ThermoFlexX

White paper

Woodpecker Nano Unique Surface Micro Structures for Flexographic Printing Plates

Introduction

The flexographic printing market was valued at $164 billion in 2017. This is forecast to grow between 2-3% annually. This growth depends on continual improvement. Advances in print quality enables flexo to win business from traditionally 'high-quality' print mediums, for example rotogravure and offset litho. However, improving efficiencies in these technologies makes this a worthy challenge. Digital print continues to emerge in flexo's core markets. As digital technologies evolve, competitive volumes are under constant challenge.

Of course this must apply to many industries but the key targets for the continued growth of flexo are:

- Constantly improving print quality
- Continual cost reduction through improved efficiency
- Faster turnaround, reduced pre-press time through higher productivity

Relevant Background – Flexo Ink Transfer Challenges

A large proportion of the flexo market is the printing of flexible packaging on transparent or white films. Popular examples include polypropylene, polyethylene and polyester. Millions of tons of these substrates are converted into flexible packaging. To be competitive, high printing speeds are required. Specialist wide-web presses, most often use solvent-based inks and run around 400m/1000ft per minute on multi-ton orders for continuous rolls of these printed substrates. Given the demand for higher quality of printing on these packaging products, good ink transfer, giving smooth opaque coverage particularly in solid areas, is an extremely important challenge.

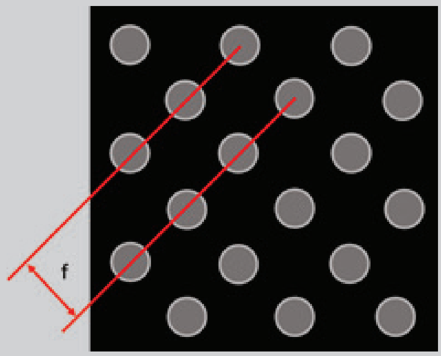
In theory an 'ascending' surface tension or energy chain ('surface-energy' for solid items as in anilox, plates and substrate and 'surface-tension' for liquids, the inks) should give the best possible coverage. Some even specify this within a tight tolerance of 'Dyne-levels'. However, in practice, measurement methods vary, substrate energy levels can change with age, plate properties can change due to processing variances etc. Also, even if the ascending chain is stable and within tight tolerance, perfect transfer isn't always guaranteed! So, it was recognised that more 'help' from flexo plate technology could be available to assist ink transfer and contribute immediately to a better overall print quality. Hence the development of Surface Micro Structures (SµS) in modern flexo plate making.

The first attempts at microstructures in solid areas really stem from the observation that the shadow tones, 90% and up on a screened plate, may in some cases actually print a higher solid density than the 100% areas. Line screens as high as the imaging and developing technologies would allow, typically film negative exposed and solvent washed-out flexo plates with a 90% 'plate-cell' in solids at line-screens of up to 400lpi, enjoyed some limited success. Engineered structures built into the plate surface are also available. However it is established that super-fine patterns, typically with a screen frequency of 1400lpi and up, are far more effective. The ability to create and control such surface structures with a laser imaging system, and to hold super fine arrays firmly on a finished flexo plate, provides much greater performance.

Definitions of key terms in this document

Microns (µm) is a measurement of distance
1m x 10-6
1µm = 0.001 mm or 0.039 thou

Image File Resolution (dpi) is the number of pixels per inch, counted in one dimension and expressed in dpi (dots per inch), alternatively the term ppi (pixels per inch) can be used. Pixels are always rectangular and in almost all cases square. The pixel size, width or length in microns is the inverse of the resolution in dpi multiplied by 25400.



Screen Frequency (lpi) is the number of screen elements per inch, counted along a line where the elements are closest together. The diagrams in this document use f to designate this distance as it is also used to determine screen frequency. Screen frequency in lpi equals the inverse of distance f in microns multiplied by 25400.

In plate making this is also referred to as 'line-screen ruling' (lpi) and is applied to the dot screens required for tone reproduction. In this document we also use the terminology Screen Frequency or Pattern Screen Frequency in lpi to give a relative measurement of Surface Screen arrays (fine-ness) in terms that plate makers and printers are familiar with.

Enabling Technology – Flat Top Dot

Now common, 'Digital' flexo plates were introduced in the 1990's. A Laser Ablatable Mask (a carbon 'LAMs layer') was applied to the surface of the plate replacing the need for a film negative. Laser imaging systems could remove or 'ablate' the mask and create fine patterns and screens.. The main complications of making a film and applying it to the plate for main UVA exposure, namely poor film contact and light scattering, were avoided. This brought a step-change to flexo plate production, enhancing quality, reliability and ease-of-use. The downside of this technology was that oxygen present during main UVA exposure that was previously excluded by the film, contributed to a loss of detail in the finished plate. This is often referred to as 'dot-loss' or 'dot-sharpening'.

As such, 'dot-loss' did not impair the quality of digital plates as it could be easily counter-acted by a 'bump-up' curve applied usually at the RIP stage to ensure that a suitable small but stable minimum dot was help on the finished plate. Well controlled small 'round-top' dots gave very fine printed results. This new level of possible fine highlight dots further improved flexo print quality. To give a scale of the 'dot-loss', a typical solvent-washout flexo plate with 150lpi line-screen tones would need 6-7% 'bump-up' in the image file (subject to UV intensity) to keep the smallest dots retained consistent and strong. This means that at 'standard' resolution (2540dpi), dots smaller than 12 pixels in size would be completely washed away by processing. At 4000dpi dots would need to be above 20 pixels at the file stage to survive through to the finished plate.

In 2008, Eastman Kodak launched the 'Flexcel NX' technology. This utilised a special film negative, referred to as a 'Thermal Imaging Layer' or TIL.

The TIL once imaged is then laminated to a flexo plate before UVA main exposure. This eliminates the problem of oxygen presence during main exposure. All fine details are retained on a finished plate meaning that no, or a very small (<1%) bump up is necessary. Furthermore, it was found that extremely small structures or patterns could be applied to the print surface of the plate and held through the solvent wash-out process. These 'Digicap' patterns were found to substantially improve solid ink density and Flexcel NX became generally considered the benchmark of flexo plates for highest quality print.

Of course this isn't a perfect solution. The extra expense of the TIL, the extra process step of laminating it to the plate and the premium cost of the plates and higher process wastage all make a tempting 'target' for LAMs plate and equipment manufacturers to aim at.

Alternative 'Flat-Top-Dot' (FTD) technologies that worked with LAMs, usually giving users a far greater choice of plates, quickly developed and continue development to this day. Lamination of foil for main-exposure, starving of oxygen by elimination (usually with positive nitrogen pressure) and main UVA exposure with high-power LEDs have all enjoyed varied technical and commercial success.

Furthermore, manufacturers of flexo plates managed to develop effective FTD plates with an oxygen barrier layer 'built-in'. Such plates can be exposed with normal UVA lamps or 'tubes'.

Even with the relatively high-cost of LEDs that emit the correct wavelength for digital flexo plates (370nm) it is LED technology that seems to be gathering momentum. Costs for higher power modules reduce as capacity increases. Initial cooling problems have been over-come. It seems that LEDs provide cost-effective, efficient and stable solutions for FTD flexo plate making. Such solutions leave the user an open choice with multiple manufacturers providing a good choice of appropriate flexo plates.

To recap, a normal LAMs layer flexo plate with standard (tube) main exposure and solvent wash-out retains a minimum dot (within a dot array, rather than isolated - which is a further challenge) with a diameter of around 50 microns. Thus a significant 'bump-up curve is required to keep small dots on the plate. Effective Surface Screening, to emulate the successful Kodak Flexcel NX, needs to hold single pixels in the range of 5-6 microns in size on the finished plate. So, it can easily be seen that **Flat-Top-Dot technology is a critical, essential and unavoidable component** of applying fine Surface Micro Structures to LAMs layer ('digital') solvent wash-out flexo plates.

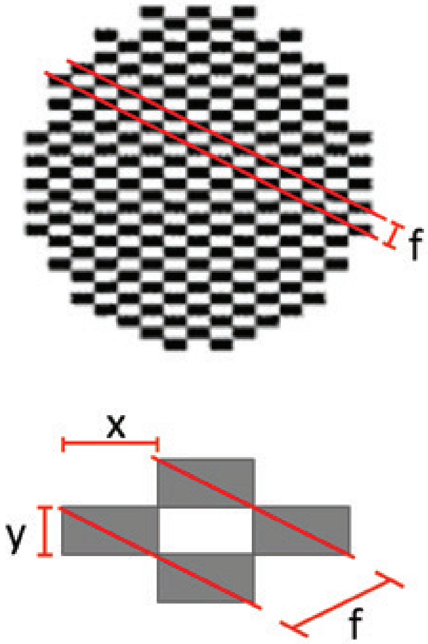
It is also worthy of note that even though FTD in-the-plate was developed to be exposed with normal UVA tubes, owners of LED exposure frames often combine these plates with LED exposure for 'extra-fine' dots and micro structures.

Flexcel NX Vs LAMs Digital Plates

It is interesting to observe that Kodak Flexcel NX continues to be considered by many the benchmark of flexo plate printing quality. Image input image files at a standard 2400dpi resolution are normally used.
In competition Esko applies various surface patterns in the workflow during the RIP stage. By far the most popular of these patterns is 'MCWSI', a single pixel pattern. This indeed continues to be a critical component of the new 'Crystal Screens'. As the micro-structure is applied in the RIP, higher resolution files of 4000dpi are utilised in combination with the CDI imager's 'HD Optics' capability.
Applying these single pixel patterns to LAMs layer plates is itself a challenge. A 'boost' function is applied when laser imaging to clear the mask layer adequately (to allow enough UVA during main exposure to hold the patterns) and maintain reasonable production speeds.

See below a comparison of 'addressability' of the two technologies at the resolutions they are typically utilised at. Detail retained on the finished flexo plate will depend on the plate and processing, particularly main-exposure. However, good practice using the latest equipment (as detailed in the previous section) will result in very similar structures being held on the finished plates.

Kodak Flexcel NX
From a 2400dpi input image, the y (vertical) direction resolution can be multiplied, typically to 4800dpi

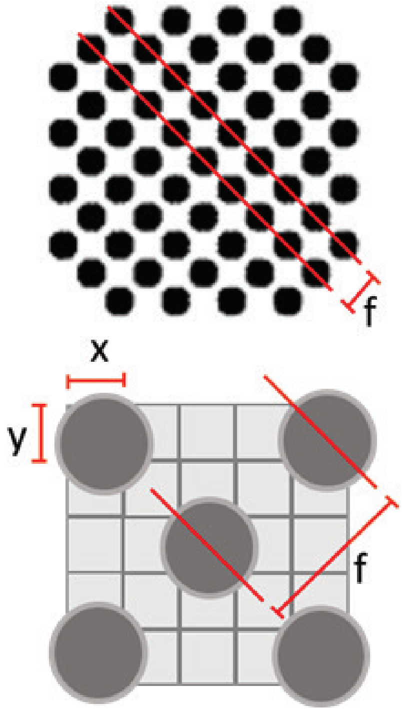


At 2400dpi, the x or horizontal pixel size is 10.58µm. With y or vertical resolution multiplied to 4800dpi, pixel size becomes 5.29µm

Distance f = 11.83µm

This equates to a pattern screen frequency of **2147 lpi**

Esko MCWSI
Input image file is 4000dpi



At 4000dpi, the x and y pixel size is 6.35µm.

Distance f = 17.96µm

This equates to a pattern screen frequency of **1414 lpi**

Conclusion: Although, no specific research has been completed to our knowledge, comparative experience tends to back up anecdotal evidence that finer patterns give superior results (smooth opaque ink solid ink transfer) from the range of relatively high-line screen anilox required to give high quality fine line and tone flexo printing.

Woodpecker Nano Surface Micro Structures – A Technological Breakthrough for LAMs Flexo Plates

After developing ThermoFlexX imaging systems to reproduce surface patterns applied in the RIP (already present in the input TIFF or LEN file), we went on to develop our own finer surface patterns. The course of this extensive R&D led to the conclusion that, with the continuing improvement of plates and processing equipment, a different approach producing finer structures was possible. Woodpecker Nano utilises the high resolution ThermoFlexX optics, usually used to output 5080dpi image files. Careful and accurate laser beam control allows repeatable and stable implementation of these fine screens. It has been established that an input file resolution of 2000dpi gives an optimum surface micro structure output for this optical path, already in place in most ThermoFlexX large format imagers.

Working with 2000dpi image files still provides excellent quality flexo print results. Files are dramatically reduced in size. Fast transfer and storage of files all becomes an easier proposition contributing to production efficiency. Very importantly, high imager productivity is maintained.

LAMs Layer Technologies - Woodpecker Nano v Esko MCWSI

Woodpecker Nano Surface Micro Structures are applied by the imaging engine at the output stage meaning that expensive RIP options are not required. No additional RIP step is necessary and patterns do not need to be decided or controlled at the Studio artwork stage.

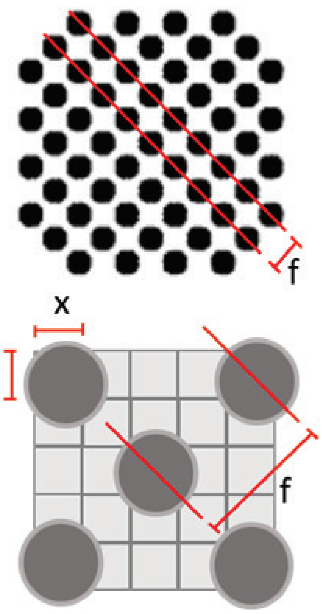
Inherently finer achievable surface patterns certainly improve solid ink density and smoothness compared with standard plates or even other lower frequency structures. In addition to SID improvements, half-tone dot screens are greatly enhanced by reducing or even eliminating 'dot-bridging' effects that further limit flexo print quality. Nano's perfectly symmetric Surface Screen Patterns from 2000dpi and above are fine enough that the need for a protection border or 'Edge Definition' (a different pattern) around half-tone dots or fine details is unnecessary.

These finer structure arrays reduce the risk of damage particularly on small half-tone dots as they fit closer-together for more uniform dot sizes. Dot and fine detail edges are more predictable as there is no 'one line off, one line on' effect in the image. Furthermore the close and uniform structure greatly reduces the risk that the surface pattern will interfere with the main dot line-screen and cause moiré effects. Being able to run full range dot-screens or vignettes is very advantageous as it avoids the need to use a 'fade-out' or 'protection border'. Both of these functions can give protection for small dots but the transition from screened to solid dot is almost impossible to hide in all images without a screen break often visible somewhere. Such problems make the screening settings 'object based' thus more decisions required at the RIP stage. Fine Nano screening allows simple output giving optimum results for every job with no decisions required or variants to consider.

Further precision laser beam control allows the smallest highlights to be reproduced with Nano screens in conjunction with no or very low bump-up curves. ThermoFlexX Automatic Calibration delivers meticulous beam timing and intensity, another important component of precise Nano screens. Precision 'tuning' with the Auto Calibration system provides the platform to make fine Nano patterns consistently, between each imaging head and from engine to engine. Although Nano works very well with good Hybrid (AM/FM) half-tone screens it is usually possible to achieve excellent results with conventional AM screening.

Esko MCWSI

Input image file is 4000dpi



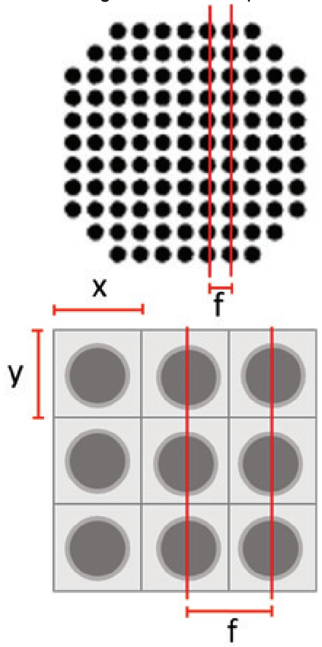
At 4000dpi, the x and y pixel size is 6.35µm.

Distance f = 17.96µm

This equates to a pattern screen frequency of **1414lpi**

Woodpecker Nano

For this example Input image file is 2000dpi



At, for example, 2000dpi, the x and y pixel size is 12.7µm.

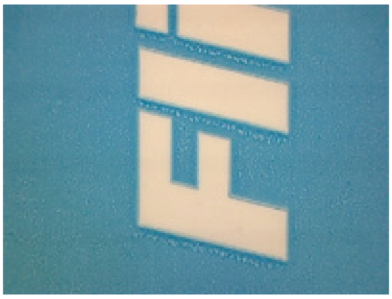
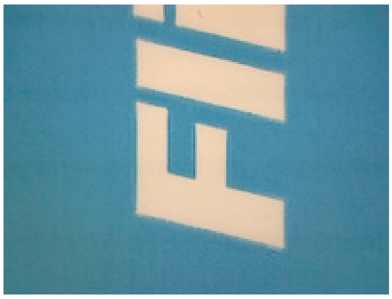
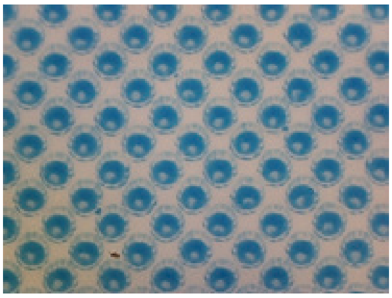
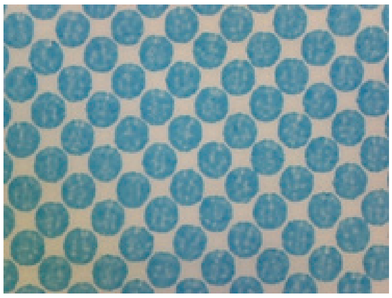
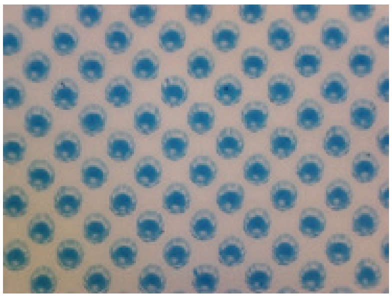
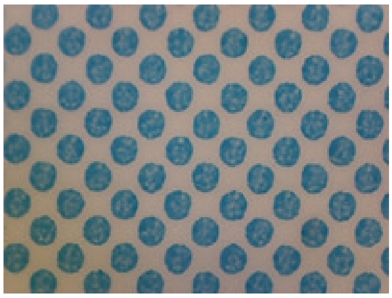
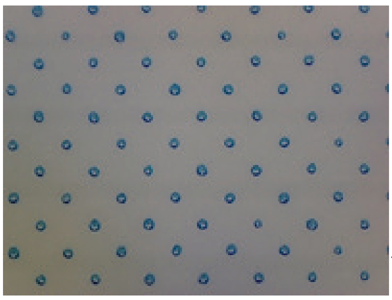
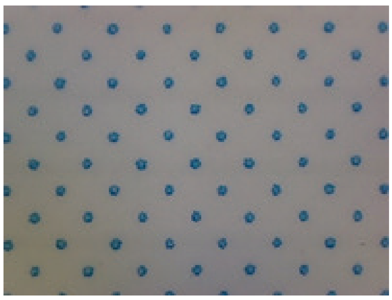
Distance f = 12.7µm

This equates to a pattern screen frequency of **2000lpi**

Woodpecker Nano - Printed comparisons with standard flexo plates

The microscope pictures below show how Woodpecker Nano screening can address common flexo ink transfer problems. These examples were printed at the DFTA using solvent based inks on a white PE.

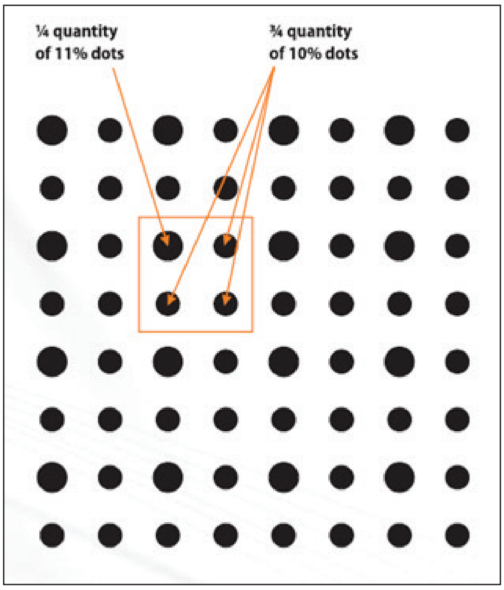
Importantly a common 'standard' plate is used, Flint ACE 114. Main UVA exposure is with a Flint NExT LED frame. SID without Nano is 1.52, with Nano 1.68. Note the considerable improvements in ink laydown, halo effects (around positive text and trailing edge voids). Dot definition is much improved with pre-mature bridging eliminated.

	Reference - no SμS	Nano @ 2000 dpi
Positive text (50x)		
Solids & negative text (50x)		
50% Dot (200x)		
30% Dot (200x)		
Min printed dot (200x)		

Supporting Technology – RIP Super Cells

After many years of the promotion of 'High Definition' technologies in flexo plate making, using higher resolutions typically 4000dpi and up, it is sometimes difficult to accept that lower resolutions can provide the necessary image quality. Remember though that Flexcel NX has become the flexo quality benchmark working with standard resolution 2400dpi files. Also note that Woodpecker screens give higher (optical) resolution and finer structure array output from a 2000dpi input file than WSI at 4000dpi. In short a higher resolution file is unnecessary for fine surface micro structures. So, the remaining concern for users may be the possible restriction in print quality by limited 'grey levels' available at lower resolutions?

Popular theory goes that the human eye can typically detect 256 distinct shades thus if a process colour image is screened with less than this available then a 'lower quality' may be perceived.



Before Super Cells a calculation with image resolution against available grey-levels could be made:
Number of grey levels = (file or device resolution/screen frequency)^2 +1

For example, a 2400lpi image file with a 175lpi screen has (2400/175)^2 + 1 = 199 grey levels.
So, a 2400lpi file can't give a good quality image screened at 175lpi? Industry experience clearly says it can!

In the early 1990's, to address this and moiré problems RIP developers started using 'Super Cells', resolving dot sizes and angles by combining various numbers of screens dots together to form a larger cell. In this way dot sizes could be resolved to a far greater level than previously available.

The drawing below shows simply how Super Cells may work to add grey levels. In this example, if there is no intermediate dot size between 10 and 11% available, then if a 10.25% Super Cell shade is required it can be achieved by making ¾ of the dots 10% and the other ¼ 11%. Super Cell RIPs are now standard in the flexo industry. More than a 1000 grey levels are available from any Super Cell RIP with, for example a 2000dpi input file and a 175lpi line screen.

Summary – How does Woodpecker Nano Contribute to Flexo Key Targets?

- **Improving Print Quality**
  - Smoother higher density solid ink transfer
  - Ability to achieve target SID with reduced volume/higher line-screen anilox for dot-gain control and finer highlight dots
  - Eliminates dot bridging and tonal jumps
  - Reduces or eliminates typical flexo 'halo' effects in solid type
  - Reduces or eliminates 'Trailing Edge or void' effects

- **Reducing Costs**
  - Saving ink costs
    - i. More efficient ink pick-up and transfer from low volume anilox
    - ii. Choice of using lower cost less pigmented ink and still achieve target densities and quality
  - Saving press costs
    - i. Greater ability to run combined (tone/solid) plates
    - ii. Increased tonal range (hence colour gamut) makes fixed colour palate more viable thus saving set up times

- **Faster Turnaround**
  - Plate imaging with highest productivity
  - No extra RIP steps or decisions
  - Smaller image files, faster to process and transfer