Paper Design Characterisitics for DOD Ink Jet Printing at Medium to High Resolution

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Abstract

Increase in dot resolution at smaller drop volume requires an adjustment of paper characteristics of both coated and plain papers for best print quality in drop-ondemand (DOD) ink jet printing. For coated papers, the paper coating is required to provide a suitable spread factor for both text and full color printing, and without ink bleeding between adjacent full color areas. For plain, uncoated papers, the ink penetration rate determines their suitability for color printing. Rapid penetration creates better print definition at expense of color saturation. Slow penetration creates print graininess with the possibility of inadequate ink uptake at increased dry times.

From a paper perspective, it is clear that paper sizing treatments are key design characteristics to consider for the suitability of plain paper for ink jet printing. Acid-made, rosinsized paper brands are less likely to provide adequate print quality for full color printing. Testing reveals that alkalinemade, synthetic-sized paper brands generally will offer better print quality if treated with limited amounts of water resistant chemicals. The use of modern sizing application methods, using surface size treatments, could provide further progress in plain papermaking for ink jet printing.

Introduction

Lately, full color drop-on-demand (DOD) ink jet printers have become available that print at a resolution greater than 300 dpi with a relatively small drop volume (<100 pl). While this creates improved print quality with brilliant color rendition for full color prints, it also changes the requirements for the paper substrate in both full color printing using coated paper and in text and spot color printing using plain papers. This paper examines some of the paper requirements for both text and color printing for one of these printers (IMB Color Jetprinter PS 4079).

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Experimental

Paper Choice and Print Pattern

In view of the limited guidelines available for choosing media for ink jet printing[1], a wide variety of available coated and plain papers was printed up using an IBM Color Jetprinter PS 4079. The coated papers were those designed for mk jet printing[2], including that developed for the machine. The plain papers were primarily ofthe type used in the office environment and particularly those available for copying and printing (the xerographic paper grade).

Both paper nature and print pattern affect the printed output. That is, one paper type chosen for one print pattern may or may not be acceptable for another print application. Consequently, a wide variety of print patterns was chosen for trial printing. These included the test patterns loaded in the machine as well as full color print-outs from available graphic programs. All print evaluations were subjective ones done by observers trained in print evaluation of both color ink jet images and text requirements for office and business printing.

Laboratory Characterization

Standard paper characterization for, for example, surface smoothness and porosity, was carried out according to TAPPI procedures. As it rapidly became clear, and in accordance with the experience of others[3], these were not major functional paper parameters for print quality characterization in ink jet printing and, therefore, they were not done for the complete sample set. However, all plain paper samples were characterized as to papermaking process (acid versus alkaline/ neutral) and ability to retain water on the surface by drop testing using inks or plain water. Two paper brands had previously been characterized using the dynamic penetration procedure originally developed by Bristow[4]. The quantitative uptake of different glycolwater mixtures was measured using a Noram Paprican Bristow Tester[5]. Colorimetry evaluation of selected papers was carried out using a Minolta Chroma Meter CR-200.

Results and Discussion

Coated Paper

All commercially available coated papers tested were found to generate print quality differences from that of the paper developed for the printer. Most predominant ones were ink accumulation on the paper surface at heavy ink application (see plain paper, in the following) and heavy print character definition due to inappropriate spread factor (1) for the paper tested as seen in Figure 1. Also affected were the color characteristics and "graininess" of full color areas.

At present, coated papers are formulated for specific printer and ink combinations. The paper for the printer used in the present study is no exception.

```
========== Current Settings ==========
   Printing Mode =  MODE-A
    Country Code =  ENGLISH
    Media Select =  NORMAL PAPER
       Dump Mode =  DUMP OFF
======================================
========== Current Settings ==========
   Printing Mode =  MODE-A
    Country Code =  ENGLISH
    Media Select =  NORMAL PAPER
       Dump Mode =  DUMP OFF
======================================
```

Figure 1. Heavy Print character Definition (top) versus Desired Print character Definition (bottom).

Plain Paper

While differences in print quality exist for nearly any plain paper brand tested, one significant one is the ability to create transfer of ink from the paper surface within the time frame of printing. Ink accumulation there would generate bleeding between adjacent full color areas, varying print graininess as shown in Figure 2, and increased drying times affecting paper handling when printing up multiple sheets. We behave that the paper sizing treatment affected by the papermaking process (acid versus alkahne/neutral) plays a significant role in whether or not adequate ink transfer is created at the fast-time interval of ink jet printing. For a subset of 27 paper brands tested with the same print pattern,[2] alkaline made papers showed minimal graininess, 9 acid and 7 alkaline/neutral were average to good and 6 acid and 3 alkaline/neutral were unacceptable. The papers can be further differentiated by simple drop testing using water. Those that permit relatively fast water penetration are candidates for less graininess and those are more likely to be alkaline-made and synthetic-sized.

Testing using a dynamic penetration tester like a Bristow device[4] or similar fixture[6] provides a quantitative measure ofthe liquid uptake during the fast time interval of ink jet printing. For one of the acid-made, rosin-sized papers, the liquid uptake would vary as shown in Figure 3 when tested with variousglycol-water mixtures[5]. This contrasts with a much faster uptake for an alkaline made, synthetic-sized paper when tested with glycol-water mixtures of relatively high water concentration like that used for the printing ink formulations (Figure 4).After some what similar uptake in the very short time frame, the liquid sorption into the synthetic-sized sheet structure is much more pronounced (Figure 5).

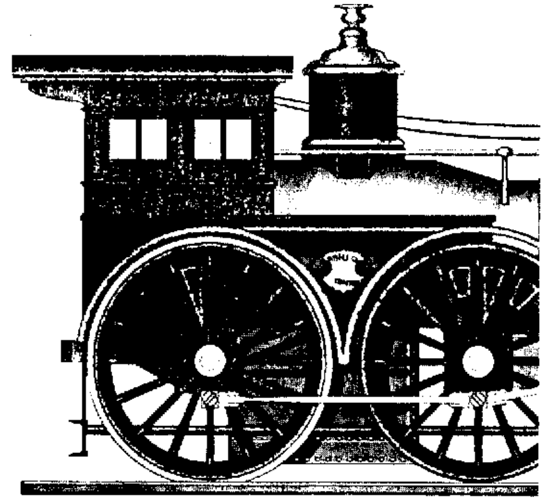

Figure 2. Print Graininess of Full Color Areas.

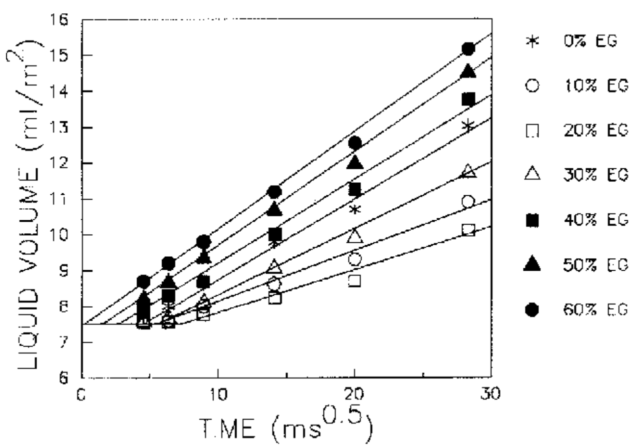

Figure 3. Penetration Mode for an Acid-Made, Rosin-Sized Paper (Ref.5)

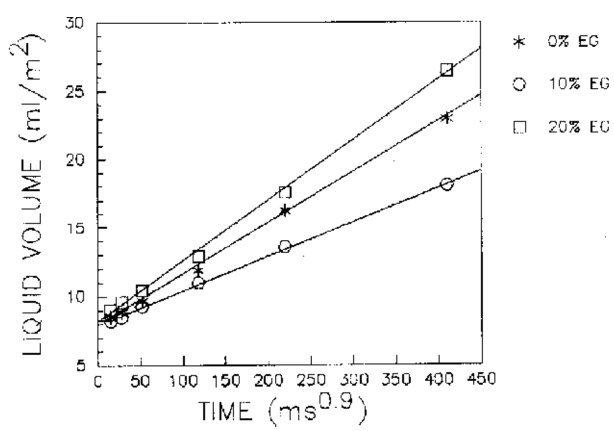

Figure 4. Penetration Mode for an Alkaline-Made, Synthetic-sized paper (Ref 5).

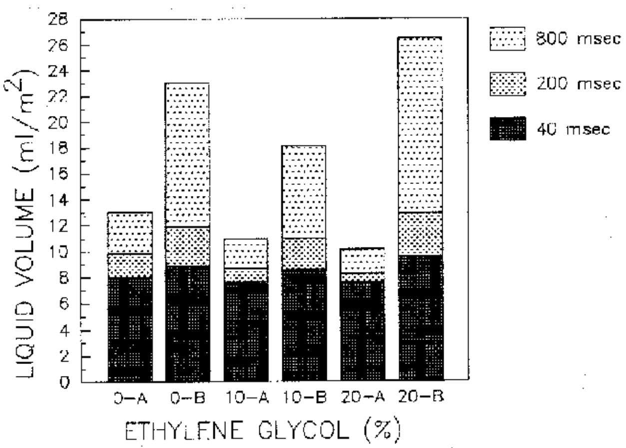

Figure 5. Liquid Sorption of the Rosin-sized sheet (a) Compared to that of the synthetic-sized sheet (b) (from Ref. 5)

Replotting Figure 3 in the format shown in Figure 5 for the complete glycol-water concentration range provides more insight into the fast-time absorption process and the effect of paper sizing. As shown in Figure 6, the liquid uptake decreaseswith an increase in glycol concentration up to 20%. Beyond this value, the absorption rate increases with concentration. We believe that this reversal is caused by better fiber wettability when the glycol content is increased similar to what would be encountered for a fast-time sorption process of mainly capillary nature[5].

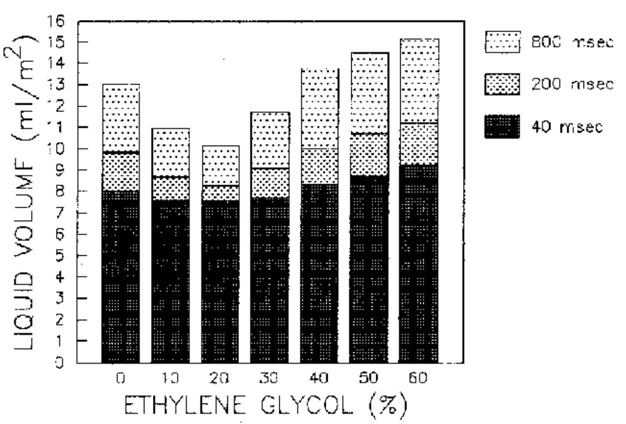

Figure 6. Liquid sorption of the rosin-sized sheet for any glycol water mixture (from ref. 5)

However, the increased absorption rate, that creates less print graininess at faster drying time, is not without expense of other print characteristics. As for previous print quality studies[3], text character printing deteriorates (Figure 7). Character definition is more ragged and may not be acceptable when text is interspersed with graphics in the final page print-out. Also, color rendition changed compared with that of the coated paper (Figure 8). For most of the papers tested, these print changes were less significant than the benefits achieved in creating better spot and full color definition, but, of course, it is up to the end user to judge the trade-offs and benefits for his application.

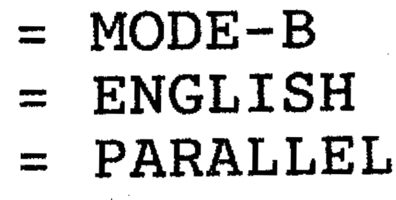

Figure 7. Ragged text character definition due to fast penetration rate.

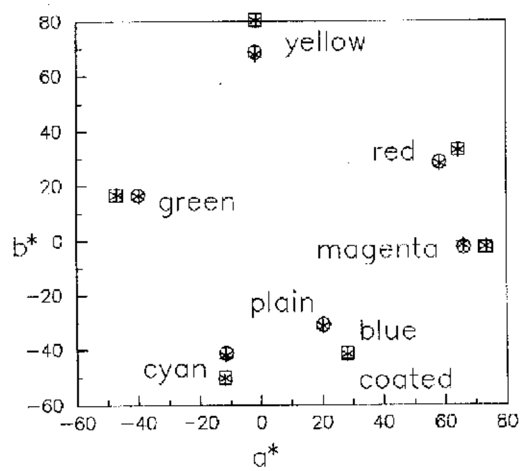

Figure 8. Color definition of a plain paper compared to that of the coated paper.

Our recommendations for the paper makers, that want to pursue the opportunities that exist in plain papermaking for generating office and business papers suitable for ink jet as well as other printing applications, are to study the ink interaction with sizing chemicals in more detail to develop improved paper products for non-impact printing including ink jet usage.[7]

Conclusions

- DOD inkjet printing at medium to high resolution creates a dependency on paper choice (plain *and* coated) similar to *that* for previous ink jet products.
- The printer needs a unique coated paper product for optimum print quality.
- Plain papers create a very significant variation in print quality that mainly is related to the papermaking process, that is, the paper sizing treatment. Slack sized sheets (papers treated with limited amounts of sizing chemicals) better transfer ink from the paper surface at adequate drying times. These papers are more often alkaline-made and synthetic-sized. However, the better definition of color print areas may be achieved on expense of text definition.

References

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