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RESEARCH ARTICLE

Comparative study of delta e of hybrid modulated and digitally modulated screening on different grades of paper

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Abstract

Screening technology has become highly advanced during past few decades. This research emphasizes on the use of hybrid modulated (XMS) and digitally modulated screening (DMS) on different grades of paper for evaluating quality parameter. The purpose of this research is to determine the significant differences that exist in measurable print attribute Delta E at 25%, 50% and 75% tint printed by multicolor sheet-fed offset printing process using XM and DM screening. The experiment isconducted using FOGRA39/ PSO standard. The master of 44.5×29.5 cm output is prepared by incorporating quality measuring parameters and printed in KCMY color sequence on different paper types by RYOBI 524HX Sheet fed offset process using XM and DM screening technologies. During test, around 150 sheets were printed to achieve target Solid Ink density value ($\pm$ 0.05). Once the density values were achieved according to standard SID values, next 50 sheets were printed, measured and evaluated. Delta E is used to determine the color difference perceived by human eye. The color values are specified in the Lab color space. To achieve quality in printing the grey component must be adjusted so that chromatic CMY values are matched with achromatic in print (grey balance correction).

Keywords: Delta E, GMG Strip, Hybrid modulated (XM) Screening and Digitally modulated (DM) screening.

Introduction

Screening is used to convert continuous tones images into printing dots. Printing is done by transferring these dots to the desired substrate under defined printing conditions. XM Screening is also known as cross/hybrid modulated screening. It places the frequency modulated microdots on amplitude modulated grid which is spaced. (Newsprint *et al.,* n.d.). XM technology is the result of developing a modern algorithm of conventional screening, which allows higher line screen printing than amplitude modulated screening (AMS), and significant reduction in the process control that was associated with frequency modulated screening (Dial, 2006). XM screening is primarily amplitude modulated screening (AMS), although frequency modulated screening (FMS) is used at tint values below 5 and above 95 %. This allows smooth transition and imaging in highlight and shadow areas (Allen, 2022b). XM screening designed to compensate for the deficiencies of each method by combining the best features of AM and FM screening technologies (Allen, 2022b). These screens are also known as "transitional" screens. By adopting hybrid screening, printers can raise line screens higher than usual halftone line screens without any rigorous process control and easier to print (Musselman *et al.,* n.d.)

DMS is the advanced stochastic screening since it not only provides ultra-smooth flat tints that are as smooth as AM conventional screening, but also achieves the high level of image detail long associated with FM stochastic screening. In DM screening, each and every pixel is modulated and controlled digitally considering the laser optics, plate technology, ink flow and press behaviour so that dot gain is eliminated, resulting in removal of artifacts and graininess completely (Screening technologies — premedia and print workflow solutions-prepress automation, n.d.). DMS is also defined as "intelligent screening". DM screening decodes an image digitally during rasterization process and then

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analyses it intelligently to determine the position of dots precisely on the plate with their proper sizes and shapes (Sherfield, n.d.). The DMS halftone dots display two crucial qualities, first they output images with dots that are small enough to produce print that is nearly photographic in quality and second, they are sturdy enough to be stable in a real-world production environment (Pandey, 2020), (Badea, 2019c).

Grey Balance patches are considered as a quick and conventional way to control inking system on press. Grey balance targets may be useful to detect variation in any of the three process colors because of dot gain, slur, doubling, density, trapping, and registration will be reflected by a shift in hue away from neutrality (Valet, n.d.). In this research work, data is collected on the GMG control strip (Figure 1). Control patches of black at quarter tone (25%), mid tone (50%) and three-quarter tone (75%) were measured and compared following the concept of ECI/bdvm grey control strip. ECI/bdvm grey control strip is based on assumption that chromatic (CMY) Grey should match exactly like true grey (K). The idea behind this target is to determine a color shift away from neutrality. However, in production printing the grey balance target may not be a reliable indicator of presswork issues (Newsprint *et al.,* n.d.). Grey balancing may be used for subjective measurement. Grey balance is the basic and substantial control parameter in image processing, which operates by balancing the correlation of substrate features and print control parameters.

Objectives of Study

The research objective of this experiment is to compare the Delta E at 75, 50 and 25% patches of chromatic grey and true grey printed by offset printing process using Hybrid Modulated Screening and digital modulated screening (DMS) techniques. An experimental approach is adopted for collecting data printed on different grades of paper to identify the significant difference between them.

Materials and Methodology

This research work is based on an experiment. To conduct this research work, the master of 44.5×29.5 cm output is prepared by incorporating quality measuring parameters

Figure 1: GMG control strip

and printed in KCMY color sequence on different grades of paper on RYOBI 524HX (Sheet fed Offset) by using XM and DM screening technologies. During printing, around 150 sheets are printed to achieve target solid ink density value ($\pm$ 0.05). After the density values are attained in accordance with standard SID values, next 50 sheets are printed for spectrophotometer analysis. To execute this research work, a particular paper type is printed with same SID by using different screening methods (XM and DM) having variations of $\pm$ 0.05 to make valid comparison. Gloss coated and matte coated sheets are printed at C-1.35, M-1.30, Y-1.35 and K-1.5 SID. Uncoated White and yellow sheets are printed at C-1.1, M-1.05, Y-1.1 and k-1.25 SID. LWC is printed at C-1.20, M-1.20, Y-1.25 & K-1.35 SID.

Printing substrates (Table 1) are selected according to the paper types defined by ISO 12647-2 for Offset Printing (Characterisation data. (n.d.)) GSM Margin of $\pm$ 5 is considered as per the availability of paper stock in the market. Below are the different paper grades used for research work for offset printing:

Data Analysis

To evaluate the quality of printed sheets, a series of test elements is printed along with the image, and each element is designed to highlight a particular aspect of the printing quality parameter. Some of these test targets are evaluated by measuring instrument and others are evaluated visually. For this research work, Delta E value is measured at 75% (Table 2), 50% (Table 3) and 25% (Table 4) patches of chromatic grey and achromatic grey with the help of Spectrophotometer-X-rite eXact™.

All the measured Delta E values for HMS at 75%, 50% and 25% patch are compared graphically in graphs 2.1, 3.1 and 4.1 respectively and Delta E values for DMS at 75%, 50% and 25% patch are compared graphically in graphs 2.2, 3.2 and 4.2 Respectively.

Results and Discussion

Hybrid screening method showed deviation in range of 1.5 - 4.3, 1.8 -4.0, 2.5 – 3.7 on coated substrates and 2.2 – 3.8, 2.2 – 3.7, 2.4 - 3.4 on uncoated substrates at 75, 50 and 25% greys respectively. While digitally modulated screening showed deviation of 1.3 – 4.1, 1.3 – 4.4, 1.6- 3.2 on coated substrates and 1.7 – 3.5, 1.4 – 3.4, 1.0 - 2.6 on uncoated substrates at 75, 50 and 25% greys respectively. Hybrid and digitally

Table 1: Specifications of different paper grades used for research work

Paper grades	*GSM*	*L*	*a*	*b*	*Company*
Paper type 1 (PT1)	120 g/m^2 glossy coated	95.24	0.44	-3.18	SAPPI
Paper type 2 (PT2)	120 g/m^2 matte coated	96.04	0.02	-1.5	SAPPI
Paper type 3 (PT3)	65 g/m^2 LWC web offset	94.61	1.02	-0.06	CENTURY
Paper type 4 (PT4)	120 g/m^2 uncoated white offset	93.89	2.09	-5.72	ITC
Paper type 5 (PT5)	120 g/m^2 uncoated yellowish offset	93.61	-0.73	8.32	RUCHIKA

Table 2: Delta E values of black ink at 75% patch on different paper types by using hybrid modulated screening and digitally modulated screening

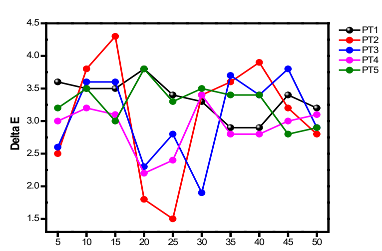
Paper types	*PT1*		*PT2*		*PT3*		*PT4*		*PT5*	
Avg of 5 sheets	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*
5	3.6	2.6	2.5	2.1	2.6	3.0	3	2.6	3.2	2.3
10	3.5	2.8	3.8	1.3	3.6	3.8	3.2	2.8	3.5	2.3
15	3.5	3.4	4.3	2	3.6	3.5	3.1	2.8	3	2.7
20	3.8	4.1	1.8	1.8	2.3	3.7	2.2	2.6	3.8	3.2
25	3.4	3.2	1.5	1.5	2.8	2.5	2.4	2	3.3	3.2
30	3.3	2.3	3.4	2.2	1.9	3.2	3.4	2.9	3.5	3.1
35	2.9	2.7	3.6	2.3	3.7	3.3	2.8	2.7	3.4	3.2
40	2.9	3.7	3.9	2.7	3.4	2	2.8	1.7	3.4	3.5
45	3.4	3.2	3.2	2.5	3.8	3.7	3	2.8	2.8	3.1
50	3.2	3.5	2.8	2.2	2.9	2.1	3.1	2.1	2.9	3.4

Delta E values of Black ink at 75% patch using XMS and DMS

Table 4: Delta E values of black ink at 25% patch on different paper types by using hybrid modulated screening and digitally modulated screening

Paper Types	*PT1*		*PT2*		*PT3*		*PT4*		*PT5*	
Avg of 5 Sheets	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*
5	3	2.1	3.3	2	2.5	2.7	2.7	2.5	2.7	2.3
10	3.4	2.5	3.2	2	3.1	2.7	3.2	2.6	3	1.6
15	2.7	2	3.3	1.9	2.9	2.6	3.1	2.4	2.6	1.6
20	3	2.1	2.8	2.5	2.5	2.9	2.6	1.7	3.1	1.6
25	2.7	3.2	3.3	2.2	2.7	2.6	2.7	1.6	2.5	1.7
30	3.4	2.7	3.1	1.6	2.9	2.8	2.6	1.6	2.5	1.8
35	3.7	2.4	2.8	1.7	2.7	2.3	2.6	1.7	3	1.8
40	3.4	2.3	3.3	1.7	2.7	1.9	2.4	1	3.4	1.7
45	3.1	2.2	3.4	1.8	2.5	1.8	2.6	2	3.2	1.9
50	2.5	2.5	3.1	1.7	3	2.1	2.5	1.9	2.7	2

Delta E values of Black ink at 25% patch using XMS and DMS



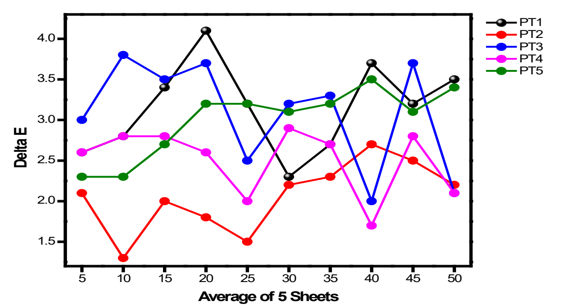
The average values of observations of Delta E of black color at 75% patch was found in the range of 3.4 ± 0.9 on gloss coated paper, 3.1 ± 2.8 on matte coated paper, 3.1±1.9 on lightweight coated paper, 2.9 ± 1.2 on uncoated white paper and 3.3 ± 1.0 on uncoated yellow paper by hybrid modulated screening.

Graph 2.1: Delta E values of black ink at 75% patch on different paper types by using XMS

Table 3: Delta E values of black ink at 50% patch on different paper types by using XMS and DMS

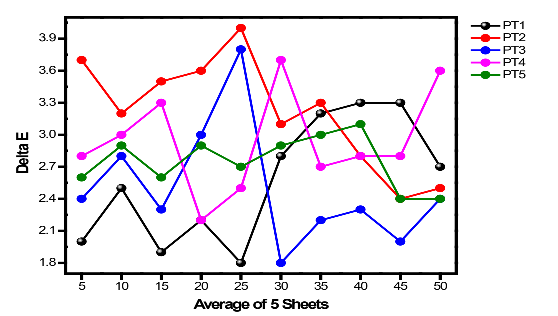
Paper Types	*PT1*		*PT2*		*PT3*		*PT4*		*PT5*	
Avg of 5 Sheets	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*	*XM*	*DM*
5	2	2	3.7	3.7	2.4	2.4	2.8	2.8	2.6	2.6
10	2.5	2.5	3.2	3.2	2.8	2.8	3	3	2.9	2.9
15	1.9	1.9	3.5	3.5	2.3	2.3	3.3	3.3	2.6	2.6
20	2.2	2.2	3.6	3.6	3	3	2.2	2.2	2.9	2.9
25	1.8	1.8	4	4	3.8	3.8	2.5	2.5	2.7	2.7
30	2.8	2.8	3.1	3.1	1.8	1.8	3.7	3.7	2.9	2.9
35	3.2	3.2	3.3	3.3	2.2	2.2	2.7	2.7	3	3
40	3.3	3.3	2.8	2.8	2.3	2.3	2.8	2.8	3.1	3.1
45	3.3	3.3	2.4	2.4	2	2	2.8	2.8	2.4	2.4
50	2.7	2.7	2.5	2.5	2.4	2.4	3.6	3.6	2.4	2.4

Delta E values of Black ink at 50% patch using XMS and DMS



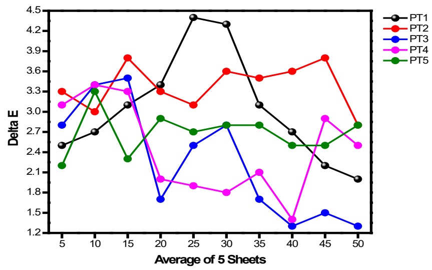
The average values of observations of Delta E of black color at 75% patch was found in the range of 3.1 ± 1.8 on gloss coated paper, 2.1 ± 1.4 on matte coated paper, 3.1 ± 1.8 on lightweight coated paper, 2.5 ± 1.2 on uncoated white paper and 3.0 ± 1.1 on uncoated yellow paper by DMS

Graph 2.2: Delta E values of black ink at 75% patch on different paper types by using DMS



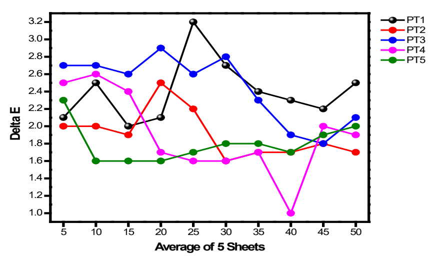
The average values of observations of Delta E of black color at 50% patch was found in the range of 2.6 ± 1.6 on gloss coated paper, 3.2 ± 1.6 on matte coated paper, 2.5 ± 2.0 on lightweight coated paper, 2.9 ± 1.5 on uncoated white paper and 2.8 ± 0.7 on uncoated yellow paper by XMS

Graph 3.1: Delta E values of black ink at 50% patch on different paper types by using XMS



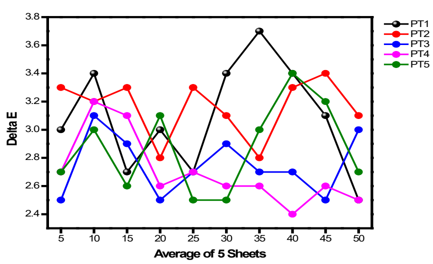
The average values of observations of delta E of black color at 50% patch was found in the range of 3.0 ± 2.4 on gloss coated paper, 3.4 ± 0.1 on matte coated paper, 2.3 ± 2.2 on lightweight coated paper, 2.5 ± 1.9 on uncoated white paper and 2.7 ± 1.2 on uncoated yellow paper by DMS

Graph 3.2: Delta E values of black ink at 50% patch on different paper types by using DMS



The average values of observations of delta E of black color at 25% patch was found in the range of 3.1 ± 1.2 on gloss coated paper, 3.2 ± 0.6 on matte coated paper, 2.8 ± 0.6 on lightweight coated paper, 2.7 ± 0.8 on uncoated white paper and 2.9 ± 0.9 on uncoated yellow paper by XMS

Graph 4.1: Delta E values of black ink at 25% patch on different paper types by using XMS



The average values of observations of delta E of black color at 25% patch was found in the range of 2.4 ± 1.2 on gloss coated paper, 1.9 ± 0.9 on matte coated paper, 2.4 ± 1.1 on lightweight coated paper, 1.9 ± 1.6 on uncoated white paper and 1.8 ± 0.7 on uncoated yellow paper by DMS.

Graph 4.2: Delta E values of black ink at 25% patch on different paper types by using DMS

modulated screening having almost same appearance of gays on LWC paper at 75% patch. LWC substrate showed deviated between 1.9–3.8, 2–3.8, 2.5–3.1 and 2–3.8, 1.3–3.4, 1.8–2.9 at 75, 50 and 25% by hybrid modulated and digitally modulated screening respectively.

It is concluded that greys are reproduced better on coated and uncoated substrates by digitally modulated screening at 75, 50 and 25% greys as compared to hybrid modulated screening. However, the greys are perceptible at a glance in the GMG strip, but images are printed satisfactorily without showing any cast.

Conclusion

Delta E is a matrix that describes how human eye perceives color differences. It defines the difference in visual color perception. By comparing achromatic grey and true grey patches at 75, 50 and 25%, it is concluded that Digitally Modulated (DM) Screen grey reproduction is better than XM screen. The performance of digitally modulated (DM) Screen is qualitative on uncoated substrates also.

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