HP-Indigo Technology and its Application to Photo Printing

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Abstract

HP-Indigo technology delivers superb print quality at a high printing speed over a wide range of substrates, including glossy matt and textured papers, as well as photo or other non paper substrates. Together with its flexibility and end to end solution portfolio it brings state of the art capabilities to a variety of photo applications, making HP-Indigo the dominant player in the digital photo printing market.

HP Indigo digital presses use liquid electrophotography based on ElectroInk®, with a hot transfer blanket. After electrically charging the photoconductor a latent image is created by a multi-beam laser scanning unit. Then ink is developed onto the latent image by one of the various colored ink development stations. After ink transfers to the blanket using electric field, the carrier liquid is evaporated off the hot blanket, and the resultant hot melted ink film is transferred to the substrate by means of pressure and tackiness. This process is repeated once for each color.

During the printing process a nearly solid ink image is created on a blanket, subsequently adhered to the surface of the substrate with almost no change and without penetrating into the media. Thus the high image quality is independent from the substrate characteristics. In addition, the ink layer is thin enough to achieve the feel of the substrate, so by choosing the substrate one can control the feel of the image, without compromising on image quality.

The flexibility of the technology enable both sheet fed and web fed presses, with nearly identical image characteristics. By using HP Indigo unique special inks, such as the white ink or the photo inks (light cyan, light magenta), print providers can create premium products.

End to end solutions of workflow and finishing are also provided by HP Indigo and through a network of partners. Work flow solutions include creation software, automatic image enhancement, imposition, high speed rips, and color transformations. Finishing solutions include in-line lamination, in-line liquid coating, cutting, stacking, book binding and more.

HP-Indigo equipment is used by the Photofinisher and professional lab, to create photo books, self-Published books, calendars, invitations, greeting cards, yearbooks, portraits, photo prints, theme items and more. Most of the photo books printed worldwide today are produced using HP-Indigo technology because there is a consensus among Print Service Providers about the Indigo technology being the one appropriate for the quality needs of the segment.

Introduction

HP's range of Indigo digital printing presses offers a unique combination of high print quality, wide color gamut, substrate versatility, speed, productivity, and flexibility. HP Indigo offers a wide range of digital presses for a variety of applications, all using the same basic principles, liquid electrophotography based on ElectroInk® with thermal offset blanket. By using liquid ink, high image quality is achievable at high printing speeds. The hot transfer blanket maintains high quality with substrate independence and minimal impact on the substrate (no fuser).

HP ElectroInk

All HP Indigo digital presses use HP ElectroInk, HP Indigo's unique liquid ink. HP ElectroInk contains electrically charged ink particles, dispersed in liquid, which enables digital printing based on the application of strictly controlled electrical fields to move charged color particles. This control enables accurate placement of the printing material. HP ElectroInk use very small particle size allowing high resolution, uniform gloss, sharp image edges, and very thin image layers.

The thin image layer closely follows the surface topography of the paper resulting in a highly uniform finish complementing that of the paper and resulting in a similar texture both on the image and on the non-image areas.

HP ElectroInk is available in an increasing range of colors, including:

- Standard process colors (cyan, magenta, yellow, black).
- HP IndiChrome wide-gamut 6- and 7- color set. These incorporate orange, violet and green inks, extending the color reproduction capabilities far beyond the range possible with CMYK inks only.
- HP IndiChrome spot colors – mixed from a set of 11 base inks, matching spot colors including most of the PANTONE® color range.
- Light cyan and light magenta for photo prints, competing with silver halide quality.
- White ink for transparent or colored media.
- Specialty inks such as security ink.

HP ElectroInk is supplied as a concentrated paste that is loaded into the press in cartridges. Inside the press it is fed into ink supply tanks, diluted with oil and combined with a charging control fluid, to form a fluid mixture of carrier liquid and colorant particles ready for printing. The mixing is done under accurate automatic control resulting in a stable ink with nearly constant physical traits leading to consistent prints.

Thermal offset

Offset simply means that there is an intermediate cylinder, covered with a renewable rubbery blanket that transfers the ink image from its origin on the plate cylinder to the final substrate (i.e. the paper, plastic or other material) which is to be printed. The rubbery blanket conforms to the local topography of the substrate, ink is adhered both to the "peaks" and the "valleys" of the substrate equally ensuring good ink transfer from printing plate to

the substrate, thus making it capable of printing on a wide range of substrates.

The HP Thermal Offset process uses a heated blanket causing the specially shaped pigment-carrying particles within the HP ElectroInk to melt and blend into a smooth film. When it contacts the cooler substrate, the HP ElectroInk adheres to the substrate, immediately solidifies and completely transfers with almost no change in dimension or shape. Since the image is completely defined on the blanket, the same high HP Indigo quality is maintained for all substrates.

The ink stays on top of the paper surface, maximizing colorant optical effect, and minimizing strike through to the duplex side.

Since the fusing and drying is done on the blanket and the transfer is by contact, it enables duplex printing or finishing with no waiting period or risk of ink set-off. Also there is little need to environmentally control the media prior to printing or to expose the media to extreme heat which limits the media types and may warp the media.

Color switching

As the HP Indigo LEP technology employs only contact transfers, the result is a process which can inherently be very fast and provide high quality at the speed. Currently the process speed, or image generation speed, is 2.15m/sec or 423ft/ min. This inherent speed is combined with the fact that HP's Digital Offset Color printing technology enables the printing of all color separations by a single engine. After one color separation has been created and printed, the next one (usually a different color) is created and printed on the same engine. This is possible since the blanket completely transfers the previous image, and none of the image stays on the blanket. It offers the flexibility to balance color content and productivity, on the same press and even within the same run. An example of this flexibility can be given by the two-engine HP Indigo W7200 Digital press. It can produce 480 duplex monochrome A4 pages per minute, which amounts to 960 A4 page sides per minute. If choosing to print 4-color pages the speed will be reduced by a factor of four to a still impressive 240 4-color page sides per minute. Going to even higher quality the printer may chose to employ 5, 6 or 7 colors and possibly add multiple passes of certain colors for added opacity and special effects. In this case the output speed will be reduced accordingly, but the value of the page increases.

Step-by-step description of the HP Indigo printing Process

The HP printing engine basically performs the following operations sequentially, for every color separation in the image (see **Figure 1** HP Indigo digital press printing cycle**Figure 1**):

1. PIP charging

The first step in LEP is the deposition of a uniform static electric charge on the photoconductor – Photo Imaging Plate (PIP) which is mounted on the imaging cylinder. This is achieved either by a charging roller or, for older press models, by scorotrons. In both techniques charged particles (atoms, molecules and free electrons) are produced by a glow discharge effect (i.e. the ionization of the air) through the application of high voltage.

The negatively charged particles are directed by electric field toward the PIP while the positive charged particles are attracted to the charging device and neutralized. In order to maintain the process stability, the voltages applied to control the transfer of the charges to the PIP are routinely and automatically calibrated to accommodate for changes in the photoconductor and the environment.

2. PIP exposure

The photoconductor becomes electrically conductive when exposed to light. As the PIP cylinder continues to rotate, it passes the imaging unit where as many as 22 laser beams in parallel expose the image area using ~2.5Gbit/s of data, dissipating (neutralizing) the charge in the image area. When the exposed PIP rotates toward the next station it is carrying a latent image in the form of an invisible electrostatic charge pattern conforming to the image to be printed.

3. Image development

Inking is performed by the Binary Ink Developer (BID) units, one for each ink. The BID units prepare a thin dense film of electrically charged ElectroInk on their roller surface (see also [3]).

During printing the appropriate BID roller engages with the PIP drum. The electrical fields between the PIP and the BID result in attracting the ink paste to the image area and repelling it from the non-image areas, shearing the ink film accurately and instantaneously. The result is the replication of the electrical latent image with a clean and sharp inked image.

4. Pre transfer erase

Just before the image is transferred a set of LEDs illuminate the PIP. The illumination causes a homogeneous conductivity across the PIP leading to dissipation of the charges still existing on the background. This enables a clean transfer of the image in the next stage avoiding the background charges from sparking to the blanket and damaging the image.

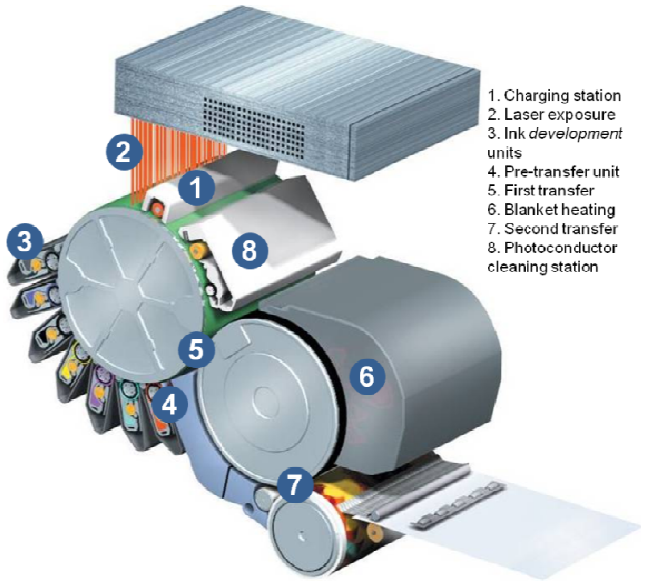

Figure 1 *HP Indigo digital press printing cycle*

5. First transfer

The PIP then rotates into contact with the electrically charged blanket on the transfer cylinder, and the ink layer is electrically transferred to the blanket.

6. Film formation (blanket heating)

Following the inked image, on the rotating and heated blanket, the HP ElectroInk is being heated both from the blanket and, in newer model presses, from an external heat source. This causes the ink particles to partially melt and blend together. At the same time most of the carrier oil is evaporated, to be collected and reused as part of fresh ink in the tanks. The result is a ready finished image in form of a hot, nearly dry, tacky plastic film.

7. Second transfer

As the ink comes into contact with the substrate, which is significantly below the melting temperature of the particles, the ink film solidifies, sticks to it, and completely peels off from the blanket, ensuring 100% transfer from blanket to substrate. The blanket is therefore clean and ready to accept the next impression with its new ink layer.

The second transfer method differs according to press models: The sheet fed models use the Multi-Shot Color imaging sequence. In Multi-Shot Color the substrate stays on the impression cylinder for several rotations of the press drums as it receives each separation from the blanket one after the other. As the final separation is printed, the substrate is either moved for duplex printing or delivered to the output tray. HP Indigo's web fed presses employ a One-Shot Color process, as it is not possible to wrap the material around the impression cylinder for multiple passes. In this case, the PIP cylinder rotates several times, transferring a succession of separations and building them up on the blanket, before they are transferred to the substrate all in the same impression pass.

8. Cleaning station

Returning to the PIP, after transferring the image to the blanket, it rotates past a cleaning station which removes any residual ink and cools the PIP from heat transferred during contact with the hot blanket. At this point the PIP surface has made a complete rotation and is ready to be recharged ready for the next image.

As mentioned before, HP Indigo presses print multiple colors from the same offset blanket. The cycle repeats itself for each color separation and the only difference between the cycles is in the ink

HP-Indigo technology and photo applications

In recent years there was significant worldwide increase in photo applications such as photo books and photo greeting cards, and the majority of them is fulfilled using HP-Indigo technology, as print service providers learned to appreciate its advantages.

Color consistency

Color consistency in the Indigo presses is based on few layers. First the inks are manufactured with tight color tolerances. Secondly the internal press parameters are kept constant using control loops (see [1] for a review).

The third layer is using the inline densitometer to automatically control, for each of the colors, the thickness of the ink layer (more precisely the optical density – the amount of light which the ink absorbs) and the area it covers on the paper (more precisely the relative amount of light absorption for each of the halftone levels).

Since using HP-Indigo technology there is virtually no interaction between the color separations, and since Indigo inks have consistent color coordinates, the color coordinates of the prints are maintained very close to a base level, over long periods of time, between multiple presses, and between screen sets. So once the print service provider defines color transformation from the input RGB to the press (ICC profile), colors are maintained within tight tolerance of his intent with no need for complex color calibrations.

Print permanence

In a print permanence study released by Wilhelm Imaging Research (see [2]) HP Indigo photo prints were rated at about 30 years as "displayed prints framed under glass" (exceeding Kodak silver halide rating) and rated above 200 years for "Album/Dark storage" (maximal rating)

Beyond the four process colors

While HP indigo presses brings high quality with four process colors, spanning ISO 12647 color gamut and reaching the darkest colors, they can also utilize up to three additional colors.

Light Cyan and Light Magenta inks for photo-realistic imaging. The light inks reduce granularity, providing smoother images and tone transitions, and a true photo look and feel. The white ink can be used for special applications, such as printing on black papers. IndiChrome enable enhanced color gamut.

Substrate variety

HP's Indigo Digital Offset Color process is compatible with a wider variety of substrate types, surfaces and thickness than any other digital printing process. These include paper, card stock, plastic, film, and metals. Only one formulation of HP ElectroInk is needed to print on any stock that the press can handle. One aspect of the compatibility is that the ink layer is thin enough to achieve the feel of the substrate, so by choosing the substrate one can control the feel of the image, without compromising on image quality. Media variety is most important to professional labs, making premium products, with special substrates.

End to end solutions

Towards the end of the year there is a peak in consumption of photo applications. HP offers a scalable DFE (digital front end) which can process all the incoming photo's during such peaks and support multiple presses printing in parallel.

Large HP-Indigo customers develop image processing technology enhancing amateur photos. HP offers image processing technology developed by HP labs, enabling smaller customers an access to automated image enhancement. The tool analyzes the picture and applies adaptive enhancement schemes to different pictures and to different areas within each picture. Customized tuning is available to the user.

Stock printed with HP ElectroInk is compatible with standard coating processes such as lamination or varnishing. Lamination of thin plastic films over the printed stock can be done in the conventional way, using a variety of solvent-borne, water-based, UV-based or solvent-free adhesives. Varnish coatings, either UV or water-based, can also be used and HP ElectroInk plastic resin withstands a large variety of chemical solvents.

The Indigo press owner can choose between a variety of inline, near-line or offline finishing solutions increasing the productivity of the full end-to-end print production.

Productivity and versatility

The robust design of the HP Indigo printing environment is aimed toward a 24/7 production flow. Critical process elements are automatically controlled by the press and reduce operator intervention. This self-management begins with the real time control of press status parameters and print quality and continues with the HP Indigo Print Care system which, in effect, places the knowledge of HP Indigo together with the press operator on the production floor.

Some of the large print service providers use large number of presses printing in parallel to achieve very high volumes, especially in peak time such as toward the end of the year. This is enabled by the scalable DFE that can drive all the presses from a single point, and by the ability to calibrate the presses so that they can all print the same jobs with no difference in color or quality.

The flexibility of the HP Indigo digital printing technology and systems enable production of different photo application and non photo applications with the same system. For smaller print service providers this means they can do photo application as part of their general offering, without the need for dedicated equipment. Larger providers can use their capacity in non peak times for commercial applications.

HP Indigo Digital Press Portfolio

HP offers a line of products using the HP technology, including:

HP Indigo Digital Press 5500	sheet fed, duplex, 68 PPM[1]
HP Indigo Digital Press 7500	sheet fed, duplex, 120 PPM
HP Indigo Digital Press 7200	web fed, duplex, 240 PPM
HP Indigo Digital Press WS6000P	web fed, simplex, 120 PPM

Recently Hp offered a solution for the cut-print photo market. The solution includes: photo base paper for the look and feel of cut-print photos; the WS6000P with outstanding print quality using light cyan and light magenta inks, offering a photo-realistic output; An image format of 317 x 980 mm gives the ability to capture applications with larger image sizes including photo prints, portrait prints, layflat books, book covers, and cards; HP SmartStream workflow solutions; Automated end-to-end solutions; An optional inline roll laminator is offered by HP Partner GMP Co. with an embossing roll for luster, gloss, and matt finishing. This solution is now used by customers as silver halide replacement in consumer and professional segments.

To summarize, HP Indigo's digital printing process offers a unique combination of quality, versatility, and productivity unmatched by any other existing digital technology. This technology was initially used in commercial printing and publishing segments, then direct mail and labels, and lately the photo segment. Applications like photo books, photo greeting cards or photo calendars are a worldwide fast growing business, where HP Indigo technology is the leading technology, printing most of the pages. Recently HP presented an end to end solution to replace silver halide prints, used by customers for consumer and professional applications. This direct AgX replacement trend is expected to grow as more photofinishers are exposed to the benefits of the HP Indigo solution.

References

[1] Gilad Tzori, Control Mechanisms for Print Quality Assurance in HP Indigo Presses, Proc. NIP20, pg. 586. (2004).

[2] http://www.wilhelm-research.com/ HPIndigo/WIR_HP_Indigo_2011_03_07.pdf (2011).

[3] Boaz Tagansky, Ink Development in HP Indigo Digital Presses, Proc. NIP24, pg. 799. (2008).

Author Biography

Boaz Tagansky received his B.Sc. degrees in mechanical engineering and computer science from the Technion - Israel Institute of Technology at 1986 and 1987, and joined Indigo as a mechanical engineer. Later he received his PhD from Tel-Aviv University at 1996. His research interests at Indigo, later acquired by Hewlett-Packard, have focused on the physics of liquid electro photography. Now he is distinguish technologist around print quality road map and future technologies.

[1] PPM – throughput in pages per minute, page being A4 size 4 colors one side