The Scientific Temper (2023) Vol. 14 (4): 1394-1397
E-ISSN: 2231-6396, ISSN: 0976-8653
Doi: 10.58414/SCIENTIFICTEMPER.2023.14.4.49
https://scientifictemper.com/

RESEARCH ARTICLE

An empirical study on the print suitability of hybrid modulated screen and digitally modulated screen in offset printing process

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Abstract

Digitally modulated (DM) screening is the advanced stochastic screening. It combines the best features of other screening technologies like AM, FM, and hybrid modulated (XM) and is compatible with heat-set, cold-set and sheet-fed offset presses. The aim of this research is to identify the print suitability of XM screen and DM screen in the offset printing process on a coated substrate by comparing different quality parameters like solid ink density (SID), trapping, print contrast and dot gain. Coated sample sheets are printed with the same solid ink density by using XM and DM screening to make valid comparisons. Around 150 sheets are printed to achieve the target solid ink density value (+ 0.05) during printing. After the density values are attained in accordance with standard SID values, next 50 sample sheets are printed, measured and evaluated.

Keywords: Print contrast, Solid ink density, Hybrid modulated screening, Digitally modulated screening, Trapping, Dot gain.

Introduction

Digitally modulated screen is also defined as intelligent screening. DM screening decodes an image digitally during the rasterization process and then analyses it intelligently to determine the position of dots precisely on the plate with their proper sizes and shapes (Pandey, 2023a). In DM screening, the algorithm is changed by considering the ink flow, plate configuration, speed of the machine and quality of paper and image is generated on plate (Auraia Digitally Modulated Screening, n.d.). The DMS halftone dots display two crucial qualities, first they output images with dots that are small enough to produce a print that is nearly photographic in quality and second, they are sturdy enough to be stable in a production environment(Ii and Modulated, n.d.).

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How to cite this article: Vandana, Kumar, P., Jangra, V., Pandey, A. (2023). An empirical study on the print suitability of hybrid modulated screen and digitally modulated screen in offset printing process. The Scientific Temper, **14**(4):1394-1397.

Doi: 10.58414/SCIENTIFICTEMPER.2023.14.4.49

Source of support: Nil

Conflict of interest: None.

Received: 12/09/2023 **Accepted:** 15/10/2023 **Published**:31/12/2023

XM screening is also known as cross-modulated screening. XM screening is primarily AM screening. Although FM screening is used at tint values below 5% and above 95%. This allows smooth transition and imaging in highlight and shadow areas. XM technology is the result of developing a modern algorithm of conventional screening, which allows higher line screen printing than amplitude modulated screening, and a significant reduction in the process control that was associated with stochastic screening (Dial, n.d.). XM screening is designed to compensate for the deficiencies of each method by combining the best features of AM and FM screening technologies. 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 (Screening, n.d.).

Research Objective

This is an experiment-based study. The objective of this experiment is to compare the print suitability of an XM screen and DM screen on a coated substrate in the offset printing process by comparing different quality parameters. An experimental approach is adopted for collecting data of solid ink density (SID), trapping, print contrast and dot gain to identify the significant difference between them.

Material and Methods

Printing substrate is selected according to the paper types defined by ISO 12647-2 (Standardization, 2013) for offset printing. GSM margin of ± 5 is considered as per the

availability of paper stock in the market. Table 1 parameter of paper substrate used for research work
shows the parameter of paper substrate used for research work:

Paper Grades GSMl a b Company Paper type 1(PT1) 120 g/m^2 glossy coated 95.24 0.44 -3.18 SAPPI

To conduct this research work a test chart (Figure 1) is prepared incorporating a number of measuring parameters to evaluate printed samples quality. The special feature of the test chart is GMG unified wedge FOGRA39 v1.0 strip (Figure 2). This FOGRA strip was used for process control in pre-press and printing to ensure high-quality output. Other elements include solid bars, Halftone strips, color registration strips, solid triangles, slur targets, star targets, cross-registration marks, reverse text, QR codes and some photographs for visual inspection. Printing is done at Thomson Press Ltd., Faridabad. The printing plates of 44.5×29.5 cm output is prepared by using XM and DM screening. Printing is done in KCMY color sequence on a gloss-coated substrate using XM and DM screening technologies on sheet-fed offset press (RYOBI 524HX). During printing, around 150 sheets are printed to achieve target solid ink density (C-1.45, M-1.4, Y-1.3 and K-1.75) with a tolerance of $\pm$ 0.05. Once the solid ink density is achieved according to standard values (Colorsource, 2012), another 50 sheets were printed for spectrophotometer analysis.

The print experiment is carried out under the standardized pre-press and press condition using XM and DM screening. For this research work, dot gain at 50% tint of cyan, magenta, yellow and black and trapping for C+M, C+Y, and M+Y solid patch and print contrast at 75% tint is measured and analyzed for finding the results. All printed sheets are allowed to dry for 24 hours and measurements were made using a spectrophotometer (X-Rite Pantone eXact^{TM}) instrument (Pandey, 2023b).

Data Analysis

To evaluate the quality of printed sheets, a series of test elements is printed and each element is designed to highlight a particular aspect of the printing quality parameter. Some of these test targets are evaluated by measuring instruments and others are evaluated visually. Print contrast is determined by particularly checking the screen in the three-quarter tone. Print contrast should have a high value as much as possible. When inking is increased and the ink density of the dots is higher, the print contrast is increased (Engineering, 2023).

For this research work, print contrast is measured at 75% patch of cyan, magenta, yellow and black ink by using XMS and DMS with the help of spectrophotometer-X-Rite eXact™. Average values of cyan, magenta, yellow and black ink at 75% tint is printed by using XM and DM screens are as in Table 1.

Graphical comparison of cyan, magenta, yellow and black for print contrast on coated substrate by hybrid modulated screening and digitally modulated screening is presented with the help of graph 1 (Pandey, 2023a).
Trapping is defined as an indication of the ability of a printed ink to accept the next ink printed compared to

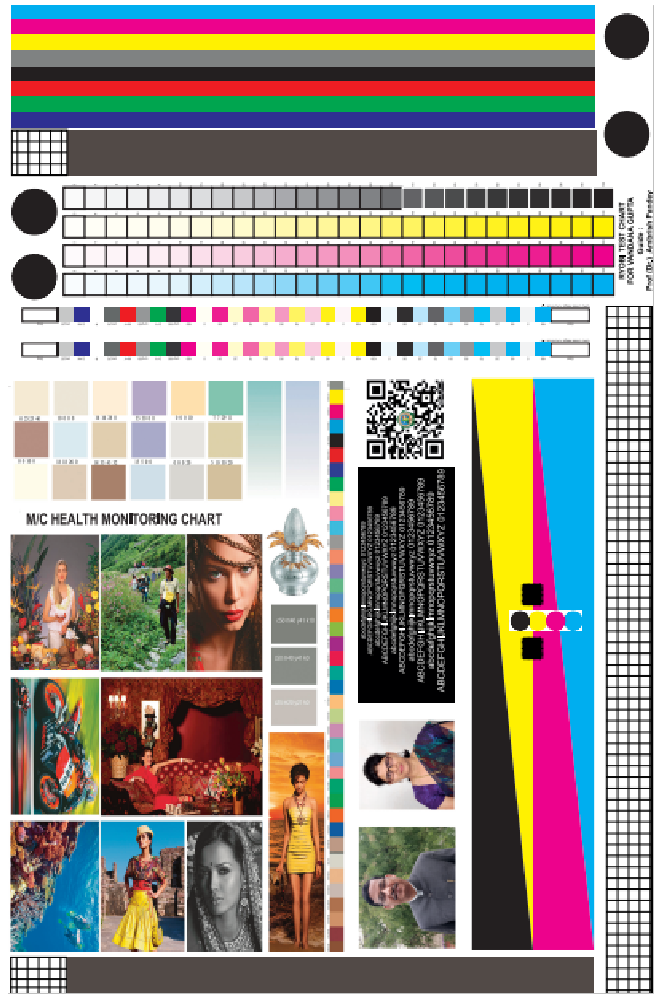


Figure 1: Test chart used for research work

Figure 2: GMG unified wedge FOGRA39 v1.0 strip

Table 1: Average value of print contrast of C, M, Y and K @ 75% tint using XMS and DMS

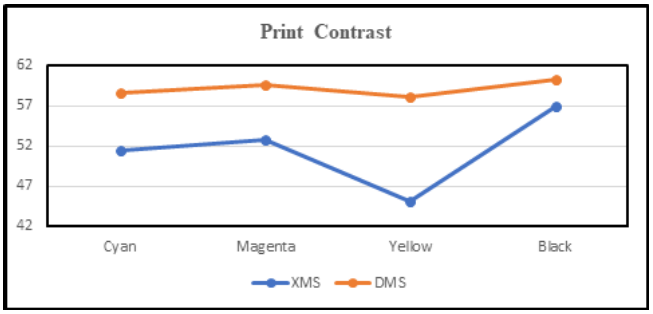
Print Contrast	*Cyan*	*Magenta*	*Yellow*	*Black*
XMS	51.5	52.7	45.2	57
DMS	58.6	59.6	58.1	60.3

Table 2: Average value of trapping for B, G, R color reproduction using XMS and DMS

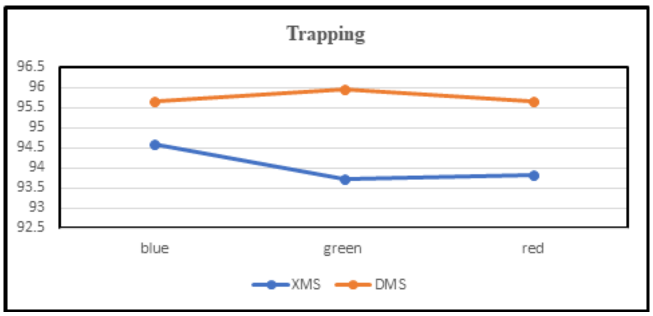
Trapping	*Blue*	*Green*	*Red*
XMS	94.6	93.74	93.84
DMS	95.64	95.94	95.67

Table 3: Average value of dot gain @ 50% tint using XMS and DMS

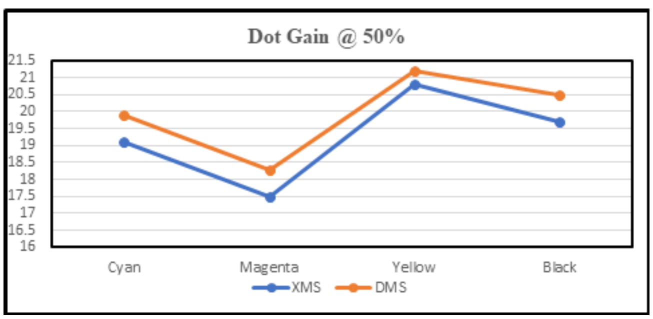
DG@50% tint	*Cyan*	*Magenta*	*Yellow*	*Black*
XMS	19.1	17.5	20.8	19.7
DMS	19.9	18.3	21.2	20.5



Graph 1: Average value of print contrast @ 75% patch of C, M, Y and K ink by using XMS and DMS



Graph 2: Average value of trapping for B, G, R color reproduction using XMS and DMS



Graph 3: Average value of dot gain @ 50% tint using XMS and DMS

how well paper accepts that ink. Trapping is crucial for the reproduction of secondary and tertiary colors. Trapping values are measured for secondary color reproduction (blue, green and red color patches) by spectrophotometer-X-Rite eXact™ and average values are shown in Table 2.

Graphical comparison of red, green and red on coated substrate by hybrid modulated screening and digitally modulated screening is presented with the help of Graph 2.

Dot gain values are measured and analyzed at 50% tint of cyan, magenta, yellow and black ink. The average values for hybrid modulated screening and digitally modulated screening is compared with the help of Table 3.

The graphical presentation of measured data is compared with the help of Graph 3.

Result and Observation

SID is considered as the primary control element on press. To execute this research work, a coated paper is printed with same SID by using different screening methods (XM and DM) having variations of $\pm$ 0.05 to make a valid comparison. Gloss-coated sheets are printed at C-1.35, M-1.30, Y-1.35 and K-1.5 SID. It is found that ink densities in DM and XM screening are consistent/within the range $\pm$ 0.05 throughout the run. It is observed that all the printed tones (Highlight tones, Middle tones and Shadow tones) are printed well and shadow dots are open in all screens. No show-through and smudging of ink was observed during the printing. The printing was consistent throughout the run for both screening technologies.

Wet-on-wet printing relies on trapping. A higher percentage of trapping is required to get the good end results. In this research work, it is observed that both screening technologies showed satisfactory color reproduction. The DM screening prints showed the maximum trapping percentage on gloss-coated paper as compared to XM screening. However, no significant difference is observed in both screening technologies.

Print contrast is observed as an integral component in printing to define an entire tonal range for image reproduction. This indicates the improved ability to reproduce an image with greater shadow details. Digitally modulated screening has more print contrast as compared to hybrid modulated screening.

It is observed that digitally modulated screening showed slightly higher dot gain than hybrid modulated screening on gloss-coated paper. Digitally modulated screening showed dot gain in range of 19 to 23.5%, 17 to 21%, 18.5 to 24% and 19 to 23.5% for cyan, magenta, yellow and black patch, respectively at 50% tint. Hybrid modulated screening showed dot gain in the range of 18 to 22.5%, 16.5 to 22%, 19 to 23% and 18.5 to 22.5% for cyan, magenta, yellow and black at 50% patch. It is observed that dot gain measured by both XMS and DMS is with in tolerance limit.

It is observed that highlight and very fine details are printed better by DMS. Pictures are printed sharper and smoother by DMS. Gradients are printed well by DMS. However better picture depth and contrast is observed in XMS. Shadow tones are printed clear by DMS.

Conclusion

SID

XM and DM screens printed with similar SID on all paper types. SID variation is within acceptable range. Printing results are consistent throughout the run.

Trapping

Performance of both XM and DM screens are satisfying acceptable range but DM screens showed exceptionally good results.

Print Contrast

DM Screen is more suitable in terms of print contrast on all paper types. Offset DM screens showed excellent results in comparison to XM Prints.

Dot Gain

Results of XM screen is close to standard values while DM screens stand little higher side. Highlight details/very fine lines/face tones and shadow tones are better visible in DM screens and pictures are printed sharper and have better details. Gradients are also printed well in DM prints It is observed that contrast and depth is better in XM prints.

Considering the above parametric conclusion, DM screen is most suitable and shows excellent results in most of the print parameters. Since the results of DM screen are better than XM screen so its application can also be utilized in the commercial sector.

Acknowledgement

The authors are thankful to all who helped while accomplishment of this experimental research activity and duly acknowledge all the technical assistance provided during the carrying out of this study.

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