Comparison of Printing Characteristics of Conventional and Water Washable Flexographic Plate Technologies

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Abstract

In order to reduce the emission of VOC's during the flexo plate making process, there has been development of water washable plate technology. The performance of conventional and water washable plates are compared. The different surface energies of the two plate materials leads to reduced TVI in the highlight region with the water washable plate as there is less ink spreading on the highlight dots. A conceptual model is proposed that attributes this phenomenon to the ink being pinned on the shoulder of the dot as a consequence of the higher contact angle of the ink with the plate.

Introduction

Printers are under pressure from customers and legislation to reduce their environmental impact. There can also be economic benefits by reducing the consumption of resources. This has to be achieved without sacrificing quality. In Flexography the conventional solvent based plate making process can be a significant source of VOC's and have a detrimental impact on the carbon footprint even of printers who are using UV or other energy curing ink systems. Water washable plate technology, can eliminate this source of emissions. However, by definition, these plates will have different physical characteristics which could affect the ink transfer and hence the image reproduction. Therefore, a project was instigated to understand the effect of the different plate technologies on the print process.

This paper compares the printing characteristics of a conventional and water washable plate technology for both UV and solvent based inks printed onto polymeric film. The methodology adopted for this evaluation is first briefly described, before the

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results of the print trials are presented. The investigations into ink transfer from plate to the substrate show that the majority of investigations ignore physical dot gain, as opposed to optical dot gain as a quality parameter. This is important as density and hence optical dot gain measurements do not accurately represent mechanical effects on ink transfer. There are 2 notables exception to this Bould[1] and Hamblyn[2]. Therefore, as well as the optical tone value increase, the physical dot gain was also evaluated. As the surface energy was deemed to be of potential importance this was also measured for the various plate materials. The findings and their implications are then discussed.

Methodology

A conventional plate (Asahi Photoproducts DSH) and a water washable plate (Asahi Photoproducts AWP) were studied in this investigation. The print trials were undertaken on a narrow web packaging press (a Timsons T-Flex 508). This is a fully equipped in-line press with 4 print units which is used for research and development (Figure 1). The print units are equipped with a chambered ink delivery system. Each unit is equipped with an independently controlled UV dryer allowing optimised performance for each ink printed. The press was also equipped with a bespoke hot air drying system for use with solvent based inks. The design of the press enabled the engagement between anilox roll and plate cylinder and between the plate cylinder and engagement cylinder to be altered independently.

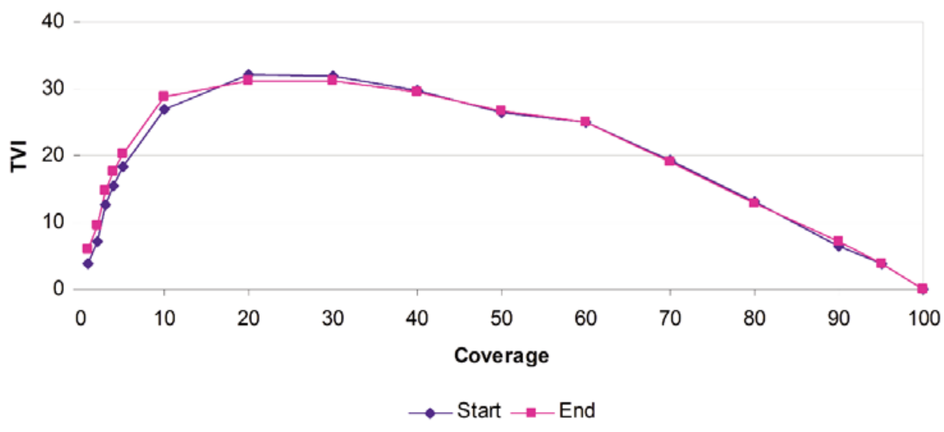
Figure 1: *Timson T500 flexopress*

An extensive investigation was undertaken with UV cured cyan ink, as this was felt to be where most environmental benefit could accrue by changing plate technology. A full factorial experiment was undertaken, with a high and low anilox to plate pressures and a soft and a hard mounting tape. A banded anilox roll was used, which varied the screen ruling from 500lpi to 1200lpi, with the outermost bands both being 500lpi, to enable side to side comparison of the image. Anilox volume was constant at 4 cm3/m2, across all bands. On the plate, each band included tonal strips at four screen rulings; 100lpi, 120lpi, 150lpi and 175lpi, although only 150lpi and 175lpi tonal strips for the 500lpi and 1200lpi line rulings were analysed in detail using image analysis and spectrophotometry as these were considered to be the most representative. Samples were removed at the start and end of each print run of 2500m of print. This length of print had been found to be sufficient for any build-up of ink on the dot shoulders to become evident.

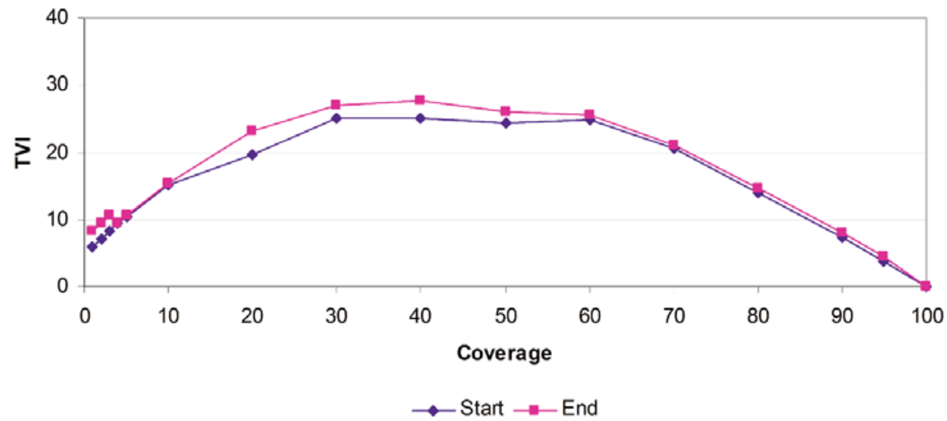
The objective of the printing trial using solvent ink was to demonstrate using a limited set of parameters that the results obtained with a UV curable ink are also applicable to the use of solvent inks. It was run using established conditions known to give good results for both solids and halftones. A medium mounting tape. The two plates with identical half tone images were mounted, side by side, on a plate cylinder. The plates were produced with no tonal correction, although 'bump-up' was applied, to allow the highlight dots to be produced. The ink used was a black ink, which was known to print well on the flexographic printing press. The anilox roll had a screen ruling of 700lpi and a volume of 3.5 cm3/m2. The trial was performed at 25m/min. Anilox to plate pressure and plate to substrate engagement were both constant for the duration of the experiment.

Results

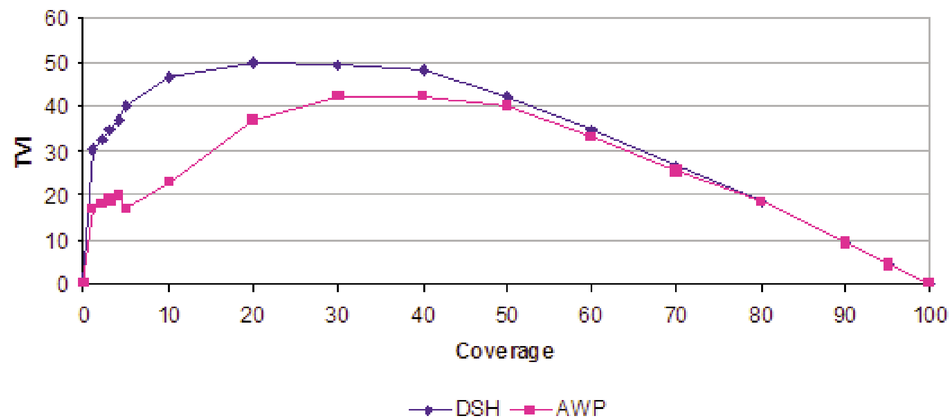
The representative TVI for the different plate and ink combinations are shown in Figure 2. The water washable plate exhibits lower dot gain characteristics, compared to conventional plate. There is little difference between the dot gain at the start and the end of the print run, suggesting a stable regime had been entered before the sample was taken. The water washable plate did not exhibit as high dot gain in the highlight region. The tone gain is higher for the trial with solvent based inks, although similar trends were observed. The water washable plate has lower tone gain, in the highlights and mid-tones with the solvent based ink.



a) Conventional plate, UV ink, Soft Tape, Low Anilox pressure – 500lpi(anilox) / 150lpi (plate)



b) *Water washable plate, UV ink, Soft Tape – Low Anilox pressure – 500lpi(anilox) / 150lpi (plate)*



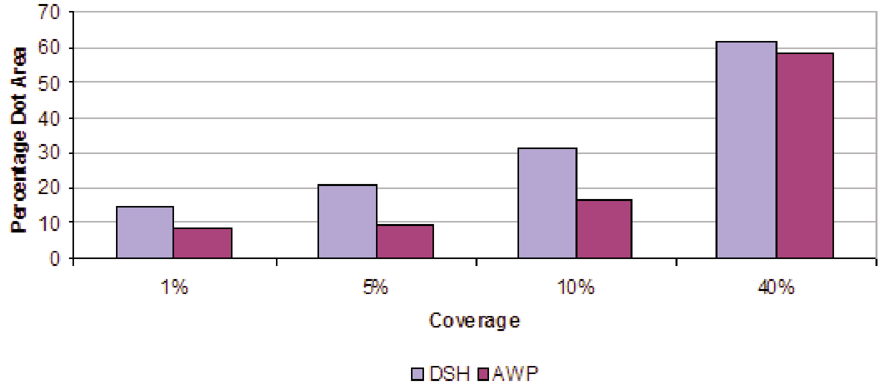
c) *Comparison of conventional (DSH) and water washable (AWP) plates printed with solvent inks*

Figure 2: *Comparison of TVI for different plate and ink combinations*

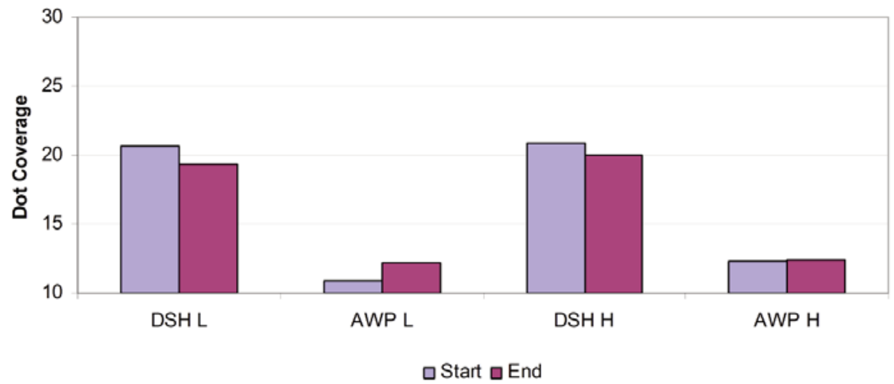
Measurement of the physical dot area, obtained using image processing (Figure 3) showed similar results for both ink types and were in line with the trends observed in the TVI curves. This suggests that the difference in TVI can be attributed to larger printed dots, rather than any differences in the amount of ink transfer, i.e. the thickness of the ink film transferred is the same with both plate technologies. The dots reproduced with the water washable plate are significantly smaller than those with the conventional plate for the same physical dot area on the plate. This particularly for the highlight dots whilst the mid tones show much less difference in measured area. Little difference was observed between the 'Start' and 'End' samples.

Figure 4 shows images of the printed 1% tones for both plate types, on the soft mounting tapes, at low and high anilox pressures. For the low anilox pressure images, the ink film transferred was even for both plate types. However, at the higher anilox to plate pressures, the centre of the dots tended to be missing (doughnuts) for the conventional plate, but not for the water washable plate.

In view of the larger dot gain with the solvent ink, images were taken of the printed 5% dots (Figure 5). Whilst both plate types produced good dot structures, smaller

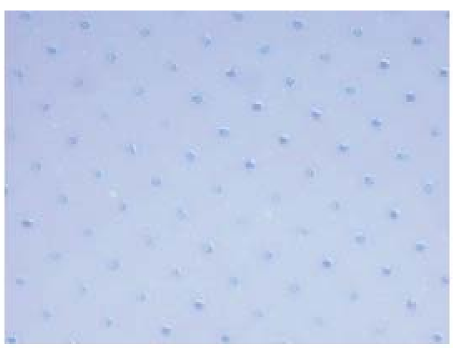


a): *Highlight and mid-tone coverage, solvent ink*

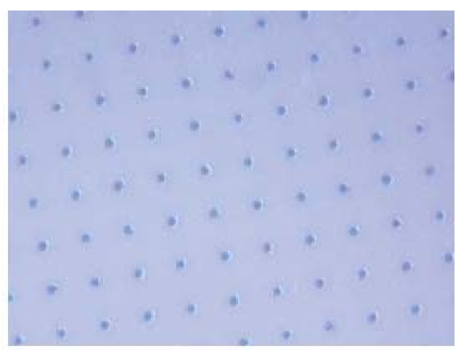


b): *10% tone, soft tape, 500 lpi anilox, 175 lpi plate (UV ink)*

Figure 3: *Measured printed dot area*

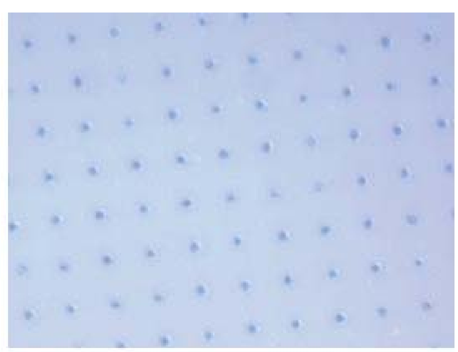


Conventional plate low pressure



Water washable plate low pressure

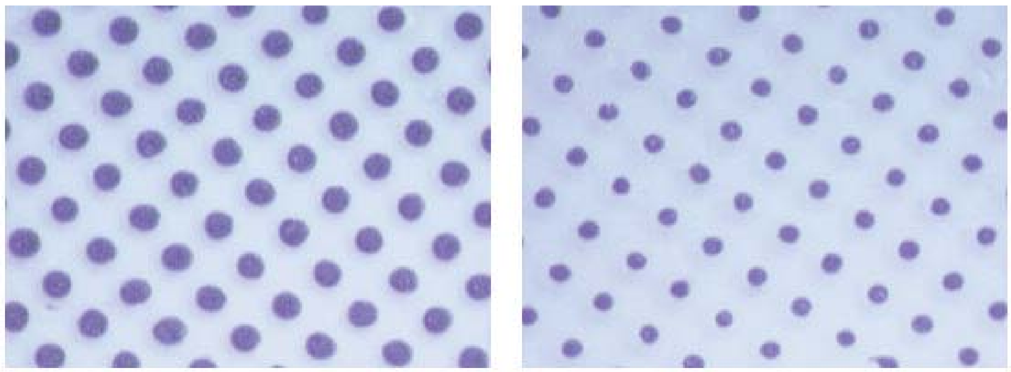
Conventional plate high pressure



Water washable high pressure

Figure 4: *1% tone images, soft tape for high and low anilox to plate pressure with UV ink*

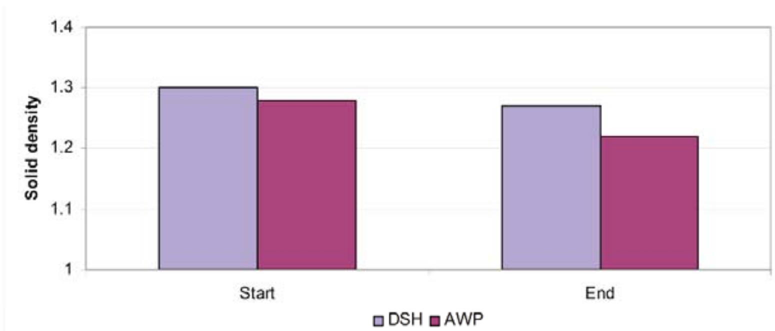
dots were obtained for the water washable plate. The water washable plate shows small holes at the centre of the dots. It is not thought that the pinholes are a function of the plate material, but can be attributed to the drying effect of the dots, where the ink migrates to the edges of the dot as the ink dries. No pinholes were observed for the conventional plate, which as the larger printed dots, would have been the result of a greater volume of ink on each feature, masking the effect of ink migration during drying.



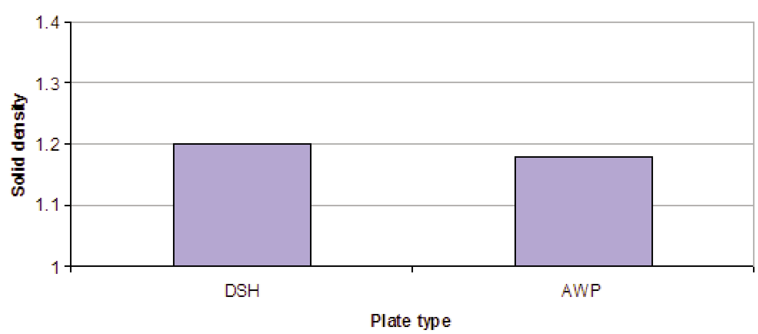
5% Dot – Conventional plate *5% Dot – Water washable plate*

Figure 5: *5% tone images printed with solvent ink*

There was little difference between the solid densities printed by both plate technologies with either ink type (Figure 6). The conventional plate produced a slightly but not significantly higher solid print density in each case. A slightly lower solid density was observed at the end of the print run, compared to the start of the run. The solvent ink is achieved a slightly lower density that the UV ink for both plate types.



a): *Soft tape at low anilox pressure (UV ink)*



b): *Solvent ink*

Figure 6: *Comparison of solid densities between the conventional and water washable plates*

The contact angle for the two plate materials was assessed using a Fibro DAT1100 contact angle equipment on the basis of the average of 5 drops. The conventional plate had a contact angle of 34°±2, while the water washable plate has a contact angle of 53°±2. The higher contact angle leads to a higher droplet volume per area coverage (Figure 7). For the test presented in Figure 7, two droplets were deposited on the plates trying to produce droplets with the same diameter of contact. The droplet deposited on the water washable plate has a volume 15 % higher than the droplet on the conventional plate for a slightly smaller contact area (table 1).

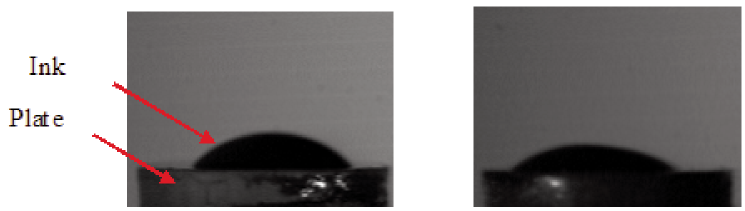


Figure 7: *Droplet on water washable plate (left), on conventional plate (right)*

Plate	Diameter	Volume
Conventional	4.33 mm	5.60 mm^3
Water washable	4.11 mm	6.7 mm^3

Table 1: *Comparison diameter and volume*

Discussion

The water washable plates were found to have lower TVI for both ink types than the conventional plates, particularly in the highlights. Both plate types produced round dots, with water washable plate being smaller reflecting the difference in TVI. This would indicate that both are laying down a similar thickness of ink film.

There is little difference in solid density between the water washable plate and the conventional plate. However, visual assessment of the prints revealed that the solid areas area produced from the water washable plate more consistent than those from the conventional plate. This is in part due to the lower coefficient of friction for the water washable plate. The coefficient of friction of a material refers to how easily the fluid can slide over its surface. For surfaces with a high coefficient of friction, there is great resistance to lateral movement, whereas materials exhibiting a low coefficient of friction allow other objects to slide over the surface more easily. A fluid on a material with a low coefficient of friction is more likely to have a higher contact angle, as it will be able to coalesce more easily. For the water washable plate, ink is able to spread more evenly over the surface of the plate, reducing mottle and pinholes. However, this effect could also be a consequence of higher surface energy (manifested as a higher contact angle) causing the ink to join and tend to form a circular dot.. This is demonstrated in Figure 8, where two droplets of water have been deposited side by side on both the conventional and water washable plates. For the conventional plate, although the two droplets have joined together, the forms of the original drops are still discernible. However, for the water washable plate, the two droplets have merged together to form a coherent single drop, and little distinction between the two original drops can be made. Therefore, when ink flows out of the discrete cells of the anilox roll onto the plate, it is more inclined to flow together to form a continuous film on the solid regions of the water washable plate than for the conventional plate, producing an even solid. The lower coefficient of friction for the water washable plate may be attributed to parameters, including surface roughness, or the different chemical composition of the photopolymer material. Therefore, the difference in performance plate technologies is not due to the ink release from the anilox to the plate, as this mechanism is consistent for both plate types, but should be attributed to the interaction of the ink with the plate.

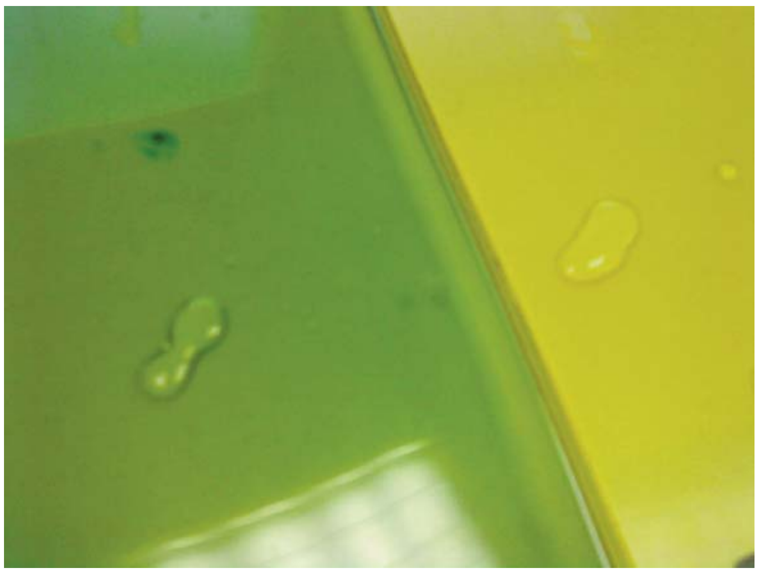


Figure 8: *Surface energy effects differences between conventional (left) and water washable plate materials*

There are two mechanisms for the ink lay on the half tone dots, which is dependent on plate material. For the conventional plate, there is a migration of ink down the dot shoulder during printing. However, for the water washable plate, the ink does not travel down the dot shoulder, instead remaining on the dot surface. Once the print run had been completed, and the cylinders removed from the press, the conventional plate, shows a build of ink on the shoulders of the highlight dots, for all anilox bands (Figure 9). The highlight dots are significantly cleaner for the waterwahable plate, although some ink build-up was observed for the 500lpi anilox bands, which are the outermost bands printed. Analysis of these images suggests that ink transfers to the water washable plate in such a way that it is not able to travel down the dot shoulder, as is commonly observed with conventional plate materials.

The higher contact angle of the water washable plate material leads to the "beading up" of the ink sittings on top of the dot, compared to the conventional plate (Figure 10). For fluids with high contact angles, there is a greater tendency for the boundary

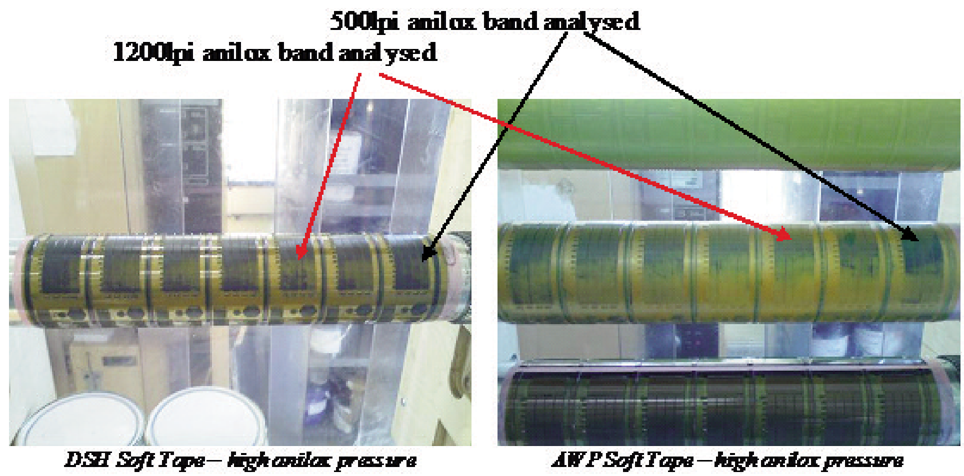


Figure 9: *Image of plates at the end of the print run*

between the fluid and the solid surface to remain pinned as force is exerted on the fluid, as the fluid tends to coalesce. This resulted in a much lower tendency of the fluid to spread, compared to liquids with low contact angles. When the ink is squeezed by the substrate during the printing process, the higher contact angle for the ink on the water washable plate results in the boundary between the ink and plate remaining pinned, with no ink travel down the dot shoulder (Figure 11). The ink on the conventional plate material, with the lower contact angle, is not pinned, and the ink is tends to move down the dot shoulder.

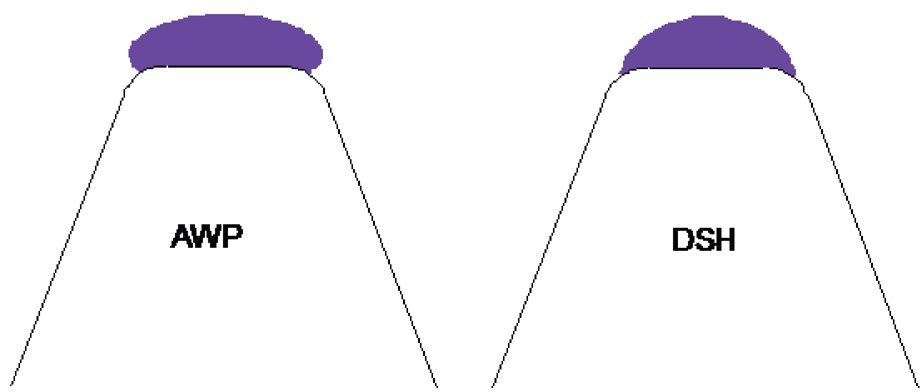


Figure 10: *Schematic diagram of the inked half tone dots for two plate types*

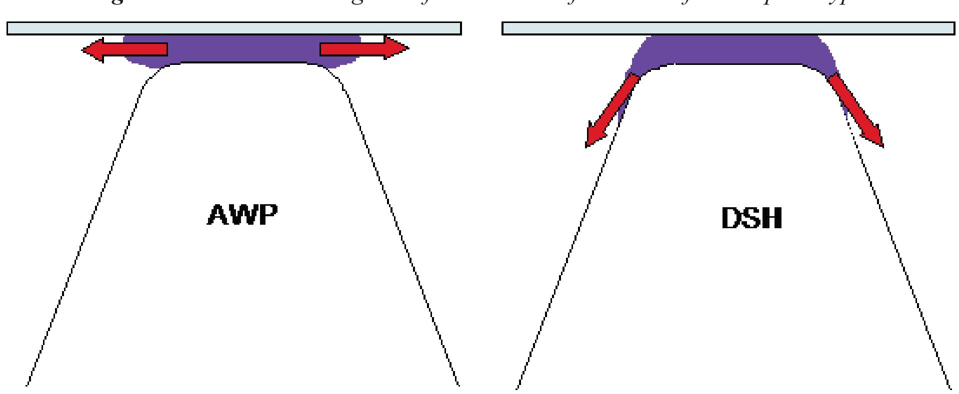


Figure 11: *Ink squeeze mechanisms for two plate types*

While the high contact angle for the ink on plate helps restrict spreading as the ink is squeezed in the printing nip, the greater coalescence of the ink allows discrete droplets of ink to flow together more easily. Although these studies have only considered solvent based and UV inks, the similarity in rheological characteristics should also mean that the results will be transferable to water-based ink systems.

However, the high tonal values for the conventional plate highlight coverages suggests that by the time the 'Start' sample was taken, the shoulders of the highlight dots were already inked, and the long print run did not result in further inking of the shoulder.

Conclusions

Two plate technologies have been compared. These were a conventional plate and a water washable plate and the following conclusions can be drawn:

- A drop of ink on the water washable plate has a higher contact angle than a drop of ink on the conventional plate. When the ink sits on top of a halftone dot, the higher contact angle for the water washable plate pins the ink-plate boundary and the ink does not move, as the plate deforms and the dot is squeezed. The ink is not pined for the conventional plate, due to the lower contact angle. As the ink is squeezed in the plate to substrate nip, ink travels down the dot shoulder, resulting in growth of the printed halftone dot.

- As the ink does not travel down the dot shoulder for the water washable plate, over the course of a long print run there should be less of a tendency for the ink to build-up in the recesses between dots.

- The appearance of the printed solids is improved for the water washable plate, due the reduced friction on the surface of the plate, which allows ink to flow together more freely, once it has been transferred from the anilox roll.

- The halftone and solids can be printed on the same plate which would normally be split, thus saving plates.

- Halftone analogue rollers can be used for printing dense consistent solids

References

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2. S Hamblyn, "The Role of the Plate in the Ink Transfer Process in Flexographic Printing", PhD thesis, University of Wales, 2004

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