New Technologies Provide a Wider Array of Products via Digital Fulfillment

Jay Hitchens, Qualex, a Kodak Company, NC/USA

Abstract

New digital technologies mean that a wider array of personalized products is available to the consumer via digital fulfillment. Qualex and its competitors have concentrated considerable effort to employ new technologies and provide leading edge products to web site and retail customers.

As digital images become the photographic standard, there are more possibilities than ever for a consumer to express themselves with photographic products and displays. Driven by more powerful processing systems and affordable software, there is a convergence of technologies which utilize digital images. The printing, sign making, textile, engraving, photographic and entertainment industries all utilize digital images in new product offerings. The convergence of technologies is generating higher quality products and lower costs for both business and consumers. Products as diverse as full color etchings in granite, a 3D version of a Wii alter-ego, or a digitally woven wall hanging can be created and ordered from the comfort of the home or office by the consumer. This paper will highlight and describe a variety of these products and the technologies behind them.

Interesting Substrates

A serious challenge for digital fulfillment is printing on the many different substrates that are requested by customers. For that reason, an awareness of advancements in substrates, especially the introduction of new substrates is critical to keeping abreast of the industry.

Azuna

One of the more interesting substrates is a product from Azuna LLC. The product from Azuna is a thin, two dimensional sheet of polypropylene plastic that appears as a stunning 3D visual effect. This is not lenticular, but 3 to 5 perceptual layers of four-color printing that exhibit amazing depth. Pocket change laid on a sheet of Azuna material will appear to be below the surface of whatever the material is resting on. This substrate is produced using offset press technology, but once produced can be personalized in a number of different ways. It is currently being used in the packaging, printing, marketing and promotional industries, and there is good reason to consider it for digital fulfillment, as it makes possible a line of greeting cards and book covers that are quite striking in their effects, yet can be personalized into a one-of-a-kind product.

The 3D technology was pioneered in South Korea and is exclusively licensed in the Western Hemisphere by Azuna. The technology utilizes polypropylene sheets (Recyclable #5 PP) that are extruded with custom-built machines owned by Azuna. Sheets are manufactured with an array of microscopic semispherical convex lenses (3600 per square inch) cut into the top of the substrate. These lenses gather and refract light so that when images are printed on the back of the substrate, the images are magnified and appear to be on different levels. The trick to producing the convincing layering effect is the position of the printed image in relation to the honey-comb cells. Correctly aligning the designs on the back of the substrate gives the illusion of up to 5 planes of depth.

Conventional presses print at 175 lines per inch. AZUNA requires printing at nearly 400 LPI to create the accuracy necessary to trigger the 3D effect. Currently, design techniques along with the files and films are proprietary to AZUNA, but a second generation product is about to launch that will make the process more flexible and time sensitive. This new product streamlines the 3D process because it is extruded with 3D embedded in the substrate so virtually any standard 2D design can be printed on the top of the sheet using conventional computer-to-plate (CTP) processes and it will exhibit the 3D effect.

The Azuna product has been used for shelf signage for Exxon Mobil, school folders for the NY Yankees and as dinner invitations to the Wired Magazine 2008 CES dinner.

Vapor Apparel

Textiles are no longer the denim, cotton and nylon that many of us grew up with. There are purpose-made fabrics for everything from billboard wraps, ecological ground covers, and performance fabrics for athletes of every stripe. The connection to digital fulfillment is digital decoration, the personalization of a garment through dye-sub printing.

The basis of the dye sublimation process is how dye is transferred onto a substrate under heat and pressure. Dye sublimation “ink” (actually dye particles in suspension) is printed to a transfer sheet usually by an inkjet printer. The liquid part of the ink is absorbed by the transfer sheet, leaving just the dye, which does not exhibit much color in the transfer state. When heat and pressure are applied, the dyes change from a solid to a gas, bonding with any polymers that are present, and then turn back into a solid. Since polyester is a polymer, the dye bonds with it and a permanent color change is made, one that will not wash out. If there are no polymers available at the time of sublimation, the dye returns to being a solid when the heat and pressure are removed and it sits on the surface of the fiber rather than bonding with it. This is what makes a polyester fabric an ideal subject for dye sublimation decoration, compared to natural fibers.

Performance fabrics have been developed to permit the wicking of moisture away from the body, so that it can evaporate. Cotton absorbs moisture, but polyester does not, so by comparison, the cotton garment feels damp and clammy. Wicking fabric utilizes a specially developed polyester fiber that has a large surface area and a specially designed cross section that improves the permeability of the fabric. Wicking fabrics will permit water

vapor to pass through them, but will prevent the passage of liquid water, making them water-proof to some extent.

The combination of these two qualities creates a fabric that is ideally suited for decoration and sports apparel. Both moderate production runs, for a specific team or fan base, as well as individual personalization and a one-of-a-kind products are possible and profitable using technical fabrics and dye sublimation.

Vapor Apparel, of Charleston, SC manufactures fabric and garments specifically targeted to these markets. Engineered to withstand the 400 degree temperatures imposed by the dye sublimation process, the fabrics and garments made by Vapor Apparel image extremely well and will hold up through the rigors of production imaging. Vapor Apparel works with customers and artists to create all over decoration of the shirt rather than the centered design on the chest.

Post-it Brand Poster Paper

In 1968 an adhesives scientist at 3M discovered a new type of adhesive, one that was not very sticky. It would take 12 years of testing and development to launch Post-it Notes, a popular 3M product, nationwide. Recently, 3M developed a more aggressive, Super Sticky version of the adhesive and has made it available on several types of media including paper suitable for digital presses, and paper adapted for inkjet printing. This product opens interesting possibilities for the digital fulfillment market, including posters for home, school or office use. These can be placed on painted or papered walls, in school lockers or on glass, ceramic or whiteboards without concern about removal or re-use.

Digital Weaving

Some of the more unique and sentimental favorites among photo fulfillment gifts are the throws, wall hangings, pillows and tote bags that are digitally woven rather than printed. The loom technology that produces these items is not new; in fact it has been in use for 200 years. Current machines are capable of using hundreds of different colored threads in weaving a full color likeness on these products.

Weaving frames were originated by the Chinese more than 3000 years ago and today's hand looms have not changed significantly from the original design. The real differences appeared with the beginning of the industrial era. In the late 1700's looms had become automated to the extent that they were capable of making plain fabric or textiles with very simple woven patterns. Changing from one pattern to another was a difficult and time consuming process. Joseph-Marie Jacquard was a French engineer who developed a system to program a loom. A loom outfitted with Jacquards' controller could produce intricately patterned cloth at almost the same rate as plain cloth. Two hundred years ago, a master weaver could produce about 1 inch of patterned fabric per day, a loom fitted with a Jacquard head was approximately 25 times faster than that. The key to his invention was the use of thick cards punched with a series of holes that controlled the warp of a loom to produce the pattern.

Using a portrait of himself as a model, Jacquard programmed his loom to create a black and white textile that was a good likeness of the portrait. It required the production of 10,000 punched cards to produce this textile image, but for the first time, the pattern could be duplicated at will and at production speeds. This is considered an important development not just in textile production, but in the history of computing hardware. Although no computation was achieved with his device, the use of the cards to store and control a pattern is the precursor to computer programming. In 1834, Charles Babbage adapted Jacquards punch cards in constructing his difference engine and in the late 1800's, Herman Hollerith pioneered the use of punch cards to catalog census data. Hollerith later left the Census bureau and started a company that would become IBM.

The intervening 205 years since Jacquard's invention have seen enormous advancements in technologies across the spectrum. It is interesting to note that by 1812 there were 10,000 Jacquard looms in use. Today, the majority of the world's programmable looms still use the punch card technology.

Lasers

What do surgery, food, atomic clocks, printing, logistics, signage and home entertainment all have in common? Lasers have become an integral part of many industries, and are becoming an increasingly greater source of products for the digital fulfillment industry. These products have developed well beyond the laser engraved wooden plaque that has a photo mounted on it. Today there are crystals with photo images engraved internally, aluminum products that have had the anodized surface bleached away by a laser, as well as stone, ceramic, metal, wood, glass and plastic substrates that are being offered with digital images marked on them with lasers.

The capability of lasers to either cut or mark has been used in many industries for thirty years or more. The difference is that the new generation of lasers is able to be much more closely controlled so that cutting, marking and engraving can all happen with a single product. Something as simple as the mat board on a photograph is good example. The surface color of the mat board can be bleached to a light color, the top surface can be etched away, leaving the core of the mat to show through, and the mat can be cut completely through, allowing the color of the under mat to be visible. Names, dates, school or corporate logos, photo likenesses, and graphic designs are mixed together to create a truly unique mat for a customer.

Laser imaging of fabric is a capability that has been exploited recently in the digital fulfillment market. Intricate patterns can be etched onto denim, cotton and leather products, creating the ability to personalize a garment in ways that was not possible until the last few years. Using a laser, it is possible to remove the pile from fleece garments, blankets and hats. This method does not darken the product in the treated area, but instead allows the base fabric of the item to show through, creating an image of contrasting color.

A new and interesting addition to the array of products that are created with a laser is ability for the laser systems to etch substrates leaving a color image behind. For example, a photograph or the image of an old master's art, corporate logo or specifically generated artwork can be imaged in full color on white marble, certain types of granite, glass, ceramic or man-made stone.

A four color, four-pass process, each color is deposited sequentially on the substrate. This process, not unlike glazing for ceramics, combines metal oxide pigments for coloration, clay and glass frit, and then the laser supplies the energy to fuse these

together with the surface of the substrate. This technology permits the marking of substrates that were previously unmarkable with a laser, and it adds machine readability to items using barcodes that would otherwise have been unreadable. The durability of this type of laser imaging is excellent, allowing exterior surfaces to be imaged in color.

Another laser application that is finding increased acceptance is laser-cut greeting cards and stationary. While this type of product has been available for some time, new technical advances result in less discoloration of the paper substrate than ever before. Highly complex cut patterns that are not possible with standard die-cutting methods can be produced on a short run basis, increasing manufacturing flexibility and improved personalization. Cutting, kiss-cutting, scoring and perforating are produced in a single pass. Paper is typically the substrate for the cards and stationary, but some plastics such as polypropylene and polyester are good candidates for this type of processing, allowing mixed media as a final product.

Photo Book Technology

It is hard to comprehend that only 15 years ago the first digital press was just being launched by Indigo after nearly 20 years of development. The Indigo broke new ground and proved that there was a market for on demand extremely short run printing. In the last five years, print quality improvements in the three leading sheet fed presses, HP's Indigo, Kodak's NexPress and Xerox's IGen, and Xeikon and Oce' digital web presses have enabled the spectacular growth in the photo book business. High quality images, and significant reduction in banding have been a major contributor to the nearly 800% growth in this market since 2004.

Press improvements were not the only contributors, a variety of binding methods, specifically those tailored to one-of-a-kind book production, such as the equipment from Powis Parker, Channel Bind and Unibind were instrumental in enabling small publishers. As the volumes of photo books increased, there has been a greater adoption of traditional bindery methods, including perfect bind, stitched and sewn bindings. The growth of the photo book industry has created an interesting mixture in the use of traditional and new production methodologies.

The cases for early hardcover photo books were relatively plain. Linen, bonded and faux leather coverings made up the vast majority of the early cases. As competition increased, windows appeared, and a greater variety of colors and patterns were used for the cases. In the last several years, custom covers have become popular, enabled in part by equipment from manufacturers like On Demand Machinery and wide format printing using inkjet or roll fed digital presses. These allowed the consumer to order a high quality hardcover book with a custom designed cover for fewer than forty dollars.

At the same time, significant improvements were made in production equipment for books made from silver halide prints. Binding methods suitable for the retail counter, and production equipment for high-speed high volume manufacturing of silver halide books were introduced.

Inkjet Developments

It was not that long ago when it was nearly impossible to make a print from a home computer at night after the family had retired. In a quiet house, the noise from a dot matrix printer was enough to wake the dead and so it was with great anticipation that consumers purchased their first inkjet printers.

Inkjet printer development started in the 1950's, but it was not until 1976 that the first commercial inkjet appeared on the market. It was large, used only black ink and was a maintenance nightmare with ink that regularly clogged the head. It took another 12 years for the first inkjets to be marketed to the general consumer. Blotches of ink on the page and voids due to dried ink were not uncommon. Price was another barrier, the first HP DeskJet printer retailed for $1,000.

The photo-printing industry was not overly concerned in those days about the inkjet, since image quality, cost per print, and general reliability caused these printers to have no foreseeable impact on the silver halide market. Additionally, the quality of photo images on computer was quite poor, and other than with the Macintosh, manipulating photos with a computer was nightmarish at best, certainly for the home user.

Developments in photo printing using inkjet technology have been driven at least in part by the work done in the 1990's by Graham Nash and Mac Holbert of Nash Editions. Their work pioneered the use of inkjet printers for fine art printing, often referred to as giclee.

It is now possible to make inkjet prints that with appropriate storage will last in excess of 200 years and which rival or exceed the best silver halide prints.

UV Inkjet

The first UV inkjet printers appeared in the early 1990's, and have been growing at a double digit rate ever since. At first targeted at the label and packaging markets, UV printing found wide acceptance in the sign, reprographics and specialty printing markets.

UV inkjet printing has some definite advantages over both aqueous and solvent inkjet printing. Increased image durability, improved print head reliability and larger number of substrate selections are possible with UV. One of the most important benefits of UV printing technology is the lack of solvents. Since there are no VOC's produced, the printer is more easily utilized in all areas of the country, even those with stringent environmental restrictions. Recent innovations have made white ink a reality, enabling print on dark surfaces and back to back printing on clings and other transparent displays

The versatility of UV cured inkjet printing can be seen in the variety of substrates and applications, including PoS displays, corrugated packaging, outdoor signage and backlit displays. Unique applications include short run printing of silk scarves and ties in Italy, printing on ABS plastic and printing car, floor and building wraps.

Silver Halide Replacement at Retail

The era of kiosk printing and dry minilabs has arrived. Printing photos on silver halide in retail locations peaked in 2000, with most major drug, food and discount chains offering film processing and silver halide prints, usually in one hour. Today, the kiosk offers prints from digital media and the back labs in most stores are dry. Printing has for the most part, migrated to dye sub

printing, as Fuji, Kodak, Sony and Dai Nippon all equip their kiosks with one or more printers each. HP has chosen to use inkjet technology for its in-store placements. This migration has been possible as the quality, speed, and reliability of the kiosk based printers have improved greatly.

Interesting Finds

This next section is a brief review of several digital products or processes that have not yet been exploited for fulfillment to the digital imaging consumer, but which may have application in the future for this industry

Foiling

Applying foil to the surface of a book, gift, or document was at one time a very expensive and inflexible process. The expense was the cost of having a die made in the pattern required, but that die was good for 1000's of impressions. Foiling was used for book titles, logos, etc and was part of a mass produced item. That situation has changed significantly over the last decade.

Digital technology has brought several new approaches to foiling. The first approach is a type wheel, not unlike an old IBM Selectric typewriter, except the fonts are larger and are computer controlled. The item to be foiled is placed under the head of the machine, the wheel rotates to the proper letter, and it presses the foil tape onto the substrate, then indexes to the next chosen letter and continues until it is complete. Multiple fonts are available and custom wheels can be purchased as required.

A more recently developed methodology is the use of a dot matrix print head to do the imaging. In this instance, the foil is transferred from its backing to the substrate by the pins of a dot matrix printer. This method allows the foiling of unlimited fonts, large and complex designs. Custom designs need only be entered on the computer and sent to the head for printing.

An even more recent innovation is the use of foil fusing. An image is created using a laser printer. The substrate with the laser toner design adhered to it is then passed under heated rollers and the foil adheres to the toner on the substrate. One serious drawback of this method is the foil is not selective, and will stick to any toner on the image, making the foiling of a seal in the middle of a printed page virtually impossible. Therm-O-Type has developed a method that permits high speed foil fusing to selected areas of toner on a printed sheet. One-of-a-kind personalization using metallic, security or holographic foils is possible using this method. A single unit which will cut, score, emboss and foil in a single pass is available.

Digital Carpet

It is possible to have a photo, corporate logo, or favorite saying printed on a carpet. That level of customization may not be a surprise, but what about on-demand, custom color and pattern broadloom carpet? Carpet mills today are producing white carpet that is then dyed custom colors or multicolor patterns using inkjet technology. The customers order is printed to the specifications of the job rather than a standard length yardage, and the management of inventory becomes simple. The base stock is not printed until there is an order for that specific color. Orders are separated from each other by several inches of white carpet, which is imprinted with order code numbers to make it easy to track the order once it has been rolled for shipment

Three Dimensional Printing

A technology that has been around for 20 years is just starting to emerge in the personalization marketplace. Stereo lithography was first patented in the late 1980's as a process for making solid objects by printing layers of UV cured material on top of each other.

Fast forward 20 years, and stereo lithography has morphed into a billion dollar industry that includes a number of direct-digital manufacturing or additive fabrication technologies, including selective laser sintering, laminated object manufacturing, fused deposition modeling, electron beam melting and 3D printing. While the technologies vary widely, the concept behind all of them is much the same. The prototype design is created using three dimensional CAD or animation modeling software. The model itself is built by stacking horizontal cross-sections or "slices" of material, layer upon layer until the final dimensions of the product are achieved. While some technologies use powdered metal, others use polyester resins and others use thin sheets of paper or metal; for all of them the layers are formed and fused together until the desired shape is reached. Not dissimilar to making a clay pot with coils of clay, except that each layer of the coil is only thousands of an inch thick.

The models that are produced by these methods may be used directly (rapid manufacturing), as master patterns for metal molding processes or may be a prototype that is used to check the size or layout of a potential product. Consumer items can be rapidly and cheaply (compared to traditional methods) manufactured in small quantities to test marketability or ergonomic qualities, using these technologies. Something like a new hand drill might be produced using rapid prototyping, then weighted appropriately and given to potential users to test the balance, aesthetics and "feel" of the new product, long before the first production models are created.

Medical uses for additive fabrication products utilize images from MRI or CT scans to create a physical model of a joint or organ for a doctor to better visualize a situation prior to treating a patient. Using computer bio-modeling and additive fabrication processes, doctors can create parts of the skeleton, or complete brain and skull models that greatly improve visualization over computer generated images on a screen. These models can be used in teaching situations or directly in clinical analysis of a patient, since the turnaround time is measured in days for these custom, one-off products.

The personalization products that are available today come specifically from 3D printing technology. That method has several advantages, but the most notable one is the ability to create a product in full color. This is not a sprayed-on or after production process, but an integral part of the printing process where the composite material is colored as it is deposited, making multi-color, complex color and even human skin tones part of the final product. Another advantage is that 3D printers from some manufacturers are office compatible; they produce no liquid waste, include on-board dust control and use only office safe build materials. These machines are finding acceptance in the architectural, digital sculpture, medical and entertainment fields.

One good example of the type of work being done in the entertainment field is in the consumer sector products. Making a 3D model of a Wii character or a Second Life avatar is as simple as capturing the image from the TV screen and emailing it to a company that builds a virtual model from that picture. They will create the character using 3D printer technology after they have the consumer's approval of the appearance of the virtual model. Serious World of WarCraft players might want to have an 8 inch tall, full color figure of their alter-ego created in composite resins and delivered in a glass-domed stand. The popularity of these items is growing, and ultimately will be limited only by the imagination and visualization of the consumer.

An interesting development is being tested by Anvil Prototype and Design, a distributor for Z Corp, a manufacturer of a line of 3D printers. Anvil has been working with several software companies to understand and refine the process of converting a photograph into a 3D object. Specifically, the goal is the ability to take a single photograph of a person, process it through 3D modeling software, and output a virtual, rotatable image on the computer screen. This image is then used to drive a 3D printer, producing a life mask of the person, in full color. The same process can be used to produce a photo realistic likeness of the person's head, which can be used to make a very life-like doll.

Using the latest printer from Z Corp, the 650, Anvil is able to improve the surface texture of the piece and the object coloration is better than previous technologies allowed. It will be interesting to see what new markets develop around this technology.

Conclusion

The impact of the growth of digital technology is creating new specialty businesses, and driving a higher level of cross-fertilization between adjacent industry sectors. This enables the introduction of even more new products and technologies and lowers the cost of manufacturing for main stream products.

Jay Hitchens is the Director of New Product Innovation for Qualex, Inc. He has more than 20 years experience in managing engineering and operations in the prepress and digital printing fields. Prior to Qualex, he worked for Hell Graphics, Linotype, Heidelberg and Varis Corp. Hitchens received an ASEE from Penn State and a BA from DePaul University. He is on the Advisory Committee for PMA's Society of Photo Finishing Engineers.