HIGH OPACITY WHITE – is it time to switch to inkjet?

By FFEI Ltd
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High opacity white is a big deal across many labels & packaging applications.

But with a drive for increased productivity, short runs, variable data and lower production/set-up costs, is rotary silkscreen still king?

High opacity white is required whenever print is applied to a reflective (metal, holographic, iridescent), transparent, coloured or illuminated background. The applications are diverse. Manufacturing, displays, safety, outdoor signage, back lit displays, road signs, textiles, food & confectionary and a near infinite number of applications within labels & packaging.

Many different techniques and processes have been used to apply high opacity white. Rotary Silkscreen is by far the highest quality and despite higher running costs, has remained the favoured method. However with the emergence of digital inkjet, the application of high opacity white is set for disruption.

This ebook looks at the history, technicalities, trends and requirements for printing high opacity white ink and explores the emergence of inkjet technology as a viable alternative to rotary screen.
Chapter 1
A short history

The challenges of printing with high opacity white inks

High opacity ink requires sufficient film thickness and pigment loading to achieve the desired result – covering factor. Due to the ability to print very high ink thicknesses screen print is an obvious choice. Although the screen-printing principal can be dated back to the Song dynasty in China, circa 960 – 1279AD, it wasn't until 1907 that the modernisation of screen-printing occurred. It was at this time that Samuel Simon officially patented the screen-printing technique for high quality custom wallpaper or textiles. In 1910 the invention of manufacturing screen stencils using photo-reactive stencils was created by Roy Beck, Charles Peter and Edward Owens – paramount to the processes used for the printing of Titanium Oxide white ink for commercial use today.
The efficiency of traditional screen-printing was poor compared to other printing methods such as lithographic printing. Yet for manufacturing, productivity and creating continuous patterns, this method was key. However, in the 1960’s, the barriers to closely guarded trade secrets and the invention of the continuous rotary screen press, resolved a number of issues and led to the technology becoming more widely adopted.

The initial idea of wrapping the silkscreen around a drum created a continuous process initially proposed in Portugal in 1947, but commercialised by Stork (now known as SPG Prints) who remain one of the market leaders in screen print today. Stork announced the system at the ITMA show in Germany in 1963. By converting the screen-printing process from semi-continuous to continuous, significantly higher production speeds are obtained. For high opacity white, more ink must be pushed through the mesh, thus course screen gauge and slower print speeds are required in order to maintain the level of quality required by brands. This balance between fine detail and covering power restricts white ink printing to around 50m/min.

Whiteness, brightness, flatness, refraction, reflection, UV absorption, sustainability – high opacity white provides a fundamental challenge to any converter needing to ensure the highest possible degree of quality.

Titanium dioxide provides excellent brightness and a very high refractive index. Titanium dioxide is the most widely regarded white pigment in paints, inks, cosmetics and skin care products. Its UV absorbing sunscreen properties also provide key resistance to discoloration under UV light. It was not until 1916 that the technology became available to produce modern TiO2 pigments. Today, titanium dioxide remains the primary pigment for providing whiteness, brightness and opacity.

Titanium is one of the most widely used but not the only pigment. Zinc Oxide, Calcium Bicarbonate and even rice starch are used in white inks. Rice Starch is particularly important; it produces the same whiteness required for food and toothpastes but is sustainable, and a foodstuff rather than a food additive.

Whiteness, brightness, flatness, refraction, reflection, UV absorption, sustainability – high opacity white is a complex science!
Chapter 2

The growing importance of high opacity white ink

Brand trends driving increased use of high opacity white

A high opacity white can enhance a label in a variety of ways – a means to block out colour, provide an opaque area on clear or metallic substrates, over print coloured or preprinted materials, ensure vibrancy of colours printed over the top and to simply add an air of quality. If the ink film is thick enough then even textures can be produced using high opacity white ink.

The most significant trend of late has been the heavy adoption of the ‘no label’ look, ‘clear-on-clear’ or transparent labelling by brands. ‘No label’ can achieve the look and feel of high-end, direct-to-shape or thermal transfer graphics, but in low volume and at a fraction of the cost. This trend not only covers transparent packaging but also coloured plastic containers. Allowing the container colour or the product colour inside to be directly integrated into the label design.
Into 2019 and beyond, consumers are set to favour clean and clear labels and packaging. They are looking for all-natural ingredients and will seek evidence by checking what is printed on the label. Being able to actually see the contents of a product through the packaging helps boost confidence – it’s all about evoking feelings of quality, purity, and freshness.

Brands, from many industries, particularly the food, beverage and beauty industries, have latched onto the ‘no-label’ look as the clear labels provide an extra element of elegance and flair, which is key in helping separate products from competitors and command greater shelf appeal. Access to a high opacity white is key to this design approach.
The beauty is in the detail

Put simply white is an enabler for detailed, vibrant label designs that evoke quality and luxury. Print buyers know exactly what they want and need – the highest opacity, the flatness, the brightness. White can be applied first or last in the printing process – although depending on press set up and label job it could be both, or even a middle stage, within a hybrid press configuration.

However, how and when you use it will allow different ‘effects’ and finishes to be achieved. It is important to note that the running order and silicon content of the ink is very important for how white is to be used – in particular can it be overprinted with other inks/fluids? Can other inks/fluids be printed on top?
Lay down options explained

Underwhite – The white is printed first to ensure that any colours printed over the top are as vibrant and clear as possible. It may be that the substrate is coloured or clear.

Overwhite – This is referred to in many forms but last down white or overwhite are the most common. Overprinting white is essential for unsupported films and window decals.

“Print buyers know exactly what they want and need – the highest opacity, the flatness, the brightness.”
Chapter 4

Opacity is key
Measurement is critical

Achieving the desired contrast and hiding power

It is not as much about the colour white (although brightness is a contributor), as it is about the opacity capability. Opacity is defined as ‘the quality of lacking transparency or translucence’. Alternative descriptions in the print industry include the terms ‘hiding power’ or ‘contrast ratio’.

Opacity can be measured in different ways but the ISO (covered by ISO 6504) describes methods for determining the opacity given by ink when applied to a black and white chart or to colourless transparent polyester foil. To judge opacity of white ink you need to measure the reflectiveness (reflective values) of the ink printed on both the white and black areas, using a spectrophotometer. If the results are identical (the reflective value is the same for the overprinted white and black) then the white ink would be deemed 100% opaque.
Illustration of white opacity effect on label performance

The simulation above shows the effect of 65% opacity (55-67% is common to flexo, toner and the majority of inkjet devices when measured according to ISO 6504).

“Opacity is defined as ‘the quality of lacking transparency or translucence’.”
Chapter 5
Common print processes used to print white

Continuous rotary screen printing

Silkscreen has the ability to provide high ink film weight. It is this characteristic by which opacities of more than 80% can be achieved. The high opacity, brightness, flatness and distinctive ‘raised feel’ provides basis of the aesthetic visual and tactile quality that lifts a brand to the next level. For this reason alone, brand managers often demand the quality of rotary screen.

Within the health & beauty and craft beverage markets almost every press has at least one screen unit. These markets are increasing in competitiveness; a large number of micro brands are all looking for that ‘Pop’! However the technology is not without its drawbacks. There are numerous problems/faults with screen-printing that skilled operators need to know how to manage.
Flexographic printing

Of course flexo technology has not stood still either. Flexo can achieve excellent results with specialist inks such as Fujifilm Super Nova White. When used with a high opacity white anilox and specialist doctor blades, Fujifilm Super Nova White can achieve up to 17g/m2, which is capable of producing excellent opacity at flexo productions speeds. This is a fantastic alternative, and for many it fits their clients’ needs for opacity, whilst reducing cost, ink usage and retaining production speeds. In contrast silk screen print can be configured to achieve laydown up to 400 g/m2! Inkjet can achieve up to 250 g/m2 although speeds are slower for these extreme applications.

However, to achieve the opacity you need to either use a special anilox or multiple print stations. To achieve detail you need a second station with another anilox and artwork carefully trapped. Consequently many customers still insist on screen. It depends on their brand, if cost/speed is the driver they may compromise and opt for flexo but many customers will only use screen.
Combination printing

Combination printing combines processes such as screen and litho or screen and flexo. Why? Often there are qualities in each process that resolves the deficiencies of the other. For example, a coarse silk screen followed by a print process capable of exceptional detail, smoothness and tints like litho is complimentary. Issues of combining processes in this way are often registration, trapping, setup and ink on ink behaviour related to surface tension and the amount of silicon used in the ink.

Toner based digital white

Laser based toner devices using white toner have been available for some time. The opacity achieved is very low and often systems requiring additional ‘hits’ are required to achieve higher opacities. Very similar to the concept of stacking flexo units. The HP indigo is capable of very high opacities but this is at ¼ of the speed and 4 times the price of a single click. Other vendors like Xeikon with their Fusion project, are combining toner’s high resolution with inkjet to achieve white. HP also have shown use of inkjet for digital finishing. But with inkjet technology approaching similar resolutions to toner devices the quality gap is closing rapidly.
Comparison table: strengths & weaknesses of using different print processes in relation to high opacity white

<table>
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<tr>
<th>Process</th>
<th>Opacity (up to)</th>
<th>Speeds</th>
<th>Strengths</th>
<th>Weaknesses</th>
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<tr>
<td>UV Screen white</td>
<td>87%</td>
<td>40-55m/min</td>
<td>Whitest white&lt;br&gt;Very flat high quality&lt;br&gt;Highest opacities&lt;br&gt;Best balance of detail vs opacity&lt;br&gt;Ink price</td>
<td>Very high cost&lt;br&gt;Setup time&lt;br&gt;High failure rate&lt;br&gt;Shortage of skilled operators</td>
</tr>
<tr>
<td>UV Flexo white</td>
<td>65%</td>
<td>70-150 m/min</td>
<td>High speed&lt;br&gt;Ink price</td>
<td>Up to 3 flexo units with 3 grades of tape, plate and anilox required&lt;br&gt;Registration&lt;br&gt;Mottling&lt;br&gt;Chatter and bounce artefacts&lt;br&gt;Pin holes&lt;br&gt;Low opacity</td>
</tr>
<tr>
<td>UV Flexo white</td>
<td>76%</td>
<td>40-90 m/min</td>
<td>High speed&lt;br&gt;Ink price</td>
<td>Mottling&lt;br&gt;Chatter and bounce artefacts&lt;br&gt;Pin holes&lt;br&gt;Low opacity</td>
</tr>
<tr>
<td>UV High Opacity White + HOW anilox</td>
<td>85%</td>
<td>45-90m/min</td>
<td>High (screen like) opacity or medium opacity at speed&lt;br&gt;Registration</td>
<td>Mottling&lt;br&gt;Chatter and bounce artefacts&lt;br&gt;Pin holes&lt;br&gt;Challenging setup</td>
</tr>
<tr>
<td>Standard inkjet WCMYK</td>
<td>70%</td>
<td>45-70m/min</td>
<td>Instant setup&lt;br&gt;No plates or screens</td>
<td>High ink cost&lt;br&gt;Low opacity</td>
</tr>
<tr>
<td>High opacity inkjet</td>
<td>87%</td>
<td>45-70m/min</td>
<td>Instant setup&lt;br&gt;No plates or screens&lt;br&gt;Can achieve both fine detail and high opacity in single process&lt;br&gt;Deskilled operation</td>
<td>High ink cost</td>
</tr>
</tbody>
</table>
Eyes turn to digital inkjet white

Reduced print runs, increasing setup costs and an ever increasing demand for quality that can only be achieved with complex combinations of print process — converters are looking for options! In the digital market inkjet is gaining serious attention not just from converters but from the brands who have always insisted on silkscreen. In both large format and ceramics markets, silkscreen has almost been entirely replaced by industrial inkjet. For labels and packaging the quality demands and just-in-time production schedules take the digital challenge to the next level.

The first digital inkjet presses to support white ink began appearing in 2009. Since this time just about every digital inkjet label press on the market has a white ink option with various degrees of coverage.
Digital inkjet options

In early incarnations of inkjet the white ink, with high pigment loading and very specific viscosity requirements, has challenged ink vendors. Often the inkjet press cannot print the white at the same speed and maintain the same jetting performance. It is a fundamental fact of physics that a system designed for high resolution process printing is going to find it difficult to also achieve up to 3 times the laydown at same speed with a challenging ink formulation. A different approach and different technology is required.

In 2015 a new alternative solution was introduced to allow white to be added as a stand alone module to standard converting equipment be it flexo, litho, digital or a hybrid press – namely a ‘printbar’. It can be integrated directly into a digital press using different technology but driven by same front-end software or a retrofit unit that can be added to a press in the same way that a screen unit can.

Many more options came to market in 2017. Some are focused purely on white, others on delivering a broader range of digital embellishments.

The capability of a printbar differs from that within other digital presses in that it utilizes printheads selected with waveforms (used to control drop firing) tuned and dedicated to the task of printing white ink and other high laydown fluids, typically varnish, black and white. A printbar can even be used as a digital adhesive for cold foil. Critically it brings a number of digital inkjet advantages – fast set-up, make-ready and VDP. There are other benefits relating to print quality such as grayscale technology allowing fine detail, cutting edge ink technology for equivalent whiteness, adaptable pinning and curing options.

“A printbar brings a number of digital inkjet advantages – fast setup, make-ready and VDP.”
Comparing rotary screen white with digital inkjet

To compare two entirely different technologies is not easy. The entire process needs to be considered. Digital white inkjet could be revolutionary for the industry providing there is a solution that realistically fits the market demands. There are a huge amount of inkjet units currently in the market place offering white. But the market for screen white is not one for compromises. The requirements, performance and cost, are mission critical.

Requirements inkjet must overcome to compete with silkscreen

- Cost of investment
- Uptime – reliability, service and availability
- Opportunity for other ink types. Silk-screen in 80% of cases we reviewed, is used for opaque white, but is also used for haptic effects/varnish and opaque overprinted black.
- Match opacity of silkscreen +\-5%
- Match the brightness or whiteness of Silkscreen inks
- No pin-holing in solids.
- Ability to be overprinted and to overprint flexo inks. Many converters run both silicone and non-silicone white for under and overprinting. Adhesion and ink flow issues occur if the surface energy of the ink exceeds the overprinted ink.
- Ability to image both high opacity and fine detail (often achieved via combinations of screen and flexo/litho)
- Smooth gradient screening
- Competitive on price on ink (This should be competitive to the total cost of a screen job not just ink)
- Match speed of conventional at 40-50m/min (min speed 40) for high opacity and up to 80m/min for lower opacity in longer production runs.
- Must be movable like screen unit e.g. station to station
- Eliminate cost of replacement screens and cylinders
- Eliminate lead time for screen make ready (up to 4 hours with in house equipment, or any thing from 24hr to 5 days via service)
The inkjet investment cost comparison

The investment cost of inkjet is naturally higher — currently twice the cost of a rotary screen unit. Silkscreen machinery is relatively simple (if auto register and UV curing are excluded). The technology is in the consumable ink, screen, photo-emulsion, squeegee. Inkjet is a greater investment due to the sophistication of the print unit and refinement of the ink (lower viscosity). Because the technologies are very different we must look at them holistically.

For example, inkjet allows converters the opportunity to run more complex jobs without having to sync two screens. It allows operators to produce more intricate designs with less expertise due to repeatability and reduction in spread and registration issues. Inkjet has almost twice the availability and uptime, resulting in higher operational availability. This means that although the capital outlay is higher, the calculated charge out rate is very similar.

<table>
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<tr>
<th></th>
<th>Silk Screen</th>
<th>Inkjet</th>
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<tbody>
<tr>
<td>Equipment cost</td>
<td>Similar to a flexo unit</td>
<td>Twice the cost of silkscreen unit</td>
</tr>
<tr>
<td>UV curing</td>
<td>Integrated or host flexo unit</td>
<td>Integrated or host flexo unit</td>
</tr>
<tr>
<td>Prepress cost</td>
<td>Very high.</td>
<td>Zero</td>
</tr>
<tr>
<td>Ink cost</td>
<td>Similar to flexo ink</td>
<td>3-4 times cost of analogue inks</td>
</tr>
<tr>
<td>Screen creation</td>
<td>1 hour (using in house system)</td>
<td>Zero</td>
</tr>
<tr>
<td>Setup time</td>
<td>&gt;20mins</td>
<td>2 mins (including inter job cleaning cycle)</td>
</tr>
<tr>
<td>Washup</td>
<td>20mins</td>
<td>0</td>
</tr>
<tr>
<td>Daily maintenance</td>
<td>20mins</td>
<td>10mins</td>
</tr>
<tr>
<td>Number of 1500m jobs per 8hr shift</td>
<td>9</td>
<td>15</td>
</tr>
<tr>
<td>Print speed (White ink)</td>
<td>50m/min</td>
<td>50m/min</td>
</tr>
<tr>
<td>Print width</td>
<td>330mm</td>
<td>330mm (also available in 210-512mm)</td>
</tr>
<tr>
<td>Potential productivity 8 hour shift (assuming 100% uptime)</td>
<td>7920sqm</td>
<td>7920sqm</td>
</tr>
<tr>
<td>Yield per 8 hour shift</td>
<td>4455 sqm</td>
<td>7425 sqm</td>
</tr>
<tr>
<td>Operational Uptime</td>
<td>52%</td>
<td>91%</td>
</tr>
</tbody>
</table>
#1 Inkjet can’t perform at similar speeds to screen

FALSE. Inkjet has the ability to print at equivalent speeds to silkscreen, and can be much wider (most screen units are 330mm) as inkjet has no limit other than those imposed by manufacture. This combined with higher availability provides increased yield (approximately twice the productivity and at improved cost).

#2 Inkjet requires more maintenance

FALSE. Provided a daily preventative maintenance process is followed, inkjet is more reliable (no split or leaking screens etc.) It doesn't require contingency (additional screens for backup), does not need to be calculated into the job cost, thus creating greater efficiency in margin estimates.
The reality

- Equivalent speed
- Improved reliability
- Lower overall TCO
- Increased productivity

#3 Inkjet is more expensive
FALSE. Inkjet ink is more expensive. But the cost of ink is balanced by the reduction in setup cost, simplification of operation and increased productivity. For the majority of run lengths the inkjet ink running cost does not exceed the setup cost of screen plus ink.

#4 Inkjet prints at an equivalent speed – no real savings to be gained
FALSE. Lead times, setup costs and setup times are reduced to below those of flexo. A silkscreen may take up to 40mins to make ready. Digital will take only the time to load a digital file, synchronise and register. This also reduces setup waste. Thus digital can make ready and run a 2000 metre job before silkscreen has even printed a single label.

"Digital can make ready and run a 2000 meter job before silk screen has even printed a single label!"
The next milestone in the history of high opacity white

High opacity white has been an integral part of label and packaging applications. However recent trends – consumer and brand related – continue to elevate its importance.

Alternatives to silkscreen have been sought that deliver the same qualities but with lower set-up times, wastage, production costs and an increase in flexibility and design options.

Inkjet has already disrupted the labels and packaging market. Integrating inkjet capability onto existing flexo, digital and hybrid systems is set to present even greater choice to converters looking to overcome the limitations of silkscreen and deliver the increasing demands of brands and consumers. It must however deliver equivalent speeds, improve on uptime and be on the whole a leaner, more efficient and cost effective solution.

Inkjet has comparable charge out rate, speed and quality. It provides similar opacities and quality. Yet also provides:

- Improved fine detail
- Lower overall job cost
- Faster setup
- Greater yield.
- Options for variable data
- Shorter lead times
Established in 1947, FFEI has an impressive reputation for developing innovative and award winning solutions - from concept to delivery.