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Analyzing the Effect of Paper's Porosity on Trapping and Colour Value

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The acceptance ratio of the second colour printed over the first colour, which is printed on the materials like paper or paperboard is called as trapping. The inks printed on papers having uncoated porous surface dry physically by themselves being absorbed by the celluloses being in the structure of the paper. Knowledge of the absorption behaviour of liquids into porous media has great importance in many application fields. During the physical drying process, formation of the ink on paper having uncoated porous surface occurs substantially due to ink-paper interaction. In that case uncoated so rough paper surface is because of the drying mechanism. The best example for this is the newspaper press. The inks are printed over each other in micro seconds time difference at the moment of CMYK process print. Drying of these inks completely printed on papers having rough surfaces sometimes takes a few days. During that drying process, ink colour changes can occur because of the behaviour of the paper's unstable porosity structure and the acceptance ratio of the inks printed over each other (trapping). These colour changes cause time, labour and financial losses. Solid tone inks printed over each other have standard trapping ratios. There are a few factors affecting the trapping ratios. However, the most important factor is the porosity of the paper. In the study, it is aimed to determine the effect of the paper's porosity on trapping ratios and colour value. This determination is practically done with the test print. Three types of paper having nonporous covered surface, less porous uncoated surface and fungous surface are chosen. Solid tone test prints are made on these papers over and over with physical drying process print inks and IGT C1 test print machine by following actuation instructions and 12647-2 printing standard. L*a*b* and trapping values of cyan and magenta colours printed on successively are measured with Gretag Macbeth spectrofotometer *via* the test prints. Trapping and colour deviations arising from the porosity of paper are determined comparing to the standards.

Key Words: Trapping, Porous paper, Colour deviation.

INTRODUCTION

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 differentiated through variations in surface energy[1,2].

In multi-colour offset printing, a wet ink film is printed over the other wet ink film. As such, lesser amount of the second-down ink is transferred or trapped than if it is printed on to a dry ink film overprinted area. As a result, ink trapping affects the hue of overprint colours. In addition, ink sequence also affects the hue of overprint colours[3].

When an offset printed document uses more than one ink on the same page, each ink must be printed, respectively with any other inks that it abuts, so that there is no gap where the different inks meet. During four-colour printing, the process of printing wet ink over another wet ink is called ink trapping. The dryers used in the production and the tack sequence of the inks is important. Inks are analyzed by comparing wet ink trap to dry ink trap. The ink-trapping ratio of two inks is compared together and inks are produced with specific ratios to assist printers in customizing their four-colour printing workflow[4].

Ink trapping value was the print quality characteristic chosen for the evaluation of hybrid printing technique.

Trapping is defined as the ability (or inability) of the printed ink to adhere to a previously printed ink[5].

Wet-on-wet overprint colour depends on ink trapping and ink sequence[6]. Good acceptance of ink on the existing ink depends on rheology (viscosity and tackiness) of the ink, which is overprinted, on the ink film's thickness and the printing sequence of the inks. A change in lay down results is a change of the colour value and therefore affects image reproduction accuracy[7].

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 influenced by the film setting[8].

Paper is a complex composite material. Its structure and its surface greatly influence its runnability and its printability. The roughness is primordial pigment for absorption and the spreading of inks[9].

Among many properties of paper, one of the most important is its ability to control the penetration of various liquids, particularly those based on water[10]. Optimized paper properties are only one factor to obtain good print quality. The topography and porosity of the papers have been found important together with a smoother and less porous paper having a lower ink demand[11]. Porosity is the property of paper that determines permeation of air through the sheet. It may affect ink saturation, which can blur print quality, especially in areas of heavy ink coverage. Porosity is especially important for coated grades because it affects the amount of coating absorbed into the sheet, ink holdout and coverage of fiber by coating[12]. Porous media consists of networks of pores[13].

Ink trapping is computed based on densitometry using the Preucil formula. As shown in eqn. 1, ink trapping (t) is a function of the overprint (D_{op}), the paper (D_0), the first ink (D_1) and the second ink (D_2). In other words, ink trapping (t) is calculated when the rest of the quantities (D_0, D_1, D_2 and D_{op}) are known.

$$t = \frac{D_{op} - D_1}{D_2 - D_0} \quad (1)$$

A problem with density-based trapping is that the wet-on-dry trapping does not yield 100 %. This is because densities are not additive. To overcome the additivity failure, we express density-based trapping, $t_{Density}$, as a ratio of the wet-on-wet trapping (t_{WW}) and wet-on-dry trapping (t_{WD}), as shown in eqn. 2.

$$T_{Density} = \frac{t_{WW}}{T_{WD}} \quad (2)$$

Table-1 shows some typical apparent trap values for three common printing conditions. These values are for a print sequence of cyan-magenta-yellow with black ink laid down first or last.

TABLE-1
TRAPPING VALUES OF CYAN-MAGENTA-YELLOW COLOR INKS COUNTED WITH STATUS-T PREUCIL FORMULA[14]

	Red	Green	Blue
Sheet-fed, offset	70	80	75
Web-offset, magazine	70	87	72
Non-heatset web, newspaper	50	89	50

EXPERIMENTAL

The investigations were performed using original offset printing inks rapida cyan (43 F7000), rapida magenta (42 F 7000), produced by Michael Huber, Germany. These printing inks, which are recommended for offset, sheet printing and whose features are given in Table-2 were used for test prints.

In the study, the mostly-used papers in print sector whose general features are given in (Table-3) and oil-based coldest ink were used.

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 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

TABLE-3
FEATURES OF THE PAPERS USED IN TEST PRINTS

	80 g/m^2 offset 1	80 g/m^2 offset 2	80 g/m^2 coated glossy	Test method
Grammage (g/m^2)	80 ± 1.5	80 ± 1.5	80 ± 1.5	Tappi 410
Moisture (%)	4.5 ± 0.5	4.5 ± 0.5	4 ± 0.5	Tappi 412
Resistance (m) MD	4.000 min	4.500 min	4.500 min	Tappi 404
CD	2.000 min	2.000 min	2.500 min	–
Whiteness (%)	86.0 min	88.0 min	82.0 min	Tappi 525
Yellowness	-6.5 ± 0.5	-8 ± 0.5	-3 ± 0.5	Tappi 525
Cobb (60 s) (g/m^2)	28 ± 4	24 ± 4	26 ± 4	Tappi 441
Radiance (75-GU)	–	–	60 min	Tappi 480
Porosity (mL/min)	650	1000	10	Tappi 547
CIE	–	160 ± 3	–	Tappi 525

The test prints of the experimental study were performed with printing pressure 350N by using IGT-C1 offset test print machine, 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 different types of print paper and process cyan and process magenta print colours as solid tone print were applied to the front surfaces of the paper. Gretag Macbeth SpektroEye was used for the measurement of CIE L*a*b* values of the printed test samples. The values of the measured colours were measured in accordance with difference ΔE CIE 1976 and they were shown in Tables 4 and 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.

RESULTS AND DISCUSSION

Viscosity and tackiness of the ink printed on the paper affect the morphology of paper-ink interface during the drying process of the ink. In other words, the ink, which the ink creates on the surface of the paper, affects the colour value of the film. The main factor that affects the trapping is the paper's porosity. The test prints in the study are made on the optimum physical conditions by following the relevant standards completely (Fig. 1). Only keeping stable all the features of the machine and the materials changes the test papers.

TABLE-4
DENSITY, L*a*b* AND ΔE VALUES DETERMINED AS A RESULT OF THE ARITHMETIC MEAN OF TWENTY MEASUREMENTS OBTAINED FROM THE TEST PRINTS MADE WITH IGT-C1 OFFSET TEST PRINT MACHINE ON OFFSET 1-2 AND COATED GLOSSY PAPERS

80 g/m^2 offset 1	Density	$\bar{x}$ L*	$\bar{x}$ a*	$\bar{x}$ b*	ΔE (CIE2000)
Cyan	0.99	59.89	-26.98	-44.87	1.92
Magenta	0.95	56.04	62.56	-4.13	2.45
80 g/m^2 offset 2					
Cyan	0.98	59.79	-24.85	-45.45	1.79
Magenta	0.96	55.64	61.22	-4.82	2.16
80 g/m^2 coated glossy					
Cyan	1.52	53.51	-35.61	-52.90	1.33
Magenta	1.49	47.25	74.64	-1.66	1.93

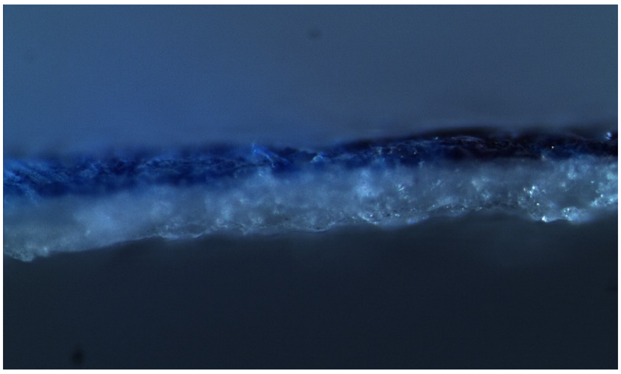

Fig. 1. Interface image of process cyan and process magenta printed on offset 1 paper which was shot blowing up 160 times with Leica S8 Apo stereomicroscope, on left side of the picture only cyan colour and on the right side of the picture magenta printed on it are seen

The hue of the new primary colour composed as a result of printing two process solid tone colour inks successively is affected more or less from the printing sequence of the colour. In other words, the changing of the printing colours' sequence is effective on the colour value.

Conclusion

Inadequate trapping affects adversely hues of reds (magenta and yellow), greens (cyan and yellow) and blues (cyan and magenta) of new colours composed of printing CMY process inks successively as surface hue. Porosity values of paper and trapping and colour values interact as inversely proportional (Fig. 2).

Difference between 'wet-on-dry' and 'wet-on-wet' density-base ink trapping values is on very low rate. That colour difference has acceptable values (Table-5). Especially the tackiness value of the ink also affects wet-on-wet trapping. The ink amount transported on print model first then on print's rubber and then from rubber to paper thanks to the inking system in offset printing also affects the trapping ratio. This is the reason that the thickness of the film created by the ink transported to the paper is important. Trapping ratio of thick ink film is more than the thin ones.

Trapping is two process inks' acceptance ratio of each other printed over successively. It does not have a unit. It cannot be determined with naked eye. It is measured proportionately with spectrophotometer. The producer formulates the ink's setting rate into the ink. For consistent trap, each ink must build tack at the same rate. Mechanical adjustments of the print machine are also effective a little on the trapping ratio.

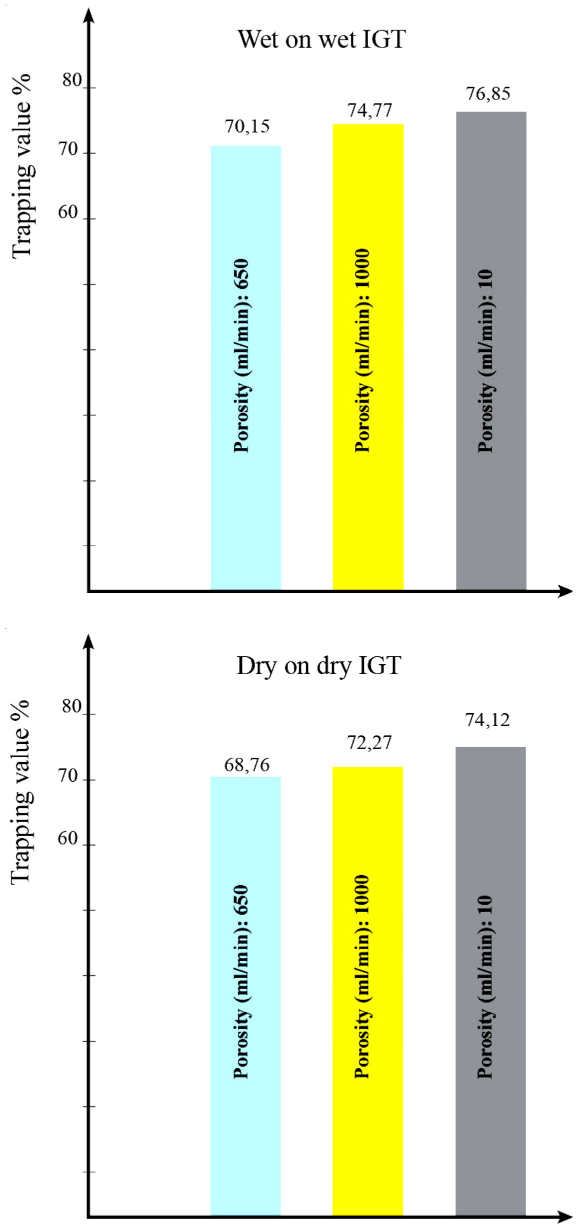

Fig. 2. Trapping values determined as a result of the arithmetic mean of wet on wet and dry on dry twenty measurements of the prints made with IGT-C1 offset test print machine on offset 1-2 and coated glossy papers having different porosities used in test print

TABLE-5
TRAPPING VALUES DETERMINED AS A RESULT OF THE ARITHMETIC MEAN OF TWENTY MEASUREMENTS CARRIED OUT WITH GRETAG MACBETH SPEKTRO EYE *VIA* (CYAN + MAGENTA) TEST PRINTS MADE WITH IGT-C1 OFFSET TEST PRINT MACHINE ON OFFSET 1-2 AND COATED GLOSSY PAPERS

Types of paper	Wet on wet		Dry on dry	
	ΔE (CIE2000)	T_{CM}	ΔE (CIE2000)	T_{CM}
80 g/m^2 offset 1	2.64	70.15	4.15	68.76
80 g/m^2 offset 2	2.27	74.77	3.93	72.27
80 g/m^2 coated glossy	2.04	76.85	3.10	74.12

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