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UV Curing • In Control

White Paper

Enhancing Label Print Quality with UV Pinning

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Overview

It is well known that the digital printing market has grown at the speed of light. While digital printing of narrow web labels may reduce costs and enhance efficiency, the prevalent use of labels with low or very low absorbance substrates often results in diminished print quality. The emergence of UV-curable inks presented opportunities to resolve this challenge, but wetting problems frequently caused dot gain, line spread, mottled solids, or incorrectly mixed colors. Working with a leading ink and pigment producer, Excelitas Technologies developed an ingenious solution that thickens the UV ink immediately after jetting to prevent spread before it reaches the UV lamp for full curing.
Figure 1: Illustrates how the LEDs are pinning immediately.

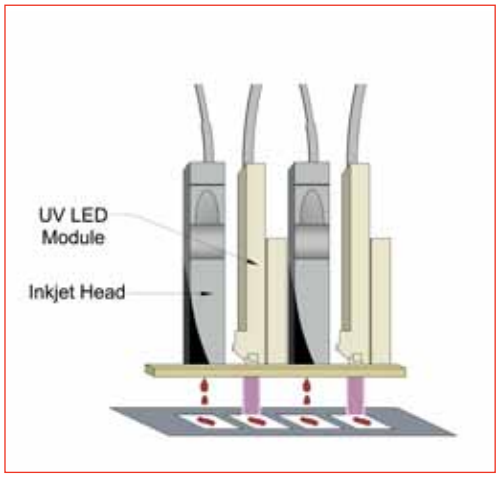

Figure 1 – LEDs are used for pinning immediately.

"The interaction between the Drop on Demand jetted UV inks and the label stock material is crucial after jetting."

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CHALLENGE

Overcome the wetting problems that were causing UV-curable inks to spread and cause ink droplets to bleed into each other before full curing during single-pass digital printing of narrow web labels.

WETTING PROBLEMS WITH UV INKS

A relatively new generation of UV curable inks is in theory an effective solution to the quality issues associated with small- to medium sized digital print runs of narrow web labels. For instance, the UV based drying mechanism caused wetting problems in some standard industrial label stock materials, particularly plastic, when printing monochrome or CMYK color.

In addition, many modern label stock materials designed for UV flexo printing have a surface coating to promote wetting. Consequently, the tiny droplets of UV ink jetted from a DoD head tended to spread out and in many cases continued to spread until they reached the UV curing lamp. Depending on the speed of the line and the distance between the inkjet head and the UV lamp, this ink spread resulted in dot gain, line spread, mottled solids, or incorrectly mixed colors.

EXPLORING SOLUTIONS TO UV INK CHALLENGES

There were three obvious solutions to the wetting problems interfering with the quality of labels printed with UV inks: vary the surface coating on the labels to modify dot gain behavior; modify the rheology of the ink itself; or reposition the UV curing lamp close to the inkjet head so that the ink droplets are cured immediately after they are jetted out.

The first solution would be effective in improving quality but is also likely to increase costs substantially. Furthermore, it limits substrate options since the chemical used to pre-treat the labels must be chemically compatible with the inks used by the print press.

The second solution, which calls for modifying the rheology or viscosity of UV inks, would be highly limited in application since the inks need to have a low viscosity, in the range of 10 cps to 14 cps, in order to be jetted from commercially available DoD ink jet heads.

The third solution – positioning the UV curing lamp close to the inkjet head – is perhaps the most problematic of all for the following reasons:

- The lamp is too large to fit within the compact frame of the inkjet head array.
- It creates significant heat-load, which may affect the inkjet heads.
- The lamp may require a larger cooling airflow, which could interfere with the jetting action.
- Some of the UV light generated by the lamp could shine directly or be reflected onto the print heads, causing the ink to be cured right at the point of output damaging the print heads.
- The lamp takes many seconds, sometimes even minutes, to reach stable operation and must often be left in standby mode when the web is not running, generating heat and air flow.

There was another, less obvious, solution: modify the viscosity of the UV ink after jetting and before it reaches the lamp for full curing. The logic behind this solution seemed flawless; the ink would still be at the appropriate level of viscosity for jetting and would polymerize just enough after jetting to hold off dot gain until it reached the UV lamp. Working with a leading ink and pigment producer, Excelitas Technologies set out to explore more possibilities of such a solution.

SOLUTION

A UV pinning system that uses high power UV light emitting diodes (LEDs) installed next to the inkjet array (print head). The UV light from the pinning system, typically lower than that of the full cure UV system, causes the UV ink to thicken, also known as gelling, but not fully cure. This ink thickening stops dot gain and holds the ink droplet pattern in place until it reaches the full cure UV system.

To prevent dot gain, the UV ink droplets would have to start gelling as soon as they were jetted onto the label surface. We knew that great care had to be taken to ensure that the UV light would not be reflected back to cure ink in the print head. With this in mind, a UV LED pinning system, the OmniCure® AC275 was developed. This new pinning system was installed next to the print head. The thought was that the lower intensity of UV light generated by these LEDs would cause the UV ink to thicken but would stop short of full curing. This interim thickening, now known as "pinning", would effectively arrest dot gain and hold the ink droplet pattern in place until it reached the full cure UV lamp.

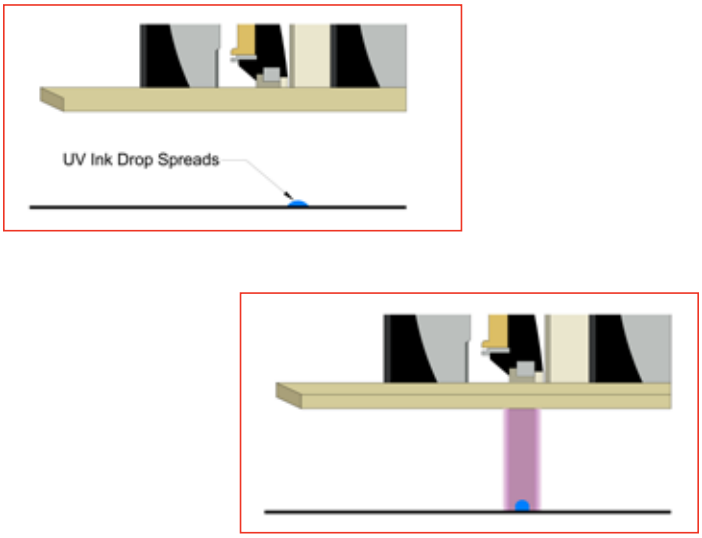

Figure 2 – Demonstrates the difference without UV vs UV pinning. With Pinning, the spreading of the UV ink drop is managed effectively to achieve the desired print quality.

The OmniCure AC275-395 nm was developed using 395 nm LEDs to mount alongside standard DoD piezo inkjet heads (for our initial trials) to provide a 75mm wide curing coverage. The OmniCure AC2110-395 nm is also available to provide a 114mm wide curing width. Larger curing widths can be achieved by adjoining multiple LED heads while still maintaining excellent uniformity. With the pinning heads in place, the OmniCure AC275 and the print inks producer were ready to begin print trials to determine which approach would yield the best print quality possible for full color graphic image.

THE BENEFITS

The OmniCure AC275-395 nm UV pinning solution delivers benefits including but not limited to:

- Improved print quality
- Higher speed printing and through-put
- Long life pinning system with low maintenance costs
- Custom optics for reducing the output angle of light to eliminate reflection onto the print heads
- Configurable pinning lengths due to optically seamless stacking features

PUTTING THEORIES TO THE TEST

The primary aim of the print trials was to test the effect of 395 nm pinning LED on line width for each process color in various speed settings. The ink producer also intended to test reproduction of the text by pinning a number of images and charts.

The trials were carried out on a prototype label press using standard inks with DoD inkjet print heads. OmniCure AC275-395 nm LED pinning heads were installed approximately two inches from the print heads. Web speed was varied between 25, 50, and 75 feet per minute (fpm), with the final curing lamp set at intensity levels of 65%, 75%, and 85%. The intensity levels of the OmniCure AC275-395 nm LED head was controlled to examine the effect on print quality. To limit the number of required experiments, only two substrates were used: Fasson Matte Litho and a #60 Elite semi-gloss pre-coated with an aqueous primer.

To compare behavior between colors, a full set of measurements was taken with only one LED unit used per color. A more limited set of measurements was also obtained at the two extremes of web speeds using multiple LED exposures to simulate real printing conditions. Due to the print head arrangement, this led to multiple LED exposures for certain colors, with each successive dose spaced by approximately six inches and the time between each clearly dependent on web speed.

A QEA portable image analysis system was used to record images and to measure the line widths of single nozzle test patterns. The same system was used to measure the width of the letter "r" in the text part of a test print, as well as the optical density and mottle of the specific sky region of the same full color image. In fact, several images with challenging mixes of tone and block color were used to gauge print quality.

AFTER THE TRIALS: Conclusions and Inferences

At the conclusion of the print trials, Excelitas and the ink producer found that on coated paper and with the appropriate web speed, the OmniCure AC275-395 nm UV LED pinning system effectively lessened ink spread. At the same time, the use of pinning on uncoated paper did not appear to increase line width by minimizing absorption into substrate.

The trials also led to a number of logical conclusions and inferences, including the expectation that the extent of ink spread after pinning would depend on the UV LED dose applied and, as well as whether the lines were exposed once or multiple times. When it came to line widths, however, the trials showed no distinguishable differences in results between single doses and repeated doses. Based on these observations, it is reasonable to infer that the time between print and pin was the single most critical factor that influenced the final print quality.

Beyond quantitative measurements, the marked differences in print quality between pinned and non-pinned images could be observed clearly and definitively. Not surprisingly, the best images were achieved using maximum power pinning on the primed substrate at speeds of about 50 fpm. In this case, 4-point text was clearly readable, lines were cleaner, tone areas were smoother, and area colors were filled 100%.

Figure 3: Illustrates the image without pinning.

Figure 4: Illustrates the image with UV pinning.

The trials also highlighted the most significant benefits of our OmniCure pinning solution:

- The small size of the LED pinning head allows it to be mounted directly next to the inkjet head to give low-levels of UV light right after jetting while not introducing significant weight.
- Variable irradiance levels between 20% and 100% including instant on/off allows pinning effectiveness to be optimized for best results.
- Custom optics for reducing the output angle of light to eliminate reflection onto the print heads
- Variable wavelength options are available, with 395 nm to provide better matching to certain inks and colors.

Creating new opportunities in digital printing with OmniCure AC275 and AC2110

The print trials that were performed demonstrated the advantages of using the OmniCure AC275-395 nm and AC2110-395 nm UV LED systems for pinning to improve image quality. This UV pinning solution supplies outstanding irradiance from an LED system small enough to be included in applications where space constraints restrict access to the substrate and quality cannot be compromised. This small form factor, air-cooled product provides excellent curing uniformity and allows for the adjoining of multiple systems to address any length application or working distance. A customized optic for reducing output angle to help eliminate back reflection makes the AC2 systems ideal for applications such as pinning, edge bonding, cable assembly and other small component assembly.

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