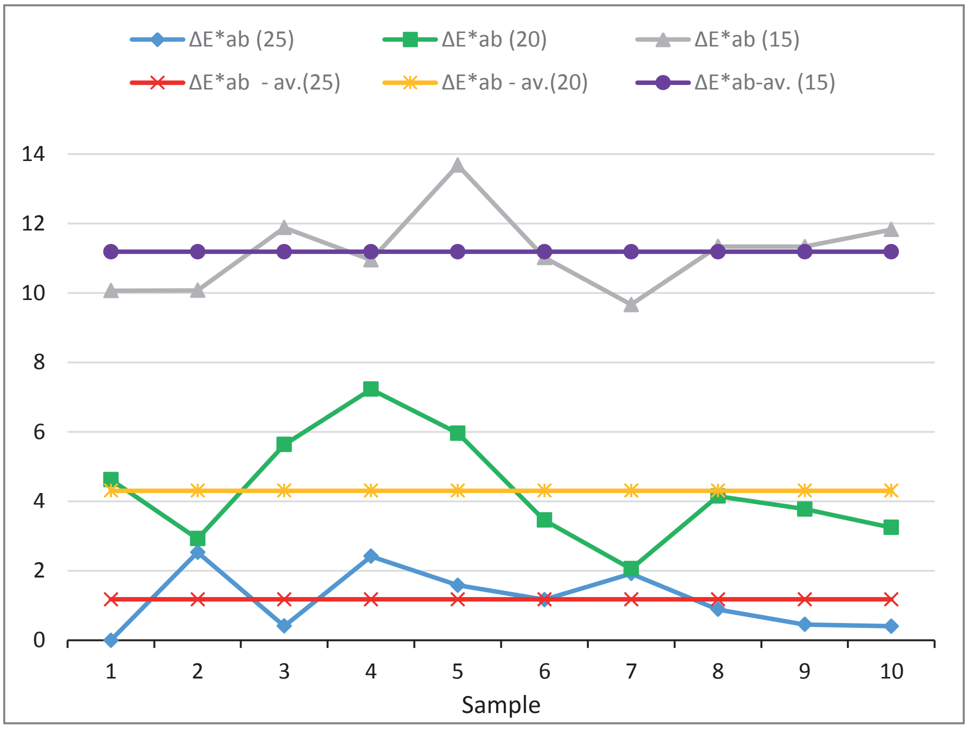


Figure 4. Comparation of color differences among different weaves and densities for woven fabrics from white color warp yarns

It was expected to be seen the similar trend of curves no meter of different densities of samples at list the same weave to be under and over the average values. From Figure 2 it can not be seen. The reason for that is the increase of area between the yarns with diminishing of weft densities.

From the Table 2 and Figure 4 can be seen that the color differences are generally lower in twill weaves comparing to color differences in plain like weaves. The reason for this can be found in the structure itself, i.e. the characteristics of the certain group of weaves. Plain like weaves are characterized by sudden and sharp changes of warp and weft interlacement points, and thus the visible threads color on the face of the fabric. There are no such sharp changes in twill weaves, but the gradual changes and the gradual change of color are emphasized. Therefore, the overall color differences caused by the density change are generally lower in twill weaves.

The group differences are almost neglectable in the construction with the lowest weft density – twill weaves in average 11.04 ΔE^*_{ab} and plain like weaves in average 11.33 ΔE^*_{ab} with quotient 0.97 and much bigger in group of fabrics with densities 20 and 25 picks/cm with quotients lower than 0.7.

Figure 3 showes similarity with Figure 2, except in values of color differences. For start, the average values of the densest group is higher and is over 1,5 ΔE^*_{ab}. The differences of the other two group are much smaller. Average in group of 20 weft pics/cm is 3,5 ΔEab*and in group with 25 weft picks/cm a little over 8 ΔE^*_{ab}. Opposite of samples with white warp in groups 20 and 25 picks/cm plain like weaves shows lower than average color differences and twill weaves higher color differences (Figure 5).

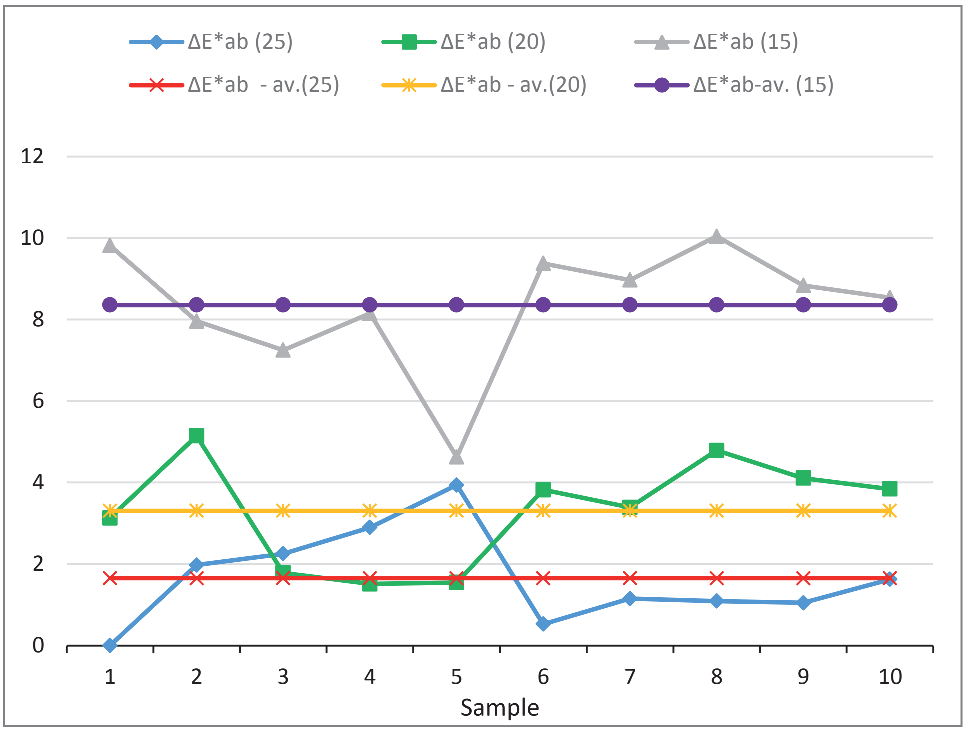


Figure 5. Comparation of color differences among different weaves and densities for woven fabrics from black color warp yarns

CONCLUSIONS

As a general concussion can be stated that samples with white color warp yarns have bigger color differences compared to samples with black color warp, regard changing of weft densities. In most cases twill weaves showed smaller color differences than plain like weaves. With diminishing of weft density samples with white color warp are getting lighter and opposite fabrics with black color warp darker. However, presented findings are valid only for the woven fabrics mixed with white and black color which technically are „not colors" since their position is at the opposite ends of lightness scale of CIE L*a*b* color space. For further investigation will be necessary to make research on mixing of two-real colors, where will be very interesting mixing of complementary colors (for example blue and yellow).

REFERENCES

[1] Dimitrovski K. Interdiscipliniranost barve. Del 2. Maribor: Društvo koloristov Slovenije; 2003. Barvno oblikovanje pestrih tkanin; p.[455-475].

[2] Kočevar TN. Interdiscipliniranost barve. Del 2. Maribor: Društvo koloristov Slovenije; 2003. Optično mešanje barv na površini tkanine; p.[195-210].

[3] Dimitrovski K, Gabrijelčič Tomc H. Napovedovanje barvnih vrednosti žakarskih tkanin. Tekstilec. 2002;45(7-8):179-194.

[4] Gabrijelčič Tomc H, Dimitrovski K. Influence of weave on colour values of woven fabrics. In: Katalinic B, editor. Annals of DAAAM for 2002 and Proceeding of 13th International DAAAM Symposium, Intelligent Manufacturing & Automation: Learning from Nature; 23-26th October 2002; Vienna, Austria. Vienna: DAAAM International; 2002.

[5] Mathur K, Seyam AFM. Advances in Modern Woven Fabrics Technology. IntechOpen; 2011. Color and weave relationship in woven fabrics; p.[129-131].

[6] Kostajnšek K. Vpliv barve in strukture na prepustnostne lastnosti tkanin [masters thesis]. Ljubljana; 2010.

[7] Golob V. Barvna metrika. Maribor: Fakulteta za strojništvo, 2001.

[8] ArahWeave 8 User's Manual [online]. [cited 2018 May 13]. Available from: URLhttp://www.arahne.eu/pdf/aweave-EN.pdf

[9] International Organization for Standardization. EN ISO 105-JO1 - General principles for measurements of surface colour [Internet]. 1997-12 [cited 2018 May 8]. Available from: https://www.iso.org/standard/3862.html

[10] Gabrijelčič H. Barva in optični pojavi na tkanini. Tekstilec. 2007;50(4/6):93-132.