Investigation into the Effect of Binder on Print Quality of Coated Paper

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Abstract: In the offset printing process, it often occurs that the coating layer can not absorb ink equably and ink on the coated paper can not dry at even speed. When coated paper moves through the next printing unit, the quantity of ink peeled off from image is not same. When the difference of ink peeled off by the blanket cylinder can be observed, the color of printing is not uniform and print mottle occurs. The physical structure and chemical properties of coating layer affect transferring and setting of the ink. Binder which is the important composition for coating layer is detrimental to surface topography and chemical properties of coated paper. In this study, the effect of binder on print quality of coated paper was investigated. Binder migration had two trends which were towards coating surface and interior of base paper. Binder can not distribute evenly on the coating surface in the process of coating solidifying and drying, which affect surface topography of coating layer and ink absorption. The main objective of this study was to investigate the effect of binder on coating layer and print quality. The binder migration of coating layer was obtained by changing drying temperature. The relationship between binder and print quality was explored by ink absorption uniformity.

Keywords: binder; print mottle; coating surface; ink absorption; dry temperature

1. Introduction

In the multi-color offset printing process, as the coated paper printed the first color moves through the next printing unit, the amount of ink peeled off from image was not same. The surface structure and properties of coating layer affect the transferring and setting of offset ink [1-5]. Because the coating layer can not absorb ink equably and ink on the coated paper surface can not dry at the same speed, the color of printing is not uniform and back trap mottle will occur. Binder migration which is the important factor for back trap mottle to appear is detrimental to surface topography and properties of coating layer. Binder can not evenly distribute on the coating surface because of binder migration in the process of coating solidifying and drying. Binder migration affects surface topography of coating, ink absorption and back trap mottle. The binder of coating surface has two conditions which were high density and low density through changing drying temperature and the amount of binder usage.

The main objective of this study was to investigate the effect of binder of coated paper on surface structure, properties of coating layer and print quality. The print mottle was tested with respect to the variety of binder density of coating layer and different dry temperature of coating. The relationship between properties and structure of coating surface and print mottle were investigated. Particular attention was paid to establish a clear correlation between binder and print quality.

2. Experimental

2.1. Preparation of the coated paper samples

Table 1. Coating color recipes.

<table>
<thead>
<tr>
<th>Sample</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaolin (pph*)</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Calcium carbonate (pph*)</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>SB (pph*)</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Solids (%)</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Coating thickness (µm)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Dry temperature (°C)</td>
<td>140</td>
<td>140</td>
<td>140</td>
</tr>
</tbody>
</table>

*Parts per hundred

Table 2. Coating color recipes.

<table>
<thead>
<tr>
<th>Sample</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
</tr>
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<tbody>
<tr>
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<td>15</td>
<td>15</td>
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<tr>
<td>Solids (%)</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Coating thickness (µm)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Dry temperature (°C)</td>
<td>100</td>
<td>140</td>
<td>180</td>
</tr>
</tbody>
</table>

*Parts per hundred

The pigments used for coating were Kaolin pigment and Calcium carbonate pigment (supplied by Mao Ming Clay Company, China). The basis weight of the wood-free base paper (supplied by Southern China Paper Mill) was 72g/m². The coatings of paper were composed with 50 parts kaolin pigment, 50 parts Calcium carbonate pigment and different parts carboxylic styrene-butadiene latex (supplied by BASF Company, China) with typical types of appropriate additives. The coating formulations
were in Table 1 and Table 2. Coating was performed with a bar coater (model K303 Multi-coater, RK Print Coat Instruments Ltd, United Kingdom) with the speed of 2m/min. The coated paper was moved to a drying oven for 1min. The coating thickness was 4µm and the drying temperature was 100℃, 140℃ and 180℃, respectively.

2.2. Printing

The Ink was offset printing fast-drying cyan ink (TOKA ink, Japan). Ink films were applied to the coated paper strips using a laboratory printing tester (model IGT Global standard Tester 2, America) and ink distribution apparatus (model IGT Speed Inking Unite 4) with a printing pressure of 500N and a printing speed of 0.2m/s. A half tone printing was performed. The measurement was according as the IGT back trap mottle standard. The interval time of printing and transferring print was 10s. The thickness of ink film was 8µm. The total time of transferring print was four. The Images of offset prints after four transferring print were obtained using stereo microscopy and the zoom was 90X.

2.3. Measurement of surface microstructure

The measurement of surface microstructure of the coated paper utilized atomic force microscopy (AFM) with a commercial Nanoscope IIIa microscopy (Veeco Instruments inc., Santa Barbara, USA). The images of surface topography were captured with tapping mode in air using standard Si3N4 cantilevers. A 10µm×10µm scanning area was chosen to describe the surface microstructure of paper. The AFM maps must be treated with flattening order before measurements. Surface plot, depth, roughness and section measurements were carried out using the Nanoscope IIIa image analysis software. The detailed information about the theory, principle and some applications of the AFM can be obtained in some literatures [6, 7].

3. Results and discussion

3.1. The relationship between dry temperature of coating layer and print quality

1) The influence of binder on surface properties of coated paper at different drying temperature

Fig.1 showed the mean value of surface properties of coated paper. The coating layer composition of sample G1, G2 and G3 were the same, but coating dried at the different temperature. It could be seen that the roughness increased with the drying temperature adding. Sample G1 had the strongest ink absorption and sample G3 had the poorest ink absorption owing to the different drying temperature. The binder would concentrate on the coating surface at high temperature and at the interior of coating layer at low temperature. High density binder would contribute to the ink absorption, Ink absorption would increase at the low drying temperature, because binder concentrated at the interior of coating layer which accelerated ink penetration. The whiteness, gloss and surface efficiency increased with the temperature adding, but the surface energy declined with the temperature increasing. More ink penetrated into the interior of paper owing to the binder concentrating at coating internal, which resulted in the decline of print gloss and surface efficiency.

2) The influence of binder on print quality of coated paper at different drying temperature

Fig.2 showed the images of a region that contained half tone dots of cyan ink for samples G1, G2 and G3. The boundaries between cyan ink and unprinted area on sample G2 and G3 were unclear. Samples with print mottle usually were correlated to the unclear boundaries between printed area and unprinted area. Print mottle were not expected which affected the print quality. The unclear boundaries seemed to come from the variation in the density of the ink which was resulted by the uneven ink drying speed and variation in the density of the binder. The uneven binder distribution on coated paper surface would lead to uneven ink absorption which was the direct reason for uneven drying speed. When the
difference of ink peeled off by the blanket cylinder could be observed, the color of printing was not uniform and print mottle produced. The conclusions could be drawn that low drying temperature compared with high drying temperature could contribute to the binder distribution uniformity and reduce print mottle occurring.

3.2. Binder quantity, surface structure of paper coating layer and print quality correlations

1) The influence of binder quantity on surface properties of coated paper

Fig.3 showed the mean value of surface properties of samples T1, T2 and T3. The coating layer binder composition of sample T1, T2 and T3 were not the same, but coating dried at the same temperature. It could be obtained that the roughness increased with the amount of binder adding. Sample T3 had the highest ink absorption value and sample T1 had the lowest ink absorption value owing to the different amount of binder of coating layer. The amount of binder was the important factor for ink absorption of coating layer. The binder would contribute to the ink absorption and Ink absorption would increase with the amount of binder usage adding. The whiteness, gloss, surface efficiency and surface energy declined with the amount of binder increasing.

2) The influence of binder quantity on surface microstructure of coated paper

The surface topography is often critical to ink penetration depth, which plays a major role in determining print gloss, print density and appearance of final printing. AFM was used to obtain three-dimensional characterization of surface topography of coated paper, which could give the whole interpretation by the numerical and visual characterization [8]. The roughness parameter values were determined by the scanned area and a 10μm×10μm image size was considered to be suitable to describe the surface roughness of the papers [9, 10]. Visual inspection of the topography maps (seen from Fig.4) suggested that there were obvious differences among sample T1, T2 and T3. The surface was defined from the top of the highest pigment particles to the bottom of deepest open pores. White of topography maps indicated the highest points and black indicated lowest points. The surface depth of sample T1 was 500nm, and the surface depth of sample T2 and T3 were 600nm and 1000nm, respectively. When sample T1 was compared with sample T2 and T3, the findings indicated that the amount of binder of coating layer affected the pore size and distribution of the coated paper surface. The section analysis performed...
on the topography maps along the diagonal gave an indication of the roughness in the z-direction. It was found that the pore depth of sample T3 is the deepest.

The depth distributions of topography maps (seen from Fig.5) were plotted for coordinate data in Fig.4. The depth distribution maps illustrated the rugged paper surface in the z-direction from numerical characterization [8]. Sample T1 had a distribution mainly ranging from 0.3µm to 0.9µm, which implied that sample T1 was the smoothest in these samples. It was clear shown in Fig.5 that the depth distribution of sample T2 and sample T3 ranging between 0µm and 1.2 µm. The depth distribution of sample T2 and sample T3 mainly ranged from 0.3µm to 0.9µm and from 0.5µm to 1.2µm, respectively. Fig.5 indicated that sample T2 was smoother than sample T3. The results suggested that the samples differed in their surface structure, the micro smoothness and macro smoothness owing to different amount of binder of coating layer.

3) The influence of binder on print quality of coated paper

It could be seen from fig.6 that the boundaries between cyan printed area and unprinted area on sample T2 and T3 were unclear. The size and shape of dots altered on sample T2 and T3. Dots of sample T3 were almost unclear, which resulted in serious print mottle. The conclusions could be drawn that low amount of binder compared with high amount of binder could contribute to the binder distribution uniformity and reduce print mottle occurring. It could be obtained from Fig.4, Fig.5 and Fig.6 that high amount of binder made the coating layer more roughness, which led to uneven ink absorption and accelerated the print mottle occurring.

Conclusions

The effect of binder on print quality of coated paper was investigated in this study. Binder could not distribute evenly on the coating surface in the process of coating solidifying and drying at high drying temperature, which affected surface properties of coating layer and ink absorption. High drying temperature could make roughness and surface efficiency increasing and make ink absorption and whiteness declined, but high temperature could make the binder distribute unevenly which promoted the print mottle phenomenon. Excessive amount of binder made the coating layer more roughness and the depth of pores were deeper, meanwhile the ink absorption was stronger and more uneven which resulted in serious print mottle.

References