Effect of Paper Properties on Print Quality of Ink Jet Printer

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Abstract

The interactions of ink jet inks with the substrate are very complex and dependent on various parameters. Since aqueous-based inks are most popular, this work is concentrated on aqueous-based inks in drop-on-demand printer. The rapid growth of ink jet printers has created a rapid expansion of ink jet paper market. However, it requires proper understanding of ink drying and ink-paper interaction. Wide variation of print quality is expected due to variation of ink formulation and paper properties. The print quality is highly dependent on paper properties specifically on its smoothness and absorption characteristics. In this study, the smoothness and absorption properties of different grades of papers are measured. A Bristow tester is used to study ink-paper interaction and drying time at different circumferential speeds. It has been seen that the paper properties have a significant effect on print quality. The study shows that the smoothness and the absorption characteristics of paper affects ink-paper interaction and finally the Image quality of printer.

Introduction

The paper market for ink jet printing has been widely expanded nowadays with rapid growth of ink jet printer. However, a detailed understanding of ink drying and print quality is essential for proper selection of paper. Suitable paper selection and improved paper properties will result in better printability. The complexity of the paper structure, both physically and chemically provide various ways in which an ink jet ink may penetrate through it. The paper properties which have been studied here are smoothness and oil absorption.

One of the most important property of paper affecting print quality is the smoothness which offers the evenness of print. Apart from that, smoothness affects drying time as well as various optical properties of print. There are several laboratory instruments for measuring smoothness. In this study, Bekk smoothness tester is used to measure the smoothness of seven different grades of paper.

The absorbency paper is very important for ink jet printing. Generally, high absorbency tends to drain the ink vehicle into the pores which results in dull ink film. High absorbency is usually associated with a rough paper surface whereas low absorbency, or high ink holdout, gives a smooth and glossy print with better print density. The absorption properties of paper have a distinct effect on the drying of ink and hence a correlation have been found here with drying time and oil absorption.

Ink receptivity of the paper is a function of both paper and ink properties. The surface tension and the viscosity of ink have been measured.

Heilmann and Lindqvist (2000) have shown that the size of the ink jet drop and the high speed dynamic phenomenon of dot spreading and drying are largely dependent on paper properties. They have also reported that the roughness and the orientation of the printing surface had a strong impact on the size and shape of the dot.

The most widely accepted method of measuring ink absorption is Bristow apparatus. Auslander et. al.(1997) has reported sorptive characteristics of commercial aqueous inkjet inks and different envelope. Selim et. al. (1997) measured the rate of penetration by Bristow tester.

In this study, Bristow tester is used to measure the drying time for different grades of paper for different circumferential speed. The optical densities of the print with time have been measured to study how the rate of penetration affect print quality for different grades of paper.

Experiment

In this study, seven grades of papers are taken for assessing the printability of paper. The smoothness of the papers are measured by Bekk smoothness tester. In this tester, the test value is reported in time required for a given volume of air to flow under reduced pressure between the paper surface and a flat polished glass surface that has an area of 10 square cm.. The results are reported in sec/10 c.c.. The oil absorption of the papers are measured by IGT Tester.

The smoothness and the oil absorption characteristics are given in table 1.

The ink-paper interaction is tested in Bristow tester for seven grades of paper.

The paper strip is affixed to the smooth rim of the Bristow wheel. 50 microlitre of the ink is then injected across the slot of the applicator evenly. The applicator is lowered onto the paper, allowing it to exert the required pressure. The wheel is then allowed to rotate at a specific speed. After the test fluid band is complete, the applicator is

lifted and the paper is removed carefully. The length and the width of the ink band at several locations are then measured to calculate the amount of liquid sorbed per unit area and the drying time. The experiment is done at different circumferential speed of the Bristow wheel. The speed of the wheel are chosen from 0 to 100 mm/sec. which simulate the speed of currently available ink jet printer.

Surface tension and viscosity of the ink used is measured.

The densities of the test samples are then measured by Macbeth densitometer RD918 to assess the print quality.

Result and Discussion

The smoothness and oil absorption has been given in Table 1 for the seven grades of paper.

Table 1. Properties of Different Grades of Paper

Sample	Bekk Smoothness (sec/10 c.c.)	Oil Absorption (1000/mm)
Paper 1	42	24.7
Paper 2	56	20.2
Paper 3	62	18.5
Paper 4	75	16.8
Paper 5	84	14.4
Paper 6	90	9.6
Paper 7	115	7.5

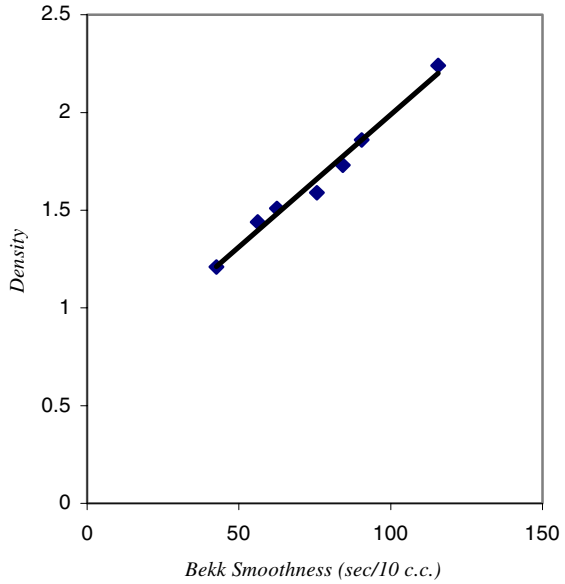

Figure 1. Effect of paper smoothness on density

The viscosities and surface tension of the water-based ink jet ink has been measured and the results are given in Table 2.

Effect of Smoothness on Print Quality

The print density of the papers are plotted against the smoothness of paper in figure 1. It has been seen from the figure that as the smoothness increases, density increases.

Very high correlation coefficient (0.94) between density and smoothness indicated strong dependence of print quality on paper smoothness.

Effect of Oil Absorption on Print Quality

Since the drying of ink is mainly controlled the drying time is plotted against oil absorption in Figure 2. From the curve, it has been seen that the drying time reduces as the oil absorption increases. After the impact, there is immediate dot spread on all grades of paper. The dot spread is more for paper having higher absorbency. The dot size has a very significant effect on drying. Absorption drying is dependent on the pore volume of the surface. Smaller drops dry faster than the bigger drops due to less amount of solvent per unit area.

The correlation coefficient obtained between drying time and oil absorption is very high (0.93).

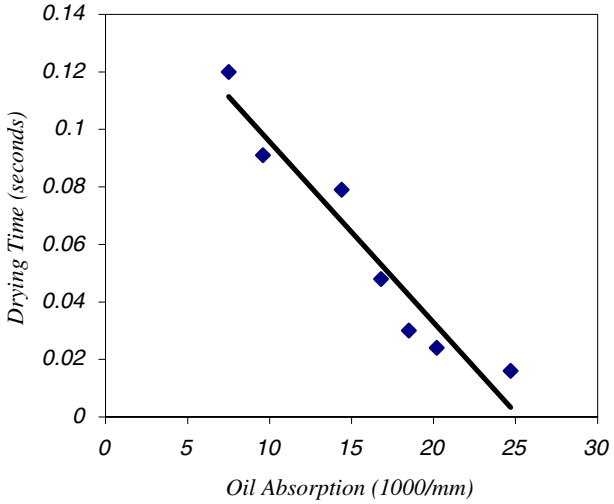

Figure 2. Effect of oil absorption on drying time

Table 2. Properties of Water-Based Ink Measured

	Viscosity (cp)	Surface Tension De Nouy (dynes/cm)
Ink	2.85	52.7

Effect of Speed on Drying Time

The drying times of the ink are measured for the seven different grades of paper at circumferential speed varying from 0 to 100 mm/sec.. The results are plotted in Figure 3. It has been observed that the drying time is decreased as the speed increase. The drying time is increased for increasing smoothness. The dot grows rapidly on paper having lower smoothness and higher absorbance as the speed increases. It has been found that if the impact speed is high, the dots

spread over a large area and a smaller amount of liquid spreads by absorption. Generally, bigger dots spread more effectively for absorbent papers for larger amount of solvent per unit area. From the curves, it has been observed That the change in drying time with speed is more evident for papers having higher smoothness values.

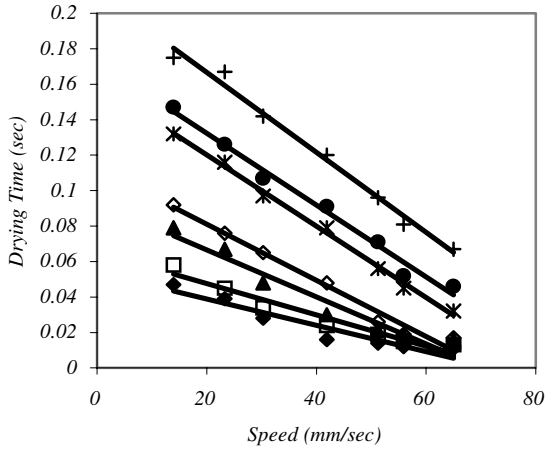

*Figure 3. Print density as a function of time for different grades of paper. ◆ paper 1; □ paper 2; ▲ paper 3; ◇ paper 4; * paper 5; ● paper 6; + paper 7*

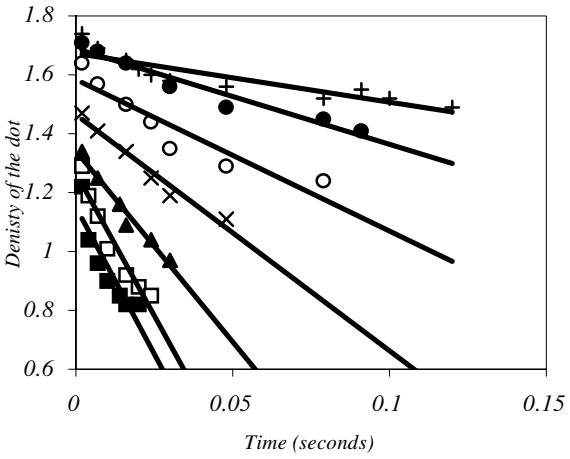

Figure 4. Print density as a function of time for different grades of paper. ■ paper 1; □ paper 2; ▲ paper 3; × paper 4; ○ paper 5; ● paper 6; + paper 7

Density as a Function of Time

The density of the dots are plotted against time from impact for the seven grades of paper in Figure 4. From the curves, it has been observed that the densities of the dots are much higher for Paper 6 and Paper 7 in comparison to Paper 1 to Paper 5. Density decreases at faster rates for papers having lower smoothness and higher absorbency. This is due to the fact that the rate of penetration is much higher for rough papers. The change of density with time is much less for Paper 6 and Paper 7 for lower rate of penetration. Since those papers are coated, the absorption of colorant is minimum for these papers which offer higher density. The densities of the dots are low for papers having lower smoothness and higher absorption characteristics. The colorants penetrate into the fiber structure due to the large capillaries of papers having higher absorption values. Comparatively smaller and rounder dots are produced for less absorbent paper because of small and even spreading.

Properly coated papers offer lower absorption and thus higher print density. But the drying time of the coated papers are much higher. Pigment and other special coatings reduces the dot spreading and its speed and thus the absorption can be controlled effectively. Pigment coating absorbs the solvent rapidly and leaves the colorant near the paper surface. Thus it offers smaller dots of higher density.

The final density of the dots are controlled by ink-paper interaction. The highest density of the dots is controlled by the tonal characteristics of the ink. But the paper properties, have a significant effect on it. Higher absorption values reduce the density as well as gloss of the print. High density levels are achieved with specially coated papers.

Conclusion

The smoothness and absorption properties of different grades of papers have been measured to study the effect of the properties on print quality. The paper properties have very significant effect on drying time and print quality of ink jet printer. It has been found that higher smoothness offer better print density by controlling size and shape of the dots. The absorption values have a strong impact on drying time. Higher absorption values offer less drying time with a very high correlation coefficient. The densities of the dots are higher for papers having higher smoothness and lower absorption values. The densities of the dots are reduced to a larger extent for papers having higher absorption characteristics in comparison to papers having lower absorption values. Increasing printing speeds improve drying time to a great extent.

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Biography

Dr. Swati Bandyopadhyay received her B.E. degree in Chemical engineering from Jadavpur University at Kolkata, India in 1987 and Ph. D. (Engg.) from Jadavpur University in 1995. Since 1990, she has worked as a lecturer of Printing Engineering Department in the same University. Now she is working as Reader of the department. Her work is primarily focused on image quality of ink jet printer and color theories. She is a member of IS&T and IIChE.