Understanding digital printing
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In an article for The Metal Packager, our guest contributor Ralf Gumbel explains how digital printing works, technical terms and some of the critical factors involved.

"Not everything that is technically possibly makes sense because ultimately it must enable customers to produce their existing product more cost-effectively while maintaining the same quality. Several small, affordable steps are less risky for the investor than one big step costing millions," writes Gumbel, a packaging consultant.

Offset printing vs digital printing:
Conventional printing processes, such as offset printing, have the same origin as digital printing processes, namely digital data. In offset printing, a static printing plate is exposed in a complex process. Time (1-4 minutes) is used to write high-resolution data onto the plate using a laser.

Digital printing is no different in a figurative sense but writes a file with a much lower resolution directly onto the substrate in a very short time (0.5-30 seconds per machine).

As you can see, resolution and time are critical factors. But what exactly is resolution and why is high resolution important? How does resolution affect the number of colours that can be reproduced, and how does the number of greyscales affect the number of colours that can be printed? Why are there different droplet sizes in inkjet printing? How does digital printing try to get around reproduction problems that offset printing can only solve through exposure time? What is the difference between screen size and resolution, and why does digital printing not print an analogue screen like most offset printers?
The easiest way to explain this is probably to start with offset reproduction.

Screen size, screen cells and screen dots:
Today's newspapers have a screen size of about 48L/cm in their images, while modern offset printing generally has about 60-80L/cm. Figuratively speaking, this means that on an imaginary line of one centimetre, there are 60 screen dots next to each other. As this is done over an area of length and width, there are 60 x 60 dots per square centimetre, or 3,600 dots per colour. You can think of this as a large chessboard, with the individual squares, known as screen cells, representing the ordered space for each screen dot.

The screen dot is nothing more than a very, very small solid area. If the screen dot is very large, it touches and partially covers its neighbours and becomes a larger area. If it is very small, the human eye mixes the small screen dot with the optically neighbouring white paper.

Even higher values, i.e. finer screens of 120 l/cm, are no problem for modern presses, whether they are 4-, 6-, 8- or 12-colour presses. The finer the screen, the higher the number of screen dots and the more photorealistic and detailed the image.

The dots of exposure or the resolution:
To produce small and large screen dots, these are made up of what are called exposure dots, and the number of exposure dots represents the actual resolution in offset printing. Today's imagesetters can achieve up to 4,800 dpi (dots per inch), but printing plates are usually exposed at 2,400-2,540 dpi or 1,000 l/cm. This means that 1,000 dots per cm are exposed in a line, like a screen dot. In both length and width, this gives over 1 million dots per square centimetre.

Number of greyscales and number of colours/colour spaces that can be reproduced:
Dividing the exposure dots by the number of screen dots per square centimetre gives the number of exposure dots per screen dot. Each screen dot therefore has more than 270 exposure dots and can have different sizes in steps from 0 to 270. This allows more than 270 different greyscales for each colour. This is called the greyscale, and of course this also applies to cyan, magenta and yellow, except that these are gradations from white to the full range of the colour.
These 270 greyscales for cyan, multiplied by 270 for magenta and multiplied by 270 for yellow, make up almost 20 million different colour tones. This means that the number of greyscales per colour multiplied by the number of process colours (excluding black) gives the displayable colour gamut.

Eye-catching digitally printed aluminium cans by NOMOQ, a Swiss digital can printing company.
More common in digital printing than in offset, but following the same principle, seven colours (C, M, Y, R, G, B + K) create a much larger colour gamut and make it possible to achieve the Pantone colour gamut (18 process colours) much faster than in four-colour printing.

At the beginning of this article, we mentioned the common origin of offset and digital printing: digital data. While offset printing can use time to set many exposure points, digital printing cannot do this due to time limitations.

Raster image processor (RIP), frequency-modulated (FM) screen, amplitude-modulated (AM) screen and hybrid screen:
Digital presses therefore always print at a lower resolution than offset and must use every technical trick available to produce an image of equivalent quality in a very small fraction of the exposure time of offset.

If a digital press prints at 1,200 dpi, one of the highest resolutions available today, this is not half the resolution, but only 1/4 of the offset resolution. The problem becomes very clear when a 30 or 40 screen is used instead of a 60 or 80 screen. This is a much lower resolution than for newspaper printing and certainly not the target for high quality digital printing. Alternatively, the print speed could be reduced to print a greater number of drops in the same area. However, this is not the aim of digital printing, which is why the manufacturers of digital presses and RIPs are trying to trick physics, or rather the human eye.

To avoid this problem, so-called **FM screens** or **hybrid screening** processes are used in digital printing. In offset printing, as described above, amplitude modulated screening is usually used. With AM screening, there are fixed screen cells in which the screen dot becomes higher (larger) or lower (smaller) like an amplitude.

With **frequency modulated screening**, there is only one screen dot size, but this is frequent locally, resulting in solid areas or bright colours. If there are so many screen dots (at FM screening equivalent to exposure dots) that they touch each other, a solid area is created.

This means that even at low resolutions, a detailed image can be achieved, like offset printing. Light, pale colours are more problematic, as a colour impression must be created with very few screen dots. To get around this problem, modern inkjet printing uses a hybrid **screen**, i.e. a mixture of AM and FM screens with different dot sizes (in Inkjet often identical with drop sizes), as well as additional colours such as light cyan or, more generally, 7-colour printing.

Only when all the variables (resolution (600-1,200 dpi), screening, different dot/drop sizes and number of colours) are optimised can digital printing achieve offset-like quality.

Nozzles:
Depending on the manufacturer and price, multiple inkjet units are also installed in the digital printer to replace unusual nozzles (drop-emitting orifices), increase resolution, increase speed, or all the above.

This increases the number of **inkjet heads** and the complexity of the machine. It is not uncommon to find machines with hundreds of inkjet heads, all of which must be adjusted and matched by the manufacturer to the nearest micron. **As a result, the complexity of digital printing increases exponentially with increasing machine width, machine speed and resolution, leading to very expensive systems that require correspondingly high-capacity utilisation.**

Not everything that is technically possibly makes sense because ultimately it must enable customers to produce their existing product more cost-effectively while maintaining the same quality. Several small, affordable steps are less risky for the investor than one big step costing millions. So, digital printing remains exciting in terms of quality, flexibility and cost.

Ralf Gumbel offers advice and training on reducing makeready times and increasing production efficiency through his consulting firm PMS Consult UG. Based on his experience, he can provide advice before or during an investment process.