Research Paper

DOT GAIN EVALUATION BY CHANGING DOT SHAPES IN OFFSET LITHOGRAPHY

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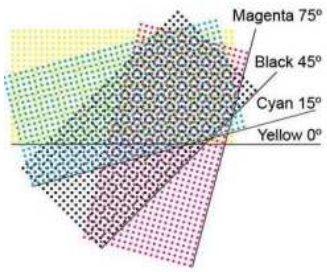
ABSTRACT

This document gives information about different screen dot shapes used in lithographic printing process for process inks and their effect on parameters like color gamut, dot gain, hue error.

KEYWORDS Dot shapes, Screening technics, Lithography, Dot gain

I. INTRODUCTION

All the printing processes are based on subtractive color theory and they use cyan, magenta, yellow and black inks which are necessarily transparent (process) in nature so that number of color combinations can be obtained by superimposing and/or just a positioning them. The inks are transparent (process colours) due to use of special pigments. It is assumed that the substrate is white. Due to impurities and limitations of pigment of cyan, magenta and yellow process inks; it is not possible to get pure black by combining these 3 primary colours hence a fourth colour – black is printed. For printing purpose all the originals in continuous tone are converted into halftone dots. For printing halftones, the process colors are imparted with screen angles and rulings. A screen is a geometric shape comprising of dots which are available in various shapes. In process color prepress and printing, the angle at which the rows of halftone dots run in relation to the horizontal axis is referred to as screen angle. It may cause generation of Moiré pattern during printing if not properly maintained. Various dot shapes are used for printing purpose – round, elliptical, square. Kind of printing process, type of work are some of the major factors deciding the dot shape.



Screen Ruling[2] is determined by the number of halftone dots counted per linear inch, measured along the axis of a row of dots. Therefore a job which requires the use of 150 lines per inch implies that the screen ruling required would equal 150 halftone dots per inch. The image above displays the traditional angles used in four colour process work (CMYK) where the axis of the rows equals the angle. Single colour jobs use a screen angle of 45 degrees for halftoned images and colour tints (flat fills of a percentage of the solid colour). The 45 degree angle is the least noticeable and offensive to the human eye whereas an angle of 90 degrees is very obvious and draws attention to the dots rather than the image detail (the picture).

Dot Shape:

There are three halftone dot shapes generally used today. The most common is the Elliptical Dot[3] that gives smoother midtones especially when printed on a Litho Offset machine. By joining the dots below 50% on one axis only and then above 50% on the other axis, the change in this important tonal area appears less harsh than is otherwise experienced with the Square Dot. The Round Dot also suffers from a fairly harsh transition as the dots get larger and start to touch, but this happens at a higher percentage than the square dots 50% point, and tends to reduce the visual effect slightly because it is in the darker areas of the image. The method of printing, the plate type and substrate can all influence the preferred dot shape. The maximum screen range possible is of course 100% - no dots in the whites of picture, to solid ink in the darkest areas. However this range is never used for most imaging because:

- The transition from 0% to the smallest dots can appear too harsh.
- There is always dot gain applied to the dots when printed.

Therefore we have to make allowances when preparing our images for output. Highlight is the correct name for the lightest area of an image (and copy). Shadow is the name for the darkest image areas, and the Midtones areas are in between. Also there will be reference to the Quarter Tones and Three Quarter Tones that appear: 1. between highlights and midtones and, 2. between midtones and shadows.

Offset printing process[1]**:**

In the offset printing process the printing and nonprinting areas of the plate are practically on one level. The printing areas of the printing plate are oleophilic ink-accepting and water-repellent, that is, hydrophobic. The non-printing areas of the printing plate are hydrophilic, consequently oleophobic in behavior. This effect is created by physical phenomena at the contact surfaces. The dampening system covers the non-printing areas of the printing plate with a thin film of dampening solution. This dampening solution (water plus additives) spreads over the non-printing areas. To achieve good wetting, surface tension has to be reduced by means of dampening solution additives.

Print Characteristics Attributes:

The main attributes influencing print characteristics are-

Substrate, Primary ink color (hue, density), Tone transfer (dot gain), Secondary color (trapping sequence), Grey balance

These individual attributes are not are not completely isolated from others. For e.g. grey balance reflects the changes of any or all the other attributes. Understanding of each attribute is required for the

printer to be able to identify, measuring the comparative prints, which attribute is responsible for any differences.

Identifying and Measurement of the Print Characteristics

Measurement of print characteristics needs constant and reliable reference and control elements or print control strips provide this. The attributes of the print characteristics and their appropriate control elements are summarized in the following table-

Table 1. Printing Attributes

Attribute	Image element	Method of Assessment
Ink color and ink film thickness	Solid Patch	Spectrophotometer or Densitometer
Tone transfer while printing	Continuous tone step wedge Microlines Highlight and Shadow dots Star Target	Visual Magnifier Magnifier Visual
Tone transfer (slur and doubling)	Star Target Concentric Circles Line tints	Visual Visual Visual or densitometer
Trapping	Solid Overprints	Visual or densitometer
Gray balance	3-color neutral half tone patch	Visual, Spectrophotometer or densitometer
Register	Fine Crosslines Concentric circles	Magnifier

Formulae for measurement of print characteristics attributes[4]

Dot Area

To measure dot area a solid area adjacent to halftone in question is required. A density measurement is made on the solid and half tone area and these values are used to calculate dot area.

Dot area (%) = $[(1-10^{-Dt})/(1-10^{-Ds})] \times 100$

Where, D_s= density of solid area, D_t= density of half tone area

Dot area (%) = $[(1-10^{-Dt/n})/(1-10^{-Ds/n})] \times 100$

Where n= a compensating factor for optical gain

Dot Gain

Is obtained by subtracting apparent dot area of the image carrier from print. formula is required to measure trapping of the third color onto the first two colors as under-

Trap (%) = $[(D_{1+2+3}-D_{1+2})/D_3] \times 100$

D_{1+2+3} = density of the three color overprint, D_3 = density of third color

Color difference or deviation-

Is done as per ΔE*2000, ΔE*94, ΔECMC and ΔEab.

II. EXPERIMENT WITH DIFFERENT DOT SHAPES

Different dot shapes and screen ruling combination would provide relative changes in dot area and dot gain. Therefore following varying and constant parameters were decided and nine trials were carried out.

Figure 2. Test chart

III.EXPERIMENTAL SET UP

Table 2. Experimental set up

No.	Parameters	Detail
1	Machine	Domain Poly 766
2	Printing Seq.	K C M Y
3	Paper	130 gsm Coated BILT
4	CTP	Technova Plates
5	Dot shape	Round, Square, Elliptical
6	Screen ruling	85, 120, 175 (lpi)
7	Screen angles	Standard i.e. K=45, C=15, M=75, Y=90 (degrees)
8	Ink	Sicpa
9	Software	MS Excel for calculations & CorelDraw for design
10	Instruments	Xrite i1pro spectrophotometer with ProfileMaker

The test form contains customized density measurement patches and an image to visually check the occurrence of discernible moire pattern. After printing the spectrophotometer was used to check the colour gamut readings, density. The data was used to calculate Dot gain, Contrast, Hue error, Vivacity, Greyness, Trapping. Spectrophotometer measures spectral energy distribution curves of each colour and can give readings in L, a, b values i.e. lightness, red or green, yellow or blue respectively. The colour difference between two printed samples can be measured using these values and expressed as delta E. Mathematical values are specified for delta E to classify the printed samples.

IV. ANALYSIS

The dot area at various values of dot shapes and screen rulings is depicted in following table.

1=85, 2=120, 3=170 lpi; E = Elliptical, R = Round, S = Square

Table3: Dot area for different dot shapes

Th	1E	2E	3E	1R	2R	3R	1S	2S	3S
10	13	16	15	13	14	12	11	13	10
20	24	29	30	25	27	28	24	26	26
30	35	42	44	36	39	43	35	38	40
40	44	51	53	46	50	55	45	50	54
50	55	62	67	55	61	67	55	62	66
60	65	72	73	64	72	77	65	71	77
70	73	80	86	74	81	86	75	81	87
80	80	89	93	83	90	94	81	90	95
90	90	96	97	92	97	99	91	98	99
95	95	99	98	96	99	100	95	99	100

1=85, 2=120, 3=170 lpi; E = Elliptical, R = Round, S = Square

Dot gain curves were plotted for elliptical, round and square dot shapes with varying screen frequencies. The graphs are shown below –

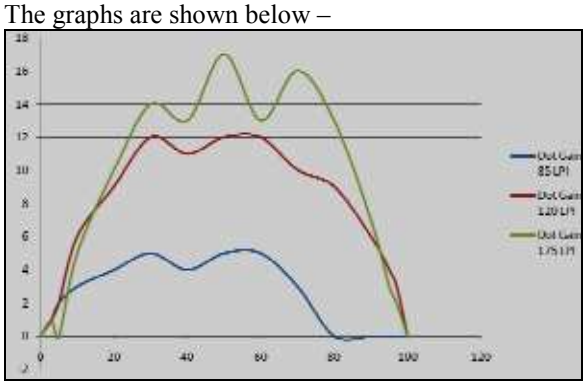


Fig. 3 Elliptical

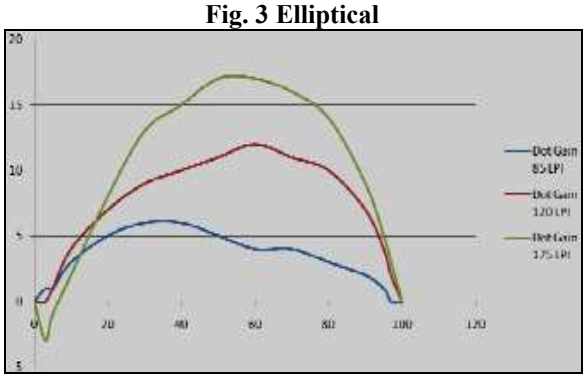


Fig. 4 Round

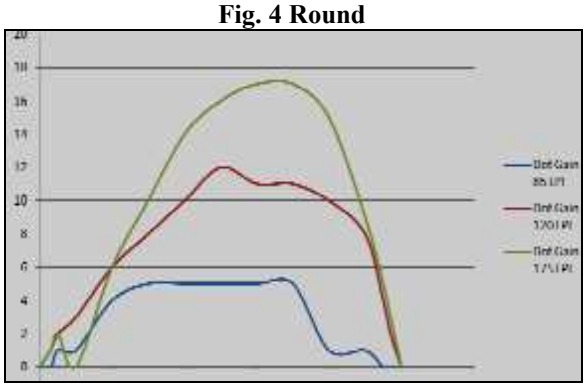


Fig. 5 Square

Table 4. Dot gain

Screen Frequency (LPI)	Dot Shape	Max Dot Gain	
		Value	Occurring at (%)
85	Square	5	70
	Round	6	40
	Elliptical	5	60
120	Square	12	50
	Round	13	60
	Elliptical	17	50
175	Square	17	50
	Round	15	70
	Elliptical	17	50

V. CONCLUSION

The experiment (9 trials) is carried out as per the design. The set of tables filled in with dot area for all trials are used to plot graphs.

The trend exhibited by graphs of theoretical dot area against measured dot gain has proved that dot gain goes on increasing with increase in screen frequency.

It is also observed that in case of round shape dot the maximum absolute dot gain shifts towards shadow area.

ACKNOWLEDGEMENT

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