Until Now There Was No Industrial Digital Printing Solution

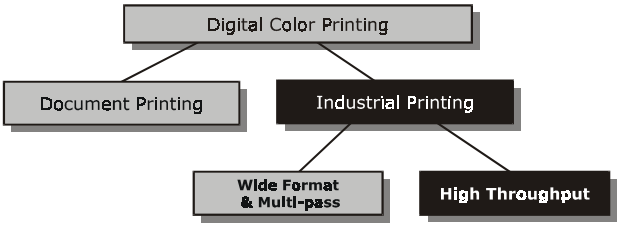
Geert Van den hole
Barco Graphics
Gent, Belgium

The Industrial Printing Market

Looking at the digital print world, we clearly distinguish 2 different worlds. The best known one is the document world. This one is steered by the look and feel of offset printing, is driven by A3, A4 and Letter formats and duplex printing. In this world the most common substrate is paper. The second one, the so-called industrial printing world, is ruled by other printing techniques such as screen printing, gravure and flexo printing. That world is "formatted" by big reels, higher speed and true industrial finishing requirements: The single side printed substrates require high color accuracy, high rub fastness and must be able to stand industrial post-treatments (e.g. heat sealing). The substrates vary from very thin foils, films and paper over thick and thin aluminum to plastics. Pressure sensitive substrates are also applied often. The finishing varies per application.

The customers' Requirements

This industrial printing market is experiencing customer demands similar to other segments of the printing & publishing industries. Time to market and flexibility are requirements in every step of the supply chain. Shorter lead times due to more mission critical printing needs, shorter run lengths, the demand for test runs of larger jobs have created the need for a productive digital printing solution for this particular market. Many industrial applications can benefit from the added value of variable data printing, in particular the security and packaging industries where the need for completely unique information is becoming obvious.



Industrial Focus

Barco never intended to focus on the document market since there are enough valid solutions available e.g. electrophotography based solutions. There are enough strong players in this market segment and this technology was not as successful as they hoped for. It appears to be a typical document printing solution. So far, nobody showed a real productive electrophotography based industrial printing solution.

The existing digital industrial printing solutions are mostly ink jet based. Amongst these, one can define 2 segmentations:

1. The "wide format & multi-pass" segment: good quality, but not at all very productive. It is slow but relatively cheap (in general only 1 print head is used) and different ink types are available. Customers will be able to find a suitable combination for proofing.
2. The "high throughput" segment: This segment should offer a solution which not only provides high throughput but also meets the requirements of industrial printing. This is the segment where an innovative digital color press can play an important role.

The Project

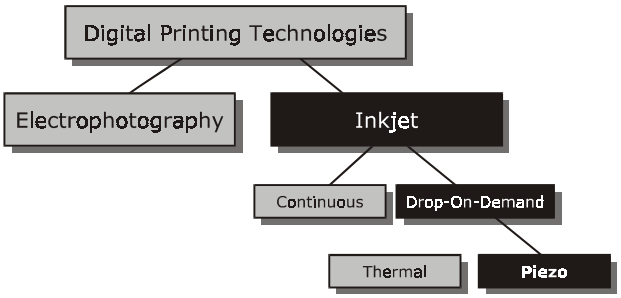
Such a new device, built by Barco, could benefit from a range of enabling technologies and applications from Barco's considerable portfolio and know-how in complicated high-end imaging and prepress technology. Barco Graphics is a total solution provider and has all the elements to provide the customer with a complete digital pre-press workflow: Barco offers a suite of products within origination, color management, imaging (film and plate setters) and file transfer architecture as well as screening and RIP technologies. To complete the full digital workflow, Barco had to build a digital press, an industrial digital color press for short-run, sampling, personalized and fully variable data production printing. The press is designed to print on the substrates of the industry, should print inks and should deliver a print quality which is as close as possible to the quality of traditional printing. Before designing it, Barco had to investigate the available technologies.

The Selection

The industrial requirements were the prime requirements. But Barco also had to look for a technology that has brilliant future perspectives, provides small footprint and straight forward implementation.

The "other" technology to take into consideration next to electrophotography was inkjet.

Within inkjet we identify 2 main groups: Continuous inkjet and Drop-on-Demand inkjet. Continuous inkjet print heads are cheaper and have a much higher firing speed. This is clearly an advantage.



A major disadvantage however, is the limited choice of inks that can be jetted with this technology: The charging of the inks to enable deflecting tolerates only a specific ink type. Another disadvantage is the ink wastage generated by continuous inkjet or one has to recycle the deflected ink. Drop-on-Demand and more precisely Piezo driven technologies don't have to deal with these restrictions. What's more, D-o-D PZT inkjet has, from a technology point of view, the ability to jet different types of ink: Solvent based inks, oil based inks, aqueous based inks and UV curable inks. Other technologies such as thermal inkjet are again much more limited as far as the choice of ink type is concerned. D-o-D PZT offered the right perspectives for industrial printing applications. See also the PZT technology track at the end of this abstract, to better understand the scoop of PZT.

Xaar Technology

From selecting the D-o-D PZT technology to selecting the best and the most promising inkjet heads was another challenge. Xaar was the only company offering gray scale inkjet capabilities. Taking as a challenge the printing of minimum 4-colors, the footprint should be very small to optimize drying. Therefore only Xaar inkjet heads enabled us to build a matrix of inkjet heads allowing us to gain speed and quality. The way the PZT ink chambers in the Xaar heads are build, their so-called shared wall D-o-D technology, results in a very compact inkjet head and allows Barco to build up to six colors into one print unit.

The Xaar gray scale inkjet head is the only gray scale ink jet head available on the market. The Barco SPICE implementation (Single Pass Inkjet Color Engine) was the only "not multi-pass" application at Drupa. Gray scale inkjet is currently the best way to optimize quality. As a rule of thumb: 360 dpi at 3 bits per spot equals 1080 dpi. One can a least state that the perceived image quality is a lot higher than the numeric value.

Xaar inkjet heads are built to live a long life, an industrial life time. Never relate to SOHO inkjet life times. MTBF calculations have shown that when operated during 2 shifts of 8 hours per day (of which 6 hours of printing per shift), they should last 3 to 6 months. In practice the life time depends upon the amount of inks passing through the nozzles, strongly related to the coverage of the jobs and the application.

When it comes to modularity, Xaar has built up experience in the 4 different inkjet ink types. Xaar has built up a strong reputation in industrial inkjet for multi-pass systems.

Gray Scale vs. Binary

Common ink jet heads are binary. In other words, they always print the same drop size. Xaar inkjet heads are 3 bit gray scale, capable of generating 7 different drop sizes. Taking into account the 0-volume drop size, this means 8 levels (2^3). The different drop sizes are created by firing (much smaller) sub drops.

It is a big advantage if the printing device itself can produce different tints of the ink, by varying the drop volume. The Xaar inkjet head is able to generate 7 different drop sizes. This way, the screening no longer needs to bridge the gap from 0% to 100% ink by adding more or less pixels. It only needs to provide a smooth transition between two successive gray levels of the printing device. Combining these different intensities (gray levels) with a stochastic screening results in doubling the visual resolution and the apparent print quality, and this not only for continuous tone images but also for very small text.

UV Curable Inks

Another important choice. Barco has selected the UV curable inkjet inks and this for several reasons: UV curable inks adhere very good to a wide range of substrates. UV curable inks have a high rub resistance, scratch fastness and high color fastness. UV curable inks do not contain components that are on the VOC-list (Volatile Organic Compounds). Because of these arguments and more especially for environmental reasons there is a general breakthrough of UV-inks in the industry. Once the ink is well cured, UV-ink is the perfect ink for many industrial printing applications.

The UV-curing unit hardens the ink immediately after printing. The substrate might be subject to high temperatures during curing. Many solutions e.g water

cooled counter rollers or cold mirror lamps can be installed to deal with this. As this (well controlled) curing is the only part of the printing process where heat is involved, this means that heat sensitive substrates such as thin foils or self-adhesive paper can be printed. Other more appropriate curing systems can be applied to fit the most severe curing requirements.

Thanks to different benchmarks, it has been proven that the currently used inks stand well the industrial finishing (tolerating higher finishing temperatures up to 230 °C). The color fastness and the scratch resistance are very high and the adhesion is very good for many substrates. The system enables fast printing and drying. The combination UV curable inks and Drop-on-Demand inkjet make sure there is no ink waste and no ink recycling. The industry acceptance is becoming a fact for UV curable inks and will become a fact for UV inkjet.

The developments over the last two years clearly show that a lot of the ink restrictions can be solved by the ink providers, most of them having different skills for different applications and substrates.

The Inkjet Cartridge System

The individual Xaar inkjet head is a 180 dpi, eight level gray scale print head having a printing width of 70 mm. Barco has designed an inkjet cartridge system that allows easy set-up, maintenance, and replacement of the individual cartridges. One cartridge consists of 2 Xaar inkjet heads. The inkjet heads are mounted face-to-face, tightly assembled within highly accurate self-positioning brackets. By slightly offsetting the individual heads in the cartridge, Barco doubles the resolution to 360 dpi. The cartridges are featured with ink manifolds, ink-level sensor and steering-, and calibration electronics. To enable easy change over, the cartridges are equipped with quick connections for vacuum, pressured air, temperature control (cooling and heating), electronic-, and data connection. All these components will reside in a stainless steel container.

The cartridge can be seen as the basic unit on modular color bar, whereas the color bar on its turn is the basic element in the modular SPICE design. This concept allows us to tailor the digital engine to the customers need; by increasing the number of cartridges on a color-bar, Barco can increase the printing width, by increasing the number of color bars, Barco can extend the number of printing colors.

The cartridge is a major element in the modular SPICE concept; therefore Barco assembles these cartridges. The expected lifetime of an individual Xaar inkjet head is 5 billion droplets. Our mechanical design allows easy cartridge replacement.

SPICE Concept

The Single Pass Inkjet Color Engine is the name for the actual print engine. At Drupa Barco showed a "technology demo", a prototype of an industrial press it intends to commercialize by Q4, 2001.

Thanks to the single pass concept (no scanning inkjet print heads) high printing speeds can be obtained. The heads are not moving (wasting precious time) and the substrate is presented under the web. Static print heads allow us to print at the top speed of the inkjet heads. The opponent of single pass is multi-pass inkjet (scanning inkjet heads). This will always be a slow concept: The web has to wait for the inkjet print heads to make the XY movement. The single pass idea has been witnessed as innovative and breakthrough technology during the Drupa fair in 2000.

Barco has implemented a matrix of 9 cartridges to print the maximum print width of 63 cm. To obtain an invisible stitching the cartridges overlap. In real size the overlap is only some nozzles. Stitching is perfectly managed both in software and/or hardware.

In a configuration with multiple heads, all heads need to be kept continuously in prime condition. To keep the heads in prime condition, you need a full automated maintenance system. SPICE is provided with a preventive maintenance unit. The SPICE unit is raised and a robotized cleaning unit passes under the nozzles and cleans them by vacuum pressure, without even touching the nozzle but well restoring the pre-firing prime condition of the nozzle plate.

Several Ink jet heads are of-the-shelve available on the market, but the challenge was to design and to develop electronics driving the cartridges in the most efficient way and with a minimum of electronics, maintaining the modularity of the concept.

In the.factory configuration the SPICE is placed on a roll-to-roll base engine. SPICE is also available for OEM integration or implementation onto other engines, both fully digital or hybrid.

The Markets, the Customers and Barco

Barco has identified a number of potential applications, including wall covering, laminates, decorative panels, labels, security printing and other specialty applications. The speed and flexibility as well as the total end-to-end

solution based upon Barco's legacy of dedicated prepress software for these types of applications positions the.factory in an entirely unique market position. At 800 square meters an hour with fully variable images at rated engine speeds, other digital printing technologies cannot offer this level of productivity and versatility to an industry with very large printing volumes and increasing demands for sophisticated printing.

It will move its customers' value chain upstream, intending to add value through making their workflow process more efficient. Having learned from its efforts in variable document information printing with other digital presses and other selected high-speed color printers, Barco felt that its other customers could benefit from an industrial printer to automate their entire workflow process

Barco is taking a well-calculated pioneering position in the industrial digital printing market, one that will change not only its own business but will add tremendous value to its customers' business – a good recipe for success.

Barco offers a wide range of specialized customer services. Through these services we help our customers maximize the uptime of the configuration, raise their productivity and increase their profits.

Besides the nice look and feel of ink on substrate, the technical aspect of it can be a very important issue in a lot of applications. Using variable data digital presses like the.factory will enable manufacturers to differentiate their products. Traditional printing technologies such as gravure and flexographic printing have limitations in flexibility due to the need of producing large print runs to lower the costs, as well as limiting the design flexibility due to the technology.

Presses as the.factory will be able to print up to 800 square meters an hour and will provide ultra-high speed, variable data, digital color printing for industrial applications.

PZT Technology Track

PZT inkjet technology's core value proposition is its unique ability to provide a cheap non-contact digital printing technology with maximized life, reliability and ability to utilize a very wide range of ink chemistries on a very wide range of substrates. It can also be applied in a modular way in-line to industrial processes and systems. This allows it to come closest of all digital print technologies to the print performance of the traditional analog technologies whose performance it is attempting to enhance. The enhancement proposition consists in being able to progressively synchronize the (today) very unsynchronized and expensive print process with the otherwise digital processes driving all manufacturing and distribution today.

Current State of the Art

Economically viable PZT technology today has mostly been designed for and utilized in the office and consumer environments. It is usable in a large-scale industrial environment, but not yet fully optimized for it.

How the Technology will Probably Develop Over the Next Five Years

PZT technology will become robust and will be configured in arrays up to 10 times larger than available today (from 2,5 cm to 24 cm wide). Low solids (=faster drying and higher speed capability) and wide chemical capability will become possible. Research efforts in the inkjet industry will focus more on PZT, rather than on thermal inkjet, as PZT becomes more important to meet the heavy duty volume requirements of industrial printing. The unit speed capability of PZT in industrial environments will likely rise at least five-fold over today (10 MHZ – 100MHZ) as an effect of increasing drop ejection rates and larger heads, and the problems of integrating many heads reliably into massive multiple arrays will be resolved - perhaps including fixed full-width arrays.

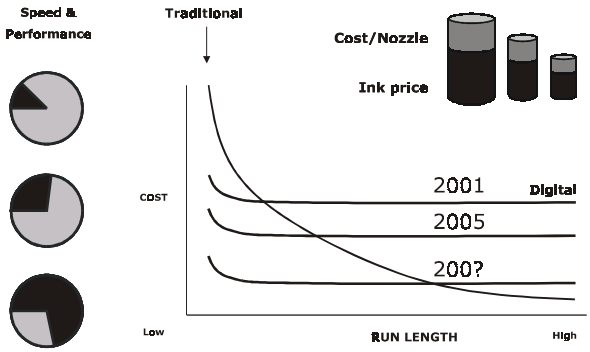
Significance of Key Suppliers of PZT Technology

There will be two classes of suppliers in the future: the Japanese commodity suppliers (up to 10 of them) who will provide the best price/performance inkjet heads in the largest volumes and the rest who will provide more expensive but initially more robust systems. The Japanese will develop equally robust industrial systems in adapting to a non office business model.

Future PZT Capabilities within Systems

The technology of PZT is capable of enhancing and renewing huge traditional analog print markets suffering enormous inefficiencies today due to their technological stasis. Non-contact printing in an essentially mechanically simple format has the capability to be not less than an epochal revolution in marking substrates. The next five years probably allows first market entrants to establish a credible lead in a systems market which

can be half a billion dollars in value within the five year period and perhaps $20 billion within ten years.



Evolution in Inkjet Technologies: Perspective

1990 saw the introduction of inkjet printing in the SOHO (Small Office Home Office) markets. A basic 180DPI binary printing head, jetting pico liter droplets found its way in the office printing environment. In 1996, with the introduction of the wide-format digital proofing systems, the first commercial usage of Piezo-electric (PZT) inkjet technology marked the start of total brandnew marketplace for inkjet printing, the industrial printing domain, not printing on paper, but on industrial substrates, such as vinyl, canvas, plastics and textile. A number of new developments took place in the development of this PZT-technologies. Companies, such as Data Products, Spectra, Trident and Xaar further improved the basic PZT for heavy duty usage and higher resolution. In 2000 Xaar announced at DRUPA the first generation of grayscale heads, that enables multi-drop sizes to further improve the print quality that will be available for single pass printing in 2001. This technology will see major improvements through better micro-manufacturing, improved electronics, higher resolutions and increased reliability. A number of Japanese companies are license-holders of these PZT-technologies and will be setting the stage for better price-performance standards, expected in 2003.

From 2005 onwards you will see the introduction of new technologies, capable of jetting at even smaller drop sizes and at very high speed and resolution.

Once available these technologies will eventually challenge the traditional offset printing process, and this even for volume printing.