Managing the Variable Characteristics of Inkjet Substrates for Profitability

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Contents:

finch

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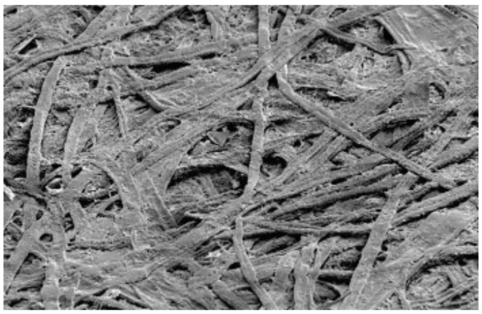
Wasn't it amazing to learn that the greater – much greater – portion of an iceberg can't be seen, because it's under water? There's so much more to these magnificent monoliths than meets the eye.

People frequently react with similar wonder when they learn how much lies "under the surface," if you will, of a sheet of paper.

Paper

Paper is a stochastic network of wood fibers that are combined in the papermaking process. Since the fibers are much longer than the thickness of the paper sheet, the network is more or less flattened out, and therefore almost two-dimensional (an x-y plane).

Printing and writing papers normally consist of 5 to 20 "layers" of fiber. The two-dimensional structure governs many paper properties, including dimensional stability, surface strength and printability.



350 × 224 - Scanning electron micrograph of the surface of normal office paper. Note the various void areas between the fibers, which need to be filled in order to provide consistent print reproduction.

In the graphic arts industries, paper is the most commonly used substrate across all printing technologies, from offset lithography to dry toner production. The properties of the paper substrate are important not only because the substrate is visible between the printed areas, but also because the substrate defines the background reflectance for the ink layer. Moreover, variables such as optical properties, mechanical properties and permeability to liquids directly affect image quality, productivity and price.

For example, by adding fillers such as kaolin clay or precipitated calcium carbonate, one can increase the opacity of the substrate, which will reduce show-through for better overall legibility and color quality.

Once customers understand the variable characteristics of paper, they can start to appreciate how advantageous it would be to control variables to meet application, budget, production, and client requirements.

The Finch Paper Advantage

The paper manufacturing industry is, by and large, inherently not flexible. It is a large, capital-intensive industry that focuses on optimizing operational efficiency to obtain profit. This results in standardized products that are homogenized by paper manufacturers for use across multiple print platforms.

Conversely, customization and tailored solutions are historically absent from the papermaker's vocabulary. The onset of digital print technology, however, brings a host of new variables including heat, water and colorants (i.e., ink or toner.)

Finch Paper recognizes that, as our industry migrates to the digital platform, customizing paper substrates will be essential to minimizing total cost of operation (TCO) and maximizing a printers' ROI.

Finch puts customers in the driver's seat. They are, more than ever before, able to define solutions that precisely meet their quality, service, and budget requirements.

By discerning how pigment or dye-based inks affect production results on high-speed inkjet systems, Finch will help industry professionals understand how customizing paper formulations can yield significant, positive quality and cost advantages in a digital print environment. The following sections provide such an overview.

The Rise of Inkjet

The rise of production inkjet printing poses new challenges to paper manufacturers. Having mastered the engineering for dry-toner printing – which relies on pressure and extreme heat – paper scientists are forced to rethink everything in regard to inkjet. That is because inkjet printing relies on ink particles that are sprayed onto the paper without any contact between the paper and print heads – a process that dictates paper formulation changes from that of offset lithography and electrophotographic printing. In addition, inks formulated for high-speed inkjet production contain over 90% water, yet must dry immediately for down-stream finishing.

Inkjet Printing
Inkjet printers shoot ink particles at the paper. Inkjet ink, unlike toner, is liquid—though some modern machines use solid ink that is liquefied only at the point where it is ejected from the print heads. Inkjet is the fastest-growing area of digital printing, with the growth of wider format printers substantially increasing the potential of inkjet in commercial print applications.

Inkjet Ink

The main components of ink are colorant and carrier fluid. The colorant can be a pigment or a dye, while the carrier may be water, solvent, or oil-based. Other chemical additives are added to the formulation to improve the ink's usability and rheological (flow) properties. For example, surfactants control the surface tension of the ink droplet and the behavior of the drop on the substrate; binders improve the elasticity of the ink; and dispersants aid the dispersion of the colorant in the carrier fluid. (Xaar 2010)

In most cases, inks are described in terms of their carrier fluids (90% of the time it's water), but in others the naming is based on their properties. Some examples include aqueous inks, solvent inks, oil-based inks, UV inks, hot melt inks, and latex inks.

The following table compares ingredients found in both pigment and dye aqueous inks:

Dye Aqueous Based Ink Jet Inks
Azo dyes or substituted azo dyes **Deionized Water** as a carrier solvent **Surfactant** to lower surface tension of the ink and improve droplet formation. Other organic solvents to lower the rate of evaporation of water, change the boiling point in the ink-jet and minimize clogging. **Humectants** such as glycerin to prevent drying out of spray nozzles. **Biocide** to prevent spoilage and inhibit growth of undesirable microorganisms in delivery systems. **pH modifier** to adjust pH of the ink for stability. **Corrosion inhibitor** to improve the lifetime of the inkjet press. Examples of formulations are given in US Patents: 5,624,485; 7,887,627; 7,833,335

Pigment Aqueous Based Ink Jet Inks
Inorganic pigments carbon black is mainly used for the black pigments. **Organic pigments azo** pigments, phthalocyanine pigments, quinacridone pigments, isoindolinone pigments, dioxazine pigments, threne pigments, perylene pigments, thioindigo pigments, quinophthalone pigments and metal complex pigments. See example patent below. **Deionized Water** as a carrier solvent **Dispersant** to keep pigment in suspension is very critical for shelf life of inkjet dyes. **Surfactant** **Humectant** **Biocide** **pH modifier** **Corrosion inhibitor** Examples of formulations are given in US Patent 7,799,123

Source: I.T. Strategies, Inc.

Dye-based inks are comprised of 10 or more ingredients, consist of small particles (1.5 to 4 nanometers) that are water soluble, and have a larger color gamut than that which can be achieved by pigment inks. The dye-based paper treatment is cationically charged, which promotes water fastness, shade, brightness and porosity control. On the downside, the smaller molecules cause some of the dyes to follow the water into the base of the sheet, producing a lower optical density. Scientists battle this problem with paper surface treatments that are more complex than those that are used for pigment. In the case of anionic aqueous inkjet dyes, the treatments must be sufficiently porous to allow the water to travel to the base, while fixing the water-soluble dye molecules by crystallizing them at the sheet surface. Additionally, dye-based inks are prone to degradation from light and ozone.

Pigment inks typically contain fewer ingredients and consist of large particles (50 to 200 nanometers) that are tightly packed together and held in a suspension (pigments are, by definition, insoluble). As soon as a pigmented ink droplet hits the substrate surface, the pigment particles are immobilized as the carrier (water) travels into the base of the sheet. Pigmented inks produce a higher optical density than dye-based inks because the particles are too large to be absorbed. The particles sit on the surface of the sheet while the water is absorbed into the base of the sheet. The pigment inks have a narrower color range than dyes, but they tend to be more resistant to fading from light and ozone.

Tom Ruch, Finch Director of Technology and Development, says the challenge to getting good printability on dye-based systems lies in achieving a "quasi-coating" with the correct micro-porosity. "The micro-porosity allows water to drain into the center of the sheet and leave smudge-free, sharply defined color on the surface. This optimization of the surface is something the industry at-large has struggled with," Ruch says, adding that "pigment-based colorant requires surface chemistry to provoke separation of the vehicle from the pure pigment."

As customers become more comfortable with increasingly sophisticated digital print technologies, their expectations for higher-end capabilities, such as color, will grow. It's therefore especially important, Finch believes, for everyone – ink scientists, original equipment manufacturers, print providers, etc. – to be aware of the significant substrate differences that are necessitated due to the distinctions between dye-based and pigment inks.

Says Finch Senior Product Development Engineer Peter J. Veverka, Ph.D., "The unique paper formulations for dye-based and pigment ink systems will optimize press performance and color density. Print providers using a standardized substrate are either under-optimizing or over-optimizing the paper in the quality/cost equation.

"Finch has given its customers a clear differentiation to maximize performance on their equipment," Veverka adds.

Dyes	Pigments
Soluble organic colorant. - Generaly not waterfast. - Easier ink formulation.	Insoluble colorant. - Generally waterfast. - Requires dispersion.
Monomolecular chromophore. - Brighter colors.	Groups of chromophores. - Decreased scattering. - UV stability.
Every molecule contributes to color. - High color saturation. - Potential for high fade with UV exposure.	Only surface molecules interact with light, giving a lower theoretical color gamut.
Penetrates into porous media. - Inks bond to coating components. - Smoother gray scale. - Decreased optical density.	Remains near porous media surface. - Less feathering. Improved optical density and contrast.

Source: I.T. Strategies, Inc.

The Crux of the Process

The success of production inkjet relies heavily on a substrate's absorption properties.
The base paper has to be able to take-up the vehicle, which is usually around 90% water.

Here's how that happens: The base stock is made up of short and long fibers. The short fibers have higher levels of cellulose and hemicellulose to absorb water, which results in better print quality; the longer fibers provide strength and flexibility for downstream folding and finishing applications.

Dye or pigment particles separate from the vehicle, which travels quickly to the base stock for immediate absorption. This is just one of many variables that Finch can adjust to precisely optimize the characteristics required by the customer.

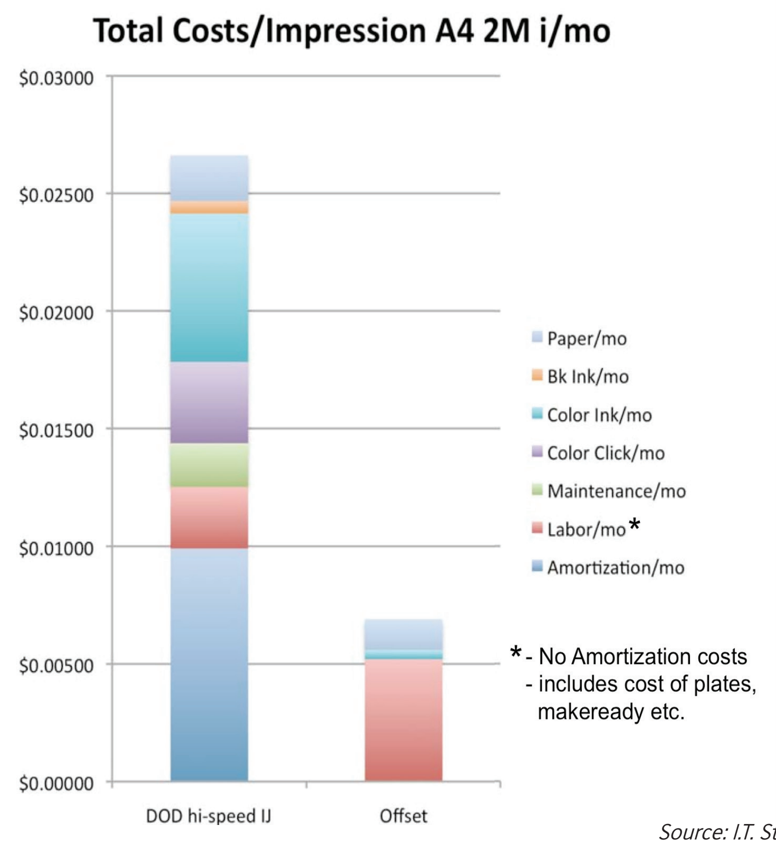
Additionally, the base of the sheet contains many additives, such as calcium carbonate and internal sizing agents, which are also useful in tailoring the paper for its intended use.

The Bottom Line

The point is that by optimizing absorption and ink-fastness specifically for unique print environments, Finch is making it possible for printers to use paper and ink with the highest possible levels of cost efficiency in their individual environments. This is an especially appealing factor when you consider that the ink – and often, bonding agents – contributes nearly 30% to the cost of an inkjet printing job. And the paper contributes only about 10% or less to the cost.

In contrast, paper makes up 30%, and ink 5%, of conventional offset job costs. Printers with a history of offset lithography will need to adjust their cost-saving assumptions accordingly.

Aqueous Inkjet to Offset Components of Cost



Source: I.T. Strategies, Inc.

Why is Finch Able to Do This?

Finch Paper's unique infrastructure is designed for fast, custom-solution development for offset, digital and specialty papers.

A team of Finch's R&D, sales, and operational representatives collaborate with customers, ink manufacturers and OEMs (print engine and system manufacturers) to understand requirements and resources thoroughly.

For instance, OEMs work in concert with ink manufacturers to develop unique ink formulas that work in their respective systems. Their emphasis is on controlling the droplet size, and controlling ink viscosity to prevent clogging in the ink heads.

These OEMs focus on optical density, viscosity and boiling points. The slight adjustments that they make all influence the reaction of the ink on the media. Finch gathers this information in its cooperative work with the OEMs, and combines it with its deep knowledge of the customer's resources and needs (an example is provided on the next page).

Finch offers the quality and cost structure of its vertically integrated operation and renowned service to optimize the customer's specific application, which in turn differentiates the customer in the marketplace.

Custom Solutions Based on Reliable, Foundation Technologies

Finch enters customer relationships armed with this deep knowledge of ink, paper, and how different OEMs engineer their specific systems. By auditing the customer's resources and end-use application, the Finch digital application team can modify the paper formulation variables to satisfy specific needs.

This is where Finch's customer relationship focus comes into play. An example is a Fortune 500 transactional printer, which recently worked closely with a cross-departmental team at Finch and an inkjet manufacturer to satisfy **three** main objectives:

- Ink savings (moving from pigment to dye-based systems),
- Postage savings (moving from 24 lb./60 lb. text to 20 lb./50 lb. text stock), and
- Controlled ink holdout.

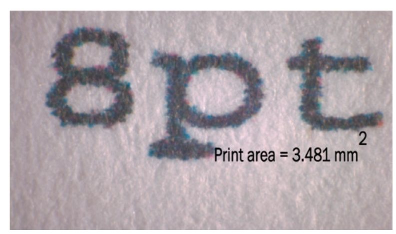
Specifically, the printer wanted to switch from offset lithography to variable data inkjet for transactional statements and was evaluating the differences between pigmented and dye-based inks, in terms of print fidelity and cost. The customer was trying to achieve "more color" on the least expensive paper, using the least amount of ink, and using the least expensive ink system (dye). They also wanted to save postage by using a paper with a reduced basis weight, yet that could retain strength in downstream operations such as folding, perforating, inserting and mailing. However, as basis weight is lowered, the relationship between show-through and image quality has to be balanced.

Essentially, Finch needed to formulate a paper that would control the dot fidelity (dot spread) to the printer's specifications, and fit their budget. By purposely spreading the dots out (i.e., dot gain with lower screens), Finch tailored a solution that met the customer's needs.

This example shows how Finch Paper is truly partnering with inkjet print providers to fulfill their specific requirements, which often include tailored products and/or custom service solutions.

"As production inkjet evolves in the commercial printing space, we fully expect to see applications with more and more color. Having a reliable, optimized substrate will make all the difference for printers to succeed," says Director of Product Marketing Phil Hart.

To learn more, call: 1-800-833-9983 or visit: www.finchpaper.com



By adjusting the surface treatment formula, Finch Paper tailored a sheet to meet specific dot gain requirements for a transactional printer using a dye-based ink system.