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Determination of the Colour Deviation in the Solid Colour Prints Applied to Newsprint Paper

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In the front/back solid colour print of newsprint papers that have a porous, unstable structure, the colours deviate from one another. In the study, cyan and yellow colours of inks from the process print colours to newsprint paper and the colour variation that is constituted in the front/ back solid colour print coinciding one after the other was examined by comparing the actual colour CIE L*a*b* values to the NAA (Newspaper Association of America) Standard Gamut CIE L*a*b* values. Keeping the newsprint paper stable, the application of front/ back ground colour test print was performed by the ink in 5 diferent grammages. In order to acquire the L*a*b* values of the ground colour process dyes that are close to standard values with the amount of ink changing, the amount of the optimum film ink to be applied to m^2 on the newsprint paper was also determined. In order to determine the penetration depth of the ink which can not be determined mathematically due to the unstable structure of the newsprint paper, the interface structure of paper-ink was evaluated by being monitored on Stereo Microscope and SEM.

Key Words: Ink paper interactions, Colour variation, Newsprint, Porous paper.

INTRODUCTION

The daily newspapers are printed by web offset lithography with a 40-50 cycle/ h speed. Offset lithography is the dominant method of printing in commercial use today. Offset lithography is the image and non-image areas that are coplanar and are differentiated through variations in surface energy[1,2]. Offset lithography refers to the printing process in which the ink is transferred from an image-containing plate to a flexible intermediate carrier (a blanket), then transferred to a printed substrate[3]. It is important to understand the interactions between ink, paper and fountain solution in offset printing in order to be able to control the quality of the printed product[4]. The quality of an ink film can be described by optical properties such as gloss and optical colour density. These optical properties are determined by parameters relating to the surface of the film and are influenced by the filmsetting. This involves the ink distillate being absorbed into the substrate and the resins and binders cross-linking at the surface of the film during drying[5]. The flow characteristics,

drying mechanism, drying time and polarity of inks are determined predominantly by the liquid vehicle, which includes materials such as oil, solvent and resin. The individual ink colours originate through the combination of dyes and pigments in the inks[6].

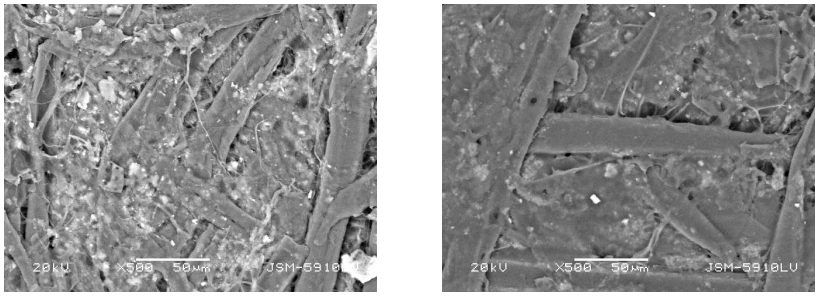
The penetration depth, vertical to the porous paper structure of the ink is another significant parameter to be kept under control from the point of this quality. The excessive penetration of the ink to the structure of the paper during and after print, during the drying process is a very important problem. In the porous papers like newsprint paper, to which ground-colour like prints could be applied in both sides, the ink on one side daviates being affected by the colour of the ink on the other side as a result of show-through. This deviation is an irrepressible and undesired condition for a fine print. The liquidity, stickiness and amount of the ink may generally arise from the structure of the paper and the print pressure at nip point during printing.

Paper is a complex composite material. Its structure and its surface greatly influence its runnability and its printability. The roughness is primordial pigment absorption and the spreading of inks[7]. The horizontal and vertical movement of the liquid ink within the paper is theoretically a good example to the liquid flow in the porous platform.

Among the many properties of paper, one of the most important is its ability to control the penetration of various liquids, particularly those based on water[8]. Printing is a process of intriguing complexity. It involves the application of the ink, the wetting of the substrate, the penetration of the liquid into the pores (if pores are present), the adsorption of the dye molecules or the pigment particles to the surface and finally, the evaporation of the solvent[9]. Capillary spreading of liquids, coupled with their infiltration into a porous substrate, is an important process in paper coating and printing[10,11].

There have been many different mathematical models used over the years to describe the relationship between print density and ink amount on the paper[12]. Darcy's law is used to describe flow in porous media. The permeability is some function of the pore geometry. Much effort has been made to link pore volume, pore size and pore connection to the permeability. The Darcy law is repetitively used as a simple means of understanding and characterizing flow in porous media, *e.g.*, the Darcy permeability nevertheless shows distinct nonlinearity as a function of porosity in compacted fine pigments which are often used in paper coatings[13,14].

The main aim of the study is to obtain the deviation amount of the colours that deviate from one another in the front/back solid colour print of the newsprint papers with a porous, unstable structure and the optimum amount of ink to be applied for the purpose of minimizing the deviation. The images of the printed and unprinted surface structures of newsprint paper are given in Fig. 1.



(a) (b)

Fig. 1. SEM images of the unprinted (a) and printed (b) surface structures of newsprint paper

EXPERIMENTAL

In the study, the newsprint paper, which is the mostly-used paper in print sector, whose general features are given in Table-1 and oil-based coldset web offset newspaper ink, whose features are given in Table-2 were used for test prints.

TABLE-1
FEATURES OF NEWSPRINT PAPER INK USED IN TEST PRINT

Properties*	Unit	Value
Grammages	g/cm^2	48.8
Brightness	%	58.5
Y-value	%	63.6
Opacity	%	94.0
Excitation purity	%	5.2
Dom. wavelength	%	575
L*		83.7
a*		-0.7
b*		4.9
Thickness	µm	73
Roughness PPS MpaSoft	µm	3.8
Tensile energy absorb. MD	J/m^2	18
Ash content	%	7.0

*STORAENSO Quality specifications Newspress, Hylte mill. Optical properties are measured with L and W Elrepho.

TABLE-2
GENERAL COMPOSITION OF THE CONVENTIONAL COLDSET INKS IS AS FOLLOWS

Content	Function	Amount (%)
Pigments	Organic pigment or carbon black	15-25
Resins	Modified rosin resins and alkyd resins	25-45
Liquid components	Vegetable oils, vegetable fatty acid esters and/or mineral oil	25-45
Additives	Waxes, driers, auxiliaries	2-5

Methods: The test prints of the experimental study were performed with printing pressure 350N by using IGT-C1 offset test print tool, taking the ISO12647-2 standard as base in the print room conditioned to 23 ºC and 60 % of relative moisture. Test prints were applied to the same type of print paper, having 5 different grammages of ink and process cyan and process yellow print colours as ground colour print to the front and back surfaces of the paper. In the CIE L*a*b* values measurement of the printed test samples, Gretag Macbeth SpektroEye was used. The values of the measured colours were measured in accordance with difference ΔE CIE 1976 and they were shown[2] in Tables 3-5. The pictures of interface sequence were taken with Leica S8 Apo stereomicroscope, having a digital camera of Leica Dfc 260 by transecting the sample of process cyan and process yellow colours without prints in the back and with prints in the front/back which are closest to the standard in the print results and they were transferred to the digital media with the help of Leica Application Suite and Leica QwinV3 programs. SEM images were also taken by utilizing Jeol JSM-5410 LV, operated at 20 kV, respectively (Fig. 2).

TABLE-3
COLOUR COMPARISON OF PRINTED PROCESS YELLOW
COLOUR GAMUT NAA STANDARD COLOUR GAMUT

NAA colour Gamut standard	L*	a*	b*	ΔE CIE1976 colour difference
	78	-3	58	
Printed colour Gamut ink grammage (g/m^2)	Yellow			
Test 1 1.18	74.46	-1.31	56.67	4.14
Test 2 1.38	74.64	-2.27	57.27	3.52
Test 3 1.57	75.67	-1.39	58.27	2.84
Test 4 1.77	76.34	-2.15	60.66	3.25
Test 5 2.08	76.65	-2.08	62.42	4.71

TABLE-4
COLOUR COMPARISON OF PRINTED PROCESS CYAN
COLOUR GAMUT NAA STANDARD COLOUR GAMUT

NAA colour Gamut standard	L*	a*	b*	ΔE CIE1976 colour difference
	57	-23	-27	
Printed colour Gamut ink grammage	Cyan			
Test 1 1.18	54.52	-21.96	-21.45	7.03
Test 2 1.38	52.78	-25.79	-32.18	6.92
Test 3 1.57	52.61	-23.65	-28.07	4.57
Test 4 1.77	50.67	-25.51	-33.19	9.20
Test 5 2.08	50.41	-23.28	-34.80	10.22

RESULTS AND DISCUSSION

There are several factors having an effect upon the ink occlusion of the newsprint paper and consequently upon the colour values which are measured on the

TABLE-5
COLOUR COMPARISON OF THE PRINTED FRONT PROCESS YELLOW, BACK CYAN COLOUR GAMUT NAA STANDARD COLOUR GAMUT

NAA colour Gamut standard	L*	a*	b*	ΔE CIE1976 colour difference
Printed colour Gamut ink grammage	78	-3	58	
	Yellow (cyan back)			
Test 1 1.18	79.06	-2.54	68.75	10.81
Test 2 1.38	78.56	-1.53	67.69	9.72
Test 3 1.57	79.03	-2.14	66.18	8.24
Test 4 1.77	77.98	-1.05	64.41	6.70
Test 5 2.08	79.16	-3.15	69.64	11.70

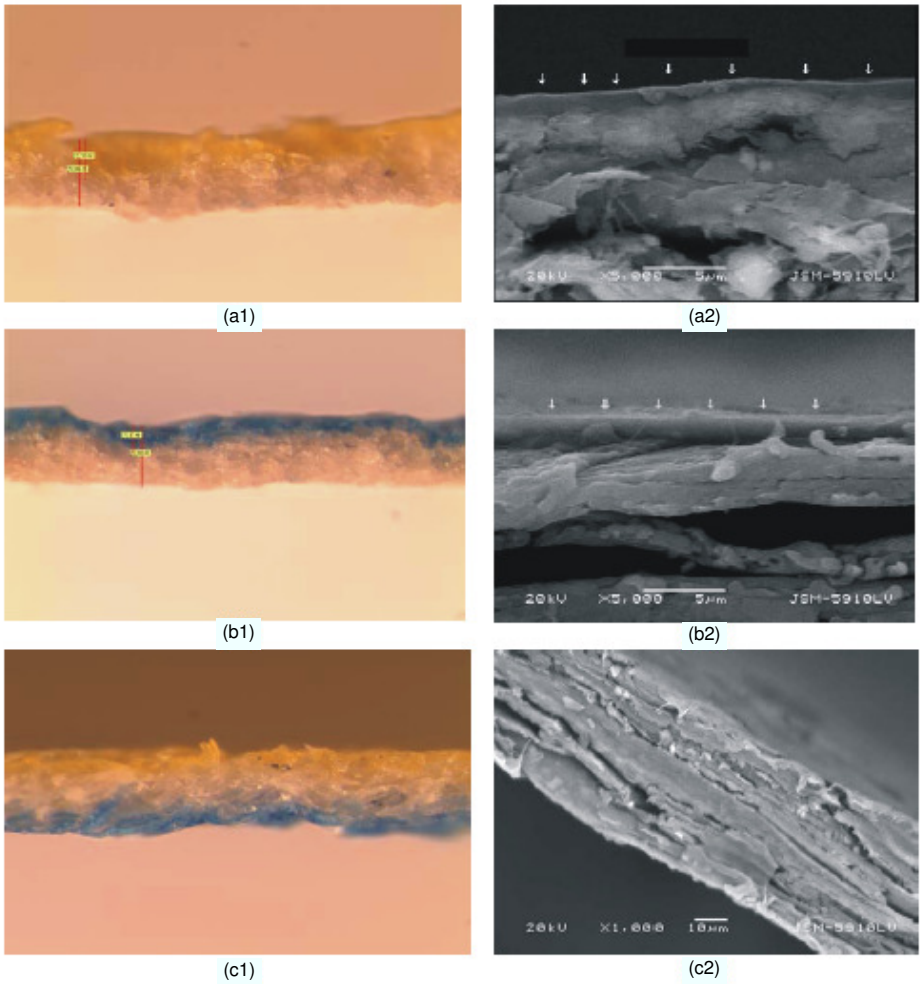


Fig. 2. Microscope and SEM sequence shoots of process cyan and process yellow colours printed on the newsprint paper

paper surface. The most important of them are the opacity, porosity, air permeability of the paper dependent on the proportion of the filling material within its content, the content and liquidity of the ink, grain size of the pigment, the amount of the ink transferred onto the paper and print pressure on the print system during the process printing. There is no standard value in the newsprint paper prints related to the amount of the ink to be given to square meter for optimum colour values during the process of printing. The rates of pigments within the newspaper inks that are produced in different countries may also variate. For example, the Swedish ink has larger pigment content, 17 %, than the Japanese inks, with a pigment content of 13 %[15]. In many printing houses, the operators make their own test prints empirically in order to get qualified print results from the paper and ink being used. Print operators are able to change the amount of ink in similar prints at the rate of 20 % in order to acquire optimum densitometric colour value. Because, depending on the unstable structure of the newsprint papers, the amounts of the ink occlusion variate as well. It was determined that the colours coinciding with each other deviate by being affected from one another in front/back solid colour print of the newsprint papers with a porous, unstable structure (Table-3).

As a result of the entire drying of the ink, it was confirmed by the measurements spectrophotometrically from the yellow colour-printed surface that process yellow colour deviated by being affected from the process cyan colour printed at the back surface of the paper. The deviation of the process yellow colour in accordance with NAA standard Gamut is given in Table-4. The amount of ink, in which the colour differences are the least for STORAENSO newsprint paper, which is commonly used for all of the test prints was determined as 1.57 g/m^2 (Table-4).

The colour evaluation of the test prints in this study was measured according to ΔE value: formula 1 by measuring L*a*b* values of the ground colour prints applied to the front and back faces of the pages. The contiguity level between two colours can be measured by using the mixture of the colour tolerance methods. CIELAB measurements are based on L*a*b* colour universe. Using the CIELAB, the location of the standard colour is definitely determined by the measurement data in the L*a*b* colour universe.

L*, is a quantity that measures the percentage of total solar spectral reflectance in relation to a pure white surface; a* is a measure of the degree red and green and b* characterizes the quantity yellow and blue. The colour difference, ΔE, between two colours $L_1a_1b_1$ and $L_2a_2b_2$ is: where: 1 = colour 1 and 2 = colour 2.

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2} \quad (1)$$

Printing the process yellow and process cyan inks to one side of the test papers separately, L*a*b* values of both colours closest to the standard were acquired (Tables 3 and 4). According to ΔE CIE1976, it was determined that these values were within acceptable limits when compared to NAA (Newspaper Association of America) Colour Gamut Standard values (Table-5)[2].

In the measurements of the yellow printed surface in the test prints with colours of yellow at the front and cyan at the back, it was determined that the yellow colour deviated since it was affected by the cyan colour printed at the back surface when the Lab measurement values were compared with NAA Colour Gamut Standard values in accordance with ΔE CIE1976 (Fig. 3), (Table-5).

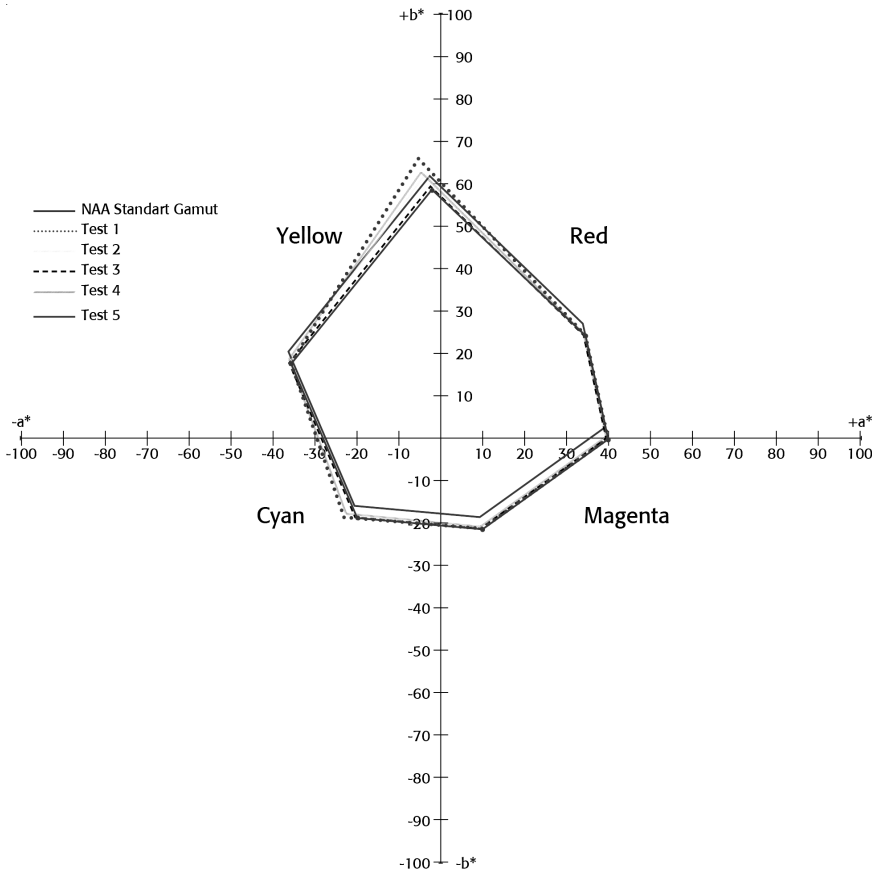


Fig. 3. CIE L*a*b* model for colour proces yellow and process cyan according to NAA Standard Gamut

The paper-ink interface microscope and SEM shootings of the measured test prints are shown in process yellow Fig. 2(a1, a2), process cyan Fig. 2(b1, b2) front-back process yellow, process cyan Fig. 2(c1, c2). It was determined that the penetration of the ink printed from both surfaces onto the page was in convenient depths, there was no print trough problem and that there was an inkless area on the interface (Fig. 2c1). Considering (Fig. 2) generally, the reason of this is the fact that the prints of the ink film amount, applied to the newsprint paper are accomplished by being kept in convenient grammages. In the prints, which are accomplished with excessive amounts of ink, the ink shall penetrate until the other surface because of

the porous structure of the paper and a completely different colour shall emerge as a result of mixing with the colour printed on the other face[16-18].

Optimum ink penetration which could be acquired through test prints is also seen in the microscopic images of Fig. 2(a1, b1, c1).

When the measurement values, acquired by test prints were compared with NAA Colour Gamut Standard values[2], it was determined that these values were within acceptable limits (Fig. 3). According to the laboratory measurement made from the face on which the process yellow colour was printed and to the test print value, in which the colour deviation seemed to be the least in accordance with NAA Colour Gamut Standard, it was determined that this deviation was observed as well (Fig. 4).

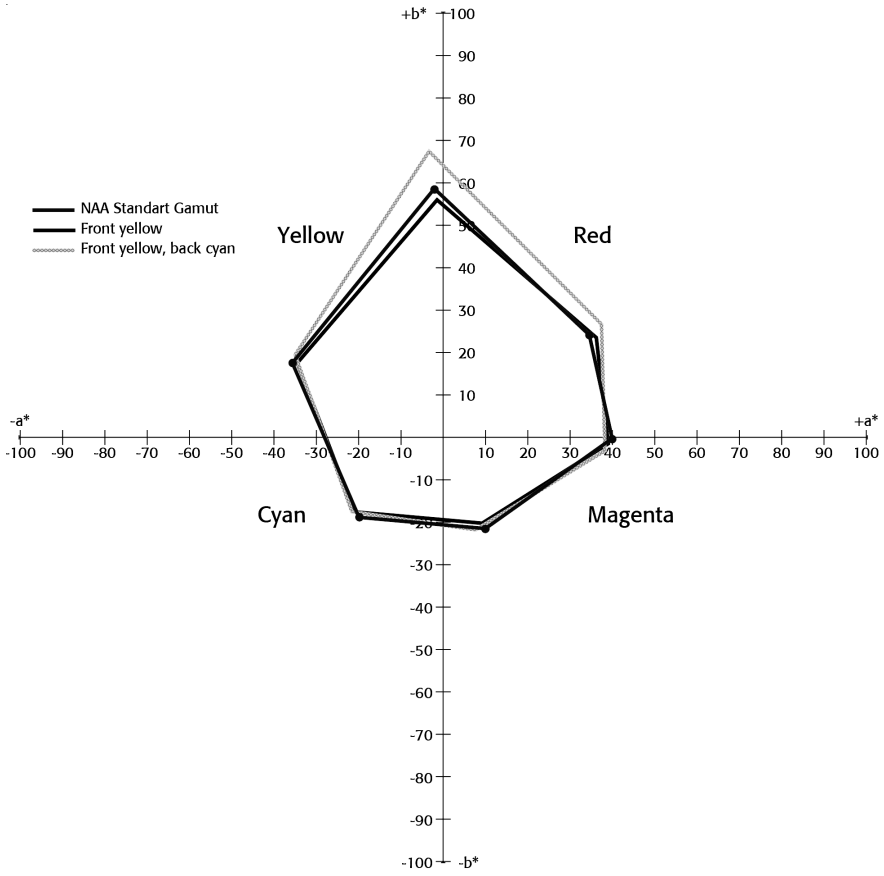


Fig. 4. CIE L*a*b* model for colour process front process yellow, back cyan according to NAA Standard Gamut

Conclusion

In the ground colour prints, applied to both surfaces of newsprint paper, front and back colours affect each other and cause colour deviations. This condition is

basically caused by the condition that the newsprint paper is not opaque enough. If the fluidity, stickiness and amount of the ink is not controlled also from the print pressure at the nip point during the printing process of the paper, the mentioned colour deviation increases even more. This problem can be reduced on condition that a paper with more opacity is used. However, the newsprint paper producers are no longer able to reform the available structure of the papers because of economic reasons. Consequently, in order to prevent the colour deviations on front and back prints, the coinciding of such colours shall be precluded in the prepress preparation stage, if this can not be carried out, possible precautions shall be taken by interfering in elements like print operator, amount and viscosity of ink, print pressure. During the printing process, the colour values shall constantly be kept under control by densitometer or spectrophotometer. On the STORAENSO quality specifications Newsprint paper, whose technical features are given in Table-1, 1.57 g/m^2 of ink was applied to per square meter in order to acquire L*a*b* values that were closest to the standards and as a result of the test prints, the values closest to the standards were acquired.

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