Integrated Digital Printing and Converting

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Abstract

For digital printing to be successful in the label market, the technology needs to include all the converting flexibility for which narrow web in-line presses are well known. The technology needs to be truly integrated into converting equipment that the label industry currently uses. It needs to have the capability to lay down spot colors and varnishes, diecut, strip the waste, foil stamp, etc. A successful solution will treat digital printing just like another printing process – and not have to run many off-line operations to finish converting the label. The key is to provide digital printing as added flexibility on current converting equipment, allowing it to print an even wider variety of labels. Thus eliminating the investment of off-line technology to provide the low-cost answer to short runs and variable information.

This paper will describe an example of how digital inkjet printing can be combined with laser finishing to satisfy the needs of the label converters. It will address the technology of the combination of inkjet printing and laser finishing. It will also address the production economics and discuss the benefits of producing the complete label in one pass through the press.

Introduction

Many of us over the last few years have heard about "Digital Printing" and how it will completely obsolete the normal methods of printing. There are some very good quality digital printing machines in the market right now. The problem is that most of these existing machines were designed primarily for the commercial printing markets.

In this paper, I'll present a new technology that is designed specifically for the tag and label printing markets. These markets have special needs that commercial printers do not. One of these special needs is to integrate the printing and converting operations into one step. I'll discuss the drivers for digital printing and then the advantages and details of using inkjet printing. I'll discuss laser finishing as a means to efficiently convert very short runs. Finally, I'll present some economic information that will show an example of where the cross-over points are in terms of costs between digital printing and converting – and running the job on a normal flexo press.

Advantages of Digital Printing in the Label Market:

First let's review what some of the advantages are of printing and converting digitally, in the tag and label markets.

Certainly one of the main ideas of printing digitally is to cut down on the amount of time for a job setup. If the operator doesn't have to clean up the ink and reload plate cylinders between each job, they will be able to run many more jobs during a day. Since there is very little setup time, the press time and the cost to run each job is lower. This allows running smaller quantities at a reasonable cost.

Printing digitally means lower inventory levels - both for the end user and the converter. Because end users want to order less of a label to keep their inventory down and reduce obsolescence costs, sometimes the converter gets squeezed. They go ahead and run a larger quantity - just because it is more efficient than running smaller quantities. Then they have to stock these excess labels creating excess inventory and costs. Digital printing allows the converter to print exactly the quantity the end user wants.

More product variation is possible with digital printing. For example, it's possible to consecutively number a barcode on a label, or run ten of one customer's name on a wine label - or even change the complete image on every label - all as the job requires. This is all possible because the technology does not use printing plates. Since there are no plates, there are no plate costs!

Finally, one of the biggest advantages of printing digitally is that it is possible to have a very short job turn around time. An end user can drop the job off in the morning and it could easily be done within a couple of hours - again because it is not necessary to burn the printing plates.

Needs for the Tag and Label Market

Let's talk about what is needed specifically for the Tag and Label Market.

The system has to be simple. It has to require little maintenance. It should be easy enough that a normal pressman can operate it. It should not require a pre-press expert to run it.

The consumables have to be relatively inexpensive. Digital printing takes the cost out of the reduced setup time and plate cost, but it would not be realistic to replace it all back again with expensive consumables.

Label converters print on a very wide variety of substrates. This system has to print on all of them and not have to worry about moisture in the web or how electrically conductive the web is.

It has to be industrially designed. The system needs to run in a print shop - not a temperature and humidity controlled room. Most printers simply do not have these specialized facilities.

Finally, the printing system must be truly and simply integrated into a converting system. This will allow the complete label or tag to be produced - all in one pass.

Main Technologies

This slide shows some of the current technologies used in different forms of digital printing. The two main groups are electrophotography and inkjet. Electrophotography uses some sort of a laser or LED imaged, photoconductive drum and then a dry or a liquid toner adheres to the proper image. This toner is then transferred to the substrate. There are some inherent consistency problems with this type of system that I will explain later.

Other than thermal bubble jet desktop printers, the two types of inkjet printers used in the label and tag market are continuous and Piezo electric, drop-on-demand ink jet.

Continuous inkjet systems produce a constant stream of ink drops. The drops that are not supposed to go onto the web get deflected into a recycling tray. These inks are typically dye based, giving a relatively flat look and fade easily in sunlight.

Piezo electric ink jet systems use a current to flex a ceramic, piezo electric element and shoot the ink out of a nozzle plate. The ink is only expelled onto the web where needed. These are usually a pigmented ink that give more dense colors.

Dotrix dot.factory

Now let's get to the new technology I want to discuss.

The company "Dotrix" has developed an inkjet engine called the "dot factory". They developed it primarily for the decorative printing market - like wall papers. It uses the piezo electric drop-on-demand inkjet system with UV curable inks. The "dot factory" is a 25 inch (630mm) wide system printing up to six colors. The engine is mounted on a web transport system with a simple unwind and rewind.

Dotrix SPICE mounted on a Mark Andy 2200

Another configuration for this inkjet engine technology is to mount it directly into a normal flexographic printing press. One recent configuration is to mount it onto a 13" (330mm) wide label press.

To further describe a typical configuration, it could consist of an unwind, two flexo printing stations, a four color UV inkjet system, two more flexo stations, then a diecutting module, and rewind.

It is easy to see how an operator could use the initial print stations to lay down an opaque white - for example on a clear film. He could then print the majority of the label using four color process, then lay down a UV varnish, or an adhesive right in line.

Finally he can diecut, slit, strip the waste, hot foil stamp and rewind or sheet onto a conveyor - all in the same pass.

Basically, the digital portion of the press is just another printing process that the operator can use.

Inkjet Station

Now we will go into more detail regarding the actual printing technology. Basically, the module consists of the top portion of the dotrix "dot factory" mounted on a module base that can be fitted into a flexographic press.

Engineering View of Module

The web will come into the module from the left, go over the set of idler rollers mounted in an arc, then down around a chill drum.

The chill drum serves two purposes. It is a servo driven roll, and paces the web through the module, and it acts as a heat sink for the UV lamps. This way the substrate does not get too hot. So it is possible to run a heat sensitive substrate through this module.

I want to also point out that the complete idler roller subframe moves down to allow a head cleaning tray to come out. This maintenance system is what periodically cleans the inkjet heads. In a programmed fashion, it moves from head to head and purges a few drops of ink out of the head and vacuums it away.

SPICE

The inkjet engine is called the "SPICE" rack - which stands for Single Pass Inkjet Color Engine. It has the capability to be configured with from one to six colorbars.

SPICE Specifications

So to review, the specifications of this SPICE printer are:

- Piezo electric drop-on-demand inkjet
- 80 feet per minute (24 mpm) run speed with six colors at full 100% ink coverage
- 300 dpi resolution with 8 levels of grayscale
- UV curable inks
- The width of each head is 2 inches (52 mm) wide, so we stitch seven of them together for a full 13" (330mm) printing width
- The ink is now being developed for the four CMYK primary colors, with more to follow. It is possible to populate the system with a total of 6 colorbars.

Colorbar Slide

To examine the technology further, each of the colorbars is mounted on a slide for easy maintenance or inspection. At the top of each colorbar is the electronics. These are the circuit boards that take the ripped data from the computer and tell which of the nozzles to fire.

Under the electronics is the utility bar. This is really a manifold that controls the flow of ink, vacuum air pressure and water. It is important that the heads are kept at a constant temperature. Instead of having to keep the room a constant temperature, there is a heater/cooler that circulates water throughout the heads. The vacuum system is what

actually keeps the ink in the heads while the piezo ceramic elements are not flexing.

Finally, the inkjet cartridges are at the bottom of the colorbar. Each of these cartridges is 2 inches (52mm) wide. They are stitched together very accurately so there is no visible indication on the label of where the heads are joined together.

The design of the printer is such that the cartridges are easy to interchange if needed. All the connections are made directly to the utility bar. These include ink, water, and the vacuum line. The colorbars themselves can be taken out of the printer for maintenance if needed. Both the cartridges and the colorbars are accurately aligned once during installation. If they need to be replaced, the design allows them to go back into proper alignment.

Nozzle Plates

By looking underneath the colorbar, one can see how the cartridges are staggered across the web.

SPICE Building Blocks

Just to review, the main building blocks of the SPICE printer are the inkjet cartridges, the colorbars that the cartridges are mounted on, and the electronics circuit board to fire the heads. The final remaining piece is the ink delivery system. The inks come in five liter jugs, and since there is actually a small buffer tank in the ink delivery system, the jugs can be changed while the printer is in operation.

XAAR Inkjet Head Technology

The inkjet head itself is based on the XAAR piezo electric drop-on-demand technology. An important feature of the Xaar technology is that these heads have the ability to print with grayscale. I'll talk more about grayscale a little later. These can heads fire at a rate of 5,000 droplets per second, giving an end web speed of 80 fpm (24 mpm).

Xaar has licensed their technology to Toshiba/TEC. We actually use the heads made by Toshiba/TEC.

Combined 300 dpi Inkjet Head

Each inkjet head is actually 150 dots per inch (dpi). By combining two heads into one cartridge, and offsetting them by a half a nozzle, we can create a cartridge that is 300 dpi resolution. These heads are assembled permanently together using a very accurate computer controlled alignment fixture.

Cartridge Drawing

A drawing of the inkjet cartridge shows how two heads are combined to make one with a higher resolution. Then Dotrix attaches the heat sink, the ink, water and vacuum supply, and the electronics - all to make one complete inkjet cartridge.

Shared Wall PZT Technology

To explain the Xaar technology further, it uses a piezo ceramic element that deflects sideways when an electric current is applied. The walls between nozzles are shared, so that when the ink in one section is being loaded, the ink in another is being expelled.

Binary vs Grayscale

As I said earlier, the ability to print with grayscale gives these heads a big advantage. These heads can print with 8 levels of grayscale. This means that we can actually vary the size of the drop - from a volume of 6 picoliters to 42 picoliters. This is done by shooting out from 0 to 7 droplets and combining them together before they actually hit the web. This is different that the binary system that most inkjet heads use. Those binary systems either print a dot - or they don't. It's always one sized dot - usually 20-30 picoliters. By being able to change the size of the dots, we can get a very good quality image with a higher apparent resolution, without having such a high dpi. The binary systems REQUIRE a higher resolution to get a good image. The SPICE inkjet heads give about the equivalent quality level of a 150 lpi flexo print job.

Grayscale Effect On Text

Printing with a binary system makes the text difficult to read, while printing with grayscale makes a big difference. We ran a test recently on 3 pt text, printing at first with a binary system. It was completely illegible. When we switched to a full 8 levels of grayscale - with the same resolution - the 3 pt text was easily readable.

Sensor for Pre-Printed Web

In this combined flexo press and inkjet printer, there are a couple of methods to register the two together. One is to simply electronically advance or retard the inkjet printer to match registration with the flexo press. Another is to use a sensor like this one to see a pre-printed mark, and automatically fire the inkjet printer. This sensor can also be used to see a mark that is printed on a job that might be printed on a different press. For whatever reason, one might want to print a large run on a different press, then break it up into smaller lot sizes and may add some variable information with this inkjet printer.

Ink Types

There are several different types of inks that are commonly used in inkjet printing. The inks used in the SPICE inkjet engine are UV curable. For many reasons, UV inks have several advantages in the tag and label markets. UV inks have no solvents, so they will not dry in the heads. They have a high scratch resistance. They are more light-fast than other types of inks. And they are really already used extensively in the industry now.

Ink Specifications

The UV curable inks used in the SPICE engine are specially made for easy jetting through the nozzles. They have a pigment grind that is around 3 microns – about half of that of a normal UV flexo ink. The viscosity of the ink is only about 10 centipoise – almost like water.

The UV ink will be offered for sale direct to the printer. Currently inks are developed from Avecia – a UK inkjet ink

manufacturer, but testing is ongoing with both Sunjet and Akzo Nobel.

There is an interesting phenomenon that occurs with a heavy laydown of the ink. The ink thickness is about a 10-20 micron thickness – more than the 6-8 micron thickness that is common in UV flexo printing. This gives a tactile quality that some would compare to screen printing.

UV Curing Lamps

As stated earlier, after the ink is deposited, the substrate travels around a chill drum, and the ink is cured by two UV lamps. One of the lamps is a mercury vapor lamp (280 nm wavelength) for surface curing, and the other is a gallium doped lamp (330-380nm wavelength) for a deeper penetration cure.

The lamps are also nitrogen-inerted for even better cure potential.

Operator Knowledge

One of the original requirements that I outlined at the beginning was the philosophy that this technology has to be simple to operate. It can not be necessary to have a pre-press person out at the press running the printer.

The normal press operator knows how to run a printing press, how to handle inks, how to get a job into registration, etc. He does not know how to create the artwork for a job, how to step and repeat a job, or what fonts are used, or even how to rip a job.

It is best to leave the pre-press end of the work to the pre-press person and the press operation to the pressman.

Job Workflow

The job workflow will take place as follows: The pre-press person will create a job in any normal program, or get it in from the customer, and pre-flight it. This means setting the step and repeat, checking for missing fonts, adding variable information, etc. and then creating a postscript file. He will create a job ticket, and then RIP the file, preview it, and make sure there are no problems. Finally, he will put it into the printer's queue.

The printer can then call up the job and preview it, change the quantity if he wants to, and print. Very simple - and each person is doing the job for which they were trained.

Operator Interface

From the operator interface, the operator is able to pick the jobs he wants to run from a catalogue of jobs that have already been queued up by the pre-press person. The operator can change the quantity and even set the priority. He can also set the type of screening, the substrate dot gain emulation curves, and of course, adjust registration.

Inkjet Maintenance

The maintenance on the inkjet system is quite simple. The operator can select an individual head to manually clean, or select to automatically clean all heads. This process takes a total of five minutes to do all the heads. It will be necessary to perform an automatic maintenance cycle on the heads in the morning, and once again during a shift. Since there are very few moving parts to this system, there is very little maintenance required.

Review of Inkjet Benefits

To review, inkjet is the best technology for the tag and label market for several reasons. First of all – it is consistent. There are no OPC drums to wear out as there are on the electrophotographic systems. There are no variations in static charges due to humidity in the air and moisture content in the substrate. The ink is a constant viscosity. All these add up to print consistency. Each little inkjet nozzle is like a fixed displacement pump. Every time it jets, it shoots out exactly the same amount of ink. The system will print the same colors and densities today as it will next year.

Obviously, other benefits include the fact that it is a simple operation and requires very little maintenance.

Finishing Options

By combining the inkjet printer onto a normal press, it is possible to do all the converting in one pass. One can complete the label by applying adhesive, diecutting, laminating, slitting, sheeting, stacking, conveying, fan-folding, or rewinding.

Advantages of In-line Finishing

The advantages of in-line finishing are that it is very simple. There is only one operator and one operation. There is no additional material waste during setup.

This is a very efficient operation when several jobs can be combined to use one die. The ultimate solution, however, is to use a laser diecutter.

Laser Converting Unit

The other half of the "quick change" equation is a laser converting unit. This laser can also be mounted in line with the inkjet printer on a normal flexo press. This is absolutely the most efficient and profitable way to run a job because again – it drastically reduces that amount of setup time for a particular job.

The other advantage that a laser diecutter offers is to reduce the amount of time required to have the die made. When a brand new job comes in, it is possible to still get it out the door the same day!

Mark Andy has partnered up with Las-X Industries in Minnesota to supply such a laser converting unit.

If desired, the laser can also be offered as an off-line converting unit – to be matched with any other press.

Laser Converting Advantages

Other advantages to a laser converting unit, in addition to the set up time and waste reduction, are the ability to create some unique shapes with the laser that cannot be achieved with a normal rotary tool.

The laser can kiss cut, through cut, or even etch off some of the applied ink. It can sheet, slit, line hole punch, perforate, or even crease a carton. It is a very versatile tool.

Laser Speed

The speed of the laser depends on the wattage applied. At 300 watts, the laser speed is 6 meters per second on polypropylene and 3.8 meters per second on paper. It has a 10 m/s jump speed to the next image.

There are also up to 1000 watt lasers available for even higher speed cutting.

Web Speed with a Laser Converting Unit

The web speed will vary, based on the amount of perimeter needed for the laser to cut.

Two examples are with a 300 watt laser, it will keep up with the inkjet printed web speed when cutting squares of 5 inches or larger. With a 1000 watt laser, it is possible to achieve 80 fpm (24 mpm) run speeds when cutting squares of 3 inches or larger. Anything smaller than these sizes will slow the press run speed down.

Laser Maintenance

As with the inkjet printer, the required maintenance on the laser converting unit is very low. It is necessary to clean the window once per week, and Mark Andy comes in once per year to make sure the optics are aligned properly.

The laser is sized to last for 20,000 hours - or ten years of a continuous one-shift operation.

Economic Production Model – with Rotary Diecutting

We can now go through two economic models to determine when it is justifiable to run a job on a digital press.

The first example will be with the inkjet printer and a normal rotary diecutter. The chart below describes the assumptions made in the model.

	Flexo press	**DT2200**
Label size	6X6 inch (15x15cm)	Same
Speed	250 fpm (85 mpm)	80 fpm (24 mpm)
Setup waste	200 feet (65 m)	100 feet (35 m)
Ink coverage	50%	Same
# Colors	4	Same
Set up time – press	10 minutes	Same
Set up time per color	5 minutes	0

Running the economic model with the assumptions listed above, we find that the press can be justified when running any job over 11,000 labels – or approximately 3,000 feet of stock.

We also find the following for a 6000 label job:

- $524K increase in profitability (88%)
- 39% ROI
- 1.44 years payback
- Increase from 2,600 to 3,159 jobs per year
- If they are not able to sell the additional jobs, they will still gain $315K in additional profit because of less waste.

Economic Production Model – with Laser Converting

In the second example, we replace the rotary diecutting unit with a laser converting unit. We also eliminate much of the 10 minutes of press setup time. The assumptions are as follows:

	Flexo press	**DT2200 w/ laser**
Label size	6X6 inch (15x15cm)	Same
Speed	250 fpm (85 mpm)	80 fpm (24 mpm)
Setup waste	200 feet (65 m)	20 feet (7 m)
Ink coverage	50%	Same
# Colors	4	Same
Set up time – press	10 minutes	1 minute
Set up time per color	5 minutes	0

Running the second economic model with the assumptions listed above, we find that the press can be justified when running any job over 17,500 labels – or approximately 4,500 feet of stock.

We also find the following for a 6000 label job:

- $1,592K increase in profitability (267%)
- 83% ROI
- 0.2 years payback
- Increase from 2,600 to 4,708 jobs per year
- If they are not able to sell the additional jobs, they will still gain $612K in additional profit because of less waste.

Keep in mind that these models take into account the labor cost, maintenance cost, consumable costs, and even the capital cost of the equipment.

Summary

To summarize, inkjet technology is really the best alternative for the tag and label markets. It will integrate very easily directly into a narrow web press and will print on most any substrate. There are no width limitations - the printer prints only where needed, so the operator does not have to use one size of substrate for all jobs, like some systems on the market now. Inkjet is a simple, reliable, consistent system - it is truly industrially designed. There are very few moving parts that will wear out.

And the best part is that it allows in-line finishing of the label - all in one operation.

It can be proven economically, that for short run jobs, it really is the more profitable method of production. In combination with the laser converting unit, it can truly produce jobs from start to finish in a matter of hours.

Biography

Ken Daming has been with Mark Andy, Inc. for 18 years in various positions, including Design Engineer, Service Manager, and now as the Director of Product Marketing Management. His education includes a Bachelor of Science degree in Engineering as well as a Master's degree in Business.