Meeting the Challenges of Digitally Printing Cans

Andrew Clippingdale, Tonejet Limited, Cambridge, United Kingdom

Abstract

Tonejet digital printing produces high quality colour images direct onto a wide range of materials at a cost and throughput that makes it attractive to the mass packaging industry. A good example is beverage cans, the printing of which presents particular challenges in terms of substrate characteristics, image quality and durability.

In this paper we talk about the demands of printing digitally onto cans, the advantages that digital printing brings such as quality, design flexibility and run length, and the technical challenges that we have overcome in order to deliver a commercial digital printing solution for this important sector of the packaging market.

Printing onto packaging

The packaging printing industry is a massive global industry with a value of some B$277 in 2010 [1]. Today the vast majority of packaging is printed by conventional methods – flexo, offset and gravure – achieving high quality, durable print onto a broad range of materials.

Packaging manufacturers and brand owners are also keen to benefit from the advantages that digital printing offers, including economic short runs, short lead time, design flexibility, personalisation and reduced inventory. Despite the desire for digital, it has had little penetration into the package printing industry: in 2010 less than 2% of the packaging market globally was printed digitally [1].

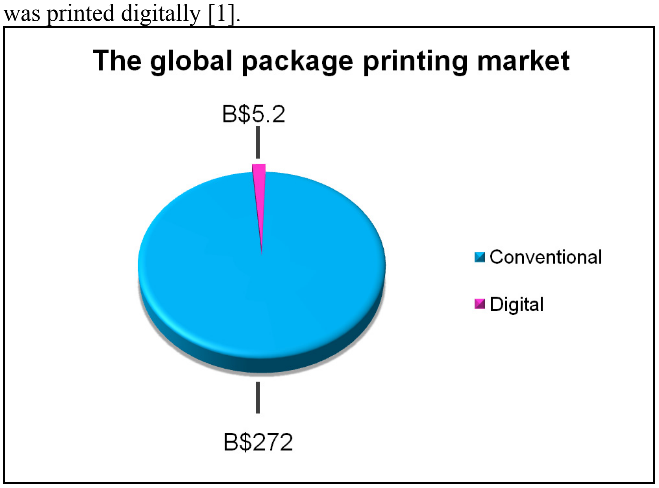

Figure 1: The global packaging printing market in 2010 was estimated to have a value of B$277, dominated by conventional printing processes of flexo, offset and gravure.

There is great potential for digital printing in packaging, although the demands of the industry are challenging - demands which combine:

- High print quality.
- Durability and the need to cope with downstream processes such as folding and sterilization.
- Low running cost.
- High productivity.

In addition, for the food packaging industry (which accounts for 50% of packaging as a whole), food safety regulations laid down by the FDA in the U.S. and EuPIA in Europe for the print materials need to be complied with and these regulations are becoming ever more stringent.

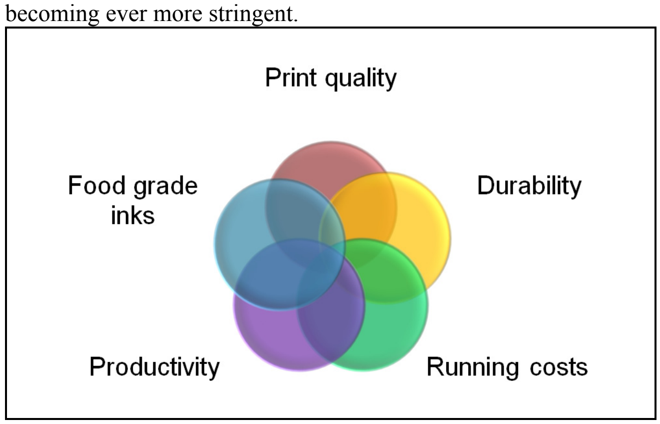

Figure 1 The requirements of digitally printing packaging.

Most other digital printing technologies available today have their roots in home and office printing, and have evolved and adapted in order to reach out to the commercial and industrial print sectors. Systems using UV inks have seen increasing application in commercial printing, although meeting the requirements of package printing with these systems remains challenging. Digital printing of labels is currently a growing market, but there is also a significant desire from brand owners to print packages directly to cut cost and gain greater value.

Tonejet has approached the packaging challenge from a different angle, seeking from the outset to emulate conventional printing as closely as possible, combining the look, feel and performance of conventional print with the advantages of digital. As a result Tonejet has inherent qualities that make it ideally suited for the packaging market:

- Thin ink layer combined with durable overprint varnish gives the print layer flexibility and robustness to mechanical and chemical downstream processes.
- Low ink cost and film thickness lead to low running costs.
- Food grade ink components give straightforward application in food packaging.

Beverage cans

Two-piece beverage cans are an important sector of packaging as a whole. Worldwide, some 250 billion such cans are produced each year and the metal can printing market is forecast to grow at an annual rate of 5.2% to $37.2 billion by 2015 [1]. Two-piece cans are conventionally printed in cylindrical form using a dry offset process, using spot colours that are simultaneously offset onto the base-coated can. The process is good for traditional brand designs using vibrant solid colours but, as the trend in package printing moves towards more sophisticated, realistic images, there is growing demand for high-resolution process colour on cans.

The drivers and challenges for digital

The drivers for introducing digital printing into can decoration have much in common with those for packaging in general but with the additional consideration of print quality:

- Print quality: high-resolution process colour is difficult to achieve on the can with conventional processes
- New design options: photographic images as well as graphics and text
- Economic short runs
- Personalisation and customisation

As well as offering flexibility and innovation within existing markets, digital printing also has the potential to create new markets for cans such as promotions and special events.

Beverage cans present particular challenges when it comes to printing:

- The surface is non-absorbent, requiring inks to be stable on the surface before fixing.
- Both the substrate and the printed can are smooth and glossy, requiring the print to have low film thickness to avoid undesirable visual and tactile texture.
- The print method must be compatible with the cylindrical form of the can.
- The print must be able to withstand the necking and crimping processes used to attach the top of the can.
- The print must also be resistant to temperatures of at least 230°C that the can is exposed to in downstream processes.
- The print needs to be safe for food contact.
- A high level of abrasion resistance is required for the print to survive the production line conveyors, palleting and customer handling.

These challenges need to be met by any candidate digital technology without compromise to print quality, which should match the ability of the conventional process for reproducing brand designs while adding high-quality process colour capability.

In the following sections we first describe the Tonejet printing process and how it is controlled in practice to produce high resolution greyscale images on a wide range of substrates, before describing the Tonejet can printing process which has been developed to meet these challenges.

The Tonejet print process

Tonejet is a non-contact, drop-on-demand printing technology in which ink is delivered to the substrate by an electrostatic ejection process. This process generates a jet of ink that flows from the print head towards the substrate.

The Tonejet print head is an array of pointed ejectors, each carrying an individually addressable electrode. The ejection process is shown schematically in Figure 2.

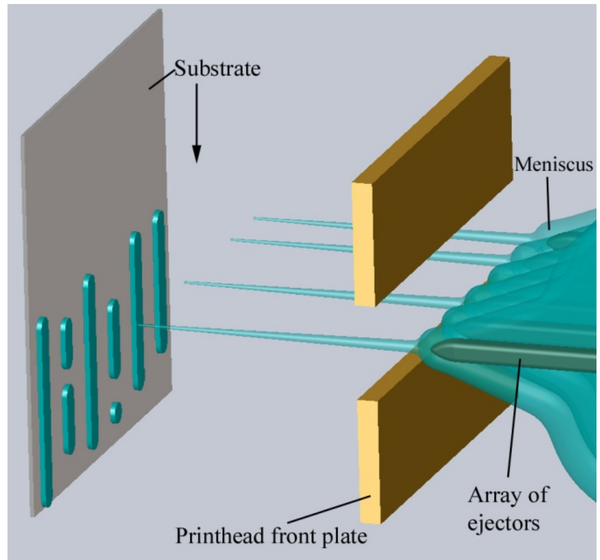

Figure 2 Schematic diagram of Tonejet ejection. Ejection is initiated through electrostatic forces acting directly on the ink.

Ink flows continuously over this structure such that there is always a fresh supply in the ejection region. The ink is isopar-based, and contains positively charged solid colourant. Application of a positive voltage to an electrode causes these charged particles to move to the ink surface at that particular ejector; if sufficient voltage is applied to exceed a critical electric field, the meniscus moves forwards and a jet of ink is ejected. Modulating the drive voltage to each ejector modulates the ejection, thereby forming the image on the substrate.

The ejectors are designed so that the jet responds quickly to voltage, giving drop on demand with a print resolution of 600dpi at a substrate speed of up to 1m/s from current printheads and inks. Small volumes of concentrated ink having high pigment content are ejected with full-density, 600dpi pixels resulting from an ink volume of 2 picolitres [2].

Control of the print process

The main methods for controlling the ejection process are:

- The duration of the voltage pulse for each printed pixel.
- The magnitude of the ejection voltage.

Both are mechanisms for controlling the ejected ink volume. In practice it is convenient to use pulse length as an addressable control variable, while pulse magnitude is used as a common control for a whole print head.

Greyscale at full print speed

Addressable pulse length control is used to control the ejection of ink from individual print head ejectors continuously, providing a mechanism to:

- Control greyscale.
- Perform spatial and temporal calibrations of ejected volume.
- Manage the stitching of printheads for single-pass printing of wider substrates.

Greyscale is achieved in this way without compromising print speed. Figure 3 shows the measured optical density versus pulse length for a print on white basecoated metal using a Tonejet magenta ink.

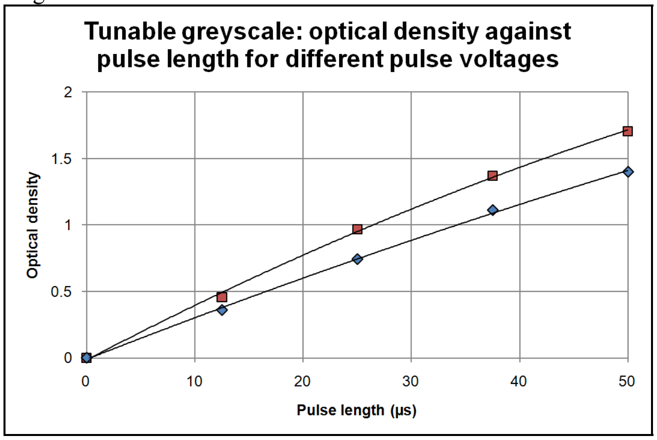

Figure 3 Optical density as a function of pulse length for the Tonejet greyscale process. The graph shows the measured density of a magenta separation printed on white basecoated metal at a speed of 0.8m/s, at two different pulse voltages.

In practice a number of discrete grey levels is chosen - 4 or 8 in current systems – and the chosen grey levels are combined with a multilevel FM screening process to render the image. Fine control of the pulse length is used for calibration of the process to control print uniformity.

Tunable performance

While pulse length is used to control ejection from individual ejectors, pulse voltage controls ejection strength for a whole print head and is used to tune the maximum print density for a particular substrate or application. This enables the use of a universal ink set for a wide range of applications having differing requirements for maximum optical density (D_{MAX}) or which need different ejected volumes to achieve the required D_{MAX}, without compromising the number of grey levels in either case (Figure 3).

Process separation

The Tonejet ejection process ejects small volumes of concentrated ink onto the substrate, producing vibrant colours from an ink layer of less than 1 micron thick. This thin layer of pigment is sufficiently stable on both absorbent and non-absorbent substrates to enable "wet-on-wet" printing of all colours prior to fixing. Fixing is achieved after printing with an overprint varnish (OPV) whose properties are tailored to the substrate and the demands and preferences of the application; for example, the mechanical resilience of the finished print and the preferred method of curing. The process is characterised by:

- No requirement for inter-colour curing.
- The same ink set is suitable for a wide range of substrates regardless of curing method.
- Integration with existing upstream and downstream processes is more straightforward.
- Existing OPVs developed for the application may be used.
- No discernable ink pile height or texture.
- A uniform finish to the print.

Requiring no fixing chemistry in the inks makes them simpler and more versatile and makes it more straightforward to achieve compliance with food safety requirements.

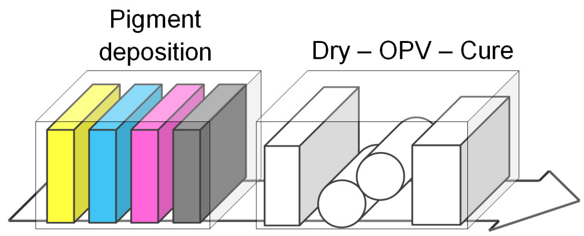

Figure 4 Separation of the printing and fixing processes enables use of a universal ink set with an OPV to suit the application.

The Tonejet can print engine

Can printing is Tonejet's leading application and a good example of how the print process described above works in practice to achieve high image quality combined with durability.

The can print engine comprises four printhead modules, each printing a single colour, 600dpi greyscale separation directly onto the white-basecoated can surface. The printheads are arrayed around an indexing carousel that moves cans from the loading position past the Y, C, M and K print heads (this lay down giving the largest colour gamut), then to a drying position and an OPV station, pausing at each position. The printed cans are then unloaded and conveyed to a standard curing oven. The linear print speed at each printhead is 1m/s.

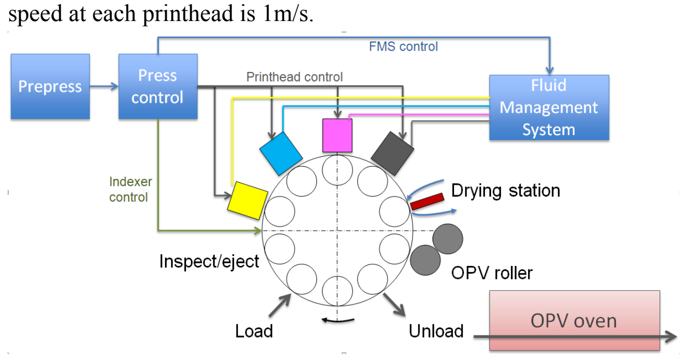

Figure 5 Schematic diagram of the can printing system. The Tonejet process lays down colour separations sequentially, wet-on-wet, before drying, varnishing and curing.

The process delivers vibrant, high-resolution designs direct onto cans with uniform gloss and finish (Figure 6). Table 1 summarises how each of the main requirements of the can printing application described earlier are delivered by the Tonejet system.

Figure 6 Ball Packaging's Tonejet can printer has been producing highly original and personalized short-run cans for over a year, developing new markets outside of conventional beverage packaging.

Table 1 Characteristics of printing onto cans and the Tonejet solution

Characteristic of Can Printing	Tonejet solution
Non-absorbent surface	Required optical density achieved with small volumes of concentrated ink which are stable on the can surface allowing "wet-on-wet" printing.
Smooth glossy appearance	Low ink pile height (<1μm) overcoated with glossy OPV.
Print must withstand necking and crimping to attach top of can	Low ink film thickness and flexible OPV.
Compatibility with cylindrical form of can	Linear array, can-width printheads.
Print must be resistant to 230°C in downstream ovens	Tonejet ink uses the same heat-fast pigments used in conventional printing inks.
Safe for food contact	Ink constituents conform to international regulations.
Abrasion resistance and other finished can properties	Industry OPV delivers required properties as for conventional cans.

The first system installed at Ball Packaging's facility in Hassloch, Germany has been producing highly original and personalized short-run cans commercially for over a year and has enabled the 2-piece can to reach new markets outside conventional beverage packaging (an example can be found at http://www.youtube.com/watch?v=KzWZslc4vbk).

In 2011 Tonejet delivered an upgraded print engine based around third generation printheads to Ball Packaging. While retaining the fundamentals of the printhead technology, the latest product is more compact and has a greater level of automation (Figure 7).

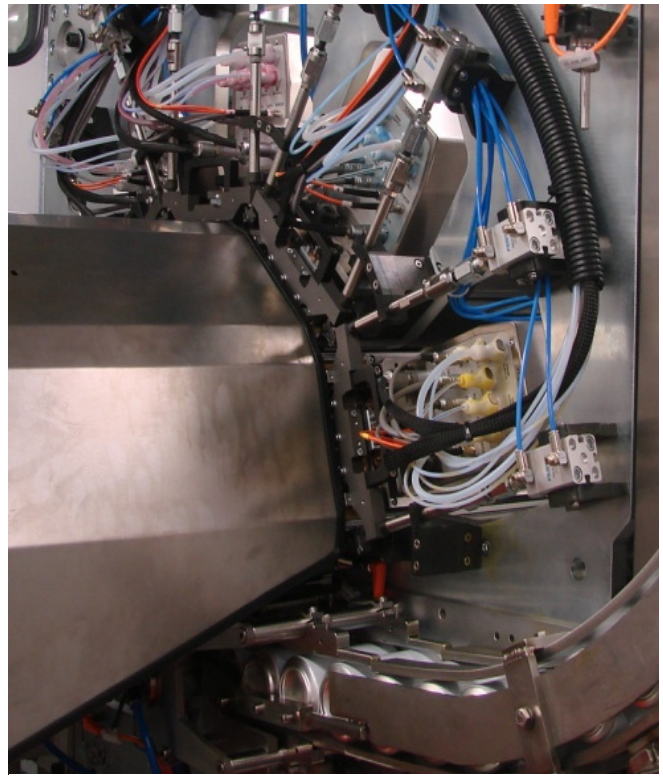

Figure 7 The upgraded can print engine contains the latest Tonejet technology.

Developed to combine the qualities of conventional printing with the flexibility of digital, Tonejet's print system delivers high-quality greyscale print using small ink volumes onto a wide range of packaging materials, successfully meeting the challenges of digitally printing beverage cans.

In the future, in conjunction with its ink partners Sun Chemical and INX, Tonejet will continue to provide digital printing solutions for this important market while offering complete solutions encompassing print engine, inks and substrate handling systems for the broader packaging industry.

References

[1] Pira International Ltd., The Future of Package Printing to 2015, Global market forecasts 2010

[2] Guy Newcombe, Tonejet: Delivering a Complete Solution for Packaging, IS&T NIP 25, 2009

Author biography

Andrew Clippingdale has been directly involved with the development of Tonejet technology and products since its inception. In that time he has led the electronics development and managed major client programmes, including Tonejet's can decorator development for Ball Packaging. Today, Andrew leads the print quality and IP activities at Tonejet Ltd.

Andrew is an electronic engineering graduate of Birmingham University and holds a PhD in Physics from the University of Sussex in the UK.