

White Paper

Full HD Flexo

Application and Implications of
Full High-Definition Flexo

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ESKO 

Table of contents

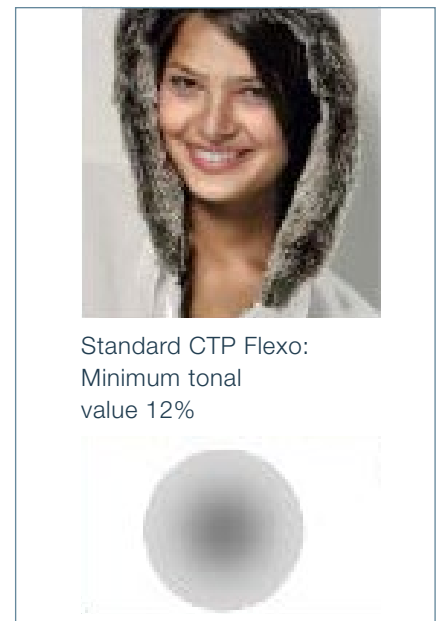
1.	The Evolution of Flexo Platemaking	3
2.	High resolution platemaking - first step to solve the Flexo problems	5
3.	HD Flexo	7
3.1	HD Flexo Highlight Screening	8
3.2	HD Flexo Solid Screening (Microcells)	10
4.	Round-top vs. flat-top dots	11
5.	The introduction of Full HD Flexo	14
5.1	Full HD Flexo for Flexible Packaging Printing	16
5.2	Full HD Flexo for Label Printing	17
5.3	Full HD Flexo for Corrugated Printing	17
6.	UV exposure consistency	18
6.1	Digital LED UV offers consistency	18
6.2	Sustainability Considerations	19
7.	What's next?	20
7.1	Extended gamut printing	20
7.1.1	There are a few prerequisites for this to happen:	21

1. The Evolution of Flexo Platemaking

While flexography is a very cost-effective print process particularly for packaging, there are times when there have been other preferred print processes, especially as it relates to print quality.

So what has prevented flexo printing from matching the 'high quality' processes like gravure and offset? It is the tonal jump at the end of a vignette to zero, caused by the fact that digital flexo plates can print dots correctly only above a specific minimum size.

With 4000ppi imaging technology, it is possible to easily hold 10-micron dots on digital flexo plates, but unfortunately these dots are not mechanically stable enough. They bend or squeeze during print. Thus, transitions to zero—as well as very light image details—cannot be printed with today's standard flexo printing process. We call this the 'Flexo Problem'.



But there is yet another basic problems that occurs in flexo printing: The incomplete ink lay down in flexible packaging printing of foils with solvent inks.

Ink lay down is typically influenced by the ‘self-organization effect’ of the ink due to surface tension. This causes the ink film to tear into cells of about 100 microns in size, and the print speed transforms these cells into lines. This results in visible defects in solids (so called ‘pinholes’) that reduce the smooth appearance of solids and overprints—and even Pantone builds. Furthermore, it leads to a reduced solid ink density (SID) in general.

This often makes it necessary to separate linework and process work into two separate plates, printing linework with higher volume anilox rollers to increase the solid appearance. However, this also has a tendency to reduce the highlight quality.

Especially for underprints or overprints, the white often needs to be printed twice which results in higher print form and ink consumption cost. All in all, the lower solid quality appearance to the human eye can result in the selection of gravure printing instead of Flexo — meaning much higher costs to the printer and the brand owner.

Today these two major Flexo problems (instable highlights at transitions to zero as well as incomplete ink laydown) can be eliminated.

This is possible thanks to the High Resolution imaging technology in combination with HD Flexo and Full HD Flexo from Esko.

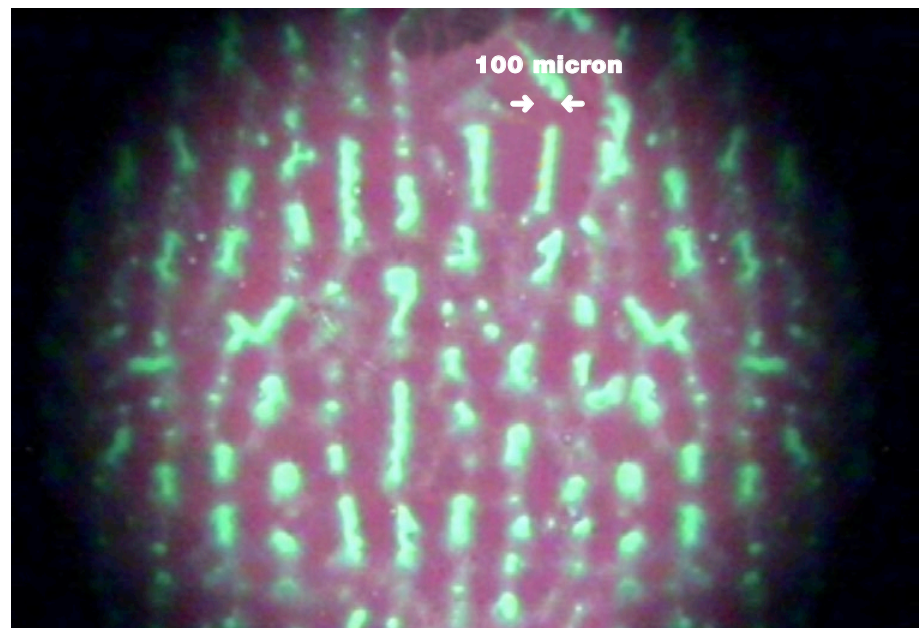


Figure: Typical “Pinhole” pattern in flexible packaging printing with solvent inks

2. High resolution platemaking - first step to solve the Flexo problems

When Esko introduced its CDI digital flexo plate imager in 1995, the typical imaging resolution was 2100 pixels per inch (ppi; also known as dots per inch). At this time, an 18-micron spot was the standard. Over the years, the resolution has been increased, while the writing spot size has concurrently been reduced.

Today the industry standard is 4000ppi imaging resolution. This not only means that we have 4000ppi **addressable pixels per inch** but also that each pixel is accurately written with a 6 micron spot.

The advantages of increasing the imaging resolution become very obvious from the images below:

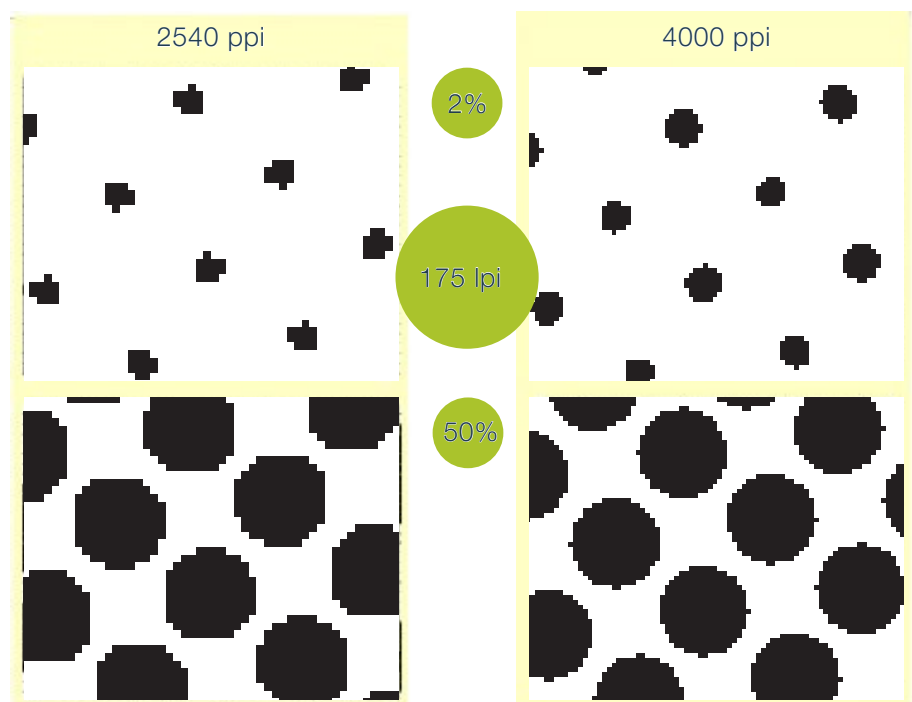


Figure: Standard imaging resolution (left) compared to High Resolution Imaging (right)

It can clearly be seen how the high resolution of 4000 ppi generates much rounder dots when compared to plate making at 2540 ppi. At 4000 ppi there is 2,5 times more data available to define the same dot shape.

Furthermore, the 4000ppi create a much higher number of natural grey levels than can be properly reproduced on the printing plate.

HD Flexo - Highlights, Image Contrast and details

- Solution to Flexo-Problem #1: Stable minimum dots

4000 ppi = Many more natural grey levels

	2400 ppi	2540 ppi	4000 ppi
150 lpi (60L/cm)	256	287	711
175 lpi (70L/cm)	188	211	522
200 lpi (80L/cm)	144	161	400

Better image contrast and detail sharpness

Higher lineatures (LPI's)

This results in dots that are more round and the dot shoulders are more evenly formed, resulting in less dot gain, higher minimum dot stability and a more uniform dot bridging behavior on press.

Due to the higher number of natural grey levels, images can be reproduced with a much higher detail level and detail sharpness, and this even compared to what is possible in gravure and offset printing.

3. HD Flexo

An answer to the 'Flexo Problem' can be found in HD Flexo. HD Flexo uses a well-balanced dot size mix of small and large dots in the extreme highlights. The rest of the tonal scale is not changed. Thus the full grey-level support of 4000ppi imaging resolution can be used.

The dot size mixture produces two benefits:

1. There are a few larger dots—even larger than the typical minimum dot size in standard screening. These dots are so stable that they can easily withstand the forces of the impression during the print process. These larger dots also serve as a distance holder to the Anilox roller, so they prevent the highlight dots from dipping into the Anilox roller cells. This helps keeping the highlight areas clean during the print run.
2. The other dots in the grid are smaller—some are 10 microns in size or even below. In fact, the image further down consists of about 30 different dot sizes. The smaller dots are supported by the larger dots and, thus, do not bend on the press, so they can deliver tiny printed dots maintain stability even during long runs. Depending on the print process, the HD method reduces the tonal values of highlights to near zero.

This mixture of large and small dots—where all dots stay on their regular grid—is confusing the human eye, so the eye only sees a homogeneous 'grey'.

This is in strong contrast to previous stochastic screen models, which use a smaller amount of dots when the tonal value is below of what is possible with standard screening. The penalty for the lower dot frequency of older methods is much more visible graininess in the highlight areas, especially when several colors are printed together.

Supporting dots for mechanical stability
and as distance holder to Anilox roller

Stable printing minimum dots

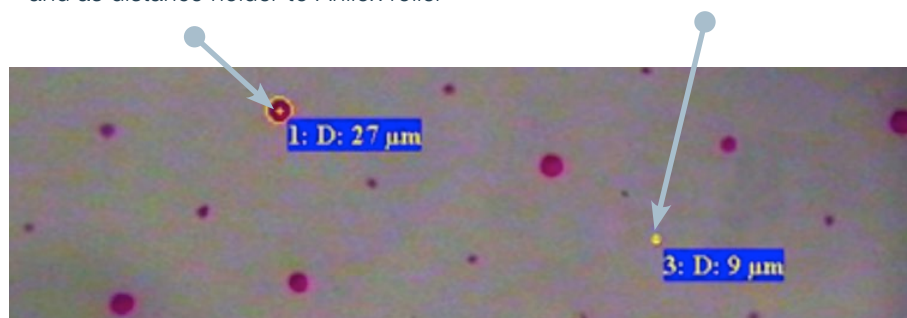


Figure: Typical printout of an HD Flexo highlight screen

3.1 HD Flexo Highlight Screening

HD screens allow the smaller dots to fade away only at the extreme end of a vignette to zero. This only appears on the last millimeter of a vignette edge and does not interfere with the perception to the human eye. Larger areas with low tonal dynamics are always printed with all dots on their regular grid, which makes the dot structure invisible to the human eye at 150lpi or higher.

HD Flexo screening technology only works for digital flexo plates, as the dot sharpening effect during processing is mandatory to generate the high number of different dot sizes needed for a smooth appearance to the human eye.

All technologies that use flat top dots (like conventional flexo plates, digital flexo plates produced under the absence of oxygen, or flexo plates produced with transfer films) cannot use the HD Flexo screening method. These plates can only be made with stochastic-like algorithms, as lower tonal values require a reduced number of dots. That is prone to a grainy appearance.

The best suitable dot size mix, of course, depends upon the plate polymer characteristics. To achieve this, HD Flexo supports each commercially available digital flexo plate and sleeve type with specifically tailored HD Flexo screens. An HD Flexo Screeninstaller provides the proper screen for each digital flexo media and print process combination. This ensures an easy and straightforward implementation for trade shops and printers.



Figure: Comparison of standard and HD flexo print quality

In the images above, there is a comparison between standard CTP Flexo and HD Flexo. This commercial long-run job that was originally printed in gravure and has now been successfully converted to flexo printing thanks to HD Flexo technology.

Standard Flexo could not deliver the required quality level with smooth highlights and transitions at 200lpi.

However, HD technology ramped up to 200lpi easily, as the minimum dot in print was still close to 0%. The difference in the results is clearly outstanding!

The astonishing fact is that nothing needed to be changed except the platemaking. The job used the same plate type, the same processing equipment, the same mounting tape, the same press and even the same anilox rollers and inks (but of course these were already on high quality level).

The dot size variation technology of HD also brings the additional benefit of making flexo rosettes nearly invisible in the highlight areas. Even in the strong enlargement of the woman's eye, flexo rosettes remain invisible in the HD Flexo image. This feature smoothens the printing appearance of the very sensitive highlight area.

3.2 HD Flexo Solid Screening (Microcells)

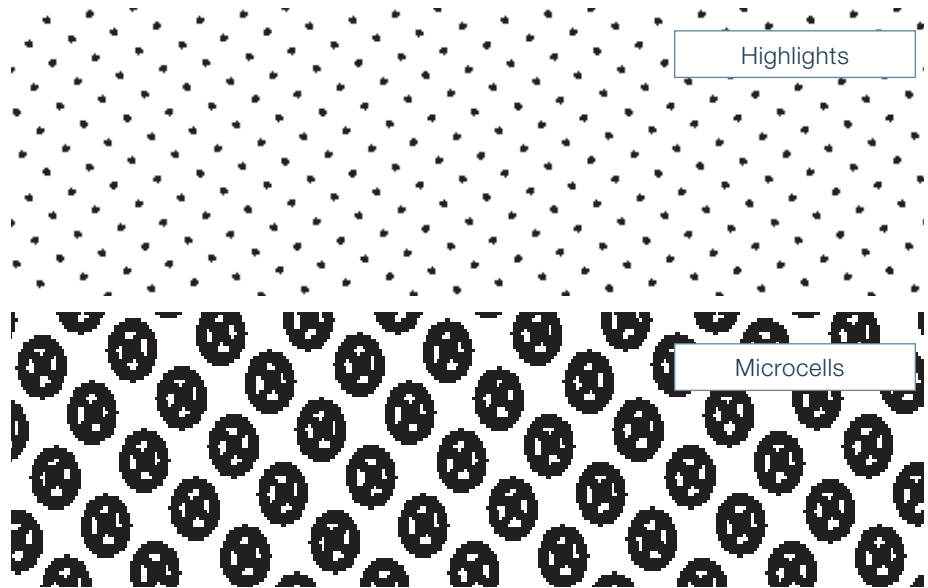


Figure: HD Flexo Microcells screening

Contrary to all former technologies, HD Flexo is generating plate surface structuring not only in the highlights, but also throughout the scale in the halftone screening dots. This enables an improvement in ink lay down for the total tonal range, without generating transition steps in gradations.

Also the shadow areas can now hold more grey levels—and thus more details—as the ink does not close the small shadow holes any more. Thus, the printer can also benefit from more shadow details.

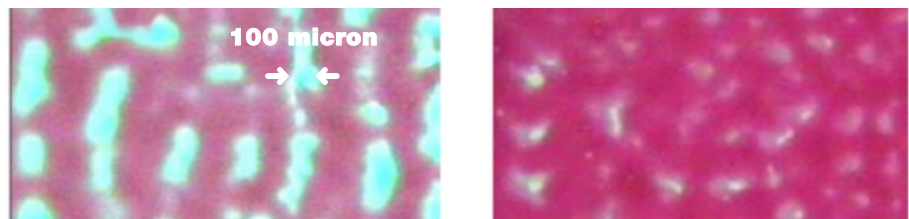


Figure: Solid areas printed with standard plate surface (left) and with microcell structure (right)

4. Round-top vs. flat-top dots

Unfortunately, while HD Flexo Microcells are giving a substantial improvement on ink transfer quality, it is still behind what gravure quality can achieve. What can be done? The answer comes with understanding round and flat top dots.

The advantages and disadvantages of round top and flat top dots are being discussed intensively. The 'round top' dot shape is the natural dot shape of digital flexo (CTP) platemaking and is created by so-called oxygen inhibition. That is, the oxygen in the surrounding air blocks the polymerization reaction at the surface of the plate during UV main exposure.

This dot shape has boosted the development of the flexo printing process from a low quality process to a serious competitor to gravure and offset printing. Round top dots are always smaller than their openings in an imaged black Laser Ablatable Mask Surface (LAMS).

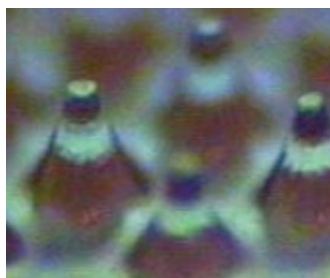


Figure: Flat top dots

The 'flat top' dot shape is well known from the analog days of flexo, when an imaged film was used for flexo platemaking. The film on top of the flexo plate blocked oxygen from accessing the photopolymer during UV main exposure. The result is that the dot grows 1:1 to the opening in the film.

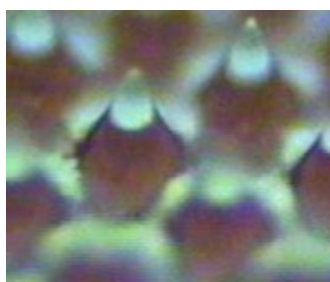


Figure: Round top dots

Recently other technologies have been developed to inhibit oxygen during UV main exposure. While these technologies use laminated foils or inert gas, all use conventional bank light frames for UV main exposure.

Oxygen inhibition can also be suppressed by a recently developed technology using very high intensive UV light. This technology can also generate a 1:1 dot formation although the UV main exposure process takes place under normal atmospheric conditions, without any additional manual and analog lamination steps.

The round top dot shape has significant advantages in all flexo printing processes. Due to the sharper top, round top highlights print much smaller and lighter than flat top dots of the same size. Round top dots are the backbone of HD Flexo highlight printing. The capability to print transitions to zero has helped it to become the industry standard in flexography.



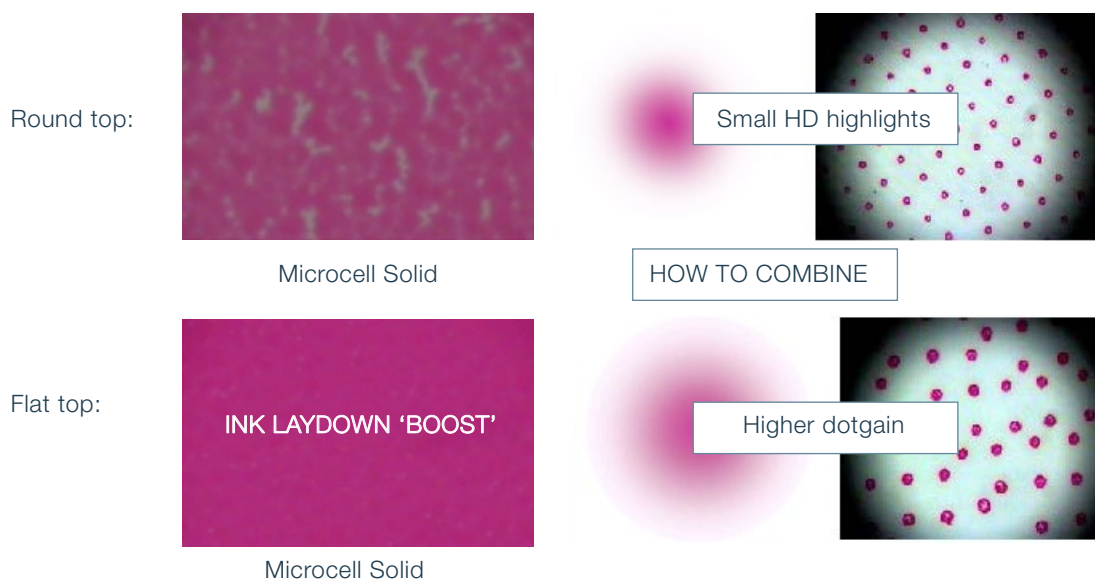
Figure: Print results with round top and flat top microcells (left) as well as an image of the corresponding flexo plate surface (right)

Flat top dot plates suffer in the highlights. Stochastic screening is often used to achieve lighter minimum tonal values, but the price for this is clearly visible graininess in the highlight areas of the print.

When we look at solid printing, the situation turns around. Microcells work much better with flat top dot plates than with round top dot plates. The result of flat top dot plates with proper microcell structures is a gravure-like ink laydown. The reason is that the 1:1 dot formation of flat top plates can hold much finer Microcell structures on the plate surface than what is possible with round top plates.

On round top plates, the top 20 micron layer of the plate is not exposed due to the so called “oxygen inhibition”, and removed during processing. This makes it impossible to hold microcells smaller than 20 microns in size.

So, the challenge has been how to combine the highlight benefits of round top dots and the solid coverage of flat top dots.



5. The introduction of Full HD Flexo

Esko has developed a technology, called Full HD Flexo, which utilizes a digital high-power LED UV main exposure head inside the CTP imager. This offers full digital control over the oxygen inhibition process by adapting UV light intensity and dwell time during UV main exposure, thus changing the polymerization process according to the application needs.

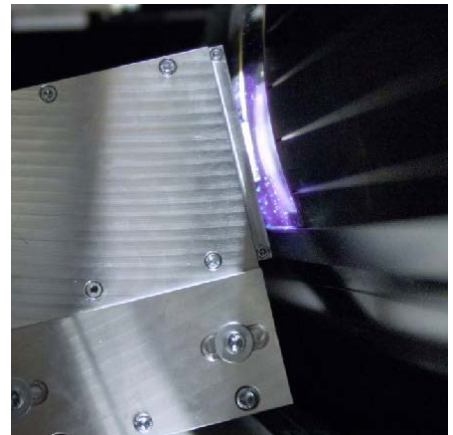
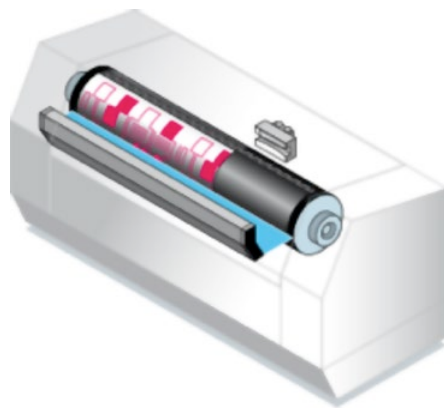
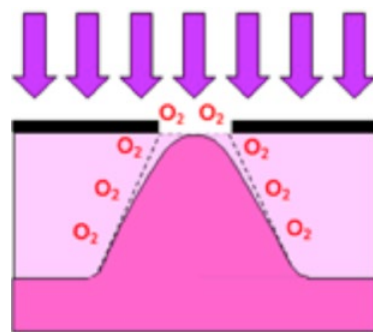
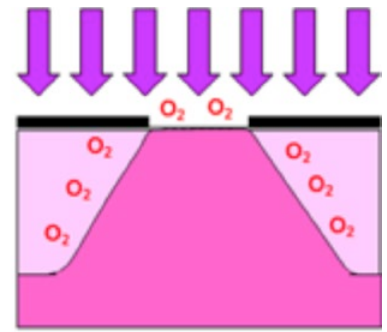


Figure: Esko CDI with digital LED UV main exposure head



Fine highlights get rounded top



Larger dots are flat

Figure: Dot formation in Full HD Flexo

With this unique UV control capability, it is possible to create small highlight dots that become round again – although larger dots stay flat. Full HD Flexo is the only technology that creates round top and flat top dots on the same plate – for perfect ink laydown in combination with smooth edge printing and transitions to zero!

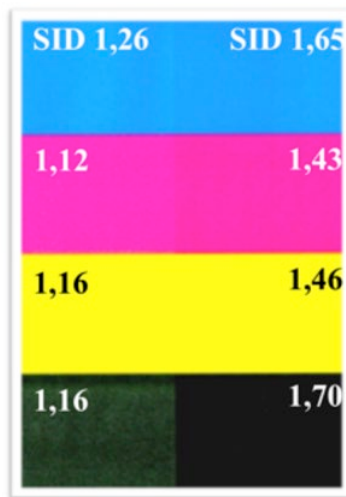
The ink laydown of Full HD plates and sleeves can compete with gravure printing in flexible packaging. Typically the Solid Ink Density (SID) can be increased by about +0.3, and in extreme cases by up to +0.6.

Full HD Flexo is also boosting ink transfer if high volume anilox rollers are used, e.g. for white or spot color printing.

The ink laydown in all areas of flexible package printing (solvent and water-based inks) is perfectly smooth without any pinholes. This leads to a very intensive appearance to the human eye.

Full HD Flexo is also improving corrugated and label printing.

Note : Absolute SID values depend on the ink system on the press.

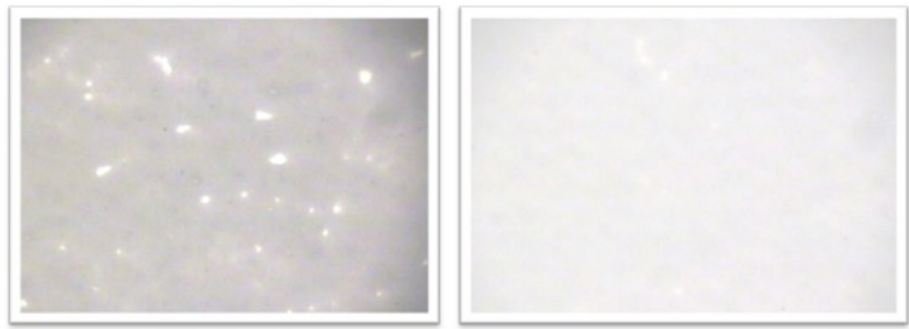


Bright intensive colors with smooth vignettes to zero:



Figure: Standard flexo with no microcells on the left and Full HD flexo with microcells on the right

MICROSCOPIC DETAILS



White printing with standard solids

White printing with Full HD Microcells

Figure: Opacity improvement for white printing

5.1 Full HD Flexo for Flexible Packaging Printing

When using Full HD Flexo, the optimum solid ink density (SID) can be selected by the proper Microcell structure. This typically works even without the need to change the anilox roller on the press, thus delivering significant process and productivity advantages in the pressroom.

All of the Full HD Microcells eliminate the pinholes, especially in flexible package printing. Printing with a pinhole-free ink laydown and the correct SID also reduces ink consumption and solvents on the press to a minimum, and guarantees brilliant overprint colors without any blackening effect. From our experience talking with printers, the ink savings can be as much as 25%.

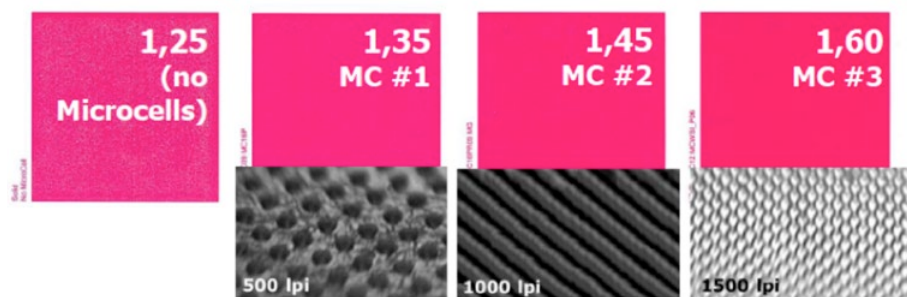


Figure: Solid ink density with no microcells on the left and different solid ink densities with different microcell structures.

5.2 Full HD Flexo for Label Printing

Full HD Flexo is delivering many benefits to Label printing as well. Besides more stable and more consistent print result, the unique dot shape is reducing mottling effects on paper label stock and even makes gear marks of older presses invisible.

There are also Microcells available that especially developed to improve ink transfer and surface smoothness of UV ink.

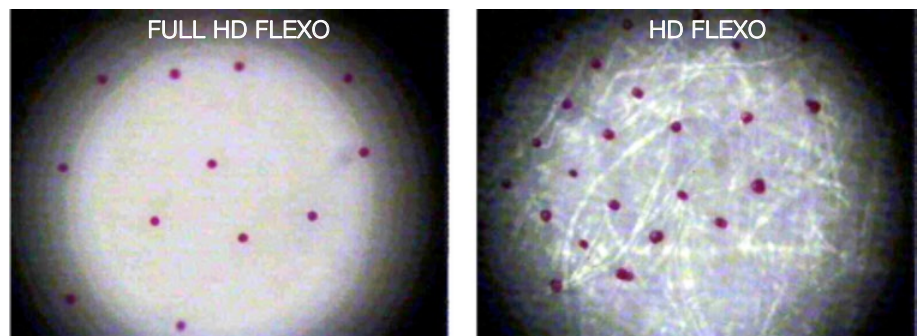


Figure: Minimum dot stability at the edge of a transition to zero (left: Full HD Flexo, right: HD Flexo)

5.3 Full HD Flexo for Corrugated Printing

Full HD Flexo delivers several benefits to corrugated printing as well.

This includes the reduction of the fluting effect on lower grade board, better edge definition of linework (barcodes) and text as well as better stability of highlight dots.



Figure: Typical fluting visibility for Full HD Flexo printing (left) and standard digital Flexo printing (right).

6. UV exposure consistency

Another very important advantage of digital LED UV exposure within the CDI unit is utmost consistency— both over time and over the whole plate.

Bank UV frame light sources (UV bulbs) degrade in UV output power over time. The reducing UV output power is compensated by gradually increasing exposure times, until the UV bulbs need to be replaced after a few 100 hours of operation.

Furthermore the UV output power changes over the area of the UV frame as all the bulbs have a different output and aging characteristics.

These inconsistency effects create inconsistent plates as dot sizes and dot shapes depend from the locally available UV power density during the main exposure process.

6.1 Digital LED UV offers consistency

On the other hand, digital LED UV is an extremely consistent light source that lasts over 5,000 hours, or enough for 30,000 plates. Due to the unique optical construction of the CDI UV head, each square inch of the plate receives the same light. Thus, for the first time ever, there is consistent dot quality in flexo platemaking!

Digital LED UV



- Consistent dot quality
- Over 5000h (= 30.000 plates)
 - And equal all over the plate

Bank UV frame



- Inconsistent dot quality
- Continuous UV change
 - UV not constant over the plate

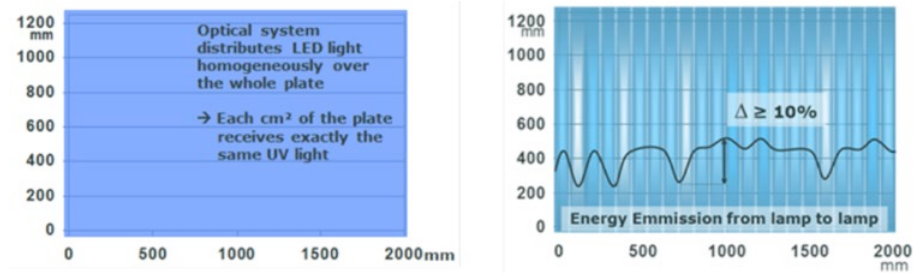


Figure: UV exposure consistency over time (top) and over the plate surface area (bottom) as a comparison between integrated digital UV LED exposure (left) and conventional bank light exposure (right).

6.2 Sustainability Considerations

Digital LED UV exposure is the most sustainable UV exposure technology as it saves both energy and waste. Furthermore, it eliminates the use and waste of toxic substances like Mercury.



Figure: Waste generation comparison between digital LED UV exposure (left) and conventional UV exposure frames (right). One conventional UV light tube contains enough Mercury to contaminate 150.000 liter of drinking water!

7. What's next?

By implementing integrated digital UV main exposure, there is now the opportunity for 'lights out' flexo platemaking.

With an attached plate stacker and plate handler, and plate output device, raw plates can proceed directly into the imager, get exposed, and be sent directly to the plate processor.

There are greater ramifications, though. One of the more costly processes for package printers involves printing with spot colors. Beyond the cost of mixing inks, the process requires the cleaning of ink stations between runs and shuts down the press for a while—not to mention the additional ink waste and extended make-readies.

7.1 Extended gamut printing

Because of this, flexo printers are now starting to simulate spot colors on press—either with a 4-color process or with extended gamut printing, typically 4-color plus orange, green and violet.

One of the benefits is that there is no cleaning of ink stations between jobs, because the printer is always using the same ink. There is a less waste of ink and solvents. There is also less time needed for job changeovers.

With this, smaller run lengths become commercially viable. And, because the same inks are used for every job, the printer can combine different jobs on the same web.

For the brand owner, besides the economic & sustainability advantages, there is better flexo print quality. Images are brighter, and higher line screens can be used for demanding job areas, such as vignettes and highlights, as finest anilox rollers can be used.

7.1.1 There are a few prerequisites for this to happen:

- There must be a controlled and consistent ink laydown that corresponds to the ΔE requirements for matching brand colors.
- There must be no visibility of 'flexo rosettes'. The appearance of the spot color must be acceptable. This usually means that there must be a minimum of 150 lpi; although it is better if it is 175 lpi.
- There must be a perfect ink laydown with fine anilox rollers. Highlights, vignettes and bright solids must be reproduced on one and the same plate.

When using Full HD Flexo, the digital UV LED exposure assures a consistent ink laydown and consistent dot quality throughout the plate at high line screens, and is the enabling technology to make spot color simulation a commercially viable reality.

This will soon become the future of flexo printing.

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