Evaluation of Pressures in Flexographic Printing

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Keywords: Flexography, pressure, experimental

Abstract

One of the advantages of the flexographic process is its ability to print at low pressures. This paper presents an evaluation of the impact of pressure changes on the print quality. Experimental data was collected using a commercial central impression printing press. The impact of pressure changes between the anilox chamber, printing plate and central impression cylinder on the print quality were assessed using orthogonal array techniques. The impact of each of the parameters and the interactions between them were evaluated using ink density and tonal reproduction, for a range of line rulings. The results showed the effects could be separated into those affecting the solid density (global ink transfer) and those affecting the tonal reproduction (relative ink transfer). The anilox to ink chamber was shown to affect the density most significantly, while it was the plate to impression pressure that affected the tonal reproduction the greatest.

Introduction

Flexographic printing is now used in many applications to produce a wide range of printed product from corrugated board, flexible packaging through to newspapers. Over the last 10 to 15 years the quality that can be achieved has increased significantly through the improvement in many of its components including photopolymer plates, anilox rolls and the sleeve technology. These technical developments have addressed both quality and productivity issues with the process now producing product that was traditionally associated with either lithography or rotogravure.

A schematic of the process is shown in Figure 1. The ink is supplied to an anilox either in a chamber as shown or from a fountain roll. The ink is metered by a doctor blade and then transferred to the printing plate. The engraving on the anilox ensures a consistent amount of ink is transferred to the plate. The plate is a compliant surface and has a raised profile in the image areas. The plate is

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bought into contact with the substrate at an impression cylinder at which point the image is transferred.

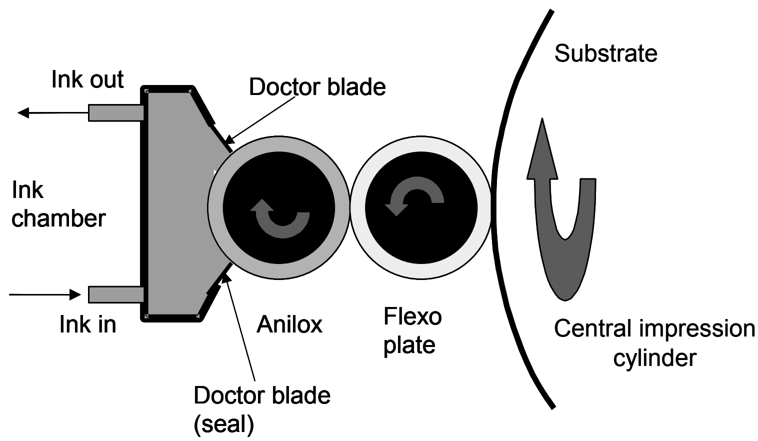

Figure 1 Schematic of press components

There are many variables affecting the quality of the final printed product, some of these are shown in Figure 2. Little work has been done evaluating the impact of different variables with the process being traditionally considered a craft. Some limited work has been done evaluating the plate to impression roller pressure. Investigations concerned with the transfer from hard plates [1] have shown that increasing the pressure increased the transfer to the substrate, with the difference between engagements reducing as the pressure is increased. However, this was carried out on a hand driven press and was concerned with transfer of solid colour.

The influence of pressure [2] was evaluated on newsprint and this showed that the pressure had minimal effect on the transfer for non-porous substrates, though the transfer was affected by the choice of substrate. It has been shown numerically [3] that the impression pressure will affect the tone gain provided that enough ink is present in the contact.

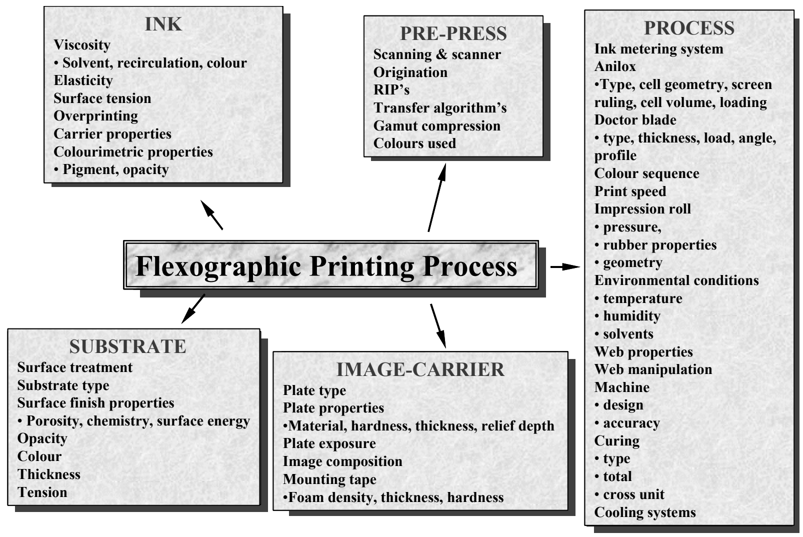

Figure 2 Some variables affecting the transfer in flexographic printing

Experimental methodology

The objective of the experimental programme was to assess the impact of changing pressure setting in the ink transfer train on print quality. Pressures at three locations on a central impression press in the train were explored used in this study

- ink chamber to anilox
- anilox to printing plate
- printing plate to central impression cylinder

A schematic of the press components is shown in Figure 1, each of the parameters was altered independently to allow their assessment. The trial was carried out after a fingerprint test and used the cyan ink and plate only. This was due to the accessibility of the unit for changes and to minimise the press time.

During the trial the press speed was maintained at 110 m/min and the press printed continuously. The changes were made and once completed the reel was marked to indicate the change. The changes were made using the press control systems. Level 1 pressure was at normal operation, level 2 was selected in each case as to cover the range of pressures used on the press. The increases were such that they would not cause damage to the press or its components and also would not result in major print problems. The press was then run for a set period to ensure consistency. The reel was again marked at this point. The material was printed onto a single reel, which was then unwound after the trial to collect the samples. All the pressures were set at two levels and this resulted in eight possible combinations, all of which were printed.

The test image consisted of a number of gradation scales at different line ruling at 85, 100, 133 and 150 lines per inch (lpi). An overview of the full test image is shown in Figure 3 with the areas for analysis located on each side of the web. The 150 and 133-lpi rulings located together, as were the 100 and 85-lpi rulings. Thirty-two samples were analysed at each condition with the averages used for the analysis.

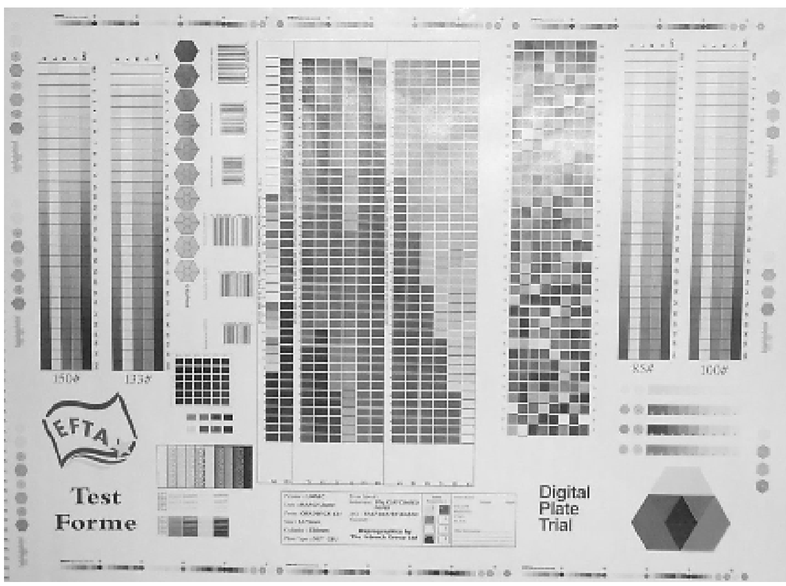

Figure 3 Test image used from the analysis

The experimental data was analysed using orthogonal arrays [4]. The three pressures assessed were entered into an L8 array such that all the interactions could easily be studied. In addition the final column was left free to allow a characterisation of the noise / experimental variability in the trials. A linear graph of the array is shown in Figure 4.

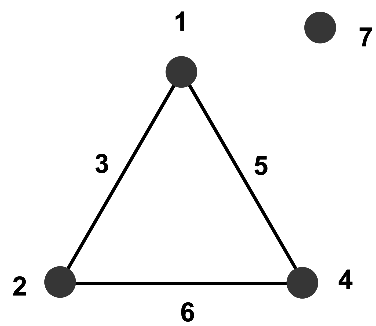

Figure 4 Linear graph used for the L_8 array

Results and discussion

The whole of the tone gain strip was evaluated for changes in both the solid density and the tonal reproduction. The results for increasing the pressures on the solid density are shown in Figure 5. These are for the effects of each parameter in turn, as well as the interactions. As only three variables were used it is possible to use the analysis to obtain an estimate of the “noise” / variability in the experiment that has been introduced. Firstly, by evaluating the noise it can be seen that this has a very low value, there was no process drift through the trail and the experimental results are reliable.

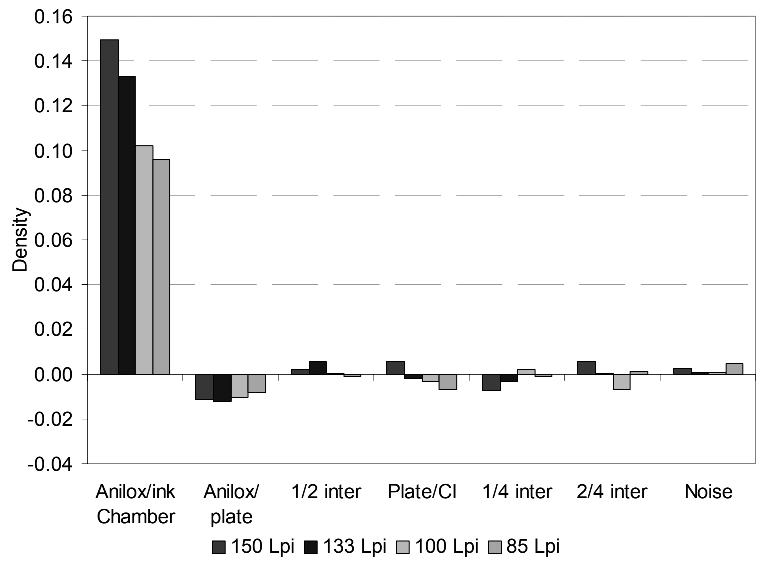

Figure 5 Variation of solid density

The anilox to ink chamber pressure has the largest effect with an increase in the density as the pressure is increased. This trend is consistent for all the line rulings, though the actual amount varies dependent on the ruling on the plate. The system used was an enclosed chamber and the change can be discussed by considering the doctoring blade. The doctor blade operates at a negative angle. As the pressure on the cylinder in increased there will be an increased load on the blade. This will cause a greater deflection with the angle of doctoring being altered. This change will reduce the effectiveness of the wiping allowing greater ink to pass through.

The reasons for the change in the level of response with line ruling are not clear. During the trial it was not possible to measure the pressure settings so there could have been an imbalance across the width of the machine. The other possible cause could have been a change in the surface profile of the solid areas in line with the halftone gradation scales.

The effect of the anilox to plate pressure on the printed density shows only a small reduction as the pressure is increased. This is in line with industry expectations that the pressure at this contact should be kept to a minimum. However, the value is very small and probably insignificant. All the other variables are shown to have no effect on the solid density and there are no interactions between any of the variables.

The data from the 0.5% coverage in the halftones has been removed from the tone gain analysis, as the results highlighted a print problem. By considering the anilox to plate pressure it can be shown that at the low coverage (0.5%) is printing at the same density as the 15% coverage with as density of 0.5. This was even worse when printing the four-colour process with the yellow density at the same value as the 40% coverage. This is a result of trying to hold too fine a dot on the plate and it collapsing. This leads to the surface of the plate being at a lower level and the transfer occurring from the non-image areas.

The influences of the pressures on the tone gain for the 133-line ruling are shown in Figure 6. This shows that the plate to CI pressure is the dominant one with respect to the tone gain and that as the pressure is increased so the tone gain increases. This is in general agreement with other published data on a narrow web flexographic press [5]. It was shown in [5] that there is a limit past which the increase in pressure does not result in increased tone gain. The results also show that the noise is minimal and that none of the other pressures or interactions have any effect on the tonal transfer of the image for most of the test conditions. However, at the lower line ruling the anilox to plate and anilox to chamber pressures showed a small effect and the cause of this is currently under investigation.

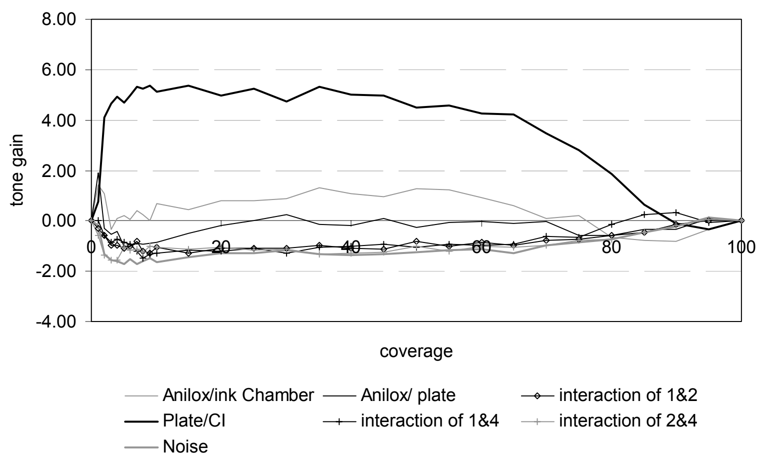

Figure 6 Tone gain for 133-line ruling

There are two causes of this increase in tone gain with pressure. Firstly, the squeezing action of the nip on the fluid needs to be considered. Previous results and numerical modelling [3] on the squeezing of a fluid have shown that as the pressure is increased the film thickness is reduced on the substrate. This reduced film thickness will result in a subsequent increase in the tonal reproduction, as the amount of fluid flowing into the substrate does not balance the increase in area.

The second feature affecting the tone gain increase relates to the deformation of the dot on the plate, which will change as the pressure is increased. This can be divided into two mechanisms, namely expansion of the dot surface and barrelling of the dot sides, Figure 7. The increase in pressure will affect the expansion of the dot and the barrelling action [6] leading to increased tone gain. The balance of the factors is dependent on the configuration used, material properties and forces applied.

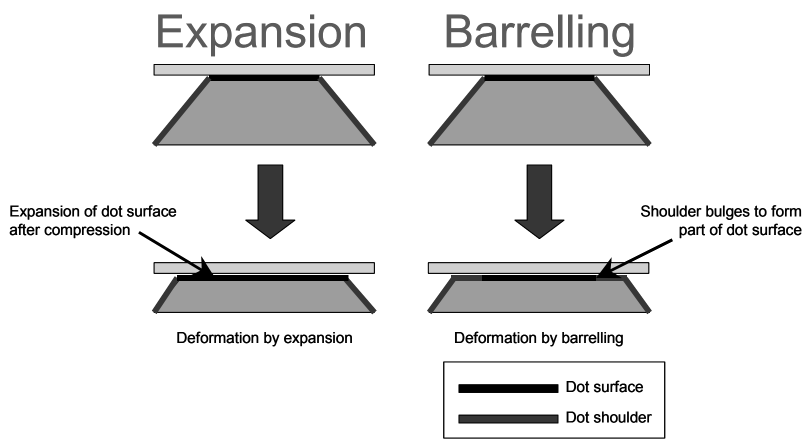

Figure 7 Schematic of dot expansion mechanisms

The effect on the tone gain of the change in pressure between the plate and CI is affected by the line ruling. The response tone gain is smaller as the line ruling is decreased, Figure 8. It was shown that the solid density was not affected by the increase in the plate to CI pressure. Therefore, the changes relate to the transfer of the halftones. The results indicate that for a smaller dot the tone gain is greater. This has been confirmed by considering the influence of line ruling alone on tone gain with an increase for the finer line rulings [5], caused as a result of the barrelling action on the dots [6].

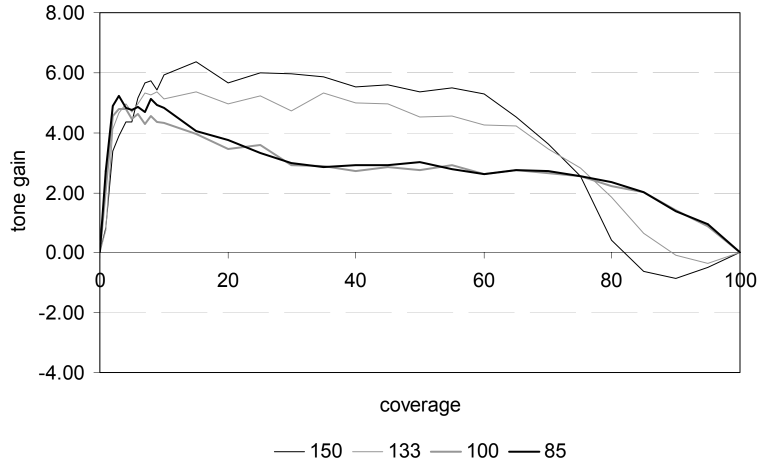

Figure 8 Effect of line ruling on tonal reproduction

Conclusions

An experimental trial has been successfully carried out on a commercial CI press evaluating the influence of contact pressures within the printing system on the solid density and tonal reproduction. This forms part of an ongoing experimental programme. The main findings can be summarised as

- The density is significantly affected by the anilox to ink chamber pressure. As this is increased so the printed ink density also increases.
- The plate to CI nip pressure primarily affects the printed tone gain. The reasons for his has been explained in terms of the ink spread / penetration into the paper and the mechanical deformation of the plate.

The data from this trial also provided information that was be used in modelling the transfer at the plate substrate interface and also in the development of the subsequent experimental trials.

Acknowledgements

The authors wish to acknowledge the financial support of the EFTA, European Community, ELWa, Welsh Development Agency and the European Regional Development Fund.

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Analysis of Doctor Blade Loading and Wear

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Keywords: rotogravure, doctor blades, experimental, numerical

Abstract

Rotogravure printing is used to produce high speed, high quality printed product. One of the key parameters in controlling the process is the doctor blade. This removes ink from the non-image areas and meters the ink in the cell. The purpose of this paper is to evaluate the doctor blade performance and investigate the difference between the set and wipe angles. Doctor blades have been collected from commercial printing operations and cross sectional analysis performed to evaluate the blade tip. These results show the amount of wear undergone and from this the actual wiping angle can be obtained. The data has then been used in a simplified numerical model to evaluate the contact between the doctor blade and cylinder. The results show both the deflection of the blade and the sensitivity of the system to changes in the doctor blade load. A parametric study has been carried out on the doctor blade evaluating the doctor blade and process settings on the blade setting.

Introduction

Doctor blades are used in many printing, coating and paper applications including rotogravure, flexography, pad printing and paper creping. The purpose of the doctor blade changes between the different applications, from removing excess ink in rotogravure to sealing the anilox chamber in flexography. The focus of this paper will be with specific respect to rotogravure printing.

Rotogravure printing is a high speed, high quality printing process, shown schematically in Figure 1. An engraved cylinder carries the images. This rotates in an ink bath with the individual cells being filled with ink. This is metered with a doctor blade and the image is transferred to the substrate under impression. The doctor blade removes the excess ink in the non-image areas to prevent print faults such as hazing / scumming / streaks. In the image areas it meters the ink in the cells to ensure a consistent ink transfer. The pressure

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