APPLICATION OF IMAGING REFLECTOMETER MAPPING TO STUDIES OF PRINT MOTTLE IN COMMERCIALLY PRINTED HALFTONE PRINTS

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1. MAPPING WITH THE IMAGING REFLECTOMETER

With the optional motorised x-y stage, it is possible to use the Imaging Reflectometer to produce maps of the spatial distribution of refractive index, gloss (2°, 3°, 5° and 20° acceptance angle), macroroughness Iin plane of reflection and orthogonal to it) and microroughness over the surface of a material. In addition to these basic parameters, it is possible to map reflection haze, displacement of the reflectogram centroid (useful for large scale surface waviness), calculated gloss (prediction based on RI, macro- and micro-roughness). The combination of data available for each mapping point is unique and allows useful insights into the spatial variations in surface structure.

In this Applications Note, data are presented to illustrate the use of mapping for the study of print mottle. The results will be limited to halftone prints, but more detailed analysis may be found in Preston *et al.* (2005) and Preston *et al.* (2007).

2. PAPERS STUDIED

Three different coating pigments were used – PCC, UK kaolin and GCC. The coated papers were prepared on a pilot coater at KCL in Finland. The coating formulation consisted of 100pph pigment, 11 pph latex, 0.6 pph CMC thickener, 0.2 pph PVOH and 0.1 pph OBA. These were applied at their maximum runnable solids using a Jet applicator with a bent blade at 1000 m/min. 14 gm^{-2} of colour was applied to both sides of a woodfree basepaper. The coatings were calendered using an Optiload calender at 700 m/min for 5 nips. The pressure was varied to obtain an online gloss of about 65%, and the pressures required were 200, 120 and 300 kN/m for the PCC, kaolin and GCC respectively.

The printing trial was carried out at Lindgren & Söner in Gothenburg, Sweden, using a KBA Rapida 105 press with 6 units and 2 varnish units. The inks used were commercial inks from Sun Chemicals: Ecolith (conventional sheetfed) and SunFount 460 was used as the fount additive. More details from this study are given by Rousu (2005).

See Preston et al (2005) for further detail of the papers, pigment details and laboratory printing conditions.

3. MEASUREMENTS

Reflectometric measurements were made using the Surfoptic SIRS 75 Imaging Reflectometer with motorised x-y stage. Maps were obtained at 128 x 128 pixels at 0.2 mm steps and at 64 x 64 pixels at 0.3 mm steps.

The DOMAS image analysis package, from PTS Germany was used to characterise the unevenness of the prints using the power spectrum model. The prints were also ranked visually by a panel of 8 laboratory staff. The prints were given a score out of 10 depending upon their degree of evenness, where 10 represented a high degree of mottle and 1 no mottle.

4. RESULTS

Figure 1 shows illustrative maps of the printed and unprinted sheets. It is hard to draw conclusions from visual inspection of the maps. To allow numerical comparison, a coefficient of variation (COV) was calculated for each map – this is essentially a standard deviation expressed as a percentage. FFT band pass filtering was also applied to maps to make an assessment of the variation over various spatial dimensions.

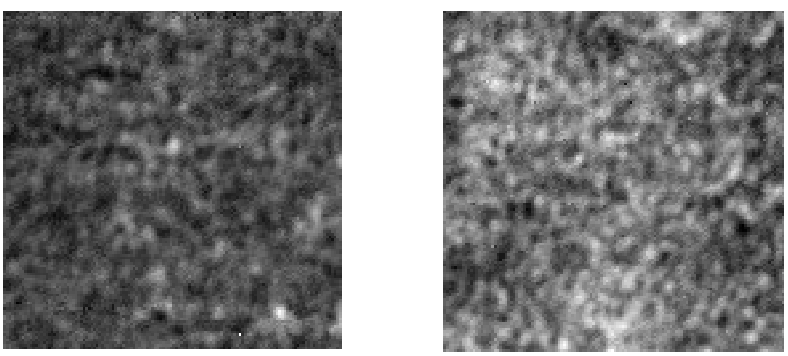

Figure 1 RI maps of clay (left) and PCC (right) coated papers (128 x128 pixels at 0.2 mm steps)

The DOMAS unevenness analysis of the pilot printed samples showed similar trends to those observed visually (Figure 2). The black halftone prints showed a higher degree of mottle than the 100% cyan prints, with the PCC coating having the highest degree of mottle and the kaolin coating having the lowest. In the 100% cyan area, the prints showed less mottle tendency and it was more difficult to differentiate between the 100% kaolin and 100% GCC coating. The PCC coating was clearly the worst in all cases.

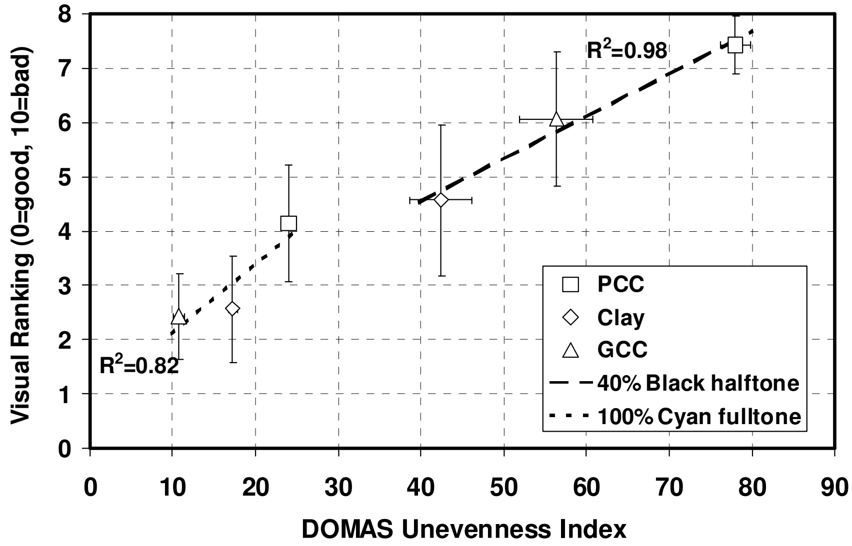

Figure 2 Visual ranking of print mottle versus the Domas image analysis ranking (unevenness index)

The prints were also analysed using the Imaging Reflectometer and there was a good correlation between the print mottle of the DOMAS system and the printed RI COV as illustrated in Figure 3 In this case the refractive index is recording variations in print density, so the correlation is not unexpected. Correlation between mottle and spatial variations in other properties (such as microroughness and macroroughness) were poor.

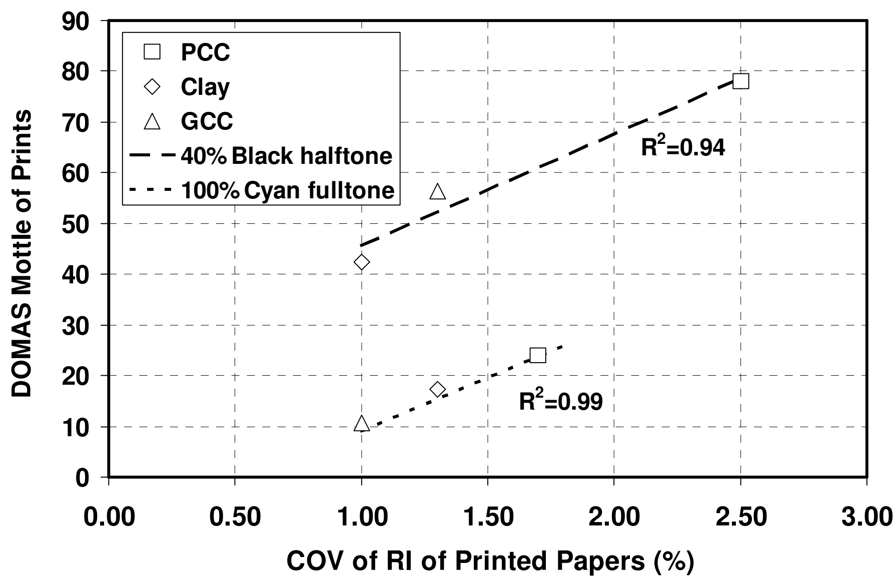

Figure 3 Refractive index versus pore volume for the same coatings.

The key aspect of this work was to map the coated, but unprinted paper to examine the variation of RI and other properties over the surface and to see whether any of the variations in coated paper properties correlated with the variation in print mottle. Figure 4 shows the DOMAS mottle of the *prints* plotted variation in effective RI for the *coated papers*. As may be seen, a fair correlation is observed in the case of the halftone prints, but little correlation for the solid cyan prints.

Other Reflectometer parameters, notably macroroughness and microroughness did not show significant correlation. From previous work, it is expected that the effective RI should be a good measure of surface porosity (specifically surface void fraction). Therefore, these observations lead toward the hypothesis that, for the halftone prints, point-to-point variations in surface porosity over the coated sheet are largely responsible for the observed print mottle. This local porosity variation may result in different amounts of ink being transferred from the print blanket to the paper or different spreading of the ink dots.

The solid cyan prints are printed on the same coated stock, but the weak correlation with RI variation suggests some other mechanism must be responsible for the mottle observed in these prints. More detailed analysis employing other print and paper methods suggests that for the solid prints, water interference mottle is responsible for the observed print mottle (Preston *et al.*, 2005).

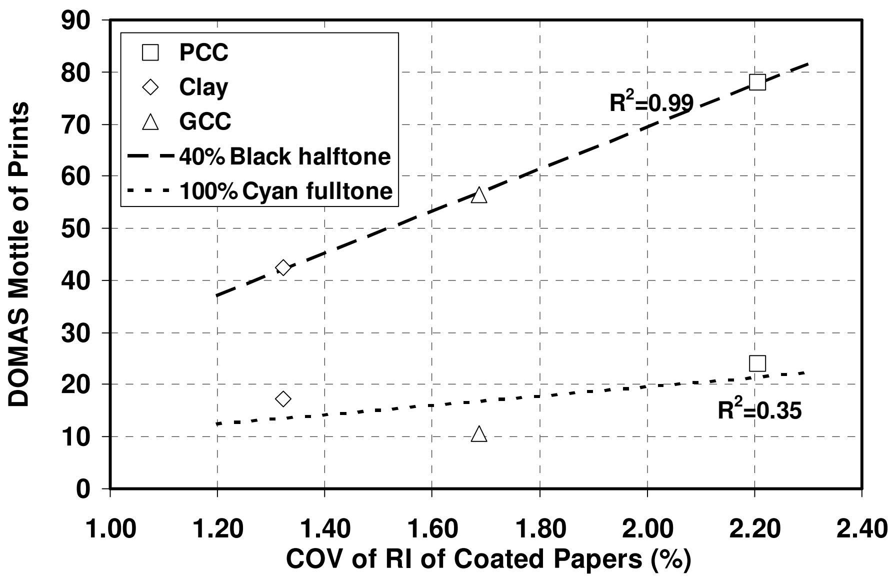

Figure 4 Domas mottle of the prints plotted against variation in RI in the *unprinted* coated paper

An assessment was also made of the size of the mottle features using FFT band pass filtering of the maps. The % COV was then calculated at each scale. Figure 5 shows the images of the print mottle for the printed PCC coating after it has been band pass filtered using the FFT. It can be seen that the greatest degree of mottle is occurring at relatively small length scales (<3 mm). This is what the DOMAS mottle system would be measuring, and is not necessarily what the eye sees. Similar patterns were observed for the other printed papers.

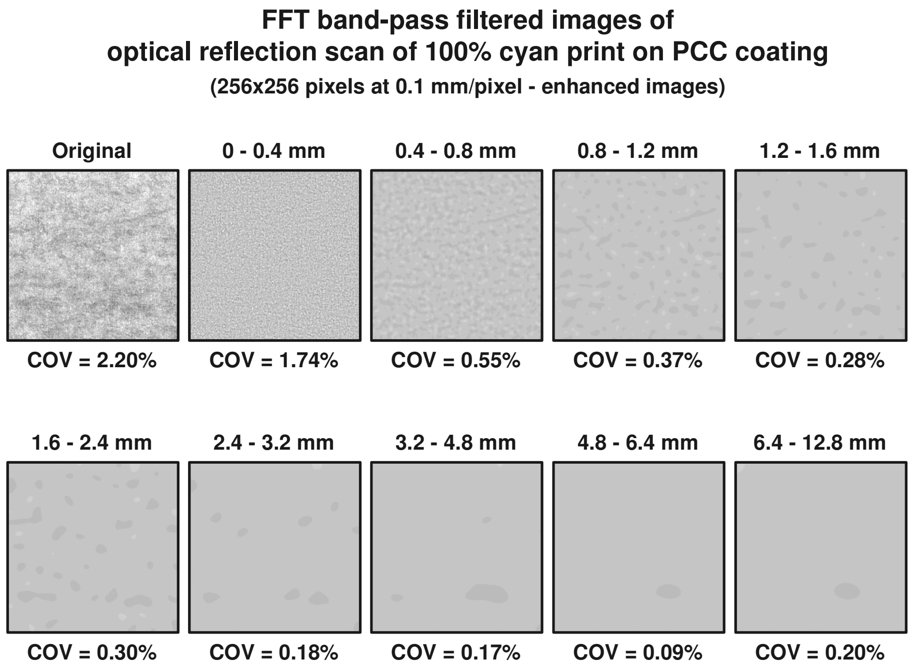

Figure 5

The different cyan coatings are compared in Figure 4. And it was seen that the higher RI COV of the PCC print was observed on a scale of between 0.4 and 3.2 mm. This is the length scale at which mottle is most evident to the human eye

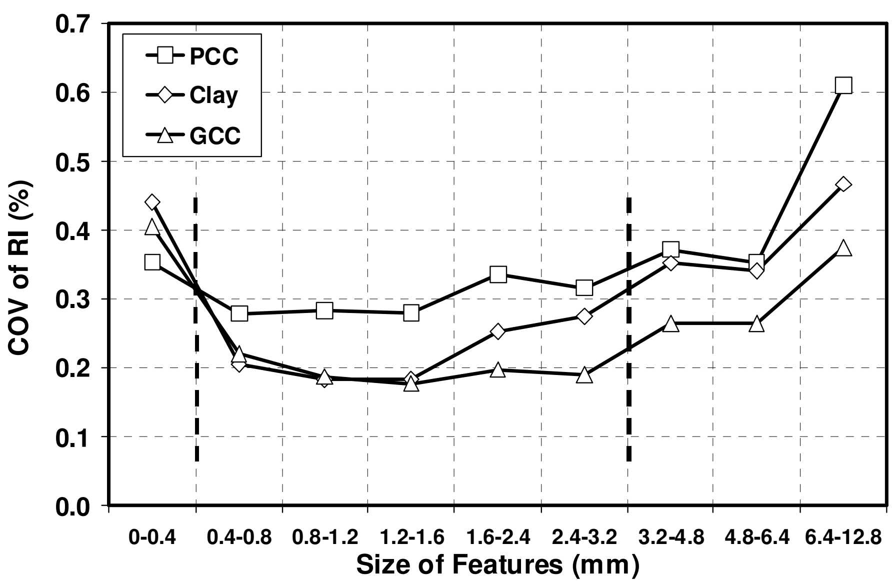

Figure 4 Variation in RI at the various feature sizes selected by FFT band pass filtering

CONCLUSIONS

Mapping of refractive index and other properties appears a promising way of studying paper and print mottle. Effective RI relates to surface porosity and point-to-point variations in surface porosity can explain certain type of print mottle features. Maps of random surfaces are generally not easy to interpret by eye, a wide range of image analysis tools can be used to help quantify image properties and variation.

It is expected that useful results should also be obtained by applying Imaging Reflectometer mapping techniques to studies of gloss mottle.

ACKNOWLEDGMENTS

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