Surface Treatment to Improve Print Quality on Recycled Paper

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Abstract

Recycled paper has been commercially introduced to the market for more than 30 years, and it has been more than 20 years since the first brand of recycled paper was introduced for use in high speed copiers. It has achieved a growing importance in the past few years, related to a new wave of public perception of recycled paper as being more environmentally friendly. However, there are usually some users-perceived setbacks in the quality of recycled paper. These are often related to fiber qualities, such as runnability, longevity of the printer, opacity (affecting strikethrough or see through on double-sided printing), mechanical properties and edge quality.

This paper discussed the impact of various paper properties to attributes of print qualities. An improvement in print quality has the potential to drive more usage of recycled paper.

Background: Recycled Paper

Paper is defined as a felted sheet of usually cellulosic fibers laid down on a fine screen from a water suspension (Webster). Throughout the decades and years, paper making evolves and adapts to the demands from the society. From chemical recovery, optimization in energy and fresh water usage, to compliance to environmental regulations, we see paper manufacturing's evolution from how it first started in mass production of paper.

Recycled paper is made of a mixture of post-consumer waste paper, recycled paper from rejects within the mill and/or converter waste that never got shipped to customer as finished paper products, or pre-consumer waste (trims, make ready and overs from printers), and may also contain virgin fibers. The recycling process involves repulping, deinking, and feeding the repulped stream into the paper-making process to produce recycled paper. In the repulped stream, there can be any % of post consumer waste in it, this information is contained on the packaging of the recycled paper to inform customers of their choices.

The concerns with recycled paper are usually around the fiber qualities. However, increasing demands and improvements in technology have been perfecting the recycled paper quality, as well as driving the cost to be in the same range compared to virgin fiber paper.

There is a stream of constant discussions about whether recycled content is correlated to paper qualities. Some users reported no difference between recycled paper and paper from virgin fibers, some users reported problems with certain brands of 100% Post-consumer paper, while some others are plainly skeptical about recycled paper. A snapshot of current perceived setbacks related to recycled paper[1] is as follow:

1. Recycled paper jams more than 100% virgin paper.
2. 100% postconsumer paper caused more dusts and wore out rollers faster.
3. Some recycled paper brands contain sticky contents that led to contamination of photo receptors in copiers/printers.
4. Problems were more common with 100% post consumer waste paper than with 30% post consumer content.
5. Some recycled paper brands perform better than others.

In this paper, we report a summary of ColorLok$^{(R)}$ technology's improvements to recycled paper quality, and its potentials to increase utilization of recycled paper.

Materials and Methods

The paper substrates used for this study are common multi-use papers available in retail and from paper distributors. The printers are commercially available printers available in retail and from distributors.

List of paper substrates:

HP Office Recycled 20lb. 75gsm (with ColorLok$^{(R)}$**)**

Evolve Everyday Recycled 80gsm (with ColorLok$^{(R)}$**)**

Copamex Cappucino Natural Bond 100% recycled (with ColorLok$^{(R)}$**)**

Staples Multipurpose Recycled 24lb. 90gsm

Office Depot Recycled Envirocopy 20lb. 75gsm

Staples Multipurpose Recycled 28lb. 105gsm

Aspen 100 premium recycled 20lb. 75gsm

Staples copy paper 30% recycled 75 g

Staples copy paper100% recycled 75 g

Hammermill Great White copy 20lb. 75gsm

New Leaf 100% Recycled Copy Paper 20lb. 75gsm

Exceedo Premium recycled 20lb. 75gsm

Steinbeis copy laser inkjet 100% Recycled 80gsm

List of printers:

HP OfficeJet Pro 8500
Epson WorkForce 610
Brother MFC 990
Lexmark Interpret S405

Print quality-related testing is evaluated based on prints from original file in text documents (Word format) and test plots as TIFF images, printed using the default printer settings for plain paper.

Optical density (KOD) of the test plots is measured using an XRite 938 spectrodensitometer set to Status T. Strikethrough used the XRite 938 set to reflectance with Illuminate A/2 degrees. A

simplex printed test plot with a black solid area was placed print side down on a white backing. Reflectance readings are taken on the back side of the paper in an area with no printing and in the area with solid printing. Strikethrough is calculated as the reduction in reflectance, normalized to the paper reflectance, $(1-(R_{solid\ area}/R_{paper})) \times 100$.

The line raggedness was measured on printed text. Measurements are made with a PIAS II from Quality Engineering Associates. The PIAS II is fitted the high magnification head. Raggedness calculated using ISO-13660. The reported figure is the average of the leading and trailing edge.

The red saturation (a measure of color richness) is calculated from L, a, b color readings of red solid fill area (100% M + 100% Y), Color measurements are made with the XRite 938. The reported figure is the color space volume in L, a, b color values.

Hercules Size Test measure the time for a water based dye solution to penetrate through the paper. The test used 10 ml of the standard Naphthol Green B dye solution and Formic acid. End pint is set to 80% reflectance.

Paper physical properties measured using ISO methods at 23^{O}C and 50%RH.

Correlation between Paper Properties and Print Quality

We examined various paper properties in previous studies, looking for correlations between print quality and paper physical properties, such as smoothness, sizing level, and opacity. In the past, paper properties showed a strong correlation with print quality. However, in this sample population for our study on recycled paper; we did not see strong correlation between paper physical properties and print qualities. An example is showcased below.

In Figure 1, sizing level is plotted against the black optical density from printed area. Sizing level is measured with HST method, and presented as the time taken for the detector ink to travel from one side to the other side of the paper (in seconds) - the longer the time, the stronger the sizing level.

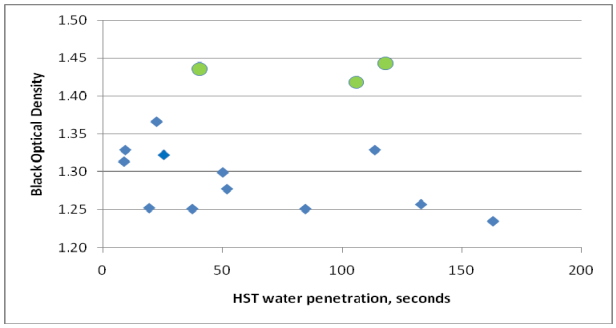

Figure 1. Sizing level (HST penetration time, seconds) vs Black Optical Density. ColorLok® paper brands are noted with green circles.

From Figure 1 above, we could see that there is no strong correlation between sizing level (HST) to Black Optical Density. The only correlation shown is between ColorLok® treatment (data points labeled with green circles) and black optical density. ColorLok® clearly delivered a strong impact on paper print optical density. ColorLok® brings improvements across the board, regardless of the sizing level. Paper samples carrying ColorLok® showed the highest optical densities, no matter whether their sizing levels are low or high or very high,

Examining further into print quality improvements from ColorLok® treatment, results showed that recycled paper treated with ColorLok$^{(R)}$ shows a great improvement in optical density and color richness of printed area, due to better ink holdout on the surface. In addition, the ColorLok$^{(R)}$ treatment improves the line acuity, the sharpness of printed lines. The summary is shown on the following graphs in Figure 2 through 4.

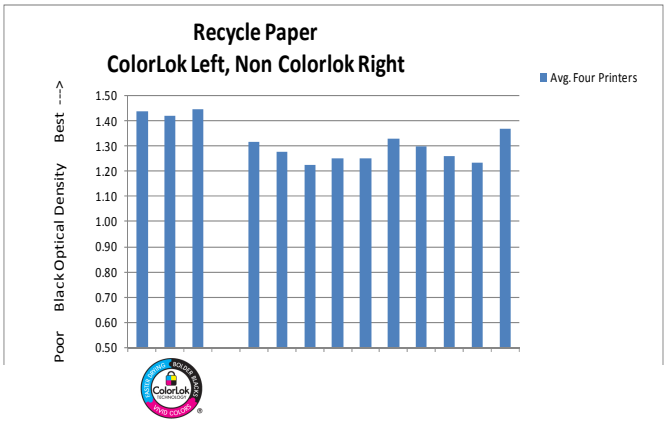

Figure 2. Improvement from ColorLok$^{(R)}$ treatment for optical density

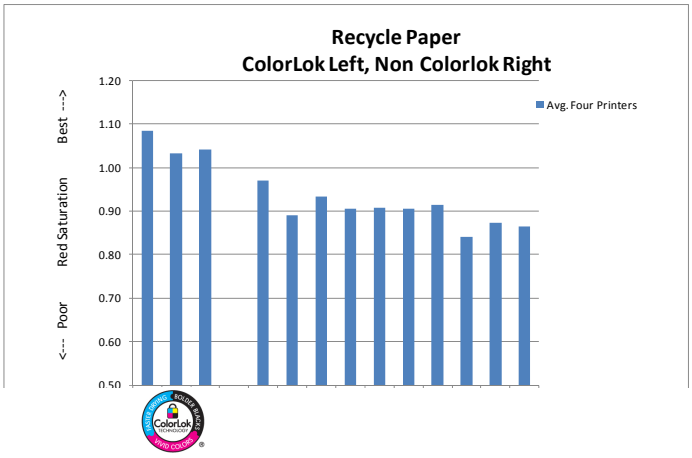

Figure 3. Improvement from ColorLok$^{(R)}$ treatment for color richness

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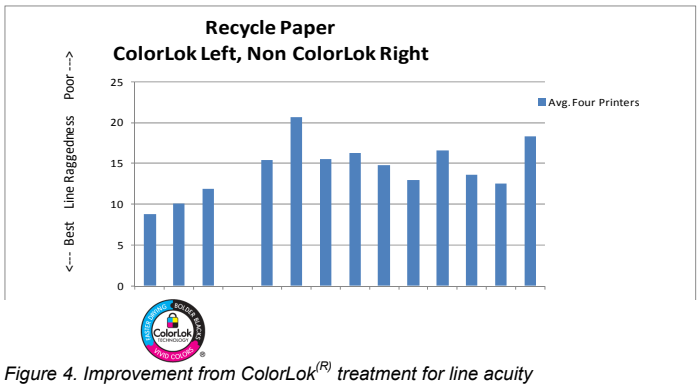

Figure 4. Improvement from ColorLok(R) treatment for line acuity

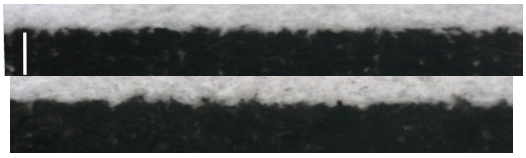

Figure 5. Micrograph of printed lines with different line acuity. Top: 10 um raggedness. Bottom: 15 um raggedness. Length of measurement bar is 0.5 mm

The results showed that recycled Paper with ColorLok(R) displayed excellent color richness, black optical density, better line quality/crisp black text, significantly improved from the recycled paper without ColorLok(R) treatment.

ColorLok® and Recycled Paper Print Quality

Our study showed a strong correlation between paper treatment with ink fixative and the improvement in print quality in recycled paper. ColorLok(R) treatment improves print quality in recycled paper significantly, especially in areas related to ink hold-out and ink fixation, such as optical density, color richness, and line acuity.

ColorLok(R) standard safeguards the quality of paper brands carrying this logo, because the standard includes both print quality and runnability issues. The same set of ColorLok(R) specifications applies to both 100% virgin paper and paper containing recycled fiber. As long as a paper product carries a ColorLok(R) logo, consumers can be sure that its quality meets the ColorLok(R) standard, regardless of the levels of recycled fiber in the paper product.

References

[1] The Environmental Paper Listening Study, http://www.PaperListeningStudy.org, 2003.

Author Biography

Gracy Wingkono *graduated from Georgia Institute of Technology with a PhD in Chemical Engineering. She started her career with HP at the end of 2007 as Media R&D Engineer. She has been working with treatments uncoated paper and development of coated paper for High Speed Inkjet Webpress.*

Thomas Oswald's *career spans working on impact printing paper and carbonless coating to the newest non-impact printing systems. He has developed process for polymerization and coating of emulsified adhesives used in office note pads. New product experience includes security papers and print features. Tom now focuses on the measurement of paper properties and how they affect reliability and print quality of office printing.*

John Stoffel *began his career at HP with projects involving plasma enhanced vapor deposition of silicon carbide, silicon design, printhead construction, and ink formulation for PaintJet, HP's first color ink jet device. After PaintJet was successfully introduced, Stoffel directed his efforts primarily to ink formulation, becoming a Senior Member of the Technical Staff in 1991, a Project Manager in 1993, and the Hewlett Packard Ink Jet Ink Technology Manager and Master in 1998. As a member of special product development teams at HP, he took part in the creation of the first color ink jet inks for HP printers; the first pigmented black ink jet ink, the black ink used in the HP 45 cartridge, and, the first six color set of ink jet photo inks. John Stoffel holds over 28 patents relating to ink jet ink, media, and printhead design.*

In 2005 he was promoted to Distinguished Technologist. His responsibilities included managing Hewlett Packard's inkjet ink technology roadmap and investments. In 2005, John led the HP team that worked with International Paper to introduced ColorLok media across HP Everyday Paper. In 2007, Stoffel moved to the HP Media supplies and Solutions Division as the position of Director of Research and Development. Under his leadership, groundbreaking photographic media for retail photo printing and coated media for HP's web press were developed. In 2010, John moved to provide technical support for both ink and media roadmaps and investments.