Characterization of the Effect of Surface Properties of Tissue Paper on Print Quality

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Abstract: Tissue paper used in industrial applications for Puer tea packaging was studied in this investigation. Tissue paper for Puer tea packaging should have good air permeability because Puer tea needs zymosis. The physico-chemical characteristics of tissue paper which were detrimental to printability were measured. Particular attention was paid to air permeability, surface roughness and print through and to establish a clear correlation between surface properties and print quality. The results indicated that tissue paper had a high air permeability rate and too strong ink absorption which resulted in ink penetrated into the backside of tissue paper and poor print quality. Tissue papers were coated with two kinds of coating which included different quantity of kaolin pigment and calcium carbonate pigment in order to see whether the final coated tissue paper could meet the demands for Puer tea packaging and improve print quality and which kind of pigment adapted to coating for tissue paper. The coating was performed on a multi-coater, and two kinds of coating thickness were applied: 2μm and 6μm. It was concluded that the thinner coating and kaolin pigment could adapt to coating for tissue paper and could improve the surface structure of tissue paper and print quality.

Keywords: print through; print quality; air permeance; coating

1. Introduction

Tissue paper has good air permeability and flexibility because of the more pores on the tissue paper surface and the more length fibers compared with the other packaging materials, which make tissue paper adapts to Puer tea packaging. The porosity distribution and surface roughness are the main factors which affect the interaction between printing ink and paper [1]. Print gloss of tissue paper is related to the rate at which the ink film hardens or sets on the paper surface, which in turn may be related to the pore structure of the tissue paper surface. The formation of ink film with the desired optical density on paper substrates is consequentially dependent on the ink receptivity by paper, which is determined by structure and optical properties of paper surface [2]. The desired optical density on paper is consequentially dependent on the ink absorption by paper, which is determined by structure and optical properties of paper surface [3].Printing process becomes difficulty because tissue paper has too strong ink absorption. Ink can not form a certain thickness film and obtain perfect optical density on the tissue paper surface. Colors of print image will become dim because of too strong ink penetration and printing process will make print through occurring easily. Tissue paper can not perform the role of substrate smoothly for printing which is a difficult problem for printer.

Investigations into the influence of the coating structure on ink setting rate have been widely performed in recent years [4-11]. In this study, coating was performed to alter the surface properties of tissue paper and improve the print quality. The main objective of our study was to investigate the surface properties and printability of tissue paper and to find whether the final coated tissue paper could meet the demands for Puer tea packaging and improve print quality and which kind of pigment adapted to coating for tissue paper.

2. Experimental

2.1. Materials

A kind of tissue paper for purer tea packaging as the base paper was used in our study. Tissue paper samples were air-conditioned before measurements, which were carried out under the same conditions. The pigments used for coating were fine Kaolin pigment (supplied by Mao Ming Clay Company, China) and calcium carbonate pigment (supplied by Mao Ming Clay Company, China). The coating layer of tissue paper was composed with kaolin pigment, calcium carbonate pigment and carboxylic styrene-butadiene latex (supplied by BASF Company, China). The coating formulations were in Table 1 and Table 2.

Table 1. Kaolin based Coating formulations

Sample	A1	A2	A3
Kaolin(pph*)	100	100	100
SB(pph*)	15	15	15
Solids(%)	55	55	55
Coating thickness(μm)	0	2	6

*Parts per hundred

Table 2. Kaolin and calcium carbonate based coating formulations

Sample	B1	B2	B3
Kaolin(pph*)	50	50	50
Calcium carbonate(pph*)	50	50	50
SB(pph*)	15	15	15
Solids(%)	55	55	55
Coating thickness(μm)	0	2	6

*Parts per hundred

2.2. Methods

1) *Coating the tissue paper samples*

Coating was performed with a bar coater (model K303 Multi-coater, RK Print Coat Instruments Ltd, United Kingdom) with the speed of 4m/min. The coated paper was moved to a drying oven for 1min.

2) *Printing of ink onto the tissue paper samples*

Ink was offset printing fast-drying cyan ink (TOKA ink, Japan). Ink films were applied to the tissue paper strips using a laboratory printing tester (model IGT Global standard Tester 2, America) and ink distribution apparatus (model IGT Speed Inking Unite 4). The amount of ink transferred onto the ink distributing roller using IGT ink injector was corresponding to the ink film thickness when applied to the tissue paper and the compensation was 25% every time. Each tissue paper sample strip included four kinds of printing areas in which dot area coverage were 25%, 50%，75% and 100%. IGT print through and IGT print gloss experiment was carried out under the following conditions in according with the IGT standards.

- Printing pressure =625N
- Printing speed =0.2m/s
- Printing length= 200mm
- Printing width =50mm
- Temperature =22℃
- Humidity= 65%
- Ink layer thickness of IGT print through=8μm
- Ink layer thickness of IGT print gloss=4.8μm

3) *Measurement of surface properties of tissue paper*

The characteristic properties of tissue paper were measured using the following instruments: tensile strength tester, paper thickness gauge, paper grammage tester, tearing strength tester, reflection densitometer X-Rite 530(USA) and air permeability tester. Measurement of the gloss valve unprinted and printed tissue papers were made using Novo-Gloss TM (75°) instrument, Stereo Microscopy SZX12.

4) *Measurement of Surface topography by SEM*

The surface topography of tissue paper was obtained using the SEM. The SEM instrument was a commercial S3700 instrument. An accelerating voltage of 10 kV was used and samples were gold coated to eliminate charging.

Table 3.The properties mean values of tissue paper

Property	A
PPS(μm)	550
Gloss (75°, %)	12.8
Opaticy(%)	50.17
Specific weight (g /cm^3)	0.618
Porosity (%)	60.13
Air permeability (ml/min)	4500
Thickness (μm)	45
Grammage (g /m^2)	27.8
Whiteness degree (%)	85.5
Bursting strength (Kpa)	116
Tensile strength (kN/m)	a 2.54 b 0.39
Tearing strength (N)	a 0.39 b 1.17

a: vertical-machine direction; b: cross-machine direction.

3. Results and discussion

3.1. Surface properties of tissue paper

Table 3 summarized the evaluated mean values (calculated from ten measurements) of properties for tissue paper material used in the investigation. The results obtained were explored as the basis for discussion about the influence of surface properties on print quality of tissue paper substrates. The Results showed that tissue paper had high air permeability and porosity which would result in too strong ink penetration and make print through easily occur. Meanwhile the opaticy and gloss value was low and the roughness value was high which made it difficult for tissue paper to perform the printing substrate smoothly and obtain good printing products. Owing to these properties of tissue paper, ink film could not set on the paper surface and get desired print density. The color and dot reproduction of printing products would make poor which seriously influenced the print quality.

3.2. Influence of coating on print quality of tissue paper

1) *The effect of coating thickness and pigment on properties of tissue paper*

The most important factor for tissue paper which was applied to the Puer tea packaging was the high air permeability, because Puer tea needed zymosis when it was reposition. Particular attention was paid to investigate the change of air permeability between uncoated tissue paper and coated tissue paper in order to find whether the final coated tissue paper could meet the demands for Puer tea packaging and to find the influence of different coating thickness on air permeability and which kind of pigment adapted to the coating for Puer tea packaging.

Fig.1 showed the air permeability of different coating thickness and two kinds of coating layer. Sample A1, A2 and A3 were the kaolin coating layer, sample B1, B2 and B3 were the 50%kaolin and 50% calcium carbonate coating layer respectively. Sample A1 and B1 had the highest air permeability owing to uncoated surface. It could be seen from Fig.1 that air permeability declined with the

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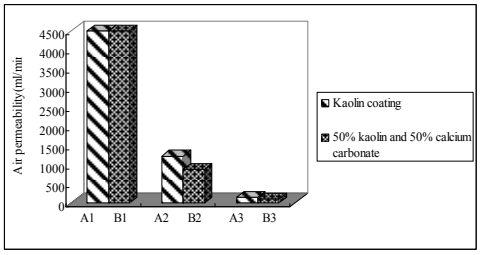


Fig.1 Air permeability of different coating thickness and pigment(A1 and B1: 0μm， A2 and B2: 2μm, A3 and B3:6μm)

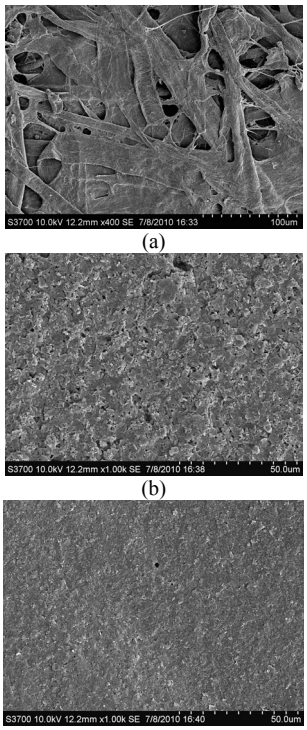


Fig.2 Typical SEM images of surface topography of different coating layer of tissue paper，(a): uncoated tissue paper, (b): kaolin coating, (c): 50%kaolin and 50% calcium carbonate coating

coating thickness increasing, because coating covered the pore of tissue paper and thicker coating layer did more disadvantages to air permeability. The kaolin coated tissue paper has higher air permeability than 50%kaolin and 50% calcium carbonate coated tissue paper. It could be concluded that kaolin coating layer was propitious to air permeability comparing sample A series with sample B series.

In order to fully understand the influence of coating on the surface properties, it is necessary to investigate the changes of surface topography between uncoated tissue paper and coated tissue paper. Fig.2 showed the SEM images of: (a) uncoated tissue paper; (b) kaolin pigment coated tissue paper and (c) 50%kaolin and 50% calcium carbonate pigment coated tissue paper. The coating thickness was 2μm. It could be seen form Fig.2 that there were many pores on the tissue paper surface so tissue paper did advantage to air permeability. The surface of image (c) was smoother and had few pores than the surface of image (b), which could explained that the kaolin coated tissue paper has higher air permeability than 50% kaolin and 50% calcium carbonate coated tissue paper.

2) The effect of coating on print quality of tissue paper

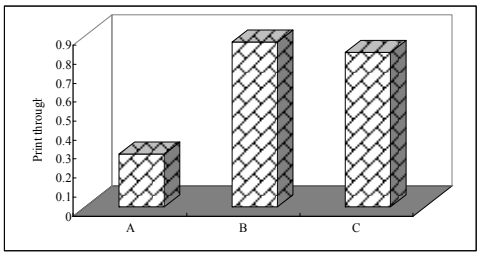
Color printing quality is determined by tone and color reproduction which are achieved through dot transferring onto the paper substrates. The size, change and quality of dot and thickness of ink film are the basic factors which determine the printing quality. The optical density of ink films and dot gain values are the significant factors. The print through was an important factor for printing substrate which affected the final print quality. The print through was tightly related to the specific weight and opacity of paper substrate. In the IGT standards, the print through was the ration of the whiteness of print area and the whiteness of unprinted area of printing backside. The value which was closed to one showed that the print though phenomenon scarcely occurred and the lower value of print through indicated more serious print through phenomenon. It could be seen from Fig.3 (a) that the value of uncoated tissue paper was the smallest which indicated that the print through phenomenon occurred most seriously. Kaolin coated tissue paper was better than 50%kaolin and 50% calcium carbonate coated tissue paper ,which attributed to that calcium carbonate pigment accelerated the ink absorption of coating surface. It could be obtained from Fig.3 (b) that print density of kaolin coated tissue paper was the highest and the print density of uncoated tissue paper was the lowest because ink could not set on the surface of uncoated tissue paper and most of the ink penetrated into the paper internal and produced serious print through.

Fig.4 showed the images of offset print in tone region with cyan ink. It could be seen from fig.4 that good print quality was produced using kaolin coated tissue paper. Tissue paper properties have the important role on the dot reproduction. The results (Table 3) showed tissue paper had high porosity and roughness. A lot of dots could not set onto the surface of the tissue paper, which resulted in dots distortion under the condition of low dot percentage and serious dot gain and dismissing under the condition of high dot percentage. It could be concluded that surface properties played an important role on the print quality.

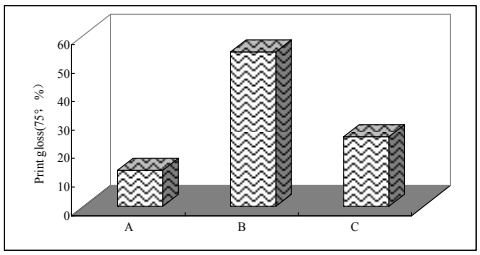
Conclusions

The investigation showed the properties and printability of tissue paper. The formation of the ink film onto the tissue paper substrate was substantially influenced by paper-ink interactions, so surface properties of tissue

paper were important factors. The results indicated that tissue paper had high porosity and air permeability which would result in too strong ink penetration and make poor print quality. Coating could improve the surface properties, but coating would decrease the air permeability,

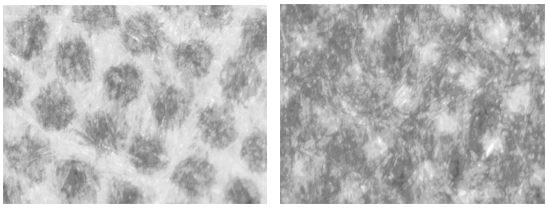


(a)

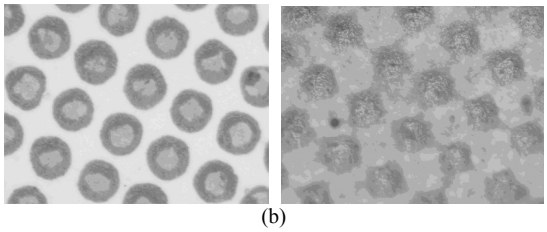


(b)

Fig.3 (a) Print through and (b) print gloss of tissue paper(coating thickness: 2μm), A: uncoated tissue paper, B: kaolin coated tissue paper, (c): 50%kaolin and 50% calcium carbonate coated tissue paper



(a)



(b)

Figure 4. Dot reproduction images of uncoated tissue paper by stereo microscopy (a) and kaolin coated tissue paper (b), left: 25% dot percentage, right: 50% dot percentage. (Zoom: 90X).

meanwhile. The thinner coating would adapt to the tissue paper to improve the surface properties of tissue paper.

Ink penetrated easily into the internal of tissue paper and could not set on the surface of tissue paper to form a certain ink film thickness, so print through phenomenon and dot distortion was serious, which resulted in poor print quality. Kaolin pigment was better than calcium carbonate pigment for coating of tissue paper, though the surface of 50% kaolin and 50% calcium carbonate coating was better than kaolin coating. Calcium carbonate pigment would increase the ink absorption of coating surface, which did disadvantage to print through and print density and better surface decreased the air permeability. In order to improve the surface properties and print quality and satisfy the need of Puer tea packaging, kaolin pigment and 2μm coating thickness were good to tissue paper.

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