Blurring the Line Between Commercial and Industrial Printing

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It sounds so simple: Ink on paper. It's a process that's been around for thousands of years. Yet getting ink to adhere to paper — or any substrate — is actually a somewhat complex chemical and physical process. Paper is easiest material to print on, but even it has adherence challenges, as anyone who has ever has their hands blackened by newsprint can tell you. Those challenges are compounded when non-paper substrates are involved.

The combination of flatbed wide-format printers and UV inks has dramatically expanded the types of materials that can be printed on. Wander the exhibit hall at the SGIA Expo and see a bewildering variety of print applications.

Exhibitors and equipment manufacturers make it look easy, but getting quality output — or any output — on an unconventional substrate is more complicated than it looks. It's not impossible, but it's hardly plug-and-play.

At the same time, technologies enabling specialty graphics printers are also transforming what is known as industrial printing, such that the line between industrial and commercial printing is starting to blur.

Sticky Wickets

A quick, basic primer: Most ink consists of two elements: a colorant, the liquid dye or pigment particles that supply the color, and a vehicle, the fluid that transports the colorant to the substrate. Ink adhesion works by a combination of absorption into the substrate, and evaporation of the vehicle. Uncoated papers more readily absorb ink than coated papers. In most printing processes, the trick is to dry the ink as quickly as possible in such a way that not too much ink is absorbed, which muddies halftones and mutes colors as the fluid ink "wicks" into the paper. Thus paper and ink combinations strive for an optimal amount of ink holdout. Meanwhile, the vehicle needs to evaporate rapidly, especially if the print will be duplexed, finished, or needs to be delivered very quickly. So ink vehicles have typically comprised some kind of volatile solvent. A class of chemicals called volatile organic compounds (VOCs) was for many years the standard for wide-format printing inks, but while VOCs are great for ink drying, they pose health and environmental hazards, so they are gradually being phased out. Eco-solvent inks use milder solvents, and aqueous inks use water as the solvent (a solvent is basically any liquid into which another substance — the solute — can be dissolved).

Most of these inks still require absorption as a key part of the drying process. But what about substrates that, unlike paper, have more impermeable surfaces and don't allow much if any absorption? Enter UV-curable inks.

UV inks dry (or cure) through exposure to ultraviolet light. They are not a new technology, and in fact have been used in web offset printing for decades. Exposure to ultraviolet light — either via traditional mercury vapor or newer, cooler light-emitting diode (LED) lamps — quickly evaporates the ink vehicle and creates a thin polymer film that sticks quite readily to virtually any surface.

Richard Romano, Industry Author

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Fine Dyne-ing

"Virtually" any surface — let's look at it another way. The extent to which an ink will adhere to a surface is a function of the respective dyne levels of the surface to be printed and the ink.

A substrate has a certain amount of surface energy, which is a quantification of the extent to which the molecules on the surface of a material have more energy compared to the molecules "deeper" down in the material. This is described as its dyne level. (One dyne is defined as the amount of force required to produce an acceleration of one centimeter per second squared on a mass of one gram.)

A liquid, such as ink, has a corresponding property called surface tension, also measured in dynes and referred to as its dyne level.

The relationship between a substrate's dyne level (its surface energy) and an ink's dyne level (its surface tension) defines how well that ink will adhere to that surface. If the ink's dyne level is lower than that of the substrate, then the ink will spread out over the surface in a uniform layer, "wetting" the surface and adhering properly. If the ink's dyne level is equal to or higher than that of the substrate, the ink will bead up on the surface of the substrate and thus not lay and adhere properly.

Think of it in terms of your automobile. An unwaxed car has a high surface energy — i.e., dyne level — compared to water. When it rains on your unwaxed car, the rain drops will spread out, form puddles, penetrate into your paint job, and do the nasty things that water does. However, if you apply a coat of wax to your car, the coating lowers the dyne level of the car relative to that of the water. When it rains, the drops will simply bead up and roll off.

The same principle applies to inks and substrates. Plastic, glass, and other non-paper materials have non-porous surfaces with low surface energy, and thus require lower-dyne-level inks, or some kind of surface treatment that will boost the dyne level of the substrate, like wax in the car example.

Newest Industry

UV printing has enabled a veritable explosion of new print applications, both large- and small-format, and has also helped bring digital technologies into the industrial printing and decorating realms, such that there's an increasing amount of overlap between industrial and specialty graphics printing.

"We're looking at industrial printing very heavily," said Larry D'Amico, VP of Digital Imaging for "We're looking at applications like floor tiling and other areas you've referred to as industrial type applications. The volumes are so big, and there are so many manufacturing applications."

"Industrial printing" is an all-encompassing term for a very large number of different print applications. In essence, it's printing that is part of a larger manufacturing process. Unlike commercial printing, where the print itself is the end product, in industrial applications, the printing adds decoration, information, and/or branding to a functional object. Think of brand names on auto parts, the text and symbols on a dashboard, the letters and numbers on a keyboard, the gradations on a medical syringe, the numbers on a TV remote — you name it.

Traditionally, industrial printing has used analog technologies such as screen printing or pad printing, the latter of which uses a flexible silicone pad to transfer a 2D image onto a 3D surface. Pad printing is ideally suited for printing onto manufactured items, particularly what can be called "complex conformable" objects, or three-dimensional shapes. Other analog technologies like waterless offset are used to print cylindrical objects like fast food "Big Gulp" cups, and 360-degree images.

Digital printing has been penetrating into industrial printing for two reasons that will surprise absolutely no one: The ability to do shorter runs, and the ability to personalize and customize printed products. UV inkjet has proven to be well suited for industrial printing applications. However, that doesn't mean that it's not without its challenges.

TransTech is an industrial printer/decorator that prints a bewildering variety of materials for verticals that include ad specialties (keychains, sporting goods, and other tchotchkes), household appliances, automotive, medical and pharmaceutical, and electric and electronics. Companies like TransTech have been greatly enabled by UV printing, but have unique needs compared to commercial printers. As a result, when the company was investigating flatbed UV inkjet equipment, they were so dissatisfied with the current offerings that they decided to design and construct their own flatbed printers.

"Most of the existing graphics solutions are designed for very specific substrates," said Chris DeMell, technical sales

manager, digital, for TransTech. "We had the challenge of having to print on steel and glass."

It wasn't so much the issue of ink adhesion (about which in a moment), but fitting larger objects through the mouth of the printer. Even industrial quality flatbeds only support objects that are so thick.

But thin substrates can also be a challenge. "Sometimes the vacuum [on a flatbed printer] can't be adjusted and you can actually see the vacuum holes on extremely thin substrates," said Agfa's D'Amico. "That can be an issue."

Then there are uneven surfaces. "Uneven surfaces are huge," added D'Amico. "On just about every machine out there, the customer is responsible for their own [print]heads. If they use a thicker material that's uneven and they get a head crash, that can be thousands of dollars to replace those heads."

UV's Sticking Point

The most significant challenge is that, despite all the hoopla about how "UV inks can print on anything," the footnote to that statement is that not all UV inks are the same. Users expecting to buy a single printer and a single inkset and immediately begin printing on everything under the sun are going to be sorely disappointed.

"There is no magic bullet," said DeMell. "There are too many different substrates." One single ink will not be compatible with every substrate, and many UV ink formulations are very specific to a given substrate — remember the earlier conversation about dyne levels. Different substrates, especially non-paper ones, will have different dyne levels, which may be higher than the dyne levels of certain inks. DeMell has even found that for many substrates, they need to apply a primer material to the surface before printing. And since UV inks are translucent, unlike opaque screen inks, if you are printing on a dark surface, you need to first lay down a layer of white.

There also remain some substrates that stubbornly refuse to be printed on using any ink. "It sounds funny, but a common one is Teflon," said DeMell. He has also found stainless steel to be a challenge.

One surprise though: "UV does not stick to rubber," said DeMell. For one customer that wanted to print on a rubber surface — then have the surface stretched and returned to normal without any image deformation or cracking — it required a wipe-on primer to help the ink bond to the surface.

Appliance Applications

"It's all about understanding the substrate and having the substrate prepared properly," said Steve Hatkevich, director of research and development for American Trim, a supplier of decorative printing to the appliance manufacturing industry. American Trim prints the control panel backsplashes for washers, dryers, ovens, and dishwashers, as well as decorative trim and instrument panels for high-end automobiles. "It's understanding the surface energy of your substrate, understanding that there's a lot of preparation that needs to take place on the surface, that all substrates may require a different inkset and that all inksets need to be formulated for their particular end use. When you understand your substrate and your ink chemistry and can control the process, you can do some pretty incredible things with it."

Like TransTech, American Trim has also developed its own customized digital printing solution, combining LED curing from one source, printheads from another, inks from yet another, and so on, integrating them all into a system that works for the vast array of products they produce.

In the industrial space — perhaps even more so than in the commercial space — it's still not quite "plug and play."

"It's not so robust that anyone can do it," said Hatkevich. "It requires discipline, it requires an intimate understanding of the technology. The devil is in the details. If you're disciplined and have the desire and the need, it can all be accomplished. You can print some really incredible things on some surfaces that 10 years ago you wouldn't have thought possible."

D'Amico concurs. "The fallacy is you just stick it in, run it, and it will work on anything," he said. "That's how unfortunately it's portrayed. The [wide-format printing] products are extremely flexible, but it takes work. Every substrate takes calibration, a profile, and time to determine the right combination of variables and how they best interact with the material. It's probably oversold as to how easy it is, but it does take a little work."

"There are experts in the ink industry that I swear can make ink stick to things you wouldn't think possible," said Hatkevich. "Some of the things I've seen them make work, I just want to stand up and clap. I'm in awe of the genius."

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Home on the Range

There is still a substantial analog infrastructure in the industrial printing industry, but as companies gradually augment their analog workflows with digital, the newer process is encroaching a little bit more into the overall process.

"A company might have three or four stations of analog, and one station of digital," said Hatkevich. "This allows us to get some of the benefit of the variable print as the technology is proving itself as being worthy."

In commercial specialty printing, personalization and customization have been the driving force for the better part of the past 20 years. But how does personalization work in the context of industrial printing?

"Go back 20 years and the idea of replacing your stove or refrigerator as a way of decorating your kitchen was unheard of," said Hatkevich. "You only replaced it when it broke. Today, a fair amount of appliances are replaced just because they want a new appearance or aesthetic for whatever environment they're in." That is, digital industrial printing allows large appliance manufacturers to offer a much wider variety of decorative options — even personalized options.

DeMell said that TransTech has also been seeing shift toward personalized and customized industrial printing. "There is a lot of need for it from anyone who does a lot of different variations of products," he said. "We see it a lot with medical. Take a syringe."

No, thank you, but please continue…

"It might come in a thousand different variations with some similar tubes. Every time you change from one syringe to the next on an analog system, you're tearing down an entire set up, putting in a new one, and starting to print. With digital, you just press a button."

Customization also means a potentially big market in automotive interiors—particularly in luxury and high-end models — customized for individual drivers. Ford Motor Company, for example, has been pursuing this strategy, said DeMell.

And then customization in a general sense gives manufacturers' customers more choices, and also is used a marketing tool. "We make the 'jewelry' for whatever our customers want," said Hatkevich. "Like the appliance control panel that will stop you in the store to look at their device and say, 'Wow, I want to take a second look.' We have that 'wow' factor, whether it's the interior of an automobile or the front of a dishwasher or range. We leverage digital deposition to help create that wow factor for our customers, and we work with their designers to come up with unique appearances. Digital deposition has been a great advance for us."

Richard Romano has been writing about the graphic communications industry for almost 20 years, and covering wide-format printing since 1998. He is a senior analyst for news and information portal WhatTheyThink.com, covering wide-format, production inkjet, and environmental sustainability. He is the author or co-author of more than half a dozen books. His most recent book is The Home Office That Works! Make Working at Home a Success—A Guide for Entrepreneurs and Telecommuters, www.homeofficeworks.com.