INKJET PRINTING ON PLASTICS

Dr. Kai K. O. Bär examines the effects that adapted drying and pre-post-print processing can have on inkjet printing on plastics for packaging applications.

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In part 1 of this article (see *Specialist Printing Worldwide* issue 2, 2021)[1], classification for potential plastic inkjet printing applications, as well as today's available water-based inkjet inks were outlined and evaluated in accordance with application challenges and current limitations.

In this article, the focus is on how adapted drying and pre-post-print processing can influence or even drive successful inkjet printing on plastics for packaging applications.

PRINTING LIMITATIONS

A 'one size fits all' printing solution does not exist. There are myriad printing requirements resulting from specific applications, e.g.: water-based inks, partially/mostly(?) approved for food and cosmetics; high print quality (>600dpi), large colour gamut (≥4 colours); low temperature polymer substrates (≈80°C or lower), but a wide range of substrate thickness (≥100 microns >50 microns, <<50 microns). Interconnecting influences also come from the selection of inkjet technology and control; ink type and recipe; substrate type and geometry (width, thickness and specific, especially thermo-mechanical properties); substrate handling and pre-post print processing; and the application market. Today, therefore, UV-ink-based inkjet printing solutions have been established for label and industrial or non-direct contact food/cosmetic applications of non-absorbent/plastic substrates.

More than a dozen commercial press designs are limited to <<100m/min speed even at ≤50 m/min with high quality print resolution.

DRYING TECHNOLOGIES

In the table below, principal potential water-based ink drying/post-print processing solutions for the major packaging applications classes (as outlined in detail in my previous article) are listed.

Potential drying technologies for water-based inkjet inks are hot air convection driers (these can also can be combined with hot drum/hot plate conduction systems), infrared (NIR, short, mid-wave) heated drying in combination with hot air moisture removal, and adphos' advanced NIR (aNIR) technology.

aNIR is a proprietary platform technology based on a high energetic photonic energy source (emitting in the near infrared spectrum) with integrated separate adjustable high velocity warm air ventilation. The special working principle of the aNIR results in a different drying mechanism compared to

"adphos' aNIR-based solutions enable fast, almost instantaneous, evaporation of the water molecules"

all other thermal driers, which are based on heating up the substrate and also the wet ink pattern. With traditional heating methods, due to the elevated temperature of the printed substrate, evaporation begins and initiates the drying of the print layer. With sufficient further heating, a dry (solid) ink layer results. Depending on the ink type (A, B1/B2 or C), the print layer might not be durable, and sometimes remains tacky, due to humectants [moisture retainers] present and/or incomplete thermal ink fixation.

Continued over

	Narrow web/label stock			Industrial/high packaging		
	aNIR	Hot drum/ hot air	IR	aNIR	Hot drum/ plate + hot air	IR
Substrates: ≥ 80 °C						
Class A inks:	Yes, end dryer only required	No	No	Yes, end dryer only required	No	No
Class B1/B2 inks:	Yes	Yes, but extreme large	Limited speed/ performance	Yes, end dryer only required	Limited speed/ performance	No
Class C inks:	Yes, end dryer only required	Yes, but extreme large	Limited speed/ performance	Yes, end dryer only required	Limited speed/ performance	Limited speed/ performance
Substrates: ≤ 80 °C, > 50 µm						
Class A inks:	Yes, with interstation	No	No	Yes, with interstation	No	No
Class B1/B2 inks:	Yes, with interstation	Yes, but extreme large	No	Yes, with interstation	Yes, but extreme large and tension sensitive	No
Class C inks:	Yes, end dryer only required	Yes, but extreme large	No	Yes, end dryer only required	Yes, but very large and tension sensitive	No
Substrates:≤ 60 °C, < 50 µm						
Class A inks:	No	No	No	No	No	No
Class B1/B2 inks:	Yes, with interstation	Yes, if low tension	No	Yes, if low tension limited speed	Yes, with low tension, but extreme large	No
Class C inks:	Yes, with interstation	Yes, if low tension	No	Yes, if low tension	Yes, if low tension, but extreme large	No

Potential dryer applications matrix

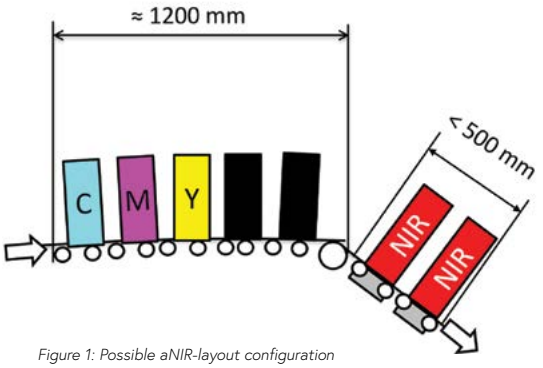


Figure 1: Possible aNIR-layout configuration

ANIR SOLUTION

adphos' aNIR-based solutions enable the drying of the wet printed water-based inks by direct photonic interaction with the polar and absorbent ink components. This results in fast, almost instantaneous, evaporation of the water molecules and the integrated WAVe (Warm Air Ventilation) ensures instant and efficient removal of the generated water cloud. A very fast drying process within a fraction of a second (<<1s) is therefore possible. Accordingly, to plastic substrates' inherent low absorption characteristics in the NIR-emitted wavelength spectrum, a low heat-up of the non-printed plastic substrate can be achieved, within the aNIR-drying process.

As a result of the extreme accelerated water evaporation within an aNIR-drying system, partially high temperature boiling alcohols and the liquid part of inkjet inks are removed due to connected molecule forces in the water vapour.

COLOUR NUANCES

The varying absorption characteristics of different ink colours can affect heat-up by means of IR (electro-magnetic) heating sources. This, and PH arrangement, explains why a fully printed layer containing CMYK + colours can never result in a fully homogenous constant temperature printed layer. The dark or black pattern will be always be the higher temperature area, and therefore dry earlier than light coloured (especially yellow) pattern.

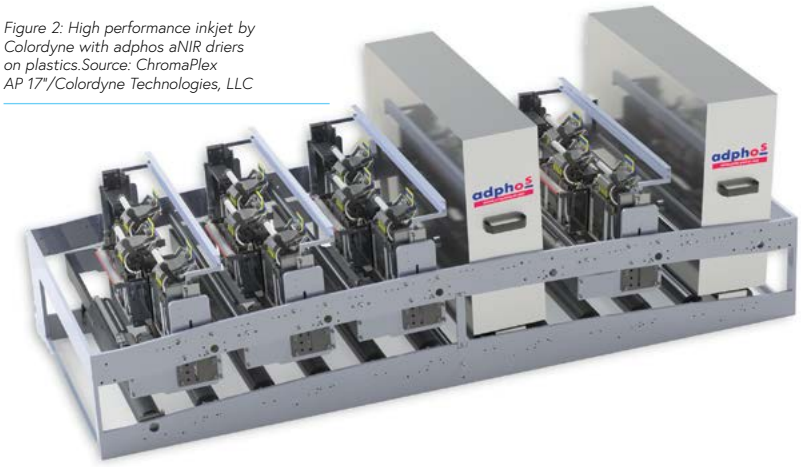
If intercolour drying according to absorption depending order of the colours is applied, the heat intensity for different colours can be controlled, and overheating of a temperature-limited substrate can be avoided. A compact and a non-damaging thermal and airflow dryer design is therefore crucial to enable this drying system solution.

PLASTIC PROPERTIES

The temperature properties of plastics are affected by applied mechanical stress. All plastics show thermal strength behaviour – i.e. at higher tension, a lower temperature can be applied to the specified plastic substrate. And a thin plastic substrate sustains less web force (N/m width) than a thicker substrate, even at same strength behaviour.

By considering all the above influences, it explains the extreme range of print process configurations, such as: substrate material behaviour (plastic type like PA, PET, PVC, PE, PP, BOPP, …; geometry (width, thickness), colour (transparent, coloured, coated, …); temperature-dependant elastic material strength; applied thermal heat and time during drying process; applied web tension (N/m) and air pressure to the web during the drying process; as well as the necessary size of the drying system.

Figure 2: High performance inkjet by Colordyne with adphos aNIR driers on plastics.Source: ChromaPlex AP 17"/Colordyne Technologies, LLC



For high temperature plastic materials (≥80°C) for all ink classes, aNIR-based drying solutions that do not limit print performance capabilities (see **Figure 1**) are commercially available.

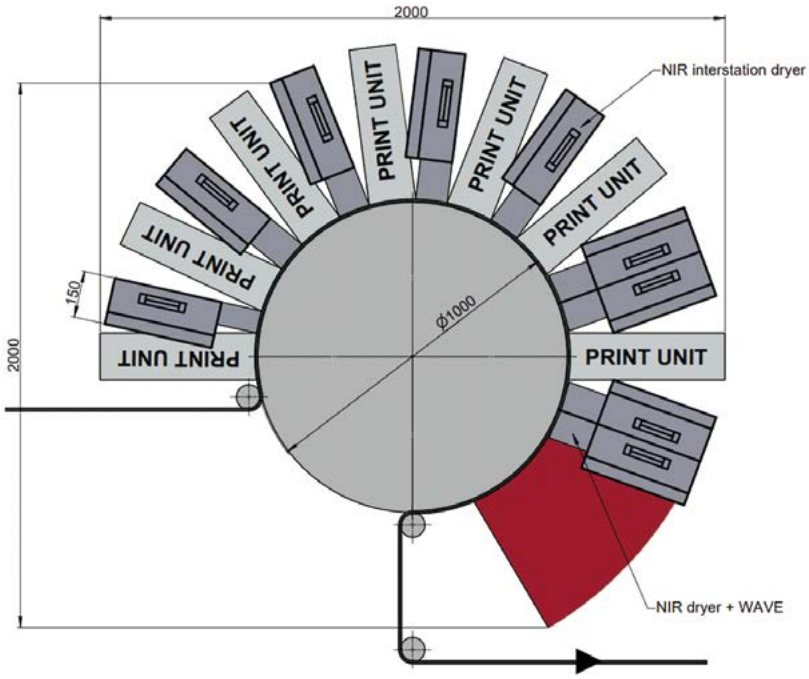


Figure 3: Potential inkjet printing process with aNIR drying for flexible packaging

Figure 4: adphos' patent-pending inkjet print production system for narrow flexible packaging and label applications

FAST-DRYING

Hot drum/hot air based drying solutions offered to the market typically require a drying length of ~10m for print speeds up to 75m/min and require B2 inks (non-tacky after physical completed drying). Due to the high thermal stress intrinsically applied to a printed plastic substrate if using an infrared-dryer, only low speed production (≤50m/min) units is seen.

For limited-temperature plastic material (<80°C) only large size, temperature-limited hot air driers or aNIR-drying solutions are applicable. A typical commercial aNIR-based 4C-print carriage with adapted aNIR-dryer configuration, as offered for label and industrial packaging applications is outlined in **Figure 2.**

Depending on the inkjet technology and applied ink, successful aNIR-dryer-based inkjet print processes have been already established up to 200m/min in the market (three times the speed of existing UV-based printing performance). The high-end flexible

"The high-end flexible packaging market is the holy grail for inkjet printing on plastics"

packaging market is certainly the biggest and most attractive and therefore seen as the holy grail for inkjet printing on plastics.

To enable a successful solution, properly adapted combination of the right inkjet-technology, ink type, plastic materials behaviour, substrate handling, drying and pre-post print processing are imperative. Illustrating this, an inkjet printing process up to 150m/min for relevant flexible packaging plastic substrates is shown in **Figure 3**. A low tension-controlled web supply to the print tower consisting of a specific colour order, PH arrangement and adapted aNIR-interstation driers arranged to a temperature-controlled support (drum) is crucial.

In **Figure 4** a continuous inkjet-based high speed and high-performance print processing demonstrator for label stock and narrow flexible packaging, up to 300m/min, is shown. With this system even substrate materials with just 15-micron thickness (e.g. PP, BOPP…) can be printed with high resolution.

INKJET PRINTING OF WATER-BASED INKS FOR PACKAGING

Packaging applications are attractive, high print volume markets, particularly for furthering the growth of inkjet printing. But for the specific application market, varying substrate/size/speed requirements explain why a one size fits all approach is not feasible. To overcome these current limitations, adphos aNIR-based drying/pre-post print processing combined with the company's experience and knowledge of adapted substrate transport/handling has achieved proven commercial success. Moreover, if the correct combination of inkjet technology, ink, web handling is adapted to aNIR-processing, this technology can be applied to high end flexible packaging. adphos believes that currently no other drying/post-print processing technology can offer similar quality and performance from compact and affordable solutions. ■

aNIR is a registered trademark of adphos Digital Printing GmbH

1 'Pre- and post-processing challenges for water-based inkjet printing on packaging and the limitations currently impeding its process in certain sectors', *Specialist Printing Worldwide* issue 2, 2021, page 14.

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