Consistency of mechanical dot gain - a hidden quality parameter

Kerstin Malmqvist*, Antanas Verikas*, Lars Bergman*

Keywords: Printing, Dot, Plates, Quality

Abstract: Demanding customers require high quality also in the most challanging printing situations, today also required for newspaper. Due to the lack of possibilities to easily measure the consistency of the picture on the printing plate limited efforts are generally made to tune the reproduction of the printing plate. A study made by means of the newly developed Malcolm system, specially modified to also measure the characteristics of every printing dot on the printing plate, has revealed the benefits of scrutinising also the printing plate.

Introduction

To achieve high quality when printing halftone pictures in offset it is important to know the dot gain characteristics. In most cases the printer knows from experience the approximate dot gain. However, it is important to be able to assess the dot gain beforehand. By a convention the dot gain is subdivided into mechanical dot gain and optical dot gain. Mechanical dot gain is the result of the growth during the printing process. Optical dot gain basically appears due to the light scattering in the ink and the paper.

The mechanical dot gain on its part originates from two sources, the production of the printing plate and the pressure in the printing nip. The size of the halftone dot on the printing plate differs generally from that on the original film. The degree of the discrepancy basically depends on the lighting conditions and exposure time. With negative film and plate the discrepancy is a dot gain, while when using a positive film and plate the result is a dot reduction. In this investigation we have used negative plates.

The Physics of Paper and Print Group, **PPP-Sweden**

* Centre for Imaging Science and Technologies, Halmstad University, Sweden
URL: //http:www.hh.se/dep/cbd/cist.html

It is desirable to keep all these factors which influence the dot gain under control in order to make a good compensation in the raster image processor. Therefore it would be of great value to be able to measure the actual dot size directly on the printing plates. The contribution from the other source to mechanical dot gain, the pressure in the printing nip, is more complicated to get hold of. It depends on the interplay between paper and ink as well as the influence from several printing press characteristics.

To measure the optical dot gain is a complicated task. In a work (Nilsson *et al.*, 1998), an investigation is presented where the spatial distribution of the pigments and the corresponding optical response in newsprint is studied. From this study the order of the size of the optical dot gain can be estimated.

We have developed a new concept, Malcolm, for fast and robust measurements during the printing process. It is based on artificial neural net algorithms and it can be used for measurements of dot sizes on films, on plates and on the printed result. It is even possible to strip the different colors in a multicolored print and to measure the dots of each color separately (Verikas *et al.*, 1999). The Malcolm concept contributes to a better quality control of multicolor print through the possibility to measure the overall color impression and to return signals for color adjustements for each one of the printing inks cyan, magenta, yellow, and black (Malmqvist *et al.*, 1999).

In this paper, we describe a method for dot size measurement on plates, show the results from an experimental study and discuss briefly the relation between the different contributions to the total dot gain.

Estimating dot size on printing plates – the method

We use a color space with three color difference signals, namely $f_1=r+g+b$, $f_2=r-b$ and $f_3=r-2g+b$, where r, g and b are variables of the RGB color space (Verikas *et al.*, 1997). The variables f_1, f_2, and f_3 are normalised in the following way. The normalised variable f_n is given by

$$f_n = \frac{f - \bar{f}}{s}$$

where $\bar{f}$ and s^2 are respectively the mean and the variance of the variable f. The mean and the variance are calculated from the input image.

The method includes three main steps, namely image acquisition, fuzzy clustering and post-processing. A flowchart of the approach is given in Figure 1.

Figure 1. Flowchart of the approach

A CCD color camera records an image from a measuring area. Next, every pixel in the image is assigned into one of two clusters aiming to assign pixels from the printed dots into one cluster (*"dot")* and those from the background to the other cluster (*"background"*). We adopted the fuzzy Kohonen clustering algorithm for this purpose (Tsao *et al.,* 1994). Figure 2 and Figure 3 show an example of an image before and after the partitioning into the clusters *"dot"* and *"background"*.

The clustering, actually, binarises the input image. After the binarisation some noise may appear in both the "dot" and the "background" areas. In order to eliminate the noise, post-processing is performed after binarisation. The post-processing eliminates small connected components in both "black" and "white" areas of the binary image.

Now the average dot size is easily calculated, since we know the size of the image as well as the number of pixels in the clusters *"dot"* and *"background"*.

Estimating dot size on printing plates – experimental investigations

In this investigation, we used two printing plates with a number of test areas with known nominal tonal values between 0% and 100% located at different places on the plate. On each plate, we used 3 test areas, six test areas in total, placed at the lower left-hand side of the plate, in the middle of the plate, and at the lower right-hand side of the plate, respectively. The CCD camera recorded images with a resolution such that an image consisting of 512x512 pixels was recorded from an area of 2.8x4.0 mm^2.

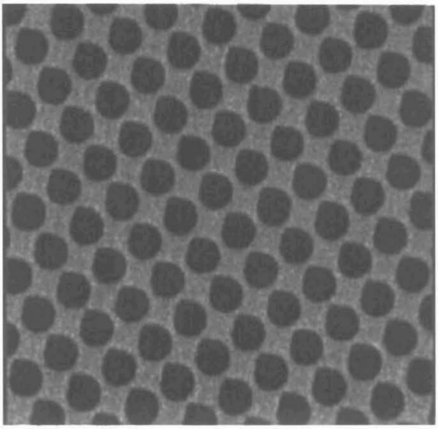


Figure 2. An example of an image before partitioning into the clusters *"dot"* and *"background"*

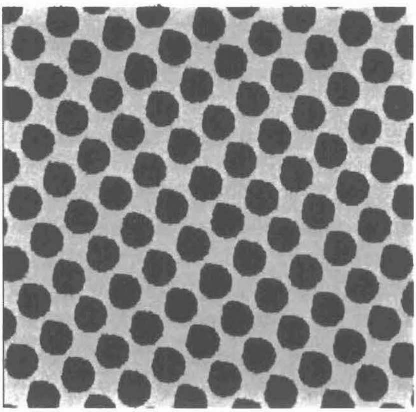


Figure 3. The same image as in Figure 2 after partitioning into the clusters *"dot"* and *"background"*

Table 2 provides the nominal and the actual tonal values for all the test areas measured while Table 3 shows the nominal tonal values and the dot gain measured. We use notations *L1, M1* and *R1* for the first plate and *L2, M2* and *R2* for the second plate, where *L* stands for left, M for middle and *R* for right. As can be seen from the figures and the tables, the dot gain is different for the different places at the plate measured. If the nominal tonal value is less than approximately 50% the *lowest* dot gain is observed in the middle part of the plates. By contrast, we observed the *largest* dot gain in the middle part of the plates when the nominal tonal values exceeded 50%. Both plates are quite similar from the point of view of the dot gain. Figure 4 illustrates the dot gain for the three test areas of plate 1.

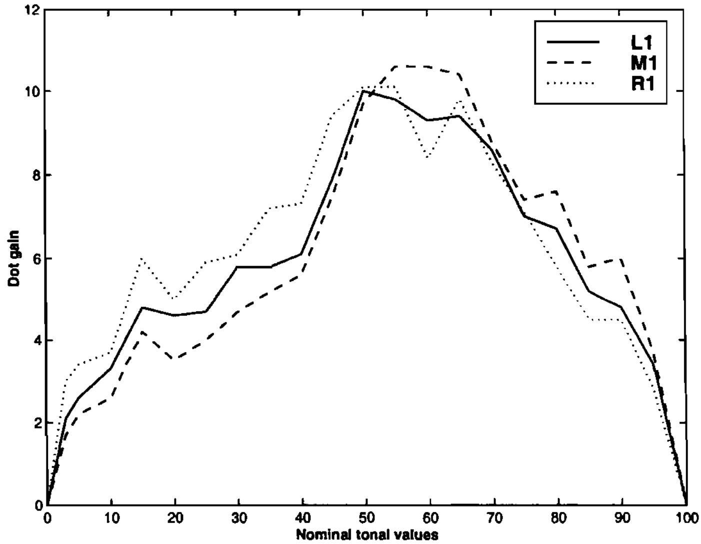


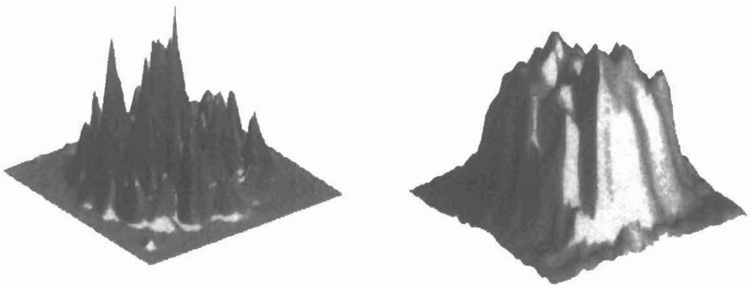
Figure 4. Dot gain for the test areas measured on plate 1

The optical dot gain

Much effort is done with the aim to understand and to develop methods for measuring the optical dot gain. In most of the modelling research work, the methods developed are based on different more or less idealized models of the paper structure and of the light scattering phenomenon. (Gustavson, 1997). If we, however, for a specific dot could seize full information about the spatial distribution of the colored pigments which actually form the dot and compare this area with the optically observed area of the dot, e.g. via a CCD camera, we would get a measure of the "real" optical dot gain.

A method implementing this idea is together with experimental investigations presented in two papers (Nilsson *et al.*, 1997, Nilsson *et al.*, 1998). The experiments are performed on cyan dots printed on newsprint. The result showed that under the given conditions the optical gain was in the order of 15% for newsprint.

The left part in the figure below, Figure 5a, shows the spatial distribution of the pigments which form the dot. The pigment distribution is observd by using a non-optical technique, the PIXE-technique. The right part, Figure 5b, shows the optical response of the dot. A CCD-camera is used for image acquisition.



a. b.

Figure 5. Pigment distribution and corresponding optical response for a dot

Discussion

The total dot gain is a combination of dot gain originating from three sources, the exposure of the plate, the pressure in the printing nip and the optical response. To get a high quality print it is necessary to have as good control as possible of all three sources separately and thus be able to trim the different steps in the pre-press and the printing process. Differences in dot gain over the plate can not be neglected. It seems wise to check out the reproduction properties of the plate production unit if highest quality is required.

Much work is done to empirically determine the behavior of the dot gain under different circumstances. Standard curves for dot gain is used in every printing plant. A standard curve for dot gain in newsprint tells us that, when printing with tonal values between 20% and 60%, the total dot gain approximately lies between 30% and 33%.

The enlargement of the dot which appears in the printing nip can roughly be estimated by simple subtraction using the figures above. The relation between the different contributions to the dot gain can be expressed in the following way:

Table 1. Estimation of the size of the different types of dot gain

Total dot gain	Dot gain due to exposure of plate	Dot gain in printing nip	Optical dot gain
30% - 33%	7% - 11%	7% - 11%	15%

From Table 1 the following conclusions are obvious

- The optical dot gain contributes with approximately half the enlargement of the dot;
- The dot gains due to the exposure of the plate and to the printing nip are of approximately the same size.

Table 2. The actual tonal values measured.

	Plate 1			Plate 2		
Nominal	L1	M1	R1	L2	M2	R2
0	0	0	0	0	0	0
3	5,1	4,7	6,0	5,1	4,8	5,9
5	7,6	7,2	8,4	7,6	7,4	9
10	13,3	12,6	13,7	13,2	12,3	14,1
15	19,8	19,2	21,0	19,4	19,7	20,9
20	24,6	23,5	25	24,6	24	25,1
25	29,7	29	30,9	30,3	29,4	31,5
30	35,8	34,7	36,1	35,8	35,2	36,3
35	40,8	40,2	42,2	40,9	40,7	42,4
40	46,1	45,6	47,3	46,7	46,3	47,5
45	52,9	52,5	54,4	53,2	53,4	54,7
50	60	59,7	60,1	60,5	60,3	60,1
55	64,8	65,6	65,1	65,2	66,2	65,5
60	69,3	70,6	68,4	69,8	71,5	69
65	74,4	75,4	74,8	75,1	75,7	75,3
70	78,6	78,8	78,3	78,7	79,4	78,3
75	82	82,4	82,1	82,5	83	81,9
80	86,7	87,6	85,8	86,9	88	85,6
85	90,2	90,8	89,5	90,6	91,3	89,5
90	94,8	96	94,5	95,2	95,7	94,6
95	98,4	98,7	97,8	98,6	98,7	97,8
100	100	100	100	100	100	100

Table 3. The dot gain measured.

	Plate 1			Plate 2		
Nominal	L1	M1	R1	L2	M2	R2
0	0	0	0	0	0	0
3	2,1	1,7	3,0	2,1	1,8	2,9
5	2,6	2,2	3,4	2,6	2,4	4
10	3,3	2,6	3,7	3,2	2,3	4,1
15	4,8	4,2	6,0	4,4	4,7	5,9
20	4,6	3,5	5	4,6	4	5,1
25	4,7	4	5,9	5,3	4,4	6,5
30	5,8	4,7	6,1	5,8	5,2	6,3
35	5,8	5,2	7,2	5,9	5,7	7,4
40	6,1	5,6	7,3	6,7	6,3	7,5
45	7,9	7,5	9,4	8,2	8,4	9,7
50	10	9,7	10,1	10,5	10,3	10,1
55	9,8	10,6	10,1	10,2	11,2	10,5
60	9,3	10,6	8,4	9,8	11,5	9
65	9,4	10,4	9,8	10,1	10,7	10,3
70	8,6	8,8	8,3	8,7	9,4	8,3
75	7	7,4	7,1	7,5	8	6,9
80	6,7	7,6	5,8	6,9	8	5,6
85	5,2	5,8	4,5	5,6	6,3	4,5
90	4,8	6	4,5	5,2	5,7	4,6
95	3,4	3,7	2,8	3,6	3,7	2,8
100	0	0	0	0	0	0

Literature cited

Gustavson S.
1997 "Dot gain in colour halftones"
Linköping University, dissertation no 492 1997

Malmqvist K., Verikas A., Bergman L., Malmqvist L.
1999 " Malcolm – a new partner in graphic art quality control"
TAGA Proceedings 1999

Nilsson C.M., Malmqvist L., Busk H., Kristiansson P.
1997 "Optical enhancement of closely positioned screen dots",
TAGA Proceedings 1997

Nilsson C.M., Malmqvist L., Carlsson J:, Kristiansson P.
1998 " Study of pigment distributions and corresponding optical response in newsprint"
TAGA Proceedings 1998

Tsao E., Bezdek J.C., Pal N.R.
1994 " Fuzzy Kohonen clustering networks"
Pattern Recognition, vol. 27, N# 5, 757-764, 1994.

Verikas A., Malmqvist K., Bergman L.
1997 "Colour image segmentation by modular neural network"
Pattern Recognition Letters. **18**, 173-185, 1997

Verikas A., Malmqvist K., Malmqvist L., Bergman L.
1999 "A new method for colour measurements in graphic arts"
Color Research & Applications 1999 (3)