Removal of Ink by Defibration: Colorimetric Properties of Recycled Paper

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Abstract

The removal of roto ink from the newspaper prints by defibration is such a laboratory process, which does not demand the usage of any chemicals, but the ink is washed away by tap water. From the purified fibers, the new paper is produced. The lightness of such paper will be smaller than the lightness of the original paper. This is the most interesting thing for us, i.e. how does the new-formed paper differ from the pure newsprint paper before printing, according to its colorimetric properties?

Defibration of the newspaper print has been done in disintegrator. During the process, the greatest particle size of ink has been removed from the fibers, but one smaller part can stay on the new-formed paper and it can give it a certain color. In order to speak about the difference in optical properties of such papers in relation to the properties of the original paper, the lightness degree is not sufficient measure, because it has not been unambiguously defined as such, but it depends on the used expression in calculations. The detailed and complete spectrophotometric analysis will show the differences in hue, lightness and saturation. The defined values for L*, a*, b*, C*ab, ΔE*ab, ΔL*ab, Δa*, Δb*, ΔC*ab, ΔH*ab will help in evaluating the optical quality of the recycled paper.

In researches, the defined number of daily newspaper of the Croatian editors was used, and for the comparison, the laboratory prints in the defined conditions were used too. Black and colored inks (CMYK), and cyan, magenta and yellow separately were used. By removing the ink by means of the mentioned process, numerous different recycled papers were obtained according to the optical properties. We directed the spectrophotometric analysis to mutual comparison of the real newspaper and laboratory prints as well as to their deviation from the originally pure newsprint paper.

Introduction

For a long series of years we are aware that the production of paper from the cellulose fibers already used, has become ecological and economic necessity. But we are aware as well, that in the whole production of the printing paper, the recycled papers are represented in relatively small quantities.

The newsprint paper is positive example of the possibility to produce the paper completely from the old paper as the raw material.[1]

Because of the fact that in the newsprint paper there exist already the used cellulose fibers, it itself cannot be used alone as the exclusively raw material for the production of the new newsprint paper. The reason for that is gradual wear of fibers during the recycling process. The fibers are chopped, decomposited, broken, and these small parts or they alone are lost from the mass during the pulping process.

For the production of new newsprint paper, together with the printed newsprint paper it is necessary to use other kinds of old paper which have been in the recycling process for the first time. Cellulose fibers of such papers will have decisive role in achieving the necessary printing properties of the new newsprint paper. When mentioning the printing properties of paper, one should have in mind the fact that the recycled papers have weaker quality than the ones produced from the primary fibers.

Quality elements can be decomposited to areas of mechanical properties, surface properties, printing properties and finally optical properties.[2] We shall deal with them. What happens in the production process of the recycled paper that its optical properties are different from the optical properties of the original primary paper?

It happens that it is not possible to remove all the ink from the fibers of the input papers, i.e. prints by means of the deinking processes.[3] Additional difficulties come out from the fact that prints printed in different techniques, which have different mechanism of ink adhering to the printing substrate, are subdued to the recycling process. So in offset printing, the inks on print are dried by oxypolimerization , in digital printing techniques, liquid and powder toner are fixed onto the print by resins and in newsprint the low viscosive ink penetrates into very absorbent substrate, etc.

Experimental

The performed laboratory researches consisted of the production of the laboratory prints on unprinted newsprint papers, which are used for printing different newspaper in Croatia, with the same printing inks used for printing newspaper.

Printing each ink separately, there was the possibility during the recycling process, to analyze the influence of each ink (CMYK) on optical properties of the recycled newspaper.

The real newspaper printed in printing companies (two of them are in Zagreb and one is in Split, all in Croatia) and the laboratory newspaper printed on the same paper with the same inks in equal ink proportions as in the real newspaper were subdued to the recycling process.

We have also recycled separate prints of each ink, printed in the proportions represented in the real newspaper.

In the laboratory recycling process defibering is performed in the disintegrator, in which the rotation of the propeller acts mechanically for some time on the determined quantity of the printed paper and tap water. After such repulping and additional diluting, the production of recycled handsheets starts in laboratory "column". The fibers are retained on the filter screen and the water washes away the particles of the printing ink form the pulp, which separated from the fibers in disintegrator. We are aware that through such de-coloring few ink particles remain in the mass of the recycled fibers and that they influence the tone of the recycled paper.

The idea of this investigation was to examine the possibility of producing the laboratory recycled newspaper which would have optical characteristics of the real recycled newspaper. As today's newspapers often imply four-color print, a question was put if and how much separate color influences the optical properties of the new recycled paper. The estimation of the coating of each separate printing ink (Cyan C, Magenta M, Yellow Y, Black K) was determined on the basis of the total approximate coating (CMYK) and it was in relation to the ink coating in the laboratory newspaper. Colorimetric characteristics of the laboratory newspaper are given in the relation to the colorimetric characteristics of the real newspaper. As reference value the unprinted (pure) newsprint paper before printing process was used. The reflection with spectral photometer CPC2/S was measured on the recycled paper obtained from the real newspaper, laboratory newspaper and single color prints. Measuring results are presented as colorimetric values CIELAB color space.[4] The illumination source was D65 and the viewing angle was 2°.

For all the samples obtained by recycling as well as for unprinted newsprint paper, the following colorimetric values were determined: L*ab, a*, b*, C*ab. Differences determined as Δ, ΔL*ab, Δa*,Δb*,ΔH*ab, ΔC*ab, were determined for all samples in regard to the reference value.

Because of separate prints of yellow Y, magenta M, green-blue C and black K the expressions ΔC*ab and ΔH*ab were used, which are not usual in neutral inks. For total color difference the expression ΔE*ab was used, which does not say anything about the cause of the resulting difference.[5]

Results and Discussion

Measuring results were given in tables (table 1 to table 6) and bulk diagrams (fig. 1, fig. 2 and fig 3).

Table 1. L*a*b* values of the recycled paper, printing house 1

	Real newsp.	Lab. newsp.	C	M	Y	K	Ref. value
L*	71,40	75,43	80,20	79,40	81,13	77,37	81,50
a*	-1,06	-0,14	-1,63	1,37	-0,90	-0,77	-0,40
b*	4,50	3,53	3,37	3,70	5,87	4,63	5,20

Table 2. Colorimetric values of the recycled paper, samples and reference values, printing house 1

	Real newsp.	Lab. newsp.	C	M	Y	K	Ref. value
ΔL*	-10,10	-6,07	-1,30	-2,10	-0,37	-4,13	
Δa*	-0,66	0,26	-1,23	1,77	-0,50	-0,37	
Δb*	-0,70	-1,67	-1,83	-1,50	0,67	-0,57	
ΔE*	10,15	6,30	2,56	3,13	0,91	4,19	
ΔH*	0,81	0,17	1,64	1,95	0,41	0,49	
C*ab	4,62	3,53	3,74	3,95	5,94	4,69	5,22
ΔC*ab	-0,59	-1,68	-1,47	-1,27	0,72	-0,52	

Table 3. L*a*b* values of the recycled paper, printing house 2

	Real newsp.	Lab. newsp.	C	M	Y	K	Ref. value
L*	66,46	76,26	79,34	78,42	80,62	76,63	79,40
a*	0,08	0,03	-1,66	0,94	-1,14	-0,85	-0,90
b*	1,63	1,74	1,79	2,68	4,01	1,89	2,20

Table 4. Colorimetric values of the recycled paper, samples and reference values, printing house 2

	Real newsp	Lab. newsp.	C	M	Y	K	Ref. value
ΔL*	-12,94	-3,14	-0,06	-0,98	1,22	-2,77	
Δa*	0,98	0,93	-0,76	1,84	-0,24	0,05	
Δb*	-0,57	-0,46	-0,41	0,48	1,81	-0,31	
ΔE*	12,99	3,31	0,87	2,14	2,20	2,79	
ΔH*	0,87	0,84	0,87	1,85	0,40	0,20	
C*ab	1,63	1,74	2,44	2,84	4,17	2,07	2,38
ΔC*ab	-0,74	-0,64	0,07	0,46	1,79	-0,30	

Table 5. L*a*b* values of the recycled paper, printing house 3

	Real newsp.	Lab. newsp.	C	M	Y	K	Ref. value
L*	72,10	76,30	82,10	80,50	82,90	78,40	82,10
a*	-0,10	-0,20	-1,80	2,00	-0,70	-0,50	-0,40
b*	4,10	5,40	5,90	7,10	9,30	7,30	5,50

Table 6. Colorimetric values of the recycled paper, samples and reference values, printing house 3

	Real newsp.	Lab. newsp.	C	M	Y	K	Ref. value
ΔL*	-10,00	-5,80	0,00	-1,60	0,80	-3,60	
Δa*	0,30	0,20	-1,40	2,40	-0,30	-0,10	
Δb*	-1,40	-0,10	0,40	1,60	3,80	1,80	
ΔE*	10,10	5,80	1,50	3,30	3,90	4,10	
ΔH*	0,14		1,35	2,21	0,24	0,78	
C*ab	4,10	5,40	6,17	7,38	9,33	7,32	5,51
ΔC*ab	-1,41	-0,11	0,65	1,86	3,81	1,80	

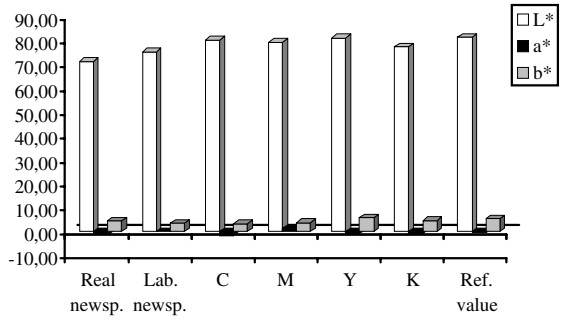

*Figure 1. L*a*b* values of printing house 1*

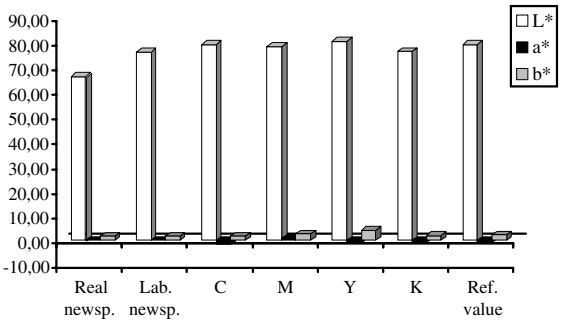

*Figure 2. L*a*b values of printing house 2*

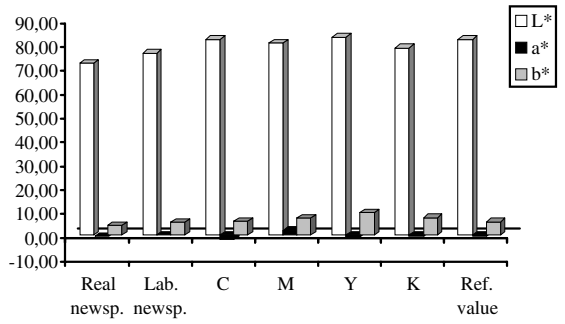

*Figure 3. L*a*b values of printing house 3*

If we compare the colorimetric values of the real and laboratory newspaper, the difference in value L*ab appeared on all samples.

Laboratory newspapers have greater lightness from the real newspaper in the range of 4 to 10 CIELAB units. Chromatic values a* and b* are in the interval up to 1,5 CIELAB unit.

Maximal Δa* and Δb* between the laboratory and real newspaper in relation to the reference value are 2 CIELAB units.

Total difference ΔE*ab has maximal value in relation to the real newspaper / reference value and the one is 13 CIELAB units. This difference, which is visually noticeable, originates from the difference in lightness.

Because the samples are in color space near the achromatic axis, the used expression for determination tone change was as in equastion no. 1:

$$\Delta H^*ab = [(\Delta E^*ab)^2 - (\Delta L^*ab)^2 - (\Delta C^*ab)^2]^{1/2} \qquad (1)$$

The mentioned expression uses total color difference ΔE*ab and the lightness difference ΔL*ab, which are in the case of real and laboratory newspaper numerically equal. The appeared difference in hue ΔH*ab resulted from the low values Δa* and Δb*.

In comparing L*ab, a*, b* values of the recycled paper obtained by single color and laboratory newspaper, it can be seen that the laboratory newspaper in relation to all the samples have lower L*ab value. It was expected, because the residual particles from four-color print influence the lightness decrease.

If we compare the recycled papers obtained from mutual single color prints the conclusion is as follows: values of L*ab in recycled paper of black print has on all the samples in all three groups the lowest value L*ab. The reason for that was the fact that daily newspapers contain the greatest quantity of that color on their pages.

In all the samples of the recycled paper on which only yellow color was printed, the greatest value of L*ab was present. Because of greater and positive value of b*, and smaller and negative value of a*, papers had yellowish hue. With all recycled magenta prints, greater values of b* in relation to a* cause appearance of redish hue.

Conclusion

Based on the investigations it can be concluded that it is possible to produce laboratory newspaper, which could simulate the change of optical properties of the real newspaper in the recycling process. In literature the suggested values of the newsprint paper L*ab = 84, a* = 0 and b* = 7 in comparison to the colorimetric values determined in this investigation point at this possibility too.[6]

The calculation of approximate coating about the printing ink, which can vary among the printing companies proceeds to such investigations.

Investigation was performed on 180 samples. Table presentation gave among them numerical relations of the colorimetric values and the bulk diagram gave the relations graphically simple. For total understanding the investigation results, it is necessary to present the produced samples visually.

The aim of this test was to investigate the optical properties of the new paper, on which the minimal decoloring process was used. It means that every other deinking process must give better results, and in the worst case the same ones. It should be added to that, that the certain quantity of ink particles remains among the fibers of the recycled paper in each case and in each recycling process, which is in the boundaries of ecological tolerances.

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Biography

Branka Lozo received her B.Sc.at the Faculty of Graphic Arts, University of Zagreb, where she has been working as assistant at the department Materials in Printing Production. She goes in for paper as the printing substrate.

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Igor Majnaric born on 21st July 1971 in Rijeka, received his B.Sc. at the Faculty of Graphic Arts, University of Zagreb. He started working as staff associate. He has been working as junior assistant at the Department of Printing.