Tonejet: A Multitude of Digital Printing Solutions

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Abstract

The Tonejet digital printing process enables the production of stunning, full color images directly onto a wide variety of packaging with the throughput and cost levels required by the mass market. In this paper we describe the Tonejet process and how it is already enabling delivery of digitally printed product in can printing, and creating new opportunities in other packaging applications.

Packaging printing

Packaging has a powerful influence over our purchasing choices. It is the ultimate advertising opportunity for brand owners, and can be the final differentiator between competing products. Often it is the packaging that determines the buying decision.

It is therefore not surprising that packaging printing revenues make up some 30% of global printing revenue, are bigger than those of both commercial and advertising printing, and exceed US$200 billion per annum [1]. Packaging has also been largely immune to the recent economic downturn, with its share of the global printing market increasing [1].

Packaging printing: the drivers and challenges for digital

Digital printing is a highly attractive technology for packaging because it offers the ability to print short runs cost-effectively. The trend towards short runs continues as producers target consumers more narrowly, and as legislation on product information and minimum font sizes increases the number of SKUs. Digital printing will not only address this trend, but will also open up special short runs required for customization of product specifically for conferences, trade shows and sporting events, and the ultimate short runs required for product personalization.

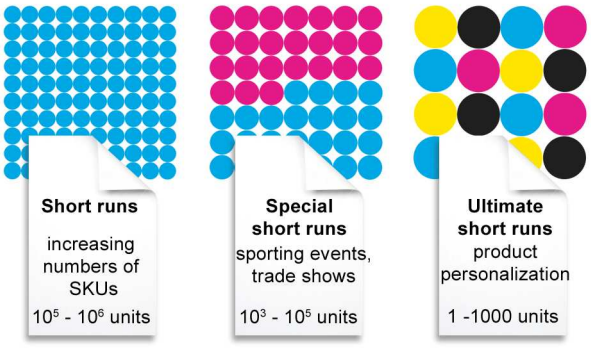

Figure 1. *The trend to short runs.*

Digital printing will also have cost benefits due to the simplification of the process flow and the elimination of much of the intermediate hardware required by conventional printing such as plates and cylinders. Finally, digital printing offers very fast turnaround. The simplified process flow means that packaging can respond quickly to events such as a change in the ingredients list or a special pack production run in reaction to new information, be it a global event or local promotion.

Although digital printing offers many advantages to the packaging sector, it has yet to penetrate this area to the same extent that it has in other areas of printing. Whilst digital printing now accounts for over 12% of global printing, in the packaging area it barely achieves 1%. There are a number of reasons for this:

- **Throughput, quality, reliability.** Digital technologies have in the past been unable to meet simultaneously the stringent requirements on throughput, quality and reliability demanded in the packaging sector.
- **Cost.** Whilst digital printing is highly cost-competitive over short runs, digital technologies must be competitive over medium run lengths in order to move from the niche to the mainstream.
- **Changing work practice**. The introduction of digital printing into packaging will shrink the gap between the producer and the consumer. Whilst this has many advantages, it will also present commercial challenges. For example, in order to fully realize the benefits, digital printers will have to be integrated onto, or close to, the packaging line. Print will no longer be sourced from a remote location at long lead time, but will be part of the production process. Implementing this significant change to work flow will require careful preparation, as well as energy and commitment from all parties involved.

Tonejet is a digital printing technology which specifically addresses the demanding needs of the packaging sector. In the remainder of this paper, we describe Tonejet technology, how its unique features make it particularly suitable for packaging printing, and how it is already being used in packaging applications.

Tonejet process

Tonejet is a non-contact, digital printing technology in which ink is delivered to the substrate by an electrostatic ejection process. This process generates a stream of small droplets that form a jet of ink that flows from the print head towards the substrate, as shown in figure 2.

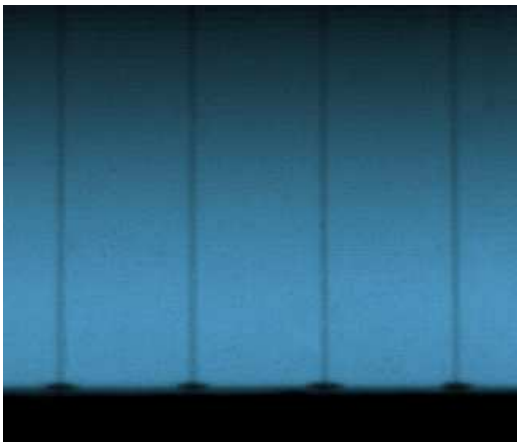

Figure 2. *A micrograph of Tonejet ejection. Jets are ejected from the print head (off the top of the image) onto the substrate at the bottom of the image. The spacing between the jets in this image is 168μm.*

The Tonejet print head is an array of pointed ejectors, each carrying an individually addressable electrode. The ejection process is shown schematically in figure 3.

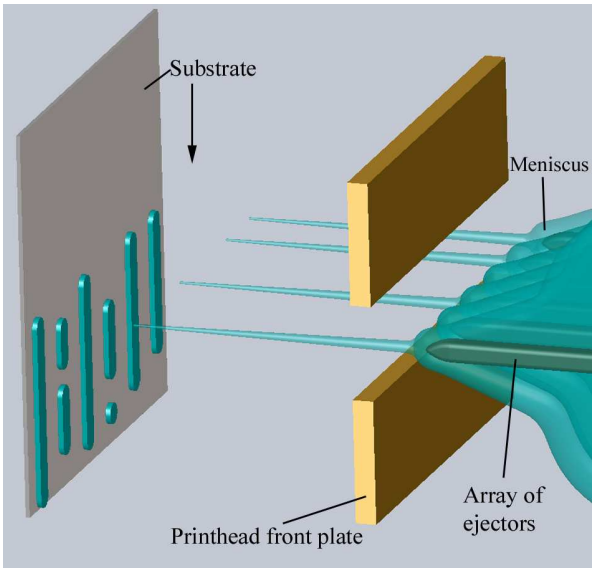

Figure 3. *Schematic diagram of Tonejet ejection. Ejection is initiated through electrostatic forces acting directly on the ink.*

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 colorant. 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 stream of small droplets is ejected in the form of a jet. Ahead of the array is a front plate with a single slot through which the ink passes onto the substrate.

Figure 4. *A Tonejet print head single color module.*

Figure 4 shows a Tonejet single-color print blade made up of four print heads. It produces a print swathe of 105mm at 600dpi. The front plates of the four print heads can be seen at the base of the unit. Multiple units are stacked together to produce color systems. The configuration of print heads within a blade is highly flexible; wider print widths are achieved by increasing the number of print heads within a blade.

Tonejet features

Tonejet was developed to address the demands of industrial printing, including the packaging sector, and in this section we demonstrate how its attributes achieve the following specific requirements of this sector:

- Throughput
- Image quality
- Cost per print
- Reliability.

Throughput

The meniscus response time to changes in the electric field is very rapid, of order of a few microseconds. The control of the meniscus at these timescales gives the dot size and dot placement accuracy for Tonejet heads to be used in systems where the substrate passes beneath fixed heads. Full coverage images with 600dpi grayscale quality can be produced at substrate speeds of 1m/s (200 feet per minute).

Image quality

A Tonejet ejector emits a jet of ink for the duration of the print pulse voltage. The volume of ink ejected is thus controlled by the pulse length, and grayscale printing can be achieved by modulating the pulse width. In the time it takes to print a single 600dpi dot at 1m/s, the volume of ink on the substrate can be

controlled between 0.4pl and 2pl; typically other inkjet technologies eject droplets with volumes in the range 2-42pl. Tonejet is therefore capable of variable dot size printing at 600dpi, equivalent to 1440dpi binary printing, giving the quality required by the packaging industry.

Cost per print

Tonejet is a highly efficient process, enabling the minimum quantities of pigment to be deposited to achieve the required optical densities. The dry ink film weight of a single color solid fill layer is given in the table below.

Table of dry ink film weight for Tonejet and other technologies

	Tonejet	Piezo inkjet – solvent inks	Piezo inkjet – UV inks	Thermal inkjet – water based inks
Film weight (g/m^2)	0.1-0.2	0.5-1	5-10	0.5-1

The film weight achieved by Tonejet is comparable or below many conventional non-digital printing processes, and when combined with Tonejet's per volume ink costs, results in a cost per print comparable to these processes, even at medium and long run length. At short run lengths, Tonejet gives a very strong cost advantage in addition to all the other benefits offered by digital printing. In addition, the low film weight gives rise to a correspondingly low dry ink film thickness. In particular, when compared to UV inkjet printing the ink layer deposited by Tonejet on films is flexible, and Tonejet prints do not have the thick and textured feel associated with many UV inkjet processes.

Reliability

Tonejet's inherent reliability was a key driver for its adoption for digital can printing. Its combination of features delivers the reliability required for industrial packaging applications through:

- Electrostatic ejection mechanism
- No nozzles
- Flowing ink architecture.

Tonejet Application Examples

Tonejet Limited is working with a number of partners to ensure that the commercialization and further development of the technology meets the needs of the packaging sector. Tonejet provides the print heads and associated hardware such as drive electronics, data systems and fluid feed systems while other supporting technologies are delivered through partnerships. In this way, the introduction of digital printing to an end-to-end process can draw on the appropriate expertise of all parties involved. Tonejet has announced three partnerships to date. One of these is an application partner, Ball Packaging Europe, with whom Tonejet has developed a digital can printer. The other two partnerships are ink companies, Sun Chemical and INX, who are sub-licensed to supply Tonejet inks.

Digital beverage can printer

The digital beverage can printer is an excellent example of the benefits of the partnership model. Tonejet worked very closely with Ball Packaging Europe to ensure that the technology met the needs of can printing. The result is a digital can printer that is now leading the field, is fully integrated into one of Ball's can production lines, and is producing digitally printed cans commercially.

Figure 5. *The Tonejet digital beverage can printer.*

Air Berlin placed the first commercial order for digital cans, a perfect example of a digital printing application where the customer needed a special short run of cans for a highly targeted promotion.

Figure 6. *A pallet of Tonejet digitally printed Air Berlin cans ready for shipment to the customer.*

Digital web and sheet systems

Tonejet is now building systems to address packaging applications in film, paper and carton board. These systems will be web based or sheet fed. Figure 7 shows a four color sheet-fed Tonejet digital press.

Figure 7. *Tonejet digital sheet-fed printer*

The four fixed print head stations (shown individually in figure 8) enable the press to produce high quality four-color grayscale images.

Figure 8. *600dpi Tonejet print head module.*

Tonejet will continue to work with partners to produce digital print systems in a range of packaging applications. Digital beverage cans was the first Tonejet commercial application and this will be followed by further metal packaging applications, as well as systems for printing films, paper and carton board. Through its partnership model, Tonejet is not only delivering digital printing technology for the packaging sector but is working with its partners to help them meet the commercial challenges of the introduction of digital printing. The combination of cutting-edge technology and the partnership model necessary for the introduction of digital printing means that Tonejet is truly able to offer a multitude of digital printing solutions.

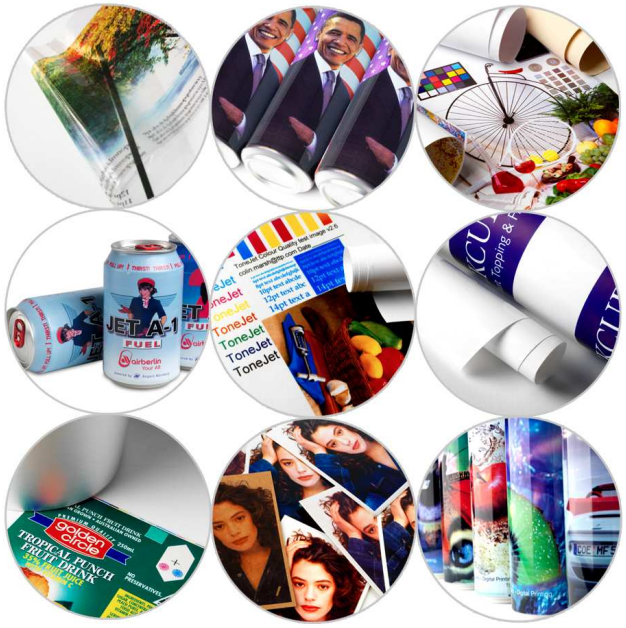

Figure 9. *Tonejet packaging solutions.*

References

[1] The Future of Global Printing, Market Forecasts to 2014. Pira International Limited.

Author Biography

Daniel Mace has been directly involved with the development of Tonejet technology and products since its inception. In that time he has lead the Tonejet print head programme, culminating in the manufacture and integration of 170mm wide print heads in the Tonejet can printer. Today, Dan leads the Technology Team at Tonejet Ltd.

Dan holds a PhD in Physics from the Cavendish Laboratory, Cambridge.