Analysis of trapping of color sequences of multicolor offset printing

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Abstract
Ink trapping is defined as the amount of the second ink transferred on top of the first ink during process color printing. It is estimated optically with the use of densities.
The problem of this paper was to compare quality of printed products of print attributes (Ink Trapping) of multicolor litho-offset printing, as a limited specific condition study, in Egypt market . It was found from the review of literature that color sequence of multicolor printing process had differences on the quality issue. The density-based is defined as the ratio of the 'wet-on-wet' ink trapping. Density-based ink trapping ratios are compared. The effect of ink sequence and ink trapping ratio on overprint colors are examined.

Keywords
color trapping, color printing sequence, process inks, multicolor offset printing, ink trapping ratio

Introduction

After several years of market hesitation, litho-offset multi color presses
have now become common. In today's printing market, where tend to multi-color objects, medium and long run, shorter make ready times and stability of quality are being demanded.
It is important for customers of multi-color press to be able to take into account the quality of the press, typically to be able to make a trade-off between price and quality. The total quality of a printing machine is, however, a very complex entity, involving technical aspects such as expected lifespan, printing speed, accepted media, as well as customer relation aspects such as service agreements.
In our study we have evaluated the color image quality of one of commercially available multi- color litho-offset presses. We have decided to publish the names of the press and devices under test, also all experimental conditions. However, we also believe that not only the results, but also the methodology is of interest to the engineers and scientists working with printing technology.
In our local printing market, there are no basic color sequence rule to print multi color (wet on wet) using process inks, which provides a poor print quality.
Therefore, the research question could be formulated as follows, "Does density-based ink trapping correlate with each other?" . It is assumed therefore that, if ink trapping can be determined from ink density and their ink sequence, a designer or a printer may predict the overprint colors of any two inks.
Printing is about transferring ink from an image carrier to substrate. At the printing nip, the ink splits. A portion of the ink transfers to the substrate while the rest remains on the image carrier [(Chung and Hsu 2008) p 67].
In the printing industry today, tradition and the concept of printing as an ability are both still valid, though the concept of printing by the numbers and standardization is more typical. In regard to offset ink sequence, it is

commonplace to print CMY, as ISO 12647:2004 Graphic technology – Process control for the production of half-tone color separations, proof and production prints – Part 1: Parameters and measurement methods defines printing process control parameters. Today, it downplays the importance of ink trapping. Instead of specifying ink trapping, it opts for specifying colorimetric values of two-color overprints, i.e., (Y+M) red, (Y+C) green, and (M+C) blue, directly (ISO 12647-1 (2004)., and part 2:2004 Graphic technology—Process control for the production of halt-tone color separations, proof and production prints-Part 2: Offset lithographic processes (ISO 12647-2: 2004). However, the opinion of K first or last is one of mixed conviction. There are some who favor K last while others say the opposite that wet ink trapping of offset printing creates lower contrast and D-max. Who is right? Can there be one answer that fulfills the diverse needs of printers? Whether K first or last matters or not, it is important to simply understand the effect of ink sequence on color and image quality to allow for repeatable and predictable results (Andersen 2008).

In recent years, this problem is growth with more imported inks from many sources sometimes from European countries and others from far-east. It can be achieved in most cases, the main theory of process inks sequence (KCMY) for four color printing press or (CMYK) in one or two printing press. In this paper, it has been obvious that in many cases in our country, there are many of printing houses, which re-sequences the inks on the printing press due to obtain the satisfied printing quality.

Recent research shows that a spectral-based ink trapping model can be used to predict spot color overprint (Viggiano & Prakhya, 2008). Input data include spectral reflectance of two solids and the substrate. The problem is that there are two unknowns, ink trapping factor and the overprint color, in one equation. Recognizing the dilemma, this research sets out to devise a method whereby ink trapping factor is estimated independently, hence, the density-based ink trapping assessment.

The purpose of this experimental research was to identify the significant differences that exist in the measurable print attributes (or characteristics) of different color sequences of multicolor (CMYK) offset printing. The ratio of trapping is then calculated between density of the first and second color sequence and the trapping of overlap two colors in wet-on-wet ink transfer.

Research Objective

The research **objective has been** to achieve the best color sequence to print multi-color (wet on wet) by using process inks, to gain highest printing quality. The purpose of the experimental study was to identify the significant differences that exist in the measurable print attributes (or characteristics) of different color sequences of multicolor (CMYK) offset printing. The ratio of trapping is then calculated between density of the first and second color sequence and the trapping of overlap two colors in wet-on-wet ink transfer.

The study results cannot be generalized as it has been carried out in a limited number of Egyptian commercial printing-houses. This may be a considerable limitation looking at the broad spectrum of the printing industry in Egypt.

Methodology

The authors uses an experimental approach with an analytical trend for collecting data about color sequence of using in printing houses and then compare between them according to the printing quality and analysis the results.

Experimental Work

This paper examined the trap attribute according to different color sequences, by used the fixed parameters, as follow;

- The experiment was carried out in film-based workflow. The test form Digital Four Color Test target was output by using Hahrlquene AM technology. Due to excessive Tone Value Increase (TVI) during the platemaking process, the film output was adjusted to achieve linear plates.

- Heidelberg GTO 4 colors printing machine, as shown in figure (1),

Figure 1: Offset printing machine – 1986

- one specified type of cold set inks (*True Ink, manufacture in China*),
  - o The tack value of ink (32c) according to technical data sheet of used ink was,
    - § process magenta = 10-12,
    - § process yellow=9-11,
    - § process cyan=9-11, and
    - § process black= 10-12.
- dampening solution (*Sappi*)
  - o pH=4.8 – 5.2,
  - o temperature= 12 c,
  - o conductivity value= 800 ɥs/cm,
- constant balance between ink and water, pressure value and speed,
- one type of coated paper 170 gsm, the paper size used was B4 ,
- the surrounding environmental condition “22-25 c” ,
- designed test form, To carry out our color image quality evaluation, we first designed test target. the resolution 2540dpi, 175lpi, and the file format PDF. The target shown in Figure 1 was specified using CMYK color space. The targets contain several graphical and pictorial elements which were used for our quality evaluation.
- as shown in figure(2) and

Figure 2: The CMYK test target designed for our study

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- Automated pressroom reflection densitometer (DensiEye 700, which include a polarization filter), as shown in figure 3.

Figure 3: X- Rite DensiEye 700

We identify the ratio as ink trapping ratio (ITR). The density-based ITR is defined as the ratio of the 'wet-on-wet' ink trapping. Density-based ink trapping ratios are compared. The effect of ink sequence and ink trapping ratio on overprint colors are examined, and measure the trapping attribute, according to the Preucil equation: % Apparent trap [3].

$$= \frac{D_{OP} - D_1}{D_2} \times 100$$

Where: DOP = Density of 2-color overprint, minus paper density

D1 = Density of 1st ink down, minus paper density

D2 = Density of 2nd ink down, minus paper density

A pilot test was conducted to achieve the target ink density values (+/- 0.10) according to ISO 12647-2 standards (ISO 12647-2: 2004).

During the experimental tests, 2400 sheets were printed as a total for all experiments, which are printed for 24 different color sequences, as shown in table (1), each state for 100 sheets. Once the density values were achieved according to the standard ink density (SID) values, the press was run continuously without operator interference, and any changes of printing parameters, another 100 were printed, from which a total of 10 sheets for each experiment were randomly selected for the densitometric analysis. Only the attributes of trapping used to compare the 24 different color sequences, as they were the three attributes that measured patches made up of trapping value.

Sample No. Color sequence	Sample No. Color sequence	Sample No. Color sequence	Sample No. Color sequence
1- K C M Y	7- C K Y M	13- M C K Y	19- Y M K C
2- C K M Y	8- M C Y K	14- Y C M K	20- K C Y M
3- C M Y K	9- M C K Y	15- Y C K M	21- K M Y C
4- C Y M K	10- M K C Y	16- Y K C M	22- K M C Y
5- C M K Y	11- M K C Y	17- Y K M C	23- K Y M C
6- C Y K M	12- M Y C K	18- Y M C K	24- K Y M C

Table 1: Experiments different color sequences

Ink trapping attributes that utilize screening ink patches only were not compared, as one could expect similar results from different test samples of test form. The findings of this study represent specific printing or testing conditions.

After print finished, the test samples remain for eight hours to be completely dry, and measure the trapping attributes for randomly 10 samples for different ٢٤ test samples, as totally 240 different samples. The measurement conditions according to ISO 5-3 [9], which samples should be at 23°C ± 2 and 50% RH ± 5, by used X-rite reflection Densitometer, model DensiEye 700, after calibrated by standard certified sheet.

Results

The study has examined whether the color impression for such a spatial color sequence could be expressed using simple adjectives (or adverbs). Table (2) shows twenty four possible color sequences in the three-dimensional RGB trap. One (indirect) path is selected randomly (as a complimentary colors in Fig.2). The twenty four trap go round are obviously different.

Table 1: Experimental Results

Sample No.	Color sequence	Solid color 1	Solid Color 2	Ink Trapping Value
1	K C M Y	C 1.99	M 1.44	56%
		M 1.44	Y 1.76	64%
		C 1.99	Y 1.79	67%
2	C K M Y	C 2.03	M 1.76	68%
		M 1.66	Y 1.74	69%
		C 2.04	Y 1.73	68%
3	C M Y K	C 2.04	M 1.28	55%
		M 1.41	Y 1.85	64%
		C 2.29	Y 1.90	70%
4	C Y M K	C 2.46	M 1.49	75%
		Y 1.8	M 1.51	87%
		C 2.41	Y 1.84	71%
5	C M K Y	C 2.41	M 1.49	56%
		M 1.49	Y 2.01	58%
		C 2.42	Y 1.96	66%
6	C Y K M	C 2.53	M 1.45	75%
		Y 1.58	M 1.38	89%
		C 2.49	Y 1.60	75%
7	C K Y M	C 2.34	M 1.32	91%
		Y 1.66	M 1.51	84%
		C 2.35	Y 1.65	75%
8	M C Y K	M 1.47	C 2.42	79%
		M 1.47	Y 1.49	73%
		C 2.36	Y 1.52	79%
9	M C K Y	M 1.72	C 2.26	86%
		M 1.35	Y 1.77	64%
		C 2.29	Y 1.77	72%
10	M K C Y	M 1.44	C 2.75	79%
		M 1.44	Y 1.78	64%
		C 2.71	Y 1.73	65%
11	M K C Y	M 1.40	C 2.29	90%
		M 1.43	Y 1.72	74%
		C 2.29	Y 1.69	92%
12	M Y C K	M 1.36	C 1.83	88%
		M 1.72	Y 1.79	69%
		Y 1.75	C 2.09	90%
13	M C K Y	M 1.52	C 2.13	77%
		M 1.56	Y 1.73	67%
		C 2.19	Y 1.75	91%
14	Y C M K	C 2.63	M 1.49	57%
		Y 1.63	M 1.50	89%
		Y 1.63	C 2.54	83%
15	Y C K M	C 2.29	M 1.52	79%
		Y 1.69	M 1.53	85%
		Y 2.10	C 2.16	83%
16	Y K C M	C 2.75	M 1.50	58%
		Y 1.71	M 1.50	91%
		Y 2.10	C 2.57	86%
17	Y K M C	M 1.48	C 2.06	87%
		Y 1.49	M 1.44	90%
		Y1.66	C 2.19	86%
18	Y M C K	M 1.50	C 2.03	85%
		Y 1.80	Y 1.98	95%
		Y 1.80	C 2.04	88%
19	Y M K C	M 1.50	C 2.08	85%
		Y 1.74	M 1.51	90%
		Y 1.79	C 2.08	90%
20	K C Y M	C 2.09	M 1.39	87%
		Y 0.73	M 1.46	98%
		C 2.11	Y 0.74	82%
21	K M Y C	M 1.64	C 2.40	78%
		M 1.45	Y 1.69	68%
		Y 1.68	C 2.38	79%
22	K M C Y	M 1.47	C 2.72	80%
		M 1.45	Y 1.48	75%
		C 2.64	Y 1.45	78%
23	K Y M C	M 1.54	C 2.24	77%
		Y 1.55	M 1.15	92%
		Y 1.91	C 2.27	80%
24	K Y M C	M 1.99	C 2.65	79%
		Y 1.79	M 1.49	90%
		Y 1.82	C 2.44	77%

Therefore, one suitable color sequence for which the subject has natural impressions is selected, according to reference value (X-Rite. 2010), as shown in table (2).

Table 2: standard value percent of trap (Status-T, calculated using the Preucil formula)

	Red	Green	Blue
Sheet Fed, Offset	70	80	75

To compare between all current experiments, we show in the next statically figures (Figure 4–11), which can be determined the best results of sequence color print on wet-on-wet, by used four color printing press.

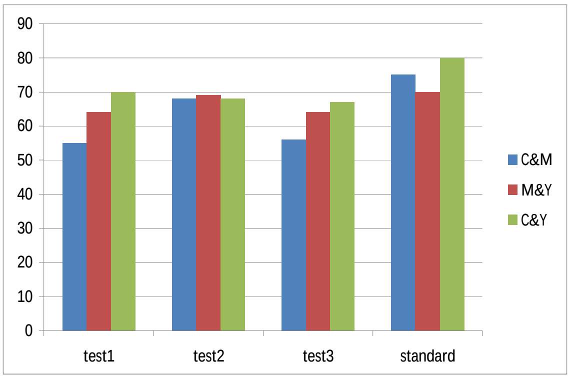

Figure 4: Compare standard result and test 1,2 and 3

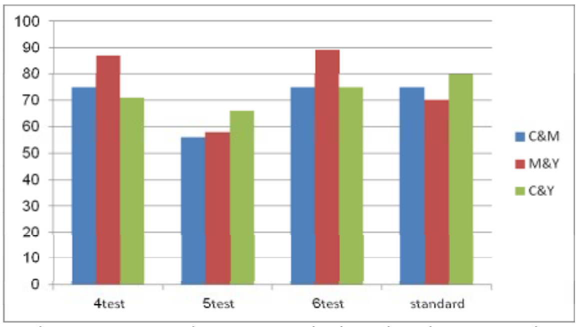

Figure 5: Compare between standard result and test 4,5 and 6

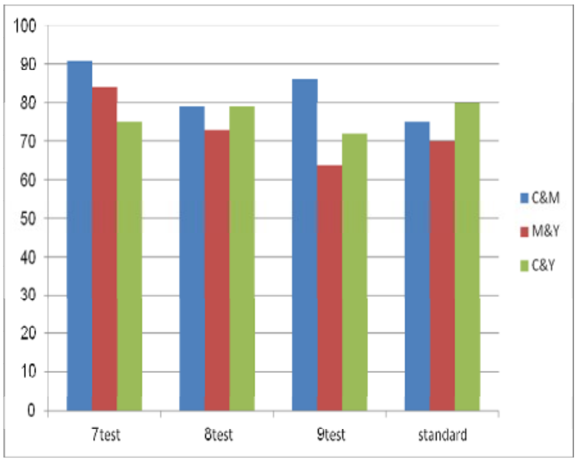

Figure 6: Compare between standard result and test 7,8 and 9

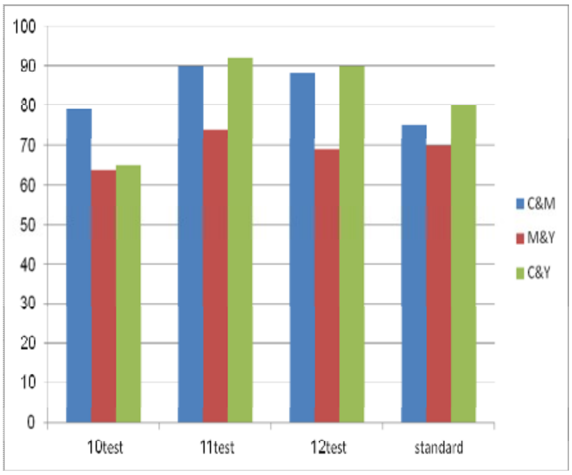

Figure 7: Compare between standard result and test 10,11 and 12

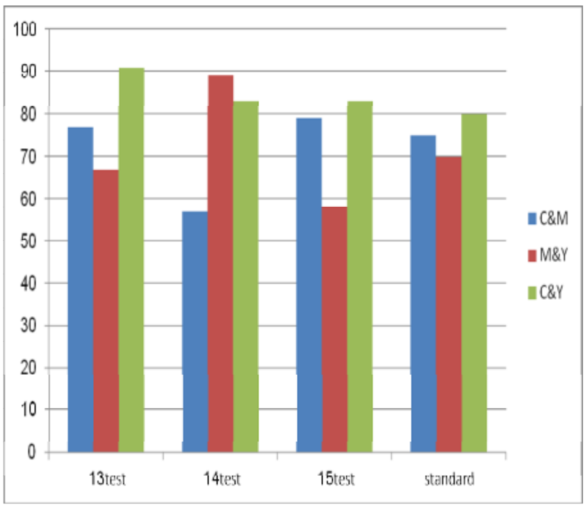

Figure 8: Compare between standard result and test 13,14 and 15

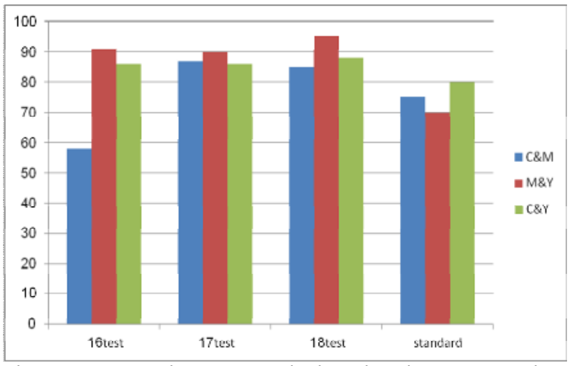

Figure 9: Compare between standard result and test 16,17 and 18

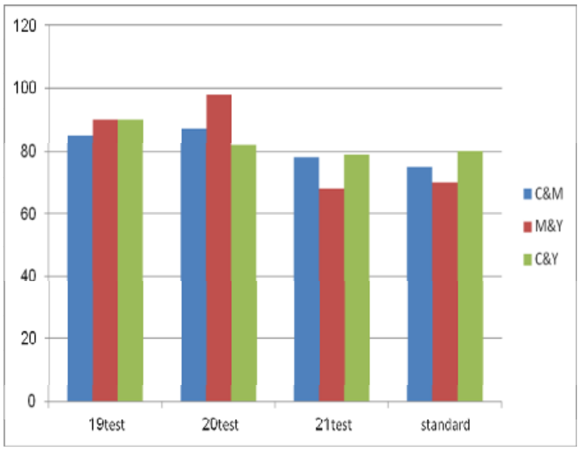

Figure 10: Compare between standard result and test 19,20 and 21

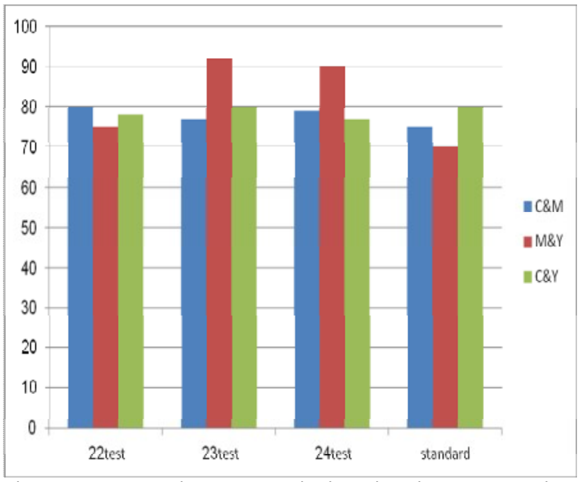

Figure 11: Compare between standard result and test 22,23 and 24

Conclusions

The main reason for carrying out such a study on density-based ink trapping is to be provide the knowledge and know how on the ability to predict overprint colors in wet-on-wet printing. The Preucil formula ink trapping formula requires optical measurement of printed samples, including the measurement of the overprint, in order to compute ink trapping.

A series of ink transfer experiments using inks of known tacks were carried out in this paper. We found that density ink trapping is relative to the tack difference between the first-down ink (high) and the second-down ink (low).

According to previous conclusions, the findings of this research comparing color sequences lead to the conclusion that KMCY or KMYC color sequences provides best trapping than other different sequences. This provides similar hue of color in the detail of printed images, as noticed by visual inspection.

Therefore, The authors are convinced that further studies are to be carried to investigate both, density ink trapping convergence for more inks of the same tacks on uncoated paper and

development of a spectral-based ink overprint model to predict the color of the overprint solid by treating ink trapping value as a constant.

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