Recording Sheets for Bubble Jet Printing

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Abstract

We have developed a new plain paper, called 'PB paper' which is usable for both Bubble Jet printing and electrophotographic printing. This paper will describe the excellent recording properties of PB paper from the ink absorption study by the Bristow's method in comparison with other plain papers for copier. There is a preferable range for Bristow's parameters: absorption coefficient, roughness index and wetting time to get the paper that will be usable for both printing technologies.

Introduction

It is said that the world sales volume of the ink jet printers in 1993 has been reached about 9 million and most of them are used in the offices. Most users are printing their documents and graphics on the papers that will be easy to get in their office for them, like plain papers for photocopiers or bond papers. But those papers will not always have good properties for the ink jet printing, so the users will not be satisfied with print quality, print density and drying time etc. of their ink jet plain paper printing. To improve this situation, we have developed 'PB paper' which will be usable for both of electrophotography (PPC) and Bubble Jet printing commonly. The PB paper has developed on the basis of the electrophotographic paper so we have focused on the improvement of ink jet recording properties of it. The ink jet recording property has related very closely to the ink absorption property of a paper. From Dr. Bristow's paper[1], there are several papers concerning about rapid ink absorption processes of ink jet paper[2] and Barker, et al[3] concluded Bristow's dynamic absorption test is very useful for a prediction of print quality. In this work, we have done the Bristow test on several plain papers and decided preferable range of paper parameters for the paper that will be usable for both of PPC and Bubble jet printer. This paper will describe the technical feature of PB paper from the analysis of ink absorption property by Bristow's method.

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The Properties Required to the PB paper

The PB paper has to have satisfied the requirements come from monochrome printing (black & white) in electrophotography and ink jet at the same time. The properties required from each technology summarized in Table 1 and 2.

Table 1. The Required Characteristics for Electrophotography and the Related Properties of the Paper

Items	The related properties of the paper
1. Feeding stability	thickness, stiffness, electric resistivity, friction coefficient, paper dust
2. Toner acceptability	smoothness, texture, electric resistivity, water content
3. Toner fixability	electric resistivity, water content, hydrophilic surface
4. Heat curl	water content

Table 2. The Requirements for Ink Jet Printing

Items	Requirements
1. Print density	≥ 1.4
2. Letter quality	no feathering
3. Black shade	no bronzing
4. Drying time	≤ 10 sec
5. Print uniformity	no mottling,
6. Print through	not strike through

Bubble Jet Recording Property and Ink Absorption Property

Bubble Jet Recording Property

Bubble Jet printing has been done with BJ-200 on 7 plain papers and evaluated the print density, the letter quality and black shade. The result is shown in Table 3. From this table, it is difficult to keep these characteristics well at the same time for commercial plain papers while keep them well independently.

Ink Absorption Property

The measurement of the ink absorption property has been performed with "Apparatus for Dynamic Liquid Absorption Test S" (TOYO SEIKI) and the test liquid is Canon's commercial black ink (BC-01). The Bristow dynamic liquid absorption test was developed for measuring rapid ink absorption processes that will occur

when an ink is transferred to a paper surface. Figure 1 shows a typical dynamic absorption curve of water based ink. In the case of water based ink, the absorption curve is consist of two parts. In the first part, the volume of transferred ink does not change with contact time and the second part, the volume will increase consistently with contact time. This phenomenon is understood that the applied ink was not absorbed but just wet the surfaceof paper in the period of first part and then the paper starts to absorb the ink. The relation between contact (absorption) time and transferred volume of liquid are expressed by Bristow:

$$V = V_r \qquad [T \le T_w] \tag{1}$$

$$V = V_r + K_a\, T\text{-}T_w \qquad [T > T_w] \tag{2}$$

V_r : roughness index
K_a : absorption coefficient
T_w : wetting time

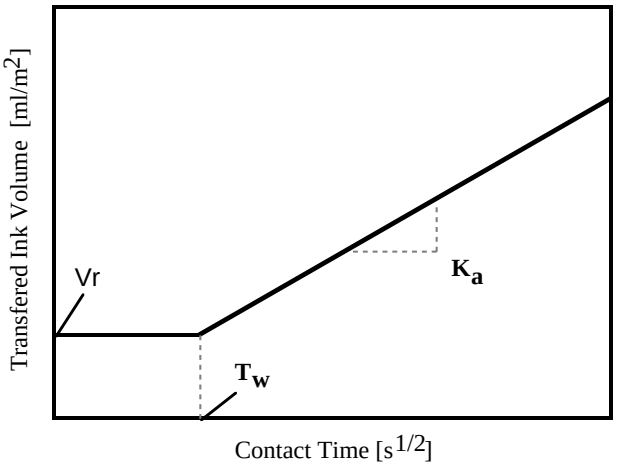

Figure 1. Typical dynamic sorption curve of water based ink absorption

Results and Discussion

Ink Absorption Behavior and Print Density

The dyes of the ink droplet should stay near the surface of the paper to get high print density because the dyes, which deeply soak into the paper, will not contribute the print density from the opacity of the fiber and the filler but also the light-scattering properties of the paper surface. Table 4 summarizes the ink absorption behavior of the plain papers and the Bristow curves of paper 1 and PB paper are shown in Figure 2.

Since extrapolation of the curves to zero contact time gives the volumetric roughness of the surface of the paper and the horizontal portion of the curve represents the wetting delay time, to get high print density the paper should have the wetting time as PB paper and the quantities of Ka and Vr should not high like paper 1. As I mention it above, in paper 1 the dyes soaked deeply and fast into the paper so that the absorbed dyes can not contribute to optical density.

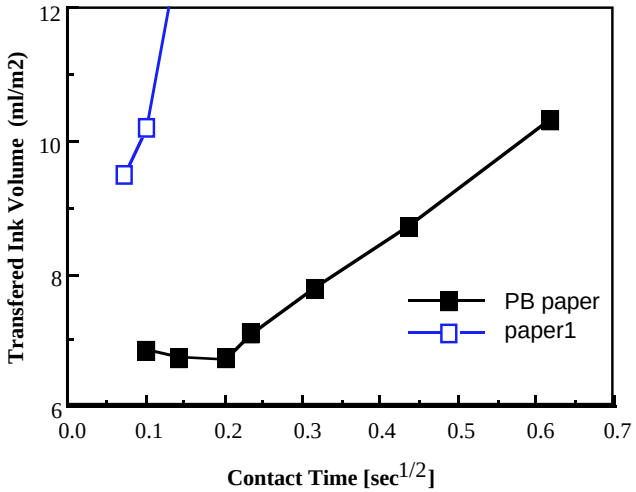

Figure 2. Dynamic ink absorption of paper 1 and PB paper

Letter Quality

Figure 3 shows a comparison of the letter quality of each papers in the enlarged photos of a letter “B.” From this figure, PB paper achieved good letter quality while paper 2 to 5 showed less quality because of feathering severely.

We have studied the cause of feathering from their Bristow curves. Figure 4 shows Bristow curves of paper 3, 4 and PB paper. It is clear from this figure that PB paper has the wetting delay time for about 40 µsec while papers 3 and 4 do not have the wetting delay time at all, and they have more smooth surface than PB paper for about 1.0 ml/m^{2}sec$^{1/2}$. On the other hand, paper 2 and 5 also show feathering although they have the wetting delay time. T_w of paper 2 is about 20 µsec and smaller than paper 5, and its letter quality is worst among them (Figure 3). From the point of roughness index, PB paper has smallest value among them and no feathering. This means that there are preferable ranges for the wetting time and the surface roughness to get no feathering letter with this ink.

Table 3. Bubble Jet Recording Property of Plain Papers

Sample number	Print density	Letter quality	Black shade	Remark
paper 1	1.15	very poor	good	commercial
paper 2	1.22	fair	good	commercial
paper 3	1.44	poor	good	commercial
paper 4	1.36	poor	good	commercial
paper 5	1.30	good	poor	commercial
paper 6	1.41	good	poor	test sample
PB paper	1.44	good	good	commercial

Table 4. Ink Absorption Behavior of the Plain Papers

Sample number	Kr ml/m²	T_w sec	K_a ml/m²s$^{1/2}$
paper 1	(10.0)	-	68.0
paper 2	7.7	0.02	6.0
paper 3	6.0	-	6.5
paper 4	5.8	-	6.4
paper 5	8.1	0.1	6.9
paper 6	7.1	0.04	6.4
PB paper	6.8	0.04	8.3

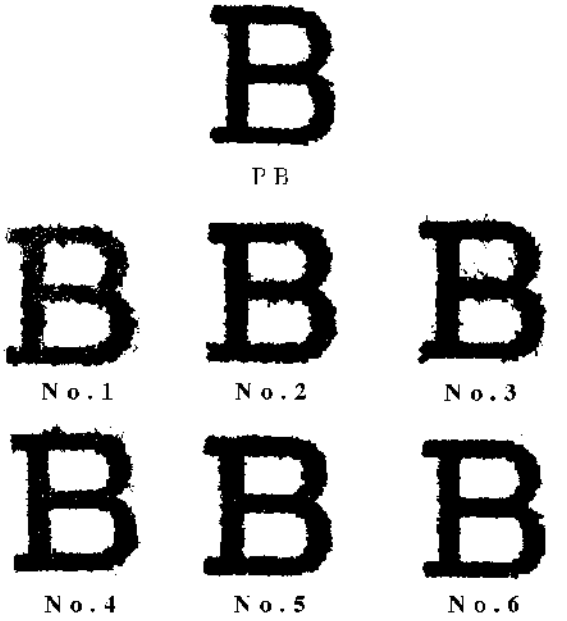

Figure 3. Letter quality of the plain papers

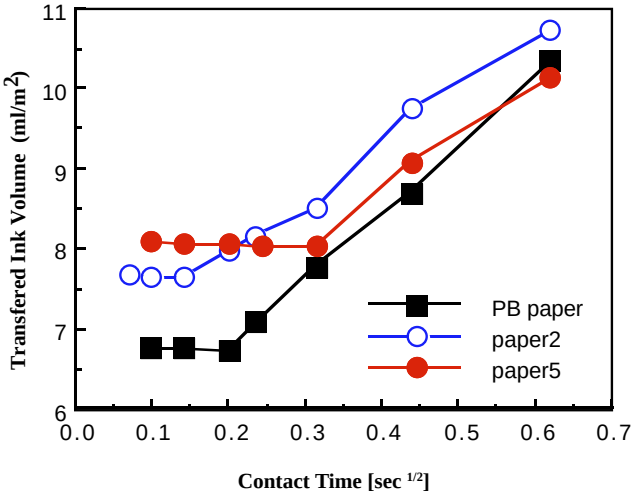

Figure 5. Dynamic ink absorption of PB paper, paper 2 and paper 5

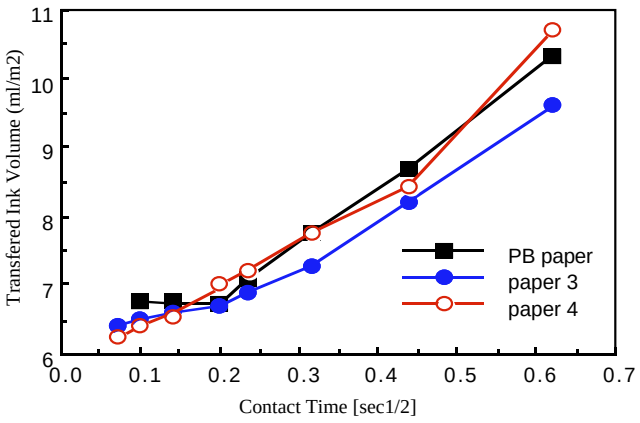

Figure 4. Dynamic ink absorption of PB paper, paper 3 and paper 4

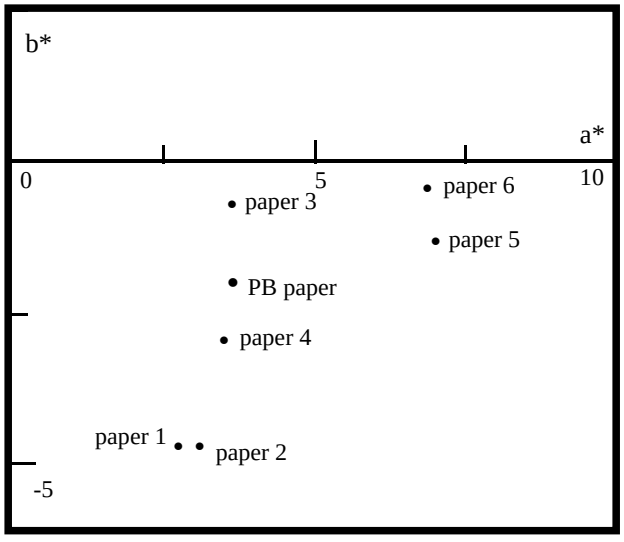

*Figure 6. Chromaticity diagram of the plain papers in CIE1976 L*a*b-Color Space*

Bronzing

Figure 6 shows black chromaticity of each papers in the diagram of 1976 CIE L*a*b* color space. As is clear from this figure, paper 5 and 6 show strong reddish black while PB paper has preferable black chromaticity (shade). On the process of ink drying up, black shade changed from black to glossy reddish black. This is a well-known phenomenon as bronzing. The mechanism of this is now studying, but from this result shows that the wetting time and the absorption coefficient of the paper have related to this. Paper 5 has five times longer wetting time than paper 2 and this seems to cause of bronzing on paper 5. In the case of paper 6, Its T_w and V_r are as same as PB's but K_a is different. This means it takes longer time to absorb and dry the ink than PB and seems to cause of bronzing. We suppose we need more understanding of paper chemistry such as sizing agent, filler etc. to solve this phenomenon.

Summary

The ink absorption properties of new ink jet plain paper "PB paper" which is usable for monochrome electrophotography was studied with Bristow's method. We have found it important to achieve following conditions for Bristow's characteristics to getting high print density, high letter quality and high blackness without bronzing in Bubble jet printing; Wetting Time : about 40 msecond, Roughness Index: around 7 ml/m^2, Absorption Coefficient: around 8 $ml/m^2sec^{1/2}$ respectively.

The PB paper has superior recording property for monochrome Bubble jet printing and is good enough for business color printing, but some improvements are need for full color printing.

References

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