Influence of paper and ink combination on the physical characteristics of newsprint

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Keywords

Gamut, Halftone, Ink, Newsprint, Paper

Abstract

In an earlier trial, an eight-page sample was printed on five different newsprint substrates with cold or heat set inks. A direct correlation was found between the value added based on visual assessment and both the chroma of individual colours and colour gamut of the printed product. This paper reports the results of the follow on study undertaken to extend the work to cover UV inks and to obtain more colorimetric and print process data. The images on the sample were changed in light of the experiences from the first trial to include both high and low key images, thus allowing the assessment of images that would be more difficult to print, yet were of potentially commercial significance. An IT8 target and other colour scales were also included to allow for the analysis of tone gain, as well as solids and overprints. Bespoke software was used to obtain colour gamut information directly from the printed images.

The tone value increase was found to be highly dependent on the ink and paper combination. The heatset ink had the less tone value increase compared to the UV ink. Measurement of the physical dot area highlighted that this was in part due to reduced penetration into the substrate and thus the ink density remained high for a given dot area. The results highlighted the complex three dimensional shape of the colour gamut of the printing process and the limitations of using solids and overprints to characterize the prints.

Introduction

Increasing the value added to newsprint by improved substrate or printing process is seen as a way of attracting higher revenues to the newspaper industry. VAPoN is a Print City sponsored cross industry project evaluating the Value Added Printing of Newspapers (VAPoN). One aspect of this project was to

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compare the quality attributes of different grades of newsprint when printed with different generic types of ink.

In the first trial, VAPoN 1, a bespoke eight-page sample was printed on five different newsprint substrates with cold or heat set inks [Claypole et al]. A cross section of the industry from production to purchasing drawn from four continents visually assessed each sample using standard newsprint printed with coldset inks as the base reference. In parallel, the physical characteristics of the prints such as the colorimetric properties were measured. There was a tendency for the perceived improvement in the newsprint to reflect an increase in paper weight and also a preference for heatset over coldset. A marked contrast was found in the results of the professional groups. Those who purchased advertising tended to make a more subjective assessment compared to those who produced prints who tended to evaluate the prints from a more technical perspective. There was a distinction between the advertising who tended to purchase and the publisher who can be viewed as the seller, the latter expecting a higher rate of return for the improvements compared to the buyer. A direct correlation was found between the chroma of added value of the improved newsprint products and the additional amount those who performed the assessment were prepared to pay. The percentage the assessor would have been prepare to pay was plotted against the chroma of the four colours assessed on each print (Fig 1). The correlation coefficients in each case indicated a strong relationship between the parameters. There was a difference between the sellers and buyers (publishers and advertisers), in that a linear relationship was obtained between chroma and added value in both case, except the publishers expected the purchaser to pay almost twice what the advertisers expected to pay for the same quality of print.

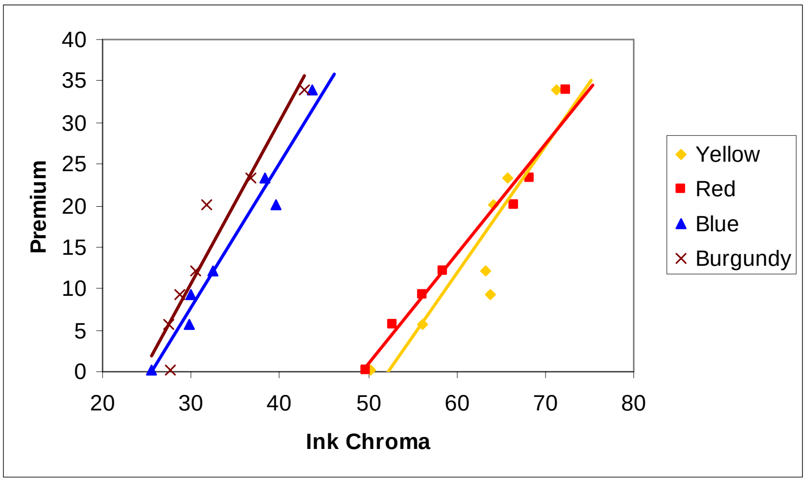


Figure 1 Premium for Run of paper (%) vs ink chroma

This paper presents the results of the follow on study undertaken to extend the work to cover UV inks and to obtain more colorimetric and print process data. A bespoke 8 page sample was printed by heat set, coldest and UV on a variety of substrates. The images on the sample were changed in light of the experiences from the first trial to include both high and low key images, thus allowing the assessment of images that would be more difficult to print, yet were of potentially commercial significance. An IT8 target and other colour scales were also included to allow for the analysis of tone gain, as well as solids and overprints.

Methodology

Coldset, heatset and Inert UV ink were printed on four paper grades on commercial newspaper presses in Europe under the guidance of Pritncity. The paper grades and ink combinations used for the VAPoN 2 trials are shown in table 1. These allowed direct comparison between UV and heatset on two of the papers. Two of the heatset ink paper combinations and coldset provided cross reference to the earlier VAPoN 1 trials (Table 2). The samples that were for the same ink paper combinations in VAPoN 1 have been highlighted.

Table 1 Paper and ink combinations used in VAPoN 2

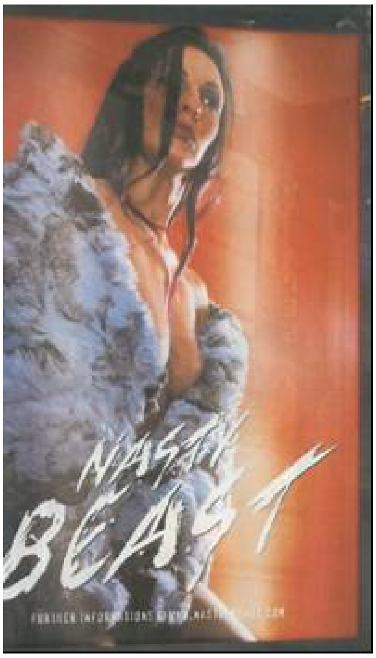
Trial	Ink	Paper
L	Heat set	UPM Cote H 54 gsm LWC
I	Heatset	UPM Eco H 49 gsm SC-B
N	Heatset	UPM 45 gsm Standard Newsprint ISO 58
Y	UV	UPM Cote H 54 gsm LWC
W	UV	UPM Eco H 49 gsm SC-B
C	Coldset	UPM Brite 72c 48.8 gsm INP

Table 2 Paper and ink combinations used in VAPoN 1

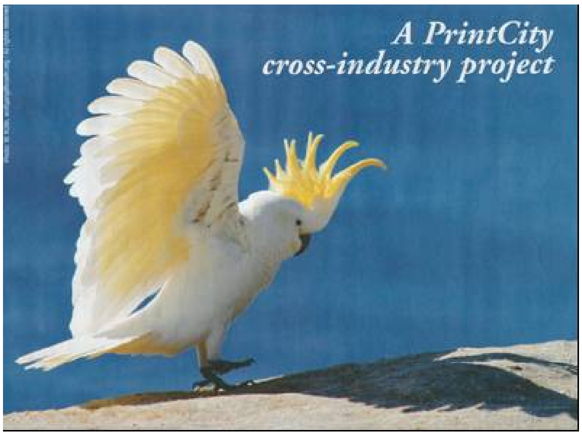
Heatset	54 gsm LWC
Heatset	54 gsm SC-B ISO 67
Heatset	45 gsm Improved Newsprint ISO 72
Heatset	45 gsm Standard Newsprint ISO 58
Coldset	52 gsm Matt C (VAC) ISO 80
Coldset	45 gsm Improved Newsprint ISO 72
Coldset	45 gsm Standard Newsprint ISO 58

Four samples of each print run were supplied to Welsh Centre for Printing and Coating for analysis. The colour was measured in the IT8 and test strips, using a Gretag 0/45˚ sphectro-densitometer. This enabled both over prints and tone value increase to be calculated. Some of the spot colours within the prints were also measured to provide reference to the earlier trial. The gloss was measured with a hand held gloss meter.

The selected images in the prints were scanned with semi – professional A4 scanner. These were analysed using Swansea Printing Technology “Digital eye glass” software to obtain gamut, lightness distribution and a*b* plots at various L*. As well as the IT8 colour target (to allow direct comparison with the sphectrophotometer), several pictures were scanned to try to ensure coverage of all hue angles and different tone distributions. The "nasty beast" was included as it was printed both VAPoN trials, whilst the parrot was include as it had detail in the shadow and in the highlight regions (Fig 2).



Nasty Beast



White Bird

Figure 2 Selection of images Scanned for Colour Analysis

As well as the optical tone gain calculated by applying the Murray Davies equation to the density values measured in the tone strips (the densities where corrected for paper whiteness), the physical tone gain was obtained by measuring the dot area with a calibrated microscope and using Swansea Printing Technology print image analysis software.

Results and discusion

The papers used in the trials increased in gloss with coat weight reflecting a smoother surface (table 3). However, there is no correlation with the lightness of the paper or its colour. The Eco S H 49gsm SC-B has a slight yellow tinge (positive b* value), while the cote H 54gsm LWC has a slight blue colour (negative b*) that could be the affect of the optical brighteners in the coating.

Table 3 Paper characteristics

	Colour			Gloss
Paper	L*	a*	b*	60°
cote H 54 gsm LWC	87.6	-0.8	-1.3	22.5
Eco S H 49 gsm SC-B	85.7	-0.5	1.1	6.6
Brite 72c 48.8 gsm INP	86.4	-0.3	0.6	4.1

The ink gloss is highly dependent on the gloss of the substrate i.e. its smoothness (table 4). This can probably be attributed to the absorption of all the ink types into the substrate, in previous studies on newsprint there has not been a measurable ink film on the surface of the newsprint nor had it been possible to detect any changes in smoothness caused by the ink [Claypole, J]. The heatset ink achieved the same gloss level as the substrate for the LWC and INP stock, but achieved a higher gloss than the raw substrate for the ECO stock. The UV ink also achieved a higher gloss than the substrate on the ECO stock, but had a lower gloss on the LWC. In both cases the gloss of the UV inks was lower than the heatset inks.

Table 4 Ink gloss

		Gloss at 60°		
Ink	Paper	Yellow	Cyan	Magenta
Heat set	cote H 54 gsm LWC	22.1	17.2	19.5
Heatset	Eco S H 49 gsm SC-B	15.0	10.9	13.9
Heatset	Brite 72c 48.8 gsm INP	3.8	2.8	3.0
UV	cote H 54 gsm LWC	16.0	13.2	11.6
UV	Eco S H 49 gsm SC-B	10.7	8.9	8.6
Coldset	Brite 72c 48.8 gsm INP	4.7	3.1	3.6

One of the major issues in undertaking a direct comparison of the prints in VAPoN 2, is the different solid densities at which the prints were made (Fig 3). The heatset inks, particularly the cyan and the yellow, were printed at significantly higher densities than for the other prints. The coldset ink density is below half and in some cases a third of the density of the other inks. This reflects a decision made on press to run with different densities for each test in order to maintain the quality of the printed images. The need for this can probably be traced to the repro.

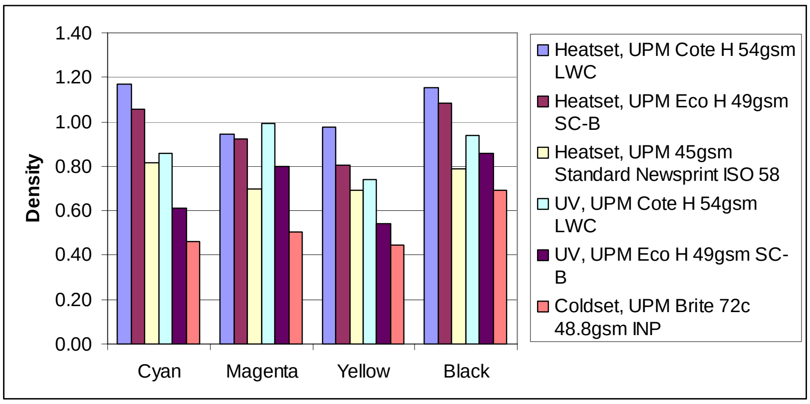


Figure 3 Solid ink reflectance densities for the six printing conditions

The colour gamuts obtained from the scanned images all lie within ISO12647-2 for four colour litho printing (Fig 4), with the exception of heatset on LWC where the yellow part of the gamut has pushed out reaching 100 on the b* axis. This particular print run had the highest yellow density. The image that pushed out the yellow area of the gamut envelope had a preponderance of yellows and orange. Where the ink densities were similar, then the gamuts are similar and all lie between the ISO12647-2 and the smaller gamut of ISO 12647-3 which is the standard for newsprint. The coldset on INP produced the smallest gamut, which was smaller than that of ISO 12647-3 in the magenta side of the spectrum. The smaller gamut reflects the lower densities at which the coldset ink was printed.

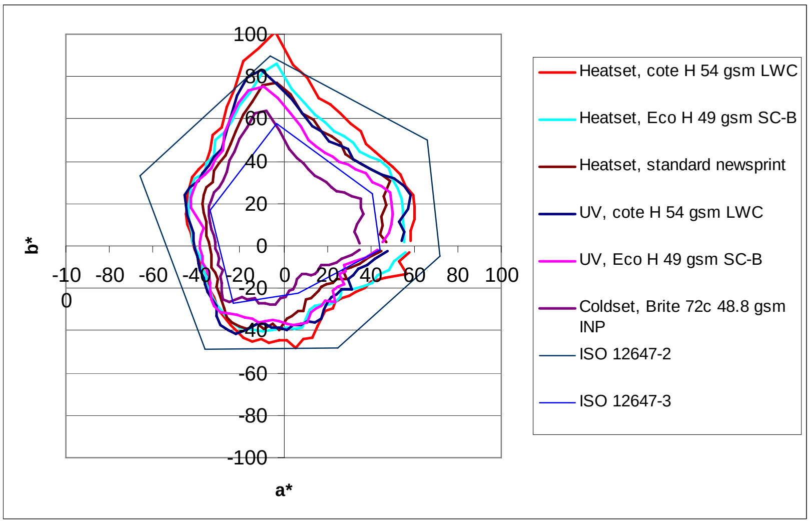


Figure 4 Colour gamut based on all scanned images

Although the difference between the various gamuts appears to be small in the a*b* plots, the difference when compared to the heatset INP is calculated in ΔC, then the difference in colour is more apparent (Fig 5). As ΔC of 1 to 3 is a perceptible difference, yet ΔC varies by up to 30. There is not a consistent difference as the density levels for each ink paper was not consistent.

The gamut obtained using the overprint patches and solids on the IT8 form show similar relationship with solid density (Fig 6). However, these suggest that in each case the gamut is smaller that that obtained from the scanned images.

Comparison of the gamut plots from the two VAPoN trials for heatset ink showed similar sized gamuts were obtained in each case, although both were shifted in the a direction between trials (Fig 7). This reflects changes in the ink densities with which the prints were produced.

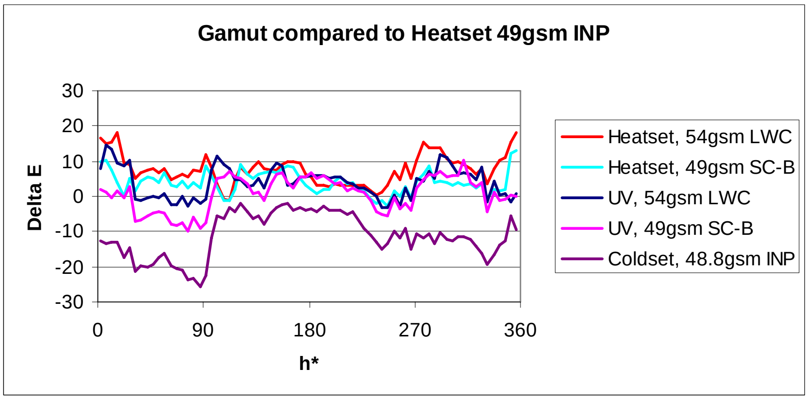


Figure 5 Colour gamut compared to Heatset 49gsm improved newsprint

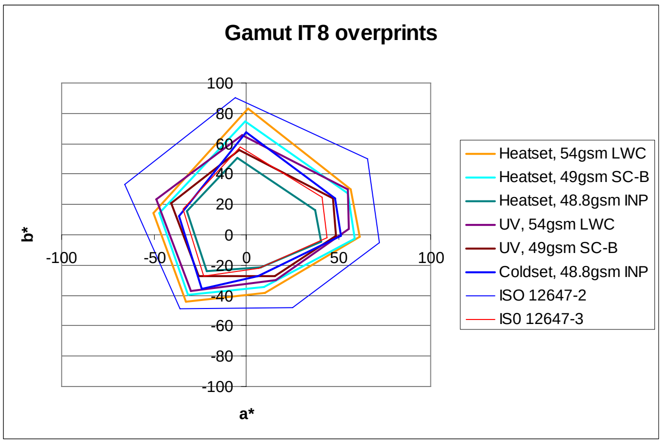


Figure 6 Colour gamuts based on overprints on IT8

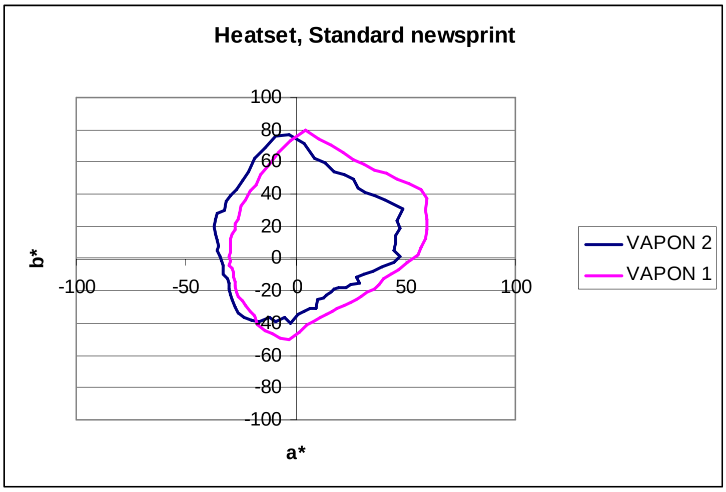


Figure 7 Comparison of gamuts obtained in VAPoN 1 & 2

One would expect for an uncorrected plates, to see the tone gain rising to a peak at the mid tone, such as shown in the aim values for tone values increase for newsprint in ISO 12647-3 of between a 22% and 30% tone value increase at 50% tone value. However, there is a negative tone value increase for all of the colours in all of the trials, i.e. there is tone value loss through out the range (Figure 8). It is unlikely that there is actual tone loss, but it suggests the prints are not experiencing as much tone gain as has been corrected for on the plates, including the tone value strips and a correction curve for tone gain has been applied which has over compensated in all cases.

One would expect to have less dot gain with the coated substrates used in VAPoN 2. Assuming the same tone gain compensation has been applied to each plate then the tone gain for the different inks and substrates combinations can be compared. The heatset inks have the most negative tone gains, which suggested that they would have experienced lower dot gain. The tone gain curves tend also to be slewed towards the shadow regions of the plate, which may be an effect of the high level of ink that were run on the LWC and Eco paper. The UV inks show tone value curves which are reflect a reasonable solid density level and a low tone gain. The coldset ink because of it mode of ink immobilisation has the least negative curve, suggesting that it experiences the highest dot gain of the ink and paper combinations tested.

The implications of applying a correction that assumes high levels of tone gain in the highlights and mid tones, when in fact the tone gain is much lower, is that when run at the correct density, then the print losses density in the highlight regions. The inks have to be run at higher densities to compensate for this. The heatset and UV inks have to carry more ink to compensate for the correction. This can be seen in the plot of density compensated for paper white against nominal tone value. The densities in the highlight regions of all the trials are all of similar values while those in the shadow high coverage regions are higher (Fig 9). It would appear the printer increased the density to be able to reproduce the highlight detail.

The physical tone gain is not as negative as the optical tone gain (Figure 10). This would infer that some of the changes seen are caused by the interaction of the ink and the paper surface. If the ink does not penetrate as far into the paper, such as one might expect with heat set or UV inks, then the optical density for the same area would tend to be higher.

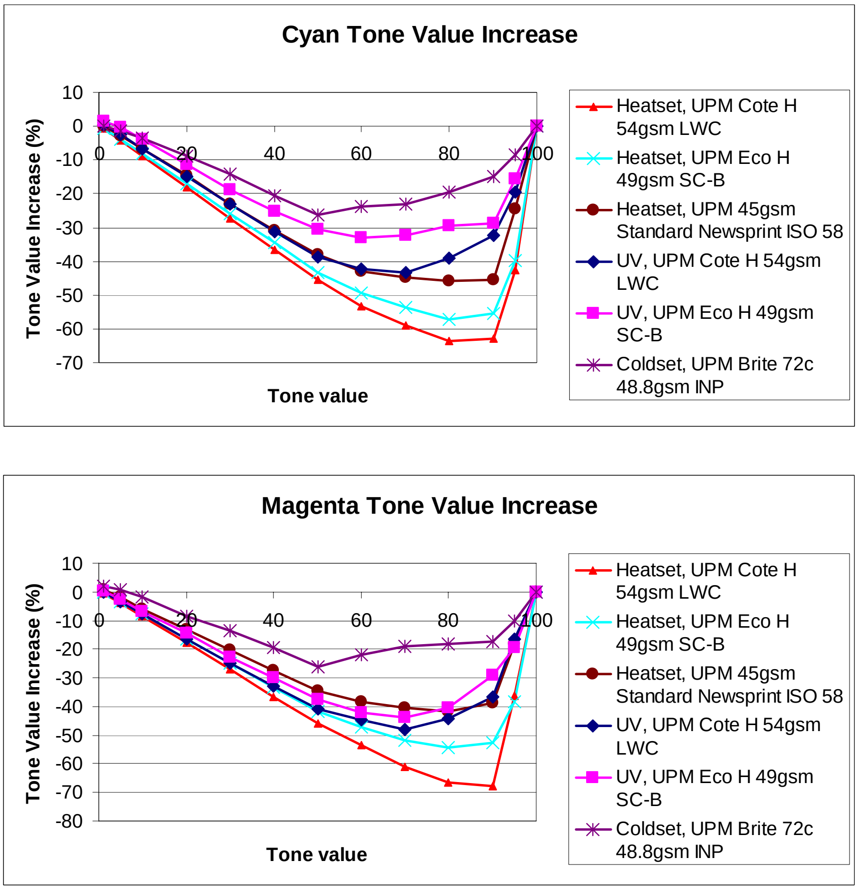
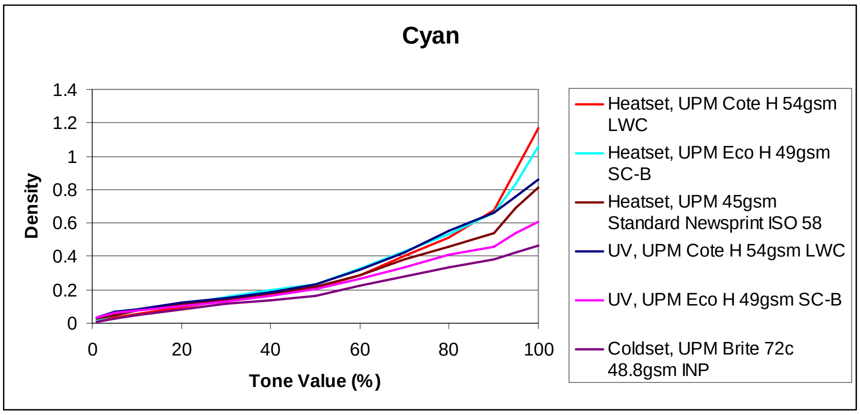


Figure 8 Tone Value Increase



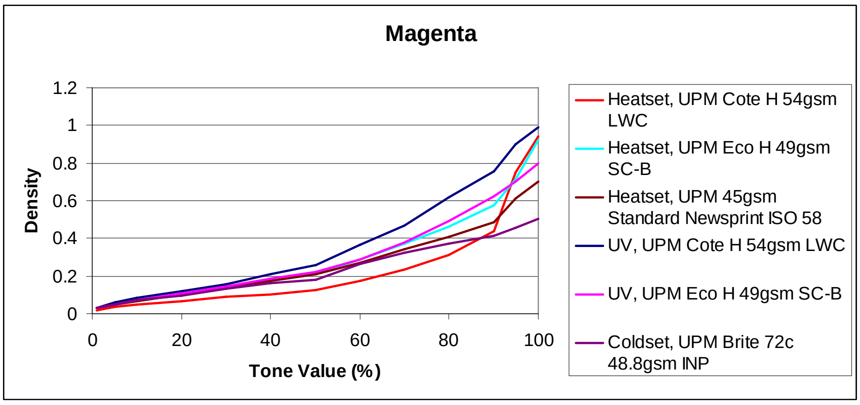


Figure 9 Density vs nominal tone value

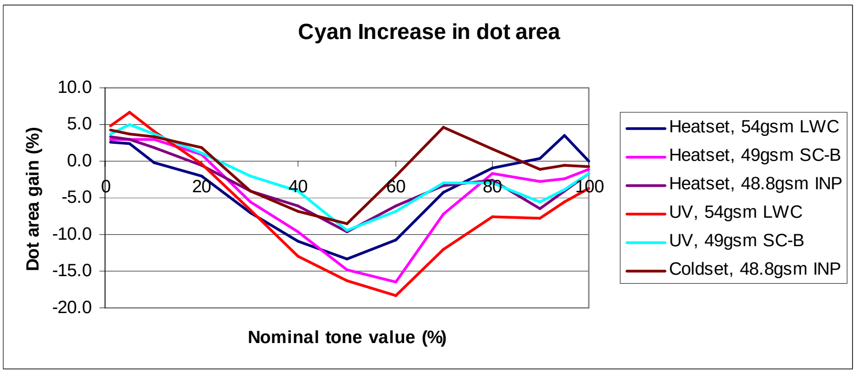


Figure 10 Physical tone gain

A measure of the tone range within an image can be made by examining the distribution of L* values (Fig 11). The upper limit of L* is set by the whiteness of the paper whilst the lower values are determined by the printing in the shadow regions. There is a spread of distributions for each image reflecting the effect of the tone gain in different parts of the images. The UV inks have a peak towards the dark scale for the “nasty beast”, suggesting there is more shadow detail being reproduced. The peak in the mid tones of the white bird is shifted to the dark end of the scale reflecting a movement in the overall density of the image. This would appear to suggest that while focused on reproducing the highlights by increasing the ink weight to compensate for the tone loss in the highlight region, this has been at the expense of the detail in the shadow regions. In the IT8 image, the heat set inks have more at the dark end of the scale probably the influence of the higher ink weights on the solid colour patches in the image. This highlights the importance in correct tone gain compensation and colour management to ensure the quality of the image is obtained on the press.

The effect of ink level ink level and substrate on the a*b* plots was examined at different L* values (Fig 12). These correspond to the shadow regions (L*=20), the mid tone region (L*=50) and the highlight (L*=50). The shadow region, shown with an enlarged scale for clarity, the area of the a*b* plot are largest for the heatset inks on LWC and SC-B paper and the UV on LWC. This is correlates with the maximum density values obtained for the magenta and cyan inks. The higher magenta level for the UV creates a larger area in the positive a*b* quadrant. In the mid tones, the a*b* plots show an increasing influence of the yellow ink. This becomes dominant in the highlight region. The difference in yellow ink levels can be directly correlated with the increase in positive a*. These results highlight that the three dimensional colour space is complex geometry and not symmetrical about the 0 a*b* axis. The plot of maximum a*b* is not a good representation of the colour space obtained nor the ability of the process to successfully reproduce an image. Thus, measuring the solid colours on a test image may not be sufficient to charcterise the colour capability of the process.

Conclusions

The major difference in the colour gamuts obtained with the heatset and UV inks can for the most part be attributed to the different ink weights printed (as seen by the measured ink densities). The printed results have also been affected by an incorrect tone value compensation having been applied during plate manufacture. IT8 target and similar test targets have enabled a more detailed appraisal to be made of the prints and also to identify fundamental colour differences.

The tone value increase was found to be highly dependent on the ink and paper combination. The heatset ink had the less tone value increase compared to the UV ink. Measurement of the physical dot area highlighted that this was in part due to reduced penetration into the substrate and thus the ink density remained high for a given dot area. The press operators set the presses so that the ink density level in the half tones were similar at the expense of the absolute solid density. This shows the importance of fingerprinting the press for the ink paper combination that is going to be used and establishing the correct ink density. The results highlighted the complex three dimensional shape of the colour gamut of the printing process and the limitations of using solids and overprints to characterize the prints.

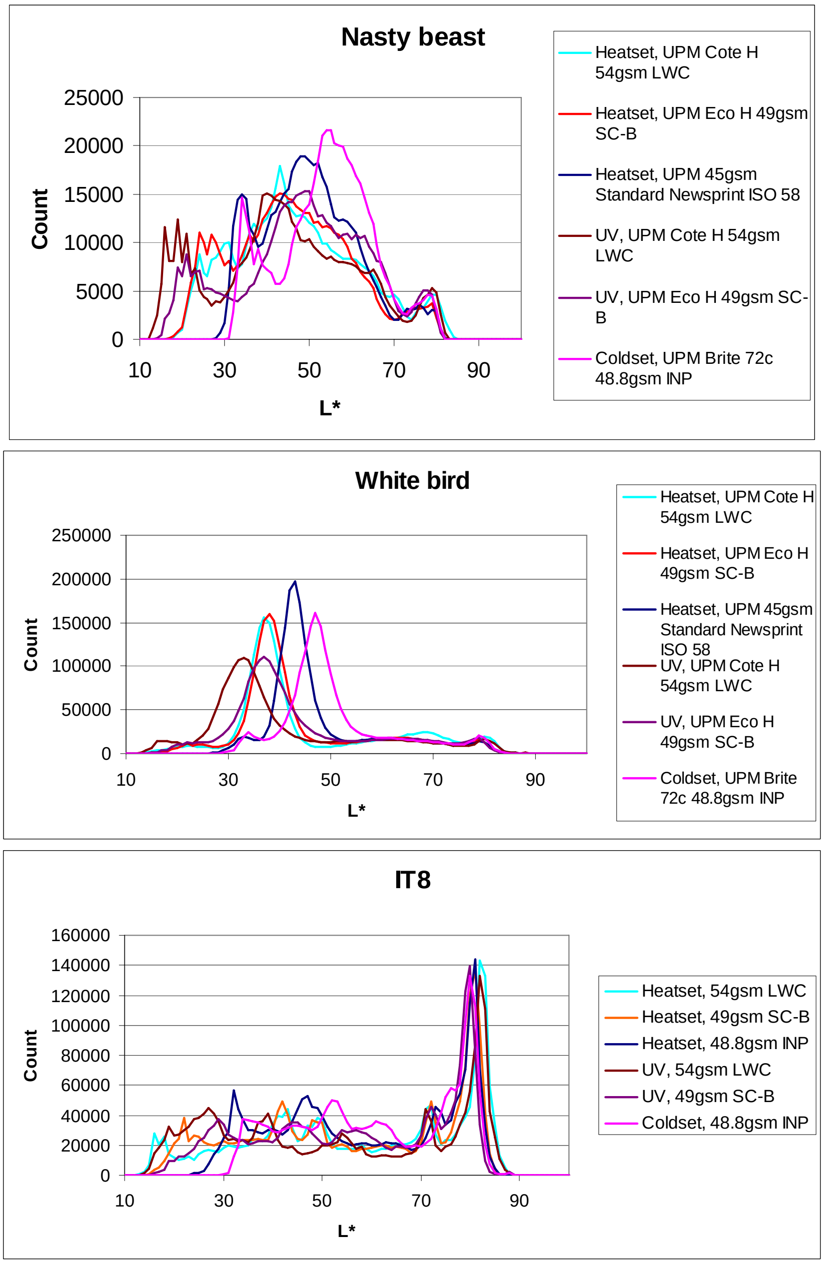
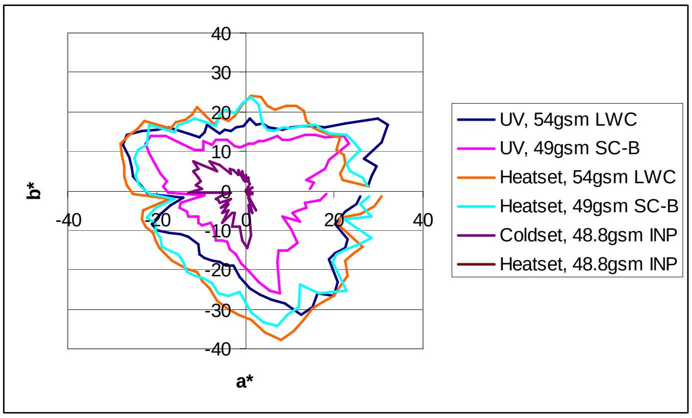
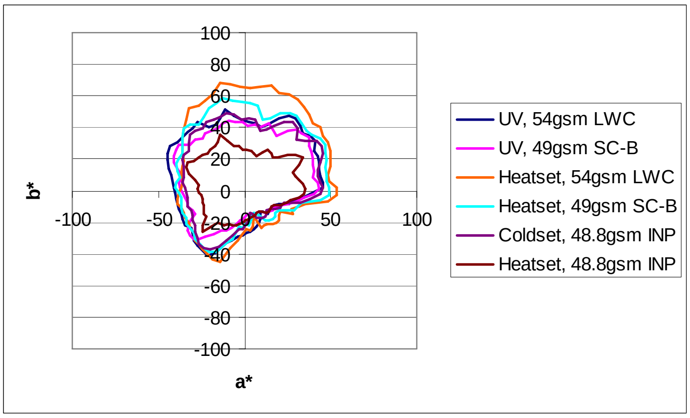


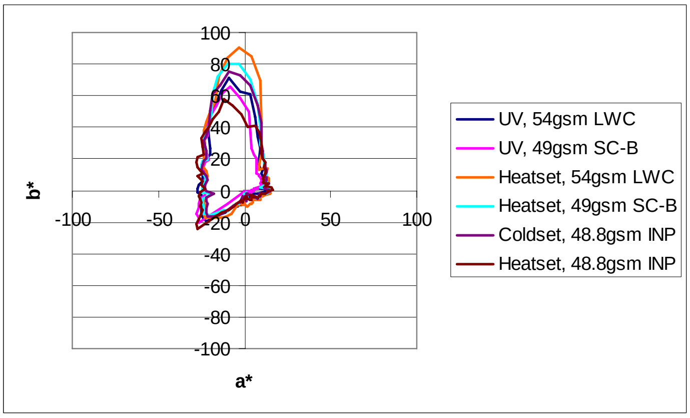
Figure 11 Distribution of L* for scanned images



Shadows, L* = 20



Mid tone, L* = 50



Highlights, L* = 70

Figure 12 a*b* plots at selected L* values

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ISO 12647-2 Graphic technology - Process control for the production of half-tone colour separations, proof and production prints - Part 2: Offset lithographic processes

ISO 12647-3 Graphic technology - Process control for the production of half-tone colour separations, proof and production prints - Part 3: Coldset offset lithographic on newsprint