

LaRio Output

## Challenges & Strategies for Single-Pass Inkjet Print

Computer capabilities doubling about every eighteen months and digital imaging and printing have revolutionized the way we communicate, photograph, design, manufacture and print. Single-pass inkjet is appearing in commercial printing and manufacturing plants as well as offices in increasing numbers. This article describes manufacturers' single-pass products, the challenges and limitations they faced and some of the ways they have devised to overcome those limitations to provide viable solutions. These single-pass inkjet systems bring with them the advantages and flexibility of digital processing with the promise of the production speed of conventional analog printing. They range in print width from very narrow marking and coding devices printing an inch or less wide, to very wide textile single-pass inkjets printing 1.6 meters (m) wide up to 3.2 m wide. Single pass inkjet textile printing systems are arriving and large print operations are beginning to acquire them.

The progress of single-pass inkjet has followed printhead development. We can begin to envision where these and

emerging technologies will take us based on their evolution and market adoption to date. The following examines the progress of the various inkjet technologies, continuous inkjet (CIJ), drop-on-demand (DOD), piezo inkjet (PIJ), and DOD thermal inkjet (TIJ), along with their challenges, limitations and solutions.

We also consider how market demands and requirements for marking and coding, carpet, transactional, commercial, label, packaging, industrial, ceramic tile and textile applications have driven single-pass developments and solutions. Market penetration of single-pass inkjet systems has grown rapidly over the past decade for labels and ceramic tile printing. Textile printing appears to be one of the next areas to experience inkjet double digital market growth.

### The Early Days of Single-Pass Inkjet

In the mid-nineteenth century, William Thomson, later designated Lord Kelvin, devised a siphon continuous inkjet type recorder (patented in 1867) for graphically recording signals sent over

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By Vince Cahill, President, VCE Solutions; with Solutions Group members Dene Taylor, PhD and Patrice Giraud



SPG Prints Javelin scanning inkjet printer



PIKE Output

the Atlantic Cable. In 1951, Siemens developed a similar continuous inkjet for medical recording EKG and similar medical data. A century after Lord Kelvin created his siphon recorder, Dr. Sweet and his colleagues at Stanford University developed a continuous inkjet that A.B. Dick commercialized as its Videojet printer for in-line single-pass marking and coding on cans, packaging and products.

From 1973 to launching it in 1975, Milliken of Spartanburg, South Carolina developed its Millitron digitally controlled carpet printer using a system that continuously generated drops. A computer-controlled valve would activate an air jet to blow drops that were not to print into a recycling circuit and not blow away drops that then printed and penetrated the carpet pile. The earliest Millitron version had a resolution of 10 dpi, but Milliken refined the Millitron to 20 dpi resolution and later to 70 dpi. In 1976, Zimmer of Austria introduced its ChromoJet. Its DOD valve jet heads produce 25 dpi resolution jetting at a frequency of 1kHz. Both companies have proven successful with their carpet and upholstery printers. While 20, 25 or 70 dpi might seem coarse, when printed on deep pile carpet and fabric and viewed from over a meter and a half distance, these resolutions produce customer-acceptable results.

#### Drop-On-Demand Challenges & Solutions: Scanning vs. Single-Pass

On the other hand, DOD, PIJ and TIJ can produce relatively high-resolution images. In scanning mode, printheads typically move over and across one axis of a substrate. Some systems, like the larger flatbed systems from Inca Digital\*, move the bed while printing instead of the printheads moving. Scanning can overlap the print swath of each head, which enables higher resolution prints than the printheads' native resolution. Overlapping jets can also compensate to some extent for jets that might be clogged and not functioning. Single-pass systems typically lack overlapping jets of the same color.

The major advantage single-pass systems have over scanning systems is speed. Scanning requires that the head assembly or print bed start, accelerate to a constant print speed, decelerate, stop and repeat for each pass, which consumes a large portion of print process time not printing. A single-pass system eliminates scanning's stopping and starting and can

greatly increase the speed of throughput. As a case and point, the 3.2-meter wide MS LaRio single-pass printing system can print 240 square meters per minute ( $m^2/min$ ) in its fastest mode and  $112 m^2/min$  in high quality mode. The MS JPK evo 3.2-meter wide scanning head device using the same type of Kyocera KJ4 heads prints  $34.14 m^2/min$  in its fastest mode and  $18.66 m^2/min$  in high quality mode. The single-pass printer is six to seven times faster than MS's fastest scanning head family model.

Scanning inkjet printing in both directions can also produce bidirectional banding, often described as the grass mowing effect, where printed and stacked drops lean in the direction of printhead movement like the pattern a mower produces moving back and forth from one swath to the next. On April 22, 1992, Paul Hoisington of Spectra, Inc. (now part of Fujifilm Dimatix)\* was awarded a US patent for describing a method for interlacing print drops to reduce the banding associated with bi-directional inkjet printing. Another way to eliminate bi-directional banding is to not print bi-directionally, but instead in only one direction or uni- or mono-directionally. Bill Baxter, Will Eve and their team at Inca Digital chose this latter solution when they designed the Inca Eagle 44 and subsequent Eagle H, Columbia, and Columbia Turbo flatbed printers. Over the past decade and a half since the introduction of the Inca Eagle 44, inkjet printing systems developers have fine tuned their devices' material movement controls, software, color profiles, print carriage alignment, clogged nozzle detection, compensation or recovery methods to reduce unsightly artifacts of inkjet printing, notably bi-directional banding among them. System developers have created sophisticated noise diffusion and interlacing algorithms and masking patterns to eliminate or effectively hide visible banding effects.

PIJ and TIJ DOD heads are prone to some jets not firing. Single-pass inkjet printers typically lack nozzle redundancy to cover streaks that missing nozzles cause, but that overlapping scanning heads can cover. Some single-pass printers feature nozzle redundancy, but it is not typical with most single-pass inkjets on the market. Hydrophobic coatings on nozzle plates can reduce ink build up that can cover nozzles and block them. Inks that contain an excess of air can release it into the ink channels on PIJ heads forming bubbles that prevent jets firing.



Roland Texart RT-640 Dye Sub Printer



Jos Notermans demonstrating the PIKE



SPG Prints Pike



SPG Prints PIKE single pass inkjet textile printer Printbar with Fujifilm Dimatix Samba PIJ heads

Ink suppliers will often remove air from ink used with PIJ printheads. They will often contain PIJ ink in collapsible bags to prevent air infiltrating the ink. Some printer and print head manufacturers offer “lung” devices that remove air from ink, keeping air below the level where bubbles can form in ink channels. In-head ink recirculation can also reduce or prevent air bubbles from blocking ink channels and jets.

Effective inkjet printing requires compatibility among many elements, including print heads, printer motion controls, inks, color profiles, print substrates and coatings, software and electronics.

### CIJ & Single-Pass

Continuous inkjet has been able to print in single-pass mode for very narrow formats from its inception. Today, CIJ printing continues as the primary print method to mark and code packaging. CIJ’s continuous drop generation of ink insures highly reliable unclogged nozzle performance. Single-pass CIJ, however, generally produced relatively low resolution characters. CIJ heads are also relatively expensive.

Matti Engineering Group of Sulgen, Switzerland, founded in 1995, was an early developer of single-pass inkjet systems using the Scitex (later Kodak) VersaMark CIJ printheads for its M-Tower line of single-pass printers. It exhibited with Kodak as early as 2005. It later adopted Kodak’s Stream CIJ technology. It also built single-pass PIJ systems with its partners. Kodak is the worldwide distributor for Matti’s VT3000 spot color printer and VJ1000 monochrome printer, VL2000 VL2200, VL4000 & VL4200 using Kodak VersaMark CIJ heads. Matti Technology is the exclusive OEM for the Xerox CiPress. It builds and customizes turn-key printing solutions with the CiPress for Xerox\* customers and partners. Matti joined with its much larger Swiss partner, Bielomatik, to create the PageMaster single-pass booklet printer employing a Kodak Prosper CIJ monochrome web width print head array with two 4-inch wide Prosper S10 heads for adding spot color. The PageMaster printing towers offer the ability to add full-color arrays or printheads from other head manufacturers.

Matti is an equipment manufacturer with engineering expertise in designing and building paper transport, print towers and single-pass inkjet print systems for major brand suppliers including Kodak,

Atlantic Zeiser, IBM, Nipson, Domino, Printing Sciences\*, Impika (now part of Xerox), Xerox, V Print, Ricoh\*, CTC Japan, Graph-Tech AG, and TectuPrint ERTEC.

During 2008, Osiris, a company in the Netherlands, released its 1.6-meter print width Isis single-pass textile multi-color textile printing system with large print bar arrays of Markem-Imaje CIJ printheads. Isis produced relatively low resolution output per print bar in single-pass mode. Osiris claimed a resolution range from 100 to 1154 dpi for the Isis. Its CIJ multi-deflection heads, however, are rated at 140 dpi native resolution. The Isis could produce 1,200 m<sup>2</sup>/hour and reported carried a price of 3 million euros. Except for its use at Vishal Fashion Private Ltd. in India, other print suppliers did not adopt it and Osiris could not continue in business. TenCate, a major Netherlands printer, then acquired the Osiris Isis printer. The Isis CIJ continuous jetting held the advantage of being able to change ink types quickly. Users could flush print heads and switch among reactive, acid and disperse dye sets in about five minutes per print bar.

Kodak’s Prosper line of web press print systems, including the monochrome Prosper 1000, and process color Prosper 5000XLi and 6000, use Kodak’s Stream CIJ technology with heated nozzles to break its continuous stream of ink into uniform drops. The 6000 provides maximum print width up to 24.45 inches (in) or 62.1 centimeters (cm), while the Prosper 5000XLi and 1000 offer a maximum print width of 24.5 in (62.2 cm). The Prosper 6000 approaches a resolution of 200 lpi (lines per inch) at 650 feet per minute (ft/min) or 200 meters per minute (m/min) and 133 lpi at 1,000 ft/min (300 m/min). The Prosper 5000XLi and 1000 produce resolution up to 175 lpi and throughput speeds up to 650 ft/min (200 m/min). The “line” in “lpi” is comprised of halftone dots. A general rule of thumb multiplies the lpi by 2.2 to arrive at equivalent dots per inch (dpi). According to this rule, the Prosper 6000 produces maximum quality of 440 dpi and the Prosper 5000XLi and 1000 print up to 385 dpi. Applications for the Prosper line include commercial, transactional, packaging, tag, and label printing in addition to book, newspaper and magazine publishing.

### PIJ DOD Single-Pass for Printing Paper, Labels, Food & Ceramic Tiles

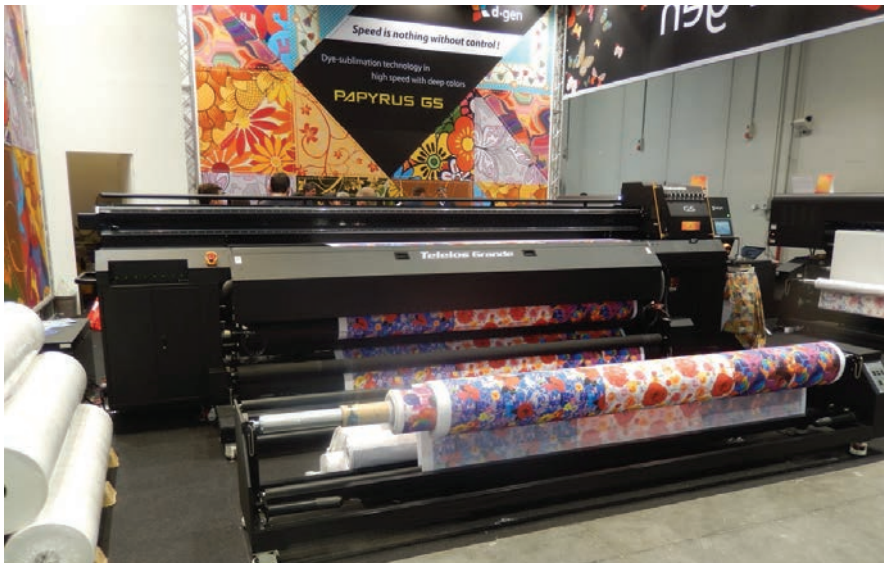
Barco (Belgium) and Cambridge Consultants (United Kingdom) co-

developed the first single-pass PIJ printer, the.factory. Barco exhibited the.factory prototype at DRUPA 2000. Initially, Barco used arrays of Xaar-500 PIJ heads and later adopted ToshibaTec PIJ heads. It designated the print engine as the SPICE, i.e. Single-pass Inkjet Color Engine. In 2001, the company introduced a SPICE engine prototype added atop a Mark Andy flexo press to print variable information. In September 2001, Barco spun off its Digital and Special Printing Division, which developed the.factory, to form Dotrix. The year 2002 witnessed the commercial release of the.factory, and in 2003, Mark Andy launched its DT-2200 flexo printer with the SPICE engine on board. Dotrix also shipped its single-pass printer for label and packaging printing. In 2004, Agfa\* purchased Dotrix for about 6 million euros. In 2003, Dotrix had sales of almost 5 million euros but lost about the same amount due to heavy investments in R & D, according to Barco. In April of 2009, Agfa Graphics Dotrix and flexo press manufacturer Edale Ltd formed a strategic alliance to promote and provide the Dotrix Modular and Dotrix Transcolor SPICE engines on Edale presses. The Dotrix systems printed UV curable inks. By March 2012, the Dotrix system had become obsolete and required a major upgrade to stay viable. Instead, Agfa suspended development of Dotrix printers reportedly because the single-pass inkjet press did not achieve the market penetration and sales that the company had projected and that Dotrix was facing strong competition from toner-based single-pass machines from HP Indigo and Xeikon, and single-pass inkjet label printers from EFI Jetrion for digital label printing business. Agfa was also in a cost cutting mode and was shifting its focus and efforts to scanning head wide format inkjet, where its Anapurna, M-Press and Jeti inkjet printer sales were growing.

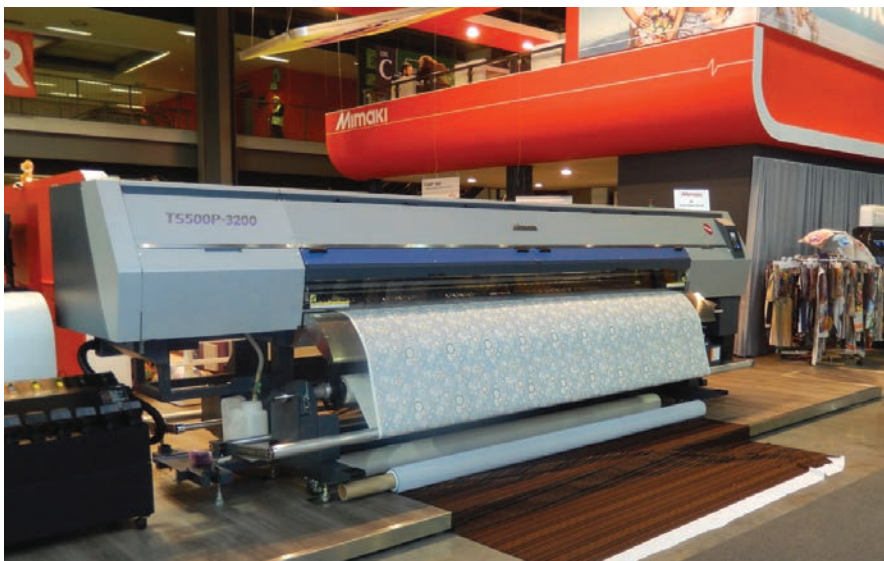
In 2004, Sun Chemical\* and Inca Digital demonstrated a half-size web concept FastJet single-pass inkjet prototype for packaging applications using Dimatix PIJ heads and Sun's UV curable pigmented ink. Subsequently, I visited Jardin Corrugated Cases in Ely, United Kingdom where an alpha 1.04 m (41 in) full width version was printing corrugated card at 300 dpi and 1.6 meters per second (m/sec) throughput speed. It contained 480 Dimatix PIJ heads printing four UV ink colors plus varnish. Sun Chemical & Inca Digital also offered nitrogen blanketing with the FastJet for improved ink curing.



Texart output



d-gen Teleios Grande



Mimaki TS500P-3200 This is a 3.2 meter print width dye sublimation printer using Panasonic PIJ heads. Targeting display soft signage printers

Reportedly, Sun Chemical placed two FastJet printers in the United Kingdom, one in Germany and one to the US. Sun Chemical, however, did not continue the project. Lower cost sheet-fed scanning head inkjet printing devices were proving more price competitive and practical.

Another challenge for signal-pass inkjet printing cardboard is lint contamination blocking printhead nozzles particularly for systems that lack nozzle redundancy.

In 2007, Impika (now Xerox Impika) introduced the Impika 600 process color 47.4-cm print width single-pass PIJ inkjet label printer using an array of 29 Panasonic 800-nozzle PIJ heads per color. It printed water-based inks producing 600 dpi resolution at 75 m/min speed. The company also offered the Impika GH-PBX600 single-pass inkjet spot color press transactional applications.

The year 2008 witnessed the growth of PIJ DOD single-pass printing for the commercial print industry with the entry of multiple providers. Miyakoshi and Océ introduced single-pass roll-to-roll web systems using arrays of the 4.25-inch wide print width Kyocera KJ4 PIJ heads. The Miyakoshi MJP600 printer reportedly achieved a print speed of 150 meters/minute. This printer used Kyocera standard ink. Miyakoshi reported that the MJP600 can print the equivalent of approximately 1,000 sheets of A4 paper per minute. A UV ink version reportedly could print at 100/minute.

Kyocera and Miyakoshi quoted the printhead life for the Kyocera KJ4 heads as 3,000 hours of printing. The Miyakoshi and Océ\* single-pass printers using KJ4 PIJ heads include a camera system that monitors and reports head failures. Camera tracking of print head performance has proven a successful strategy for detecting head failure. Reportedly, replacing one KJ4 printhead requires a trained technician about one hour.

During December 2007, Océ' announced its JetStream 600x600 dpi full-color inkjet press printing dye-based ink with a maximum print

width of 20.5 inches. It launched the full JetStream line six months later at DRUPA 2008. Miyakoshi built the JetStream line with Océ' control electronics and Prisma controller. The JetStream line offered featured two single-engine presses, JetStream 750 and 1100, and three dual engine ones, JetStream 1500, 2200 and 3000. The speed of the presses ranged from 750 A4 pages/minute for the JetStream 750 to 3,000 A4 pages

per minute for the JetStream 3000, the printer number designation indicating the number of A4 pages it could print per minute. All of the printers except the JetStream 3000 delivered 600x600 dpi resolution. The Jetstream 3000 yielded 480 dpi. Océ aimed its JetStream presses at the transactional, trans-promotional, direct mail, newspaper and book markets.

Fujifilm exhibited its J Press 720 sheet-fed single-pass CMYK inkjet concept in 2008. Fujifilm designed it to print sheets up to 20 inches x 29 inches. It used four print bars, with 17 Samba PIJ heads per bar delivering 1,200 x 1,200 dpi resolution with four gray levels (three drop volumes). Fujifilm indicated that it could output up to 2,700 sheets per hour and offered the system with its XMF Workflow. The initial J Press concept required about four years before it was ready for market distribution. The J Press 720S subsequently replaced the 720. Fujifilm also offers its J Press 540W, a single-pass roll-to-roll web inkjet CMYK press, which can print both one- and two-sided. It features a maximum print width of 53.8 cm (21.2 inches). It produces 100 meters/min (328 ft/min) at 600 x 600 dpi or 127 meters/min (416 ft/min) at 600 x 480 dpi.

Also in 2008, Fujifilm Dimatix Technology Integration (DTI) group demonstrated its purpose-built XP-200, which inkjet printed images and text in single-pass on a wide range of objects including circuit boards, plastic, cork, sandpaper, kapton, metal, sponges, fabric, paper, cardboard, wood, blister pack and leather up to 61 meters/minute (200 ft/min) at 400 x 400 dpi. Fujifilm reported that the DTI group had built similar systems that operated at over 240 meters/minute (800 ft/min). The DTI group built the XP-200 with the Dimatix Merlin controller and used standard Dimatix Galaxy PIJ heads “clustered into a 4-quad by 4-color array”. Additionally, the DTI group (formerly STI) built single-pass inkjet production printer systems for Procter & Gamble to print certified food coloring to decorate Pringles Potato Chips® with topical images and messages. It also integrated single-pass production systems for other industrial customers as well.

Further in 2008, Calypso Systems (Gloucestershire, UK) offered its Calypso Digital Press single-pass inkjet for corrugated packaging. Andoversford company developed the press using Spectra PIJ heads printing SunJet spot- and four-color process inks on corrugated packaging at 100 x 200 dpi resolution.

Sun Automation of Sparks, Maryland offers single-pass inkjet packaging systems solutions including three CorrStream model print widths. The Series 66 is Sun’s widest model for corrugated printing widths of up to 1.345 m (52.9 in) and sheet width up to 1.6 m (63 in). It uses 12 Kyocera KJ4 PIJ DOD heads. The Series 40 prints widths of up to 0.782 m (30.78 in) and sheet width up to 1 m (39.4 in). It employs 7 KJ4 heads. The Series 20 prints widths of up to 0.558 m (21.97 in) and sheet width up to 1 m (39.4 in) using 5 KJ4s. Sun Automation claims that its digital CorrStream solutions with productivity of 70 m/min equal the throughput speeds of conventional analog printers. The CorrStream printers jet aqueous based inks.

Barberan of the Barcelona area, Spain manufactures a line of single-pass inkjet industrial printers. Its top of the line Jetmaster 1260 has a print width of 1.26 m (49.6 in) and can print flat substrates from 3 to 80mm thick including cardboard, wood, melamine, paper, particle board, MDF, HDF and similar materials. It uses arrays of 360 native dpi PIJ heads with four gray levels. Barberan also offers the Jetmaster in 210, 420, 630, 840, 1050 mm print widths. Barberan makes Jetmaster C roll-to-roll single-pass web printers in 70, 210 and 420 millimeter (mm) web widths. The Jetmaster line jets UV curable CMYK inks. Bobst and Esko have also been developing inkjet solutions for packaging.

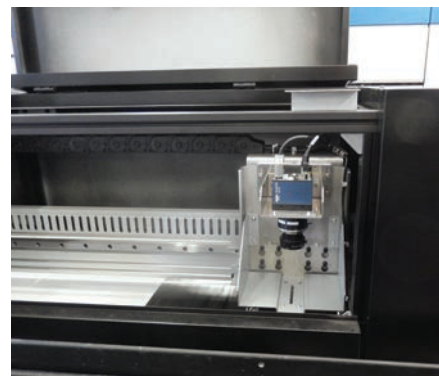
EFI Jetrion 4950LX single-pass four-color label printer jets durable UV curable ink, which can obviate the expense and need for protective top coating or lamination. The Jetrion 4950LX uses Xaar 1002 PIJ heads delivering 720 x 720 dpi at print speeds up to 157 ft/min. It provides in-line laser cutting that enables variable contour cutting to match the printer’s variable imaging capabilities and eliminating the need for tooling and dies. EFI also offers Jetrion 4900-m/4900-m 330 and 4900-milliliter (ml) single-pass inkjet label printing systems.

In 2009, Durst\* offered its Tau 330 UV label press producing 720 x 1260 dpi image resolution using Xaar 1001. Its seven-color modular press, now with Xaar 1002 heads, features in-line digital laser finishing and low-migration UV inks for food, healthcare and pharmaceutical applications.

SPG Prints markets its modular DSI® UV inkjet label printer. The company offers it as a stand-alone single-pass inkjet printer or with in-line converting. It



Konica Minolta single-pass printer



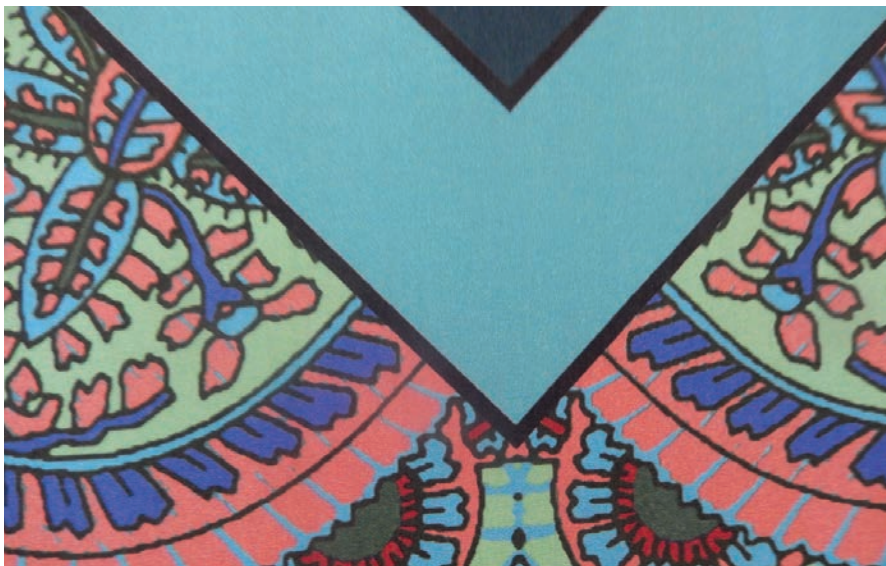
Passenger Konica Minolta single-pass printer camera



Input end view of Konica Minolta Nasseger single-pass printer



Print by Konica Minolta single-pass printer



Close up of print by Konica Minolta single-pass printer



Print by Konica Minolta single-pass printer

provides it in widths from 135 mm to 530 mm. The DSI comes standard with four printbars using Xaar 1002 PIJ heads. SPG Prints offers up to an additional six printbars as an option for printing primer, white, and extended color gamut violet and orange colors

Other OEMs that have developed single-pass label printers based on the Xaar 1002 PIJ heads include PPSI, Domino and INX Digital.\*

Screen's Truepress Jet L350UV uses 3 Kyocera PIJ heads per color to yield a print width of 12.6 inches. It delivers selectable print resolutions of 600 x 600 dpi and 600 x 1,200 dpi. It prints at a maximum throughput speed of 164 ft/min.

Epson\* also offered single-pass label printers, SurePress L-6034V and L-6034VW with LED UV ink curing and its PrecisionCore PIJ heads.

During 1999 to 2000, KERAjet of Spain developed and introduced a single-pass inkjet system for decorating ceramic tile. The company continued to develop inkjet printing of ceramic solutions. Other manufacturers also developed both scanning and single-pass inkjet printing solutions for decorating ceramic tiles, including Spanish OEMs Cretaprint (now part of EFI); Italian OEMs Durst (also located in Austria), TSC Srl, TechnoFerrari, Intesa-Sacmi, SITI-B&T Group (formerly Projecta); Chinese OEMs Foshan Meijia Ceramic Equipment Co Ltd, Hope Ceramic Machinery Co Ltd, Flora Digital Printing Systems, New King Time Machinery; Israeli OEM Jettable of Netanya, Israel; and UK OEM Xennia. Ceramic ink manufacturers, such as Torrecid, Ferro, Esmalglass-Itaca, Smalticeram, Xennia, Vidres, Chimigraf Iberica and Gruppo Colorobbia, have also played a critical role in developing refined ceramic inks and glazes for inkjet application.

Xaar pioneered in advancing the adoption of inkjet ceramic tile printing technology. First, it supplied its XJ 500 PIJ printhead for the original KERAjet inkjet printer. (As noted above, it also supplied the XJ 500 PIJ heads to Barco for its the.factory single-pass printer.) In 2007, it launched its Xaar 1001 PIJ head with in-head ink recirculation, which ceramic print equipment manufacturers quickly adopted for single-pass printing. Xaar also developed more recently its Xaar 001 printhead for single-pass depositing of high viscosity and large particle aqueous glazes. In 2014, Xaar introduced its 1002 PIJ recirculation head as an improved replacement for its 1001. Witnessing Xaar's

success and the ceramic tile industry's rapid adoption of inkjet, other inkjet printhead manufacturers also developed inkjet heads for meeting the printing and glazing needs of the ceramic tile industry. Fujifilm Dimatix developed its StarFire™ SG1024 printheads specifically targeting the ceramics and textile industries. As with the Xaar 1002, the Konica Minolta KM 1024i, and ToshibaTec CF1 series, Fujifilm Dimatix StarFire users can select one of a number of models with a range of primary drop volumes with grayscale capabilities. Durst has developed its own printhead configurations and systems, typically using some parts from other printhead manufacturers including Fujifilm Dimatix and Ricoh.



Cut Piece NeoPigment Ink print from Kornit

### TIJ DOD Single-Pass for Printing Paper & Labels

The key providers of TIJ DOD single-pass systems use either Hewlett-Packard (HP)\* or Memjet printheads.

HP offers monochrome, full-color and packaging page wide single-pass web presses. The monochrome presses include T260M, T300 and T400 Mono series. Its color web presses include T200, T300 and T400 Color series. Its packaging web presses include T400S and T1100S. The T200 prints to a 20-inch wide web, T300 a 30-inch web, T400 a 40-inch web. The HP T1100S prints the largest print width at 2.8 m (110 in) of the HP T series web presses. It uses HP TIJ heads producing 1,200 dpi native resolution and reportedly can reach throughput speeds of 183 m (600 ft)/min. The T1100S jets HP A50 aqueous pigmented CMYK inks. Pigmented inks generally provide great durability than dye-based inks for exposure to the sun's ultraviolet rays.

In June 2014, HP introduced its PageWide XL800 single-pass printer using an array of HP TIJ heads jetting pigmented inks. HP indicates that the XL800 can produce 30 D-size (22 ft x 34 in) per minute. HP promotes the XL800 as a technical printer for architects and engineers, topography imaging and mapping, as well as indoor sign and poster printing.

On August 11, 2015, Memjet filed a patent infringement lawsuit against Hewlett-Packard in the United States District Court for the Southern District of California. The lawsuit alleges infringement of eight Memjet patents related to its page-wide "waterfall" printing technology. Memjet's patent infringement concerns HP's PageWide XL series in



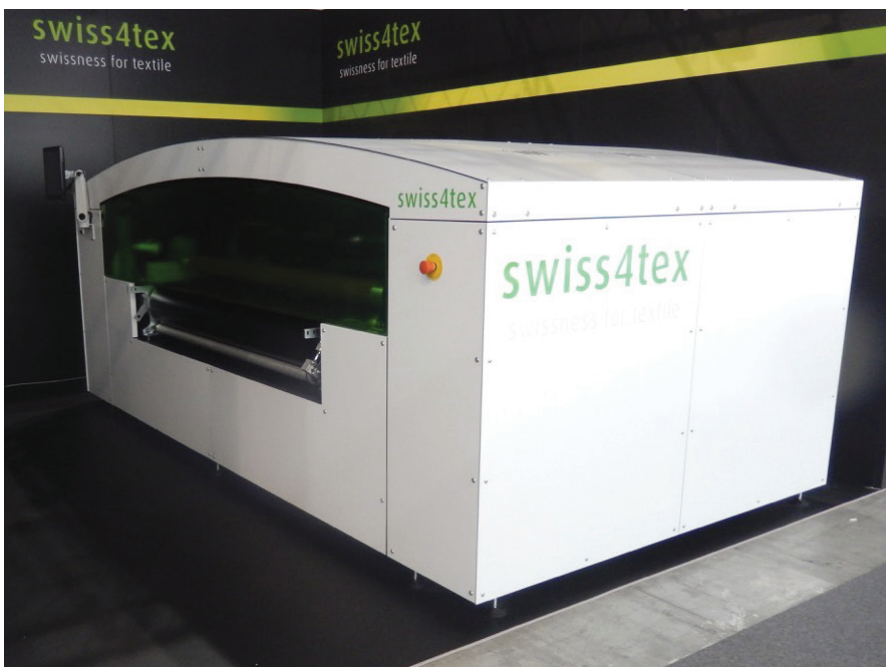
Mutoh



Mutoh printer applications



Kornit Vulcan at ITMA 2015



Swiss4Tex printer

addition to its Pro X generation of office printers and T-Series commercial presses printer. In November, a German District Court in Munich granted Memjet's a preliminary injunction preventing HP from distributing its PageWide XL Series printers in Germany.

Memjet offers its heads and dye-based inks to OEM licensees. Its TIJ heads feature 70,400 nozzles in 10 rows of nozzles with two rows per ink channel and five ink channels per head, 14,080 nozzles per channel. Each head provides a 219.5 mm (8.64 in) print width. The heads can generate one to two picoliter (pl) drops of aqueous dye-based ink or fluid. Each head typically prints CMYKK. The heads yield 1600 x 1600 dpi resolution. Each head consists of 11 integrated circuit (IC) chips with 6,400 nozzles per chip. The heads print full color 1,600 x 1,600 dpi resolution at a throughput rate of 152 mm (6 in) per second and 1,600 x 800 dpi resolution at 305 mm (12 in) per second. Memjet's dye-based inks are fugitive when constantly exposed to the sun's rays unprotected, which generally limits their use to indoor and short-term outdoor applications.

Memjet TIJ heads are used on the following single-pass label printers: Afinia DLP-2000 and L-801, Colordyne CDT 1600-C, Formax ColorMaxLP, Printware iJet Color Label Press, Neopost MACH X, Printing Innovation PI iCube, Trojan Label's TrojanOne, VIPColor VP700, RTI Vortex 850R and 851R, and Weber QuadraColor. Production commercial presses using Memjet TIJ heads include: Beiren's DP5000 Commercial Press, Colordyne 2600 and 3600 Series, Delphax elan 500, and Super Web's WEBJet 200D. Wide format printers include Océ ColorWave 900 and 910, Xanté Excelagrapix 4200, Gongzheng Pro-A1060C, RTI Vortex 4200, and Xerox IJP 2000. RTI offers its Vortex 4200 full-color 10.67 cm (42 in) paper width single-pass printer using Memjet 5 five-channel TIJ heads. It prints on paper, PP, PE, films and canvas at throughput rates of 450 to 1,000 m<sup>2</sup>/hr.

The Xerox IJP 2000 includes both single-pass printing using Memjet TIJ heads along with the Xerox 7742 scanner with optical resolution of 1200 dpi. The printer produces 1600 x 1600 dpi image resolution. It prints at a throughput rate of 152 mm (6 in) per second for color. Xerox notes its monochrome throughput rate at 330.2 mm (13 in) per second. Xerox added a Performance Package that corrects for

streaking and banding for which single-pass prints are prone.

In November 2015, Océ (a Canon company, SGIA member since 2013) launched its Memjet based single-pass ColorWave 910 upgrade to its ColorWave 900. Océ improved the device's print path tolerances to enable the printing of less flexible substrates and minimize the overlap of its print heads, thus reducing its artifact visibility on prints. The company upgraded the gearing of its head maintenance station from plastic to metal, which improves both the station's life and performance. The ColorWave 910 features an upgrade controller with improved diagnostics and the option to print color image data in monochrome. It offers two user selectable print speeds of 152 mm (6 in) and 305 mm (12 in) per second. Océ offered the ColorWave 910 for a list price about 20 percent less than the ColorWave 900 when it introduced it two years prior.

### Inkjet Single-Pass for Textiles

In 2015, Dr. John Provost, Technical Editor for WTIN, presented an overview of worldwide conventional and digital textile markets and trends toward digital single-pass solutions. The estimates presented approximate global market conditions. The projections are straight line and smooth curve calculations to describe possible general trends approximately rather than to exactly predict industry and market experience at any one time.

Provost noted that Asia accounts for about 64.4 percent of conventional textile printing, with China printing 29.3 percent, India 17.6 percent, other Asian countries 17.4 percent. Outside Asia, the Americas print 12.6 percent, the Middle East including Turkey and Africa 12.4 percent, and Europe including Russia 10.9 percent. He estimated worldwide conventional analog textile printing at 30.3 billion square meters of printed fabric for 2015. He projected a compound annual growth rate (CAGR) of 2.5 percent and production for 2019 of almost 32 billion square meters. He indicated that rotary screen printing accounts for about 65 percent of textile printing, automatic flatbed screen 25 percent, copper roll gravure less than 1 percent, hand screen printing 3 percent, analog dye sublimation transfer printing 3 percent, and digital about 3 percent. Decorating with pigment ink accounts for 52 percent of analog textile printing, with reactive dye 23 percent, direct print with disperse dye 15

percent, transfer with disperse sublimation dye 3 percent, and with acid dye 2 percent. Provost, quoting WTIN Digital Analytics, observed that 2014 digital textile decoration, excluding direct-to-garment printing, amounted to 954 million square meters, about 53 percent of which used disperse dye sublimation transfer, and about a third printed reactive dye. WTIN projects that digital textile printing will grow to about 2.4 billion square meters in 2019. Accordingly, digital textile printing would grow at a CAGR of just over 20 percent. Provost estimated digital textile printing applications included about 42 percent for signage, banners and display graphics with dye sub transfer, 40 percent for fashion apparel, 10 percent for signage with direct printed disperse dye, and 8 percent for home textiles. He tracked the evolution of inkjet textile printing from low production scanning printers, such as the Mimaki\* TX2 through medium production scanning MS JP5evo and Robustelli Monna Lisa printers and through high production large scanning head array solutions Konica Minolta Nassenger Pro and Reggiani ReNOIR to the first PIJ full width array single-pass textile MS LaRio.

A number of other single-pass inkjet textile printers were introduced in 2015. The WTIN conference represented the SPG Prints\* PIKE, Konica Minolta Nassenger SP-1, and Atexco Vega One. Other single-pass inkjet textile printers included Swiss4Tex AG with its prototype, PyungAn with both narrow and wide-format printers, and Tacome with the KERAjet Textile TS7.

The MS LaRio uses Kyocera KJ4 printheads. Kyocera announced a new version of its printhead with ink recirculation through the head. MS offers its LaRio as an open system that enables its owners to chose available inks from a number of manufacturers. While MS primarily promotes the use of reactive and disperse dye inks for use with its Kyocera PIJ printers, it also recently approved pigmented ink for use with them.

Roberto Usuai of MS Printing Solutions recently described what his company has accomplished in its evolution toward single-pass inkjet technology to include:

- Higher print resolution
- Smaller droplet size
- Nozzle level ink recirculation
- Larger/smaller printheads
- Higher speed
- More colors and print bars on the same machine



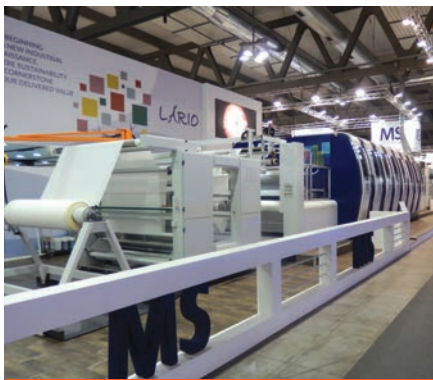
Mutoh Output



Mutoh Output



Epson SureColor S70600 Dye Sub printer



MS LaRio



MS LaRio

He reported that MS has placed 14 of its LaRio production single-pass textile inkjet systems, 12 in Europe, 1 in China and 1 in India. It also had orders for eight more: two in Europe, two in the Middle East, two in the Americas and two in the Far East. He also indicated that the operating LaRio installations had printed more than 48 million meters worldwide.

SPG Prints PIKE single-pass inkjet uses Fujifilm Dimatix Samba ink recirculating PIJ heads. Jos Notermans, Commercial Manager Digital Textiles at SPG Prints, indicated that SPG Prints is focusing on inkjet printing dye-based inks because this is where his company believes their market opportunity lies with its PIKE single-pass printer and the scanning head inkjet systems it sells, including its new Javelin printer. SPG Prints developed its PIKE Reactive Dye inks for printing cellulosic natural fibers, such as cotton and linen, which it noted, “still represents approximately 70 percent of the business of digital textile printing.” Notermans revealed that SPG Prints is also developing disperse inks to print on polyester fibers and acid dyes inks to print on protein based fibers, such as silk and wool, and synthetic protein fibers, such as polyamide. He noted his Company’s interest in disperse dye inks for polyester fabrics, which are one of the fastest growing textile segments. Notermans indicated that SPG Prints was focused on the large dye-based ink opportunities for its PIKE printer, rather than pigmented inks, which he indicated offered a much smaller opportunity.

Akiyoshi Ohno, former President and current Senior Advisor with Konica Minolta’s (KM) Inkjet Division, emphasized how his company designed its single-pass inkjet textile SP-1 Nasseger printer to not only meet the textile industry’s requirement for print quality and performance, but also to minimize its downtime. He pointed to printer downtime as the cause of lost business opportunities and user profit. It also extends the period necessary for companies to realize a financial return on their print equipment investment. His team at Konica Minolta designed the Nasseger SP-1 to greatly reduce downtime while delivering the print quality the market demands. Speaking about KM’s design considerations in developing its Nasseger SP-1 system, he emphasized that blocked nozzles, printhead maintenance, and replacement and realignment resulting in downtime were the biggest hurdles for single-pass inkjet printing systems to overcome.

Scanning printhead systems allow other jets to compensate for some jet-outs due to their multi-pass overlapping movement. But single-pass does not offer such compensation. Konica Minolta devised a system for its Nasseger SP-1 printer that combines inline jet-out detection and automatic head nozzle-plate cleaning along with a new single-pass version of its KM 1024i printheads. Its printheads’ grayscale capabilities can compensate for adjacent nozzle jet-outs. When the camera detects a blocked nozzle, the jet-out’s neighboring nozzle will print a larger drop to bridge over the blocked nozzle’s target area. The SP-1 grayscale heads can jet drop volumes of 6, 18 and 32 pl. This strategy can compensate for two adjacent nozzle jet-outs, but not for three. Three adjacent nozzle jet-outs would require head cleaning and if that did not succeed head replacement. I witnessed an operator demonstrate the procedure for replacing and realigning a printhead, which required about five minutes, significantly reducing downtime over some other single-pass systems. Also, SP-1’s scanning camera and software enable automatic printhead alignment and calibration.

I visited the Konica Minolta facility near Como, Italy to see a 6-color Nasseger SP-1 in operation. According to KM operators of the SP-1 at the demonstration facility, they have yet to have to actually replace a printhead in the three-months that their six-color SP-1 has been printing. KM has been printing bolts of fabrics for potential customers with this machine. The 6-color 1.6 m print width unit features 144 printhead modules. KM offers 4-, 6- and 8-color single-pass configurations in either 1.6 or 1.83-meter print widths. KM currently supplies the SP-1 with reactive dye ink in a selection of nine colors: Yellow, Extra Magenta, Cyan, Black, Orange, Blue, Pink, Gray, and Sky. It also offers disperse dye inks in nine colors: Yellow, Magenta, Cyan, Black, Pink, Sky, Gray, Red, and Violet. Ohno indicated that KM is developing pigmented and other textile inks for use with its textile print systems. The SP-1 can print at resolutions of 720 x 360 dpi up to 720 x 900 dpi. He also remarked that Konica Minolta is the one company producing a total solution for single-pass textile inkjet providing printers, print heads, inks and software. When users of Konica Minolta printers experience failure, they can have one company address all their printer issues and service matters instead of having to deal with different companies for each

component's possible contribution to the problem. He emphasized that with the Konica Minolta inkjet systems, Konica Minolta is responsible for all components.

Honghua Atexco's Vega One single-pass textile inkjet uses Fujifilm Dimatix Samba PIJ 1200 dpi grayscale recirculation heads. The Samba generate drop volumes from 2.5 pl to 13 pl. Like the other single-pass textile printers, it prints reactive and disperse dye inks. The company offers the Vega as a 4- to 8-color printer. It also offers it as an inline hybrid with up to three analog rotary screen heads. The 1.7-meter print width Vega One uses 40 Dimatix Samba heads per color. It can print fabric at a rate of 80 m/min.

Atexco was established to develop digital printing technology in China in 1992, becoming the China National Inkjet Research Center. It claims over 2,000 customers in 20 countries and 70 percent of the Chinese inkjet market. It also boasts that it is the only supplier in the world for digital printing systems that integrates "R&D, producing and service for printers, ink and software programming." Atexco has experience developing PIJ inkjet systems with Xaar, Kyocera, Panasonic and Fujifilm Dimatix heads. It also has developed wide color ranges of reactive-, disperse-, acid-based, and pigmented inks and coating chemistry for its textile printing systems.

Tacome's KERAjet Textile TS7 derives from KERAjet's pioneering development of single-pass inkjet for printing ceramic tiles. KERAjet has had experience for its ceramic printing and coating applications with many of the available robust inkjet PIJ heads. It has joined with fellow Spanish Company, Tacome, to market to the Textile Printing Industry, which Tacome serves with its coating equipment. The TS7 used Fujifilm Dimatix StarFire recirculation PIJ heads.

Swiss4Tex AG debuted its prototype inkjet printer, which is to be available in scanning head and single-pass models, all using Fujifilm Dimatix Samba PIJ heads, which deliver 1200 dpi resolution with 2.4 pl primary drop volume and six gray levels with a maximum drop volume of 14 pl. The Company plans to offer reactive and acid dye-based inks in CMYKOGnGyR, disperse dye for direct printing in CMYK, and pigmented ink in CMYKBR. The device offers a print width of 1.86 meters. The company boasts a maximum linear speed of 95 m/min and is targeting the fashion, transfer and home textile markets

with its concept printer.

PyungAn of Korea exhibited both the PACO-Single SA narrow format single-pass inkjet textile printer and wide-format PACO Pro 1 single-pass inkjet printer at ITMA 2015. The PACO-Single SA uses Fujifilm Dimatix PIJ heads producing 1200 x 1200 dpi resolution at a throughput rate of 60 m/min with a top speed of 80 m/min. The PACO Pro 1 used arrays of Fujifilm Dimatix Starfire PIJ heads.

### **The Future of Inkjet: Scanning Head vs. Single-Pass**

While pigment inks represent the majority of analog textile printing, digitally printed transfers currently provide the majority of digitally decorated textiles. Since digital textile printing is projected to grow significantly faster than analog textile printing, at over eight times the rate of analog growth, one can imagine digital replacing analog for applications where digital owns advantages over analog. The recent arrival of pigmented inks for use with PIJ printheads used in production textile printers including the single-pass LaRio suggest that digital could begin to supply the home textile and apparel fabric markets.

Single-pass inkjet systems come at a price that might prove too high for many users and applications. Users that have invested and paid for analog print systems will likely think twice before investing in newly arriving single-pass systems that could require a heavy financial commitment. Others will find scanning inkjet systems provide the digital advantages and are more than adequate to meet their needs for a much lower capital expenditure.

Analog printing, electrophotographic toner printing and scanning inkjet will continue to provide cost effective solutions for many applications. Digital front ends for analog method screen and plate making have improved analog competitiveness. Digital toner printing continues to enjoy a strong market position for printing paper and labels. Scanning inkjet likewise provides cost effective short to medium run production for many applications at lower capital cost than application comparable single-pass inkjet. But as the production rates and lower consumable volume costs of single-pass justify the cost of large printhead arrays and single-pass systems, we will continue to see greater adoption of single-pass inkjet.

Inkjet print head development has made single-pass wide format printing possible. The birth of PIJ single-pass relied

on Xaar's development of its XJ 500 arrays for the first the.factory and KERAjet single-pass printers, of its Xaar 1001 for single-pass label printing and improving ceramic tile decoration, along with its Xaar 1002 upgrade and Xaar 001 for ceramic tile glaze coating. Advances in manufacturing, particularly with Micro Electrical Mechanical System (MEMS), have enabled denser nozzle packing, greater precision and consistency for nozzle fabrication, and higher resolution printing for lower cost. HP has advanced its use of MEMS to overcome the kogation (the build up of burnt ink on the thermal drop actuator) limitation of TIJ with quick changing and aligning of low cost disposable printheads. Memjet has followed a similar strategy for its TIJ system. Fujifilm Dimatix's Samba MEMS PIJ head has set an example for densely packing nozzles for heads designed to permit easy and accurate assembly into large printbars. Konica Minolta and Xaar have announced that their companies will soon release their MEMS PIJ heads. Independent channel PIJ heads for shared wall shear mode PIJ heads, such as the Konica Minolta KM 1024i and 1800i, and Seiko SPT-508 GS and SPT-1024, have enabled their use with aqueous inks

for textile printing. In-head print fluid recirculation in PIJ heads, such as the Xaar 1001 and 1002, Dimatix Samba and Starfire, and ToshibaTec CF1 series heads, has greatly reduced the problem of pigment settling and nozzle clogging enabling the reliable printing of white TiO<sub>2</sub> pigmented inks. Head developers are continuing to advance the capabilities and cost effectiveness of their heads to perform for applications the markets use. More heads are on their way that will advance the cost effectiveness and performance of inkjet heads for single-pass.

*Vince Cabill, President of VCE Solutions, which provides consulting services for Fortune 500 and other companies operating in the analog and digital printing industries. He has also served as a Principal of The Colorworks, where he had a 25-plus year career in specialty graphics. Cabill also served as CEO of Datametrics Corp. as well as Principal and Technology Developer for Newhill Technologies and Specialty Materials. He is a longtime volunteer with SGIA, serving on the Association's Textile Committee for several years. Cabill has contributed several articles to the SGIA Journal. He is also a member of the Academy for Screen and Digital Printing Technologies.*

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- \*Ricoh, SGIA member since 2014
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- \*Océ, SGIA member since 1993
- \*Durst, SGIA member since 1994
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