Measurement of the ink release from the Anilox Roll

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Keywords

Flexo, Ink release, Cell volume

Abstract

The anilox roll is the primary means of ink delivery to the flexographic plate. The engraved cell geometry on the roll determines the volume of ink carried and also the amount of ink released to the plate. Understanding the ink release process is a key to having from highlights to solids on same plate. A new method has been developed in order to obtain detailed information concerning the percentage of ink released from the anilox roll to the flexographic plate. White light interferometry was used to measure the anilox roll in various states, un-inked, inked and after printing to obtain the quantity of ink released. A series of experiments where then undertaken using a printability tester to study the ink release to solid and half tone plates for varying anilox volumes and cell geometries. The influence of anilox to plate pressure and printing speed were also evaluated.

Micro interaction of the plate coverage and the anilox was found to control the ink release. The amount of ink released is a function of coverage, cell geometry (particularly open area) and pressure. This interacts with the relative size and geometry of the dots on the plate.

As a first approximation, 40% of the ink is released by the anilox to the plate when printing a 100% solid. This is not the case when printing half tones and highlighting the difficulties of having a half tone and solid on the same plate. The ink release was found to be independent of printing speed.

Introduction

The anilox roll is the primary means of controlling the ink delivery to the flexographic plate. The engraved cell geometry on the roll determines the volume of ink carried and also the amount of ink released to the plate. Although the anilox has a key roll in the control of ink flow in the flexographic printing process, the lack of detailed understanding of the ink release mechanisms means

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there is as yet no agreement on the critical aspects of the cell dimensions that have to be controlled. This is crucial for the specification of anilox rolls.

As well as the cell geometry and engraved volume per unit area of the anilox roll, the ink transfer to the plate is also determined by the ink properties and the process parameters. One approach to understanding the fundamental physics of the ink release mechanisms it is to measure the cell volume and the volume of ink in the cell before and after printing. This paper describes the development of an experimental technique for investigating the ink release mechanisms using a printability tester and white light inteferometry. Some preliminary results are presented and analysed for the effect of speed, pressure and cell volume for both solid and half tone printing.

Experimental method

The experiments were performed on an IGT F1 Flexographic Printability Tester (Figure 1). This can, with attention to detail, be used to study the flexograpihc printing of both solids and half tones in a controlled laboratory environment (Hamblyn et al). The ink is applied in the nip formed between the doctor balde and the anilox. This is allowed to rotate several times before printing to ensure the anilox is fully primed with ink. The ink is then transferred via the image on the plate to the substrate. The F1 printability tester permits variation in settings of speed, anilox pressure, anilox inking and print pressure. A range of anilox rolls were also available. For this study, UV cyan ink was used to eliminate any ink loss due to solvent evaporation during the measurement of the anilox and an

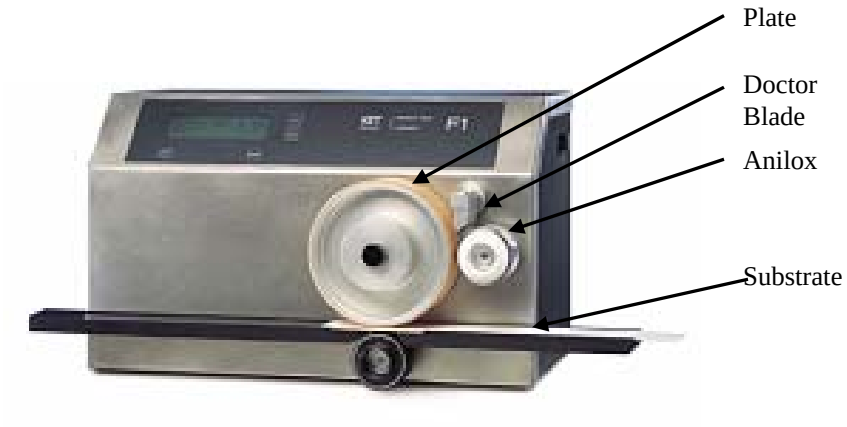
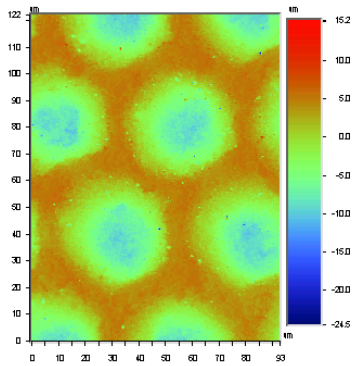


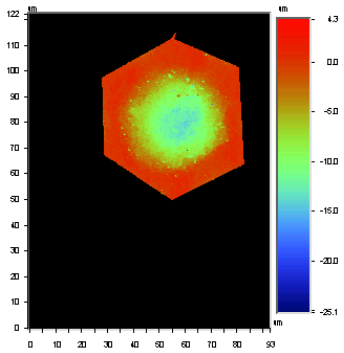
Figure 1 IGT F1 Flexographic Printability tester

impervious film substrate was used to avoid absorption into the substrate.

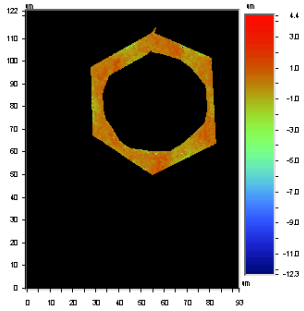
White light interferometry, a non-contact profile measurement system, is the most accurate of all the techniques in measuring cell geometry. Vertical scanning interferometry (VSI), the interferometric objective scans the surface vertically at varying heights, so the focus varies at each position. This combined with the short coherence length of white light, means that interference fringes are only visible over very shallow depths for each focus position. As the sample is scanned at the varying heights, the fringe contrast or modulation increases as the sample is brought into focus and decrease as it falls out of focus. The fringe modulation is recorded at each plane of focus, from which the signals are processed to produce the subsequent surface parameters and profile. Single Cell Analysis technique developed by the Welsh Centre for Printing and Coating, produces an accurate, user independent measurement of both cell volume and shape (Cherry et al). The technique isolates a single cell using an analysis mask (Fig. 2). A terms mask is applied to ensure the edges of the cell are level and



a. Measurement



b. Isolated Cell



c. Land Area

Figure 2 Single Cell Analysis

then the histogram filter is used to remove the land area from around the isolated cell, allowing any calculations to be calculated purely from the cell. To allow for the contribution to the depth of the cell by the land, the roughness of the land area surrounding the cell needs to be attained. Apply a further analysis mask to remove the internal area of the cell, isolates the land area so the average height based on the roughness can be obtained. The mask height is then assumed to be half Rz for subsequent masking of the cell in order to remove the land area. Having isolated then cell, it is then possible to calculate the cell volume using the volumetric analysis function.

The total cell volume is the combination of two volumes (Fig. 3). To calculate the total cell volume V1, the volumes V2 and V3 must be calculated. The volume V2 is taken as the volume below the cell roughness and is the volume calculated for the filtered isolated cell. The volume V3 is added as when the filter is applied, some of the cell volume is lost with the removal of the land area. Therefore to find V3, the lateral surface area of the cell is found, which is then multiplied by the mask coefficient to give the volume V3. This then gives the total volume V1 as:

V1 = (Cell volume V2 + (lateral surface area x mask coefficient))

The cell depth is calculated using the RZ value and the mask coefficient as follows:

Cell Depth = RZ + mask coefficient

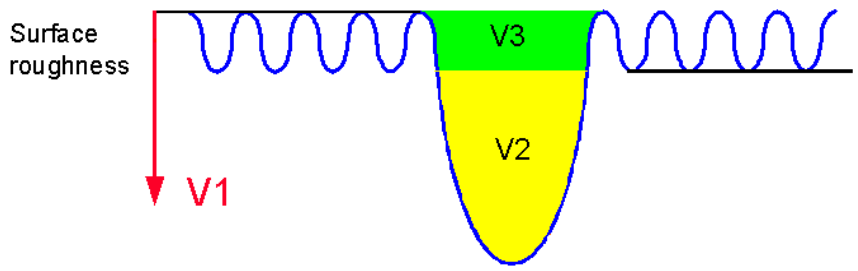
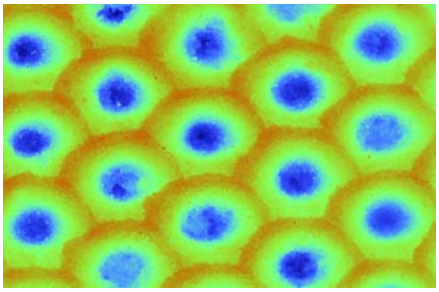
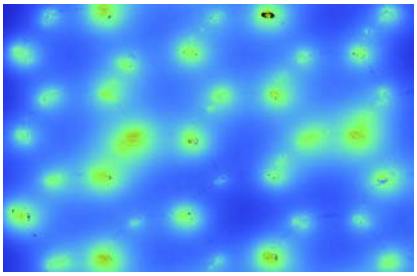


Figure 3. Calculation of cell Volume

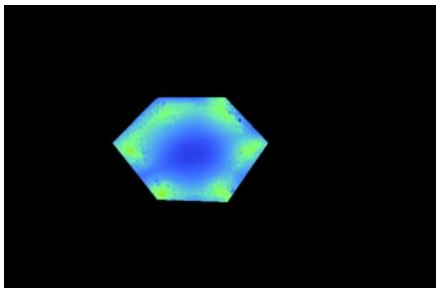
The size of the anilox rolls allows them to be removed from the F1 printability tester for measurement on the Wyko NT 2000 white light interferometer. After measuring the cells empty as described above, the same single cell analysis procedure can be used to quantify the ink in the cells before and after printing (Figure 4).



a) Anilox roll



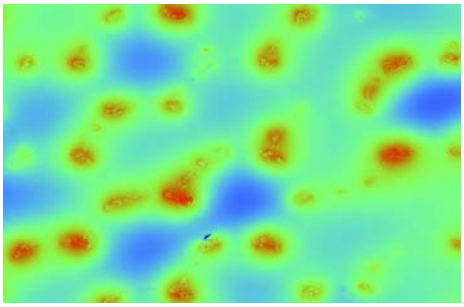
b) Inked anilox roll



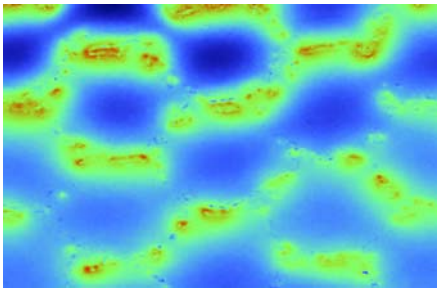
b) Single inked anilox cell

Figure 4. Measurement of inked anilox roll

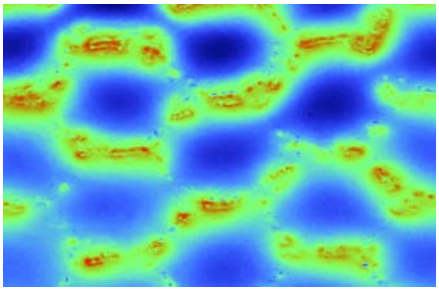
Before assessing the ink release from the anilox cell, it was critical that the volume of ink contained in the cell prior to printing was known. It was therefore important to assess whether the inked cell was full. The anilox was inked up with twenty, the maximum number of anilox rotations and doctored using the F1 printability tester with no print being made before being measured in the same position with the white light interferometer at set time intervals. (Figure 5). The darkening colours in the cells with time shows the depth is apparently increasing implying the ink volume is reducing. As this was a UV ink, then there should be no evaporation, so this infers the cells even after doctoring for 20 revolutions were not completely full of ink. It is likely that air remains trapped at bottom of cell and this slowly escapes with time. This suggests there is a need to force ink into cell to ensure it is completely full.



a). 0 minutes



b). 10 minutes



c). 20 minutes

Figure 5. Anilox inked by doctoring on F1 Printability tester

In order to overcome this problem, the IGT high speed inking unit (Figure 6) normally used for inking rolls for offset printability testing was used as a nip roller, forcing the ink into the cells prior to doctoring on the F1 printability tester. The ink was distributed for 60 seconds before the anilox was introduced under load for 40 seconds. The anilox was then doctored on the F1 Printability tester using 2 rotations and then measured over the same time intervals as the previous test. The results showed little to no relaxation of the ink into the cells, indicating the cells were full. Knowing the cell was full, it was therefore

Figure 6 High speed inking unit

possible to assume that the un-inked cell volume corresponded to the ink volume.

To allow measurement of the anilox roll at the states required (inked unprinted and inked printed), the image on the printing plate was reduced so that it did not contact the full width of the anilox. This allowed the two states to be examined after one printing. A 100% (solid) coverage plate and a 30% halftone plate were used. The latter allowing the interaction between the cells and plate halftone to be assessed. The plate dot at 30% was measured to ensure dot dipping would not occur and the average dot size was found to be 0.014387mm2. The screen ruling was 133lpi.

Three CO2 engraved anilox rolls of increasing cell volume were used for the investigation. The D-to-O ratio represents the relationship between the width and depths of the cells, a parameter sometimes consider to be relevant to the quantity of ink transferred. Anilox 1 and 2 both have similar depth-to-opening ratios and would, therefore, be likely to display similar results for percentage ink release, although the absolute volume of ink transferred should vary. Profiles of both cells can be seen in figure 7.

Table 1 Specifications for the anilox rolls

	Anilox 0 (402419)	Anilox 1 (402409)	Anilox 2 (402411)
Volume	23568 µm3	32029.91 µm3	58812.81 µm3
D-to-O	43%	35%	36%
Open area	0.00249 mm2	0.0030 mm2	0.0039mm2
Depth	23.97µm	16.34 µm	18.72µm
Screen count	600lpi	350lpi	300lpi

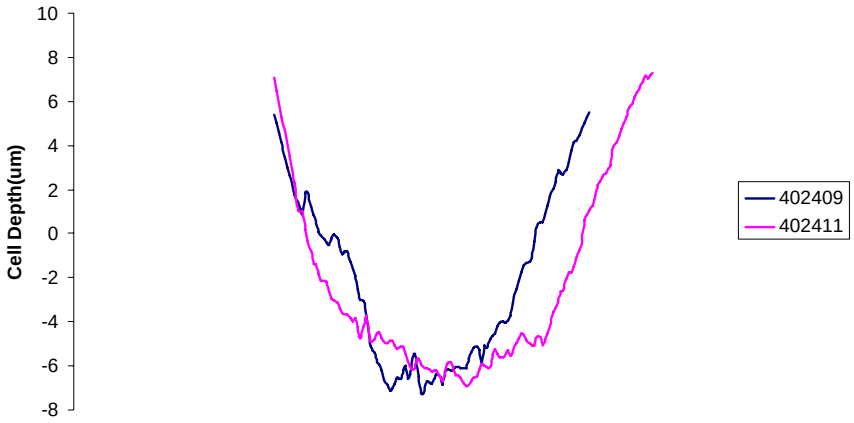


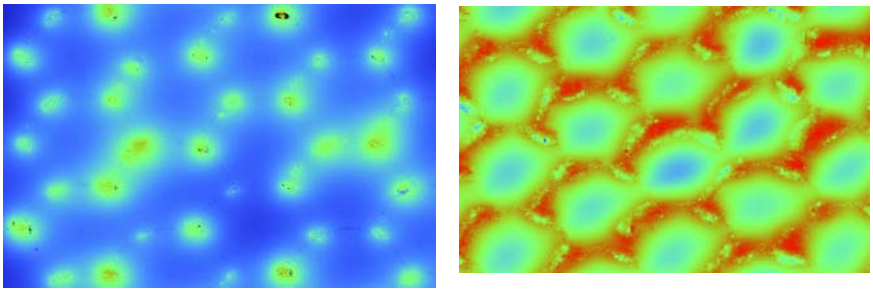
Figure 7 Comparison of cell profiles of Anilox 1 (402409) and Anilox 2 (402411)

Results

A full factorial experiment was run using Anilox 0 (402419) and the 100% coverage (solid) plate, with variation in the print speed and anilox pressure, the pressure between the plate and substrate was maintained at the same level. The speed and anilox pressure were set at 3 levels between the maximum and minimum settings as shown in table 2 and three prints taken at each setting. A typical result of the trials is shown in Figure 8. The inked roll shows only small island that correspond to where the land areas are protruding through the ink film. However, after printing the cells are plainly visible because of the amount of ink removed.

Speed (m/s)	Pressure (N)
0.4	100
0.8	300
1.2	500

Table 2 Conditions for experiment with Anilox 0 (402419)



a) Inked roll b) After printing

Figure 8 Comparison of the inked and printed areas of the anilox roll

The percentage of ink released by the anilox is shown in Figure 9. This assumes the cells were completely full before printing and therefore the volume measured after printing corresponds to the ink transferred to the plate. The first three bar graphs from the left show the effect of increasing anilox pressure at constant speed. The percentage ink released starts at 40% rises to 42% and then falls to 35% as the pressure increases. This same pattern with almost identical values is seen for both 0.8 and 1.2 m/s print speeds. As a consequence of this result which indicates that the speed has no effect, the tests for anilox 1 and 2 were only performed at one print speed, 0.8 m/s.

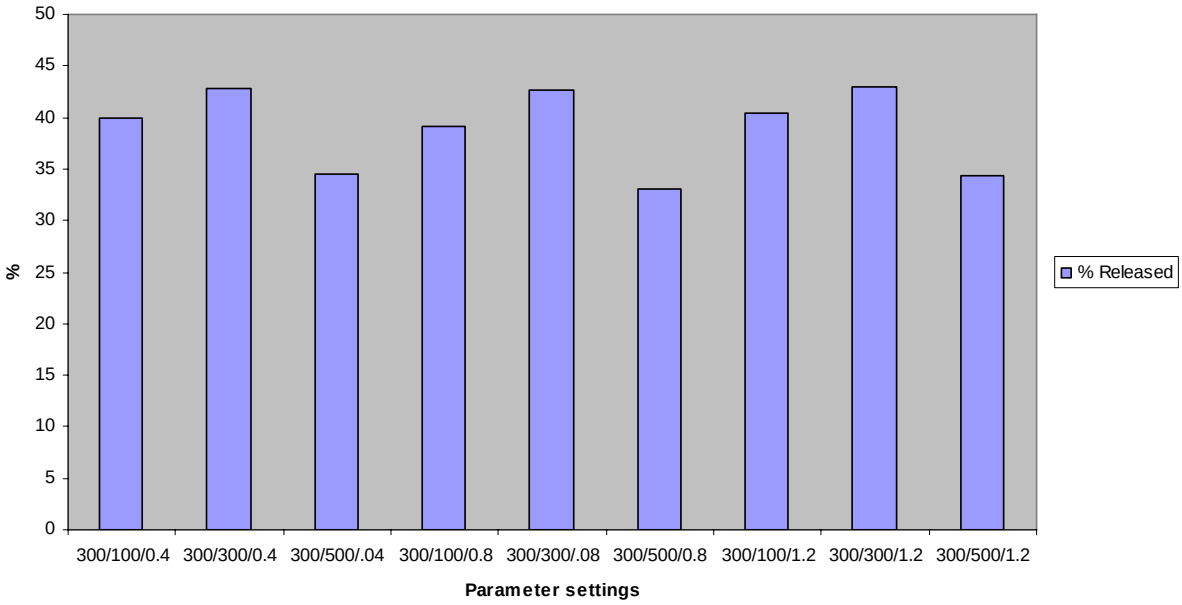


Figure 9 Percentage ink released with pressure and print speed for Anilox 0
(Labels represent the anilox cell volume - Anilox pressure(N)-print speed(m/s).

The same test was repeated for the 100% solid coverage and 30% half tone coverage with anilox rolls 1and 2, at the same anilox pressures of 100, 300 and 500N. The percentage ink released for the 100% solid coverage is shown in Figure 10. The ink released increases to a plateau of 39% for anilox 1 with increasing anilox and decreases to a plateau of 40% for anilox 2.

The results would appear to indicate the interaction of cell size and shape with anilox pressure. Anilox 0 has the smallest open area, deepest cells and the smallest volume., for which it would appear that there is one optimum pressure at which the plate release maximum ink. Anilox 1 has a medium open area and mid volume and would appear to rise to a plateau. This could be a function of the ability of the plate to enter the cell and remove ink. Anilox 2 that has the largest open area and largest volume, the plate possible reaches a point at which it cannot penetrate any further because the plate is support by the compression of the ink in the cell. A first approximation to the amount of ink released by an anilox roll to the plate for all cells and conditions would be 40% of the cell volume.

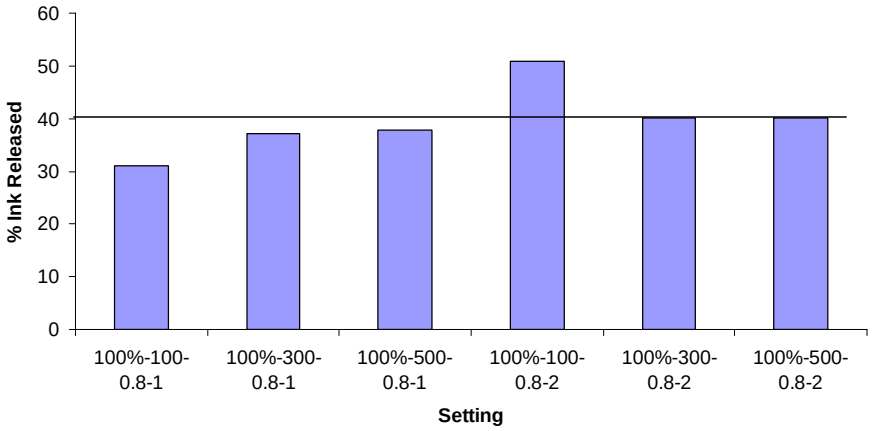


Figure 10 Percentage ink release with anilox pressure for anilox 1 & 2
(Labels represent: Coverage - Anilox pressure(N)-print speed(m/s)-Anilox No)

A pattern can be observed at the point at which the 30% halftone dot has contacted the surface of the anilox and subsequently drawn ink from the cells (figure 11). Those areas in which no contact has been made the cells are still full of ink. The amount of ink withdrawn from each cell is not identical and therefore varies depending on the position the dot has met the surface of the anilox. For each half tone dot, there is generally one cell where a high proportion of the ink has been removed (the dark blue regions on the contours).

Adjacent are one or two cells where a lesser proportion of the ink has been removed.

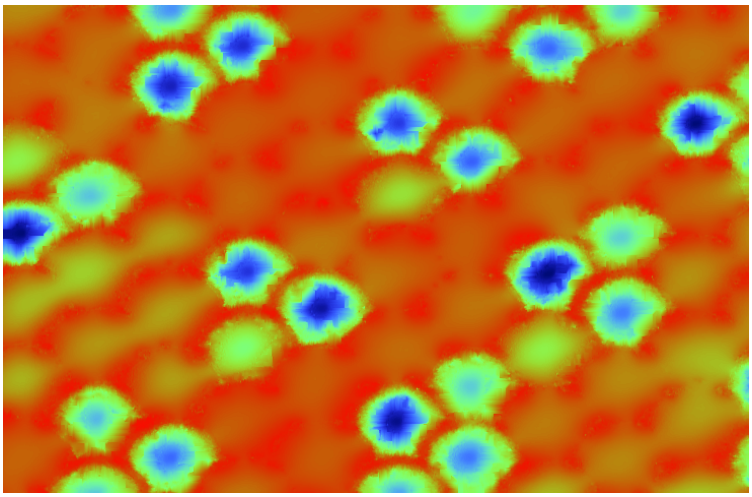


Figure 11Anilox after printing with 30 % half tone.

The pattern can be explained by examining the deformation of the individual dots (Figure 12). When the dot on the plate is pushed into contact with the anilox, it is supported only on the land areas. Unlike the solid, the surface of the dot is relatively unrestrained, i.e. there is no adjoining solid area of polymer that is trying to deform in the same manner and therefore set up elastic tension along the surface. As the dot is forced into contact, so the centre of the dot bulges under the pressure into the cell that is most covered by the dot. The edges of the dot are pulled in and provide material to allow the dot to bulge further into the cell taking more ink. Around the periphery of the dot, the shoulders are completely unsupported and bulge freely into the cells, although because they do not completely cover a cell they remove less ink.

As with the solid density anilox 2 has a higher release percentage than the smaller volume anilox 1, this once again correlates to the slightly larger cell opening area (Figure 13). As pressure increases, so the percentage ink release increases for both anilox rolls. The percentage ink released is in the region of 47-76%, which is higher than that for the solid plate. The ink released increases with pressure, as the half tone dots are not as mechanically strong as the solid and can deform more readily to scoop out ink from the anilox. The ink released is more sensitive to pressure with the 30% half tone than solid, increasing from 37% to 74% compared to 35% to 50% for the 100% solid coverage.

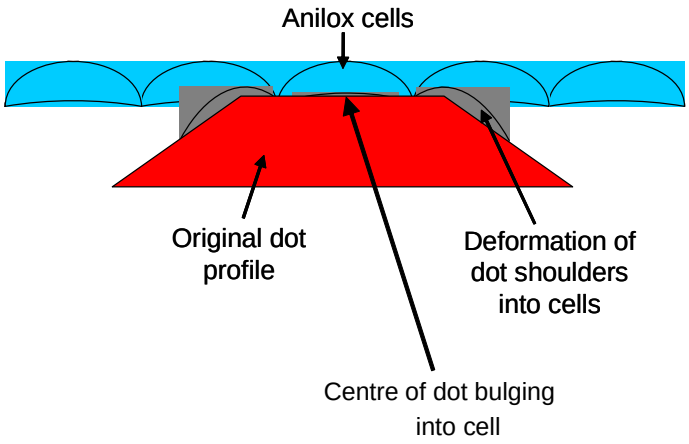


Figure 12 Deformation of dots into cells:

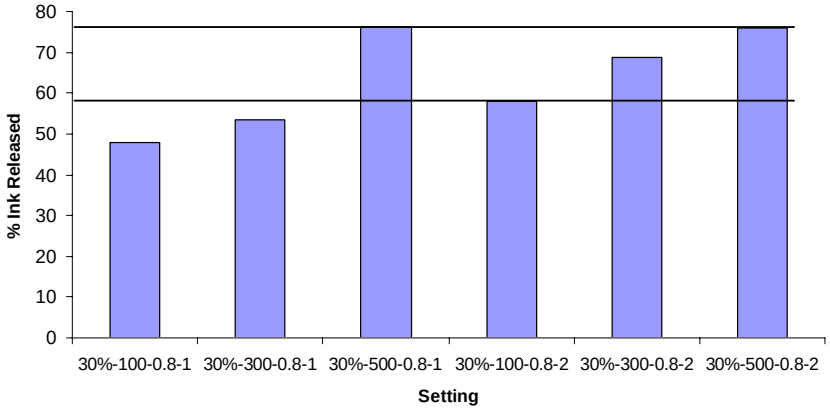
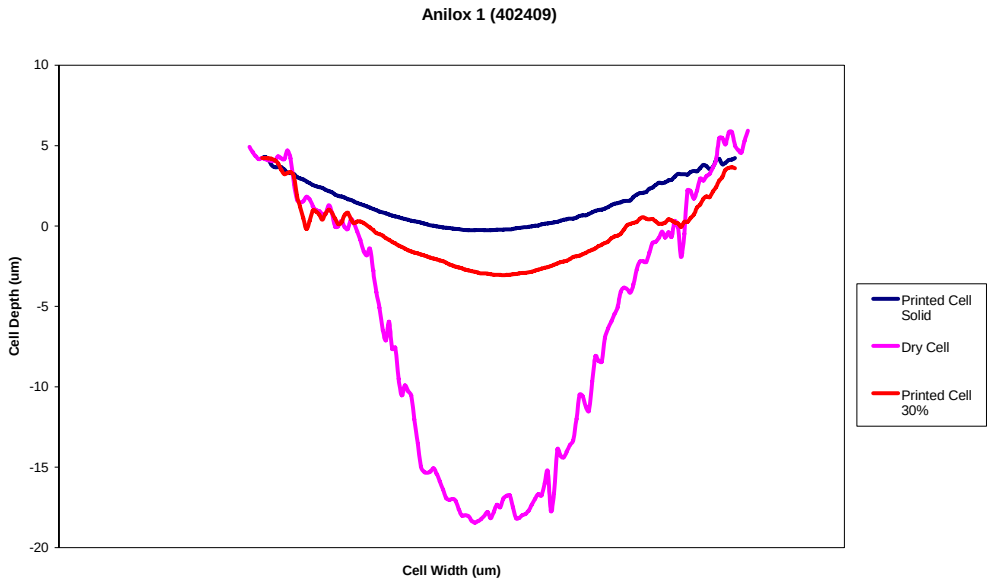
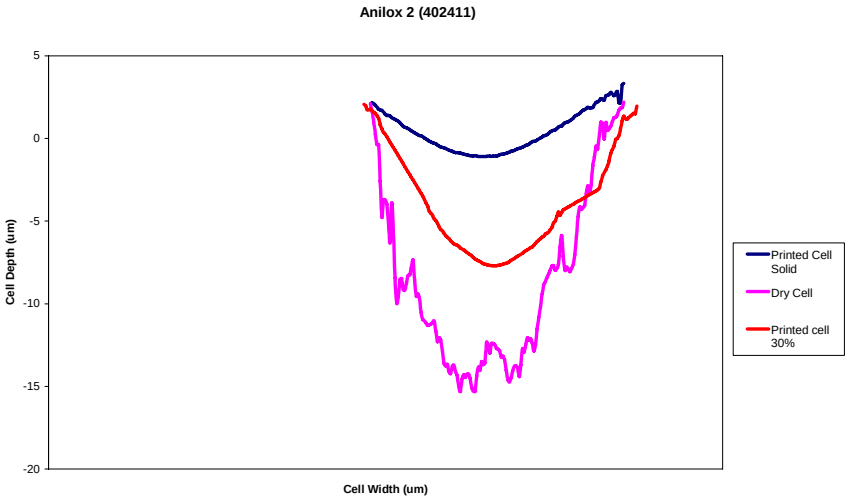


Figure 13 Percentage ink released for 30% half tone plate
(Labels represent: Coverage - Anilox pressure(N)-print speed(m/s)-Anilox No)

A comparison of the ink released by the solid and the half tone compared with the dry volume of the cells is obtained by comparing the profiles of the ink released from the anilox cells for anilox 1 and 2 (Figure 14). Anilox 1 has the smaller open area. The 30% half tone dot penetrates only slightly further into the cell than the solid and removes a little more ink. This would suggest the dot is better supported and therefore deforms in the centre only slightly more than the solid. However anilox 2 has larger open area, so less force required to deform the plate into the cell. The solid penetrates further and the half tone enters to approximately 50% of the depth.



a) Anilox 1 Ink profile



b) Anilox 2 ink profiles

Figure 14 Individual cell profiles for anilox 1 and 2 printing the solid and 30% half tone compared to the dry cell volume
(N.B. Anilox 2 cells are wider than Anilox 1).

Conclusions

A new method has been demonstrated to evaluate the ink released from the anilox roll to the flexographic plate based on white light interferometric measurement of the anilox roll cells when empty, filled with ink and after printing. It proved necessary to force the ink into the anilox to ensure it was completely full of ink. A series of experiments where undertaken using an IGT F1 printability tester to access the affect of solid and half tone printing for varying anilox volumes and cell geometries. The influence of anilox to plate pressure and printing speed were also investigated.

Ink release is controlled by the micro interaction of the plate coverage and the anilox. Understanding the ink release process is a key to having from highlights to solids on same plate.

The amount of ink released is a function of coverage, cell geometry (particularly open area) and pressure. This interacts with the relative size and geometry of the dots on the plate. The edges of dots deform into cells, whilst the centre of dots can expand into cells by lateral expansion of surface. As the coverage increases, particularly the relationship between the area of the half tone dot and the open area of the cell, then the dots bridge more cells and there is less opportunity for expansion of the centre of the dot.

In practical circumstances, as a first approximation it can be assumed that 40% of the ink is released by the anilox to the plate when printing a 100% solid. This is not the case when printing half tones and further highlights the difficulties of having a half tone and solid on the same plate. The ink release was found to be independent of printing speed. This is when the anilox cells are completely full of ink. In practise, the amount of ink in the cells may depend on the chamber design and also probably on the speed.

Acknowledgments

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