LIQUID ASSETS

Dr. Kai K. O. Bär assesses pre- and post-processing challenges for water-based inkjet printing on packaging and explores the limitations currently impeding its progress in certain sectors

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Packaging printing is often viewed as the holy grail in our industry. Besides decorative printing, the main focus of most – if not all – inkjet-involved parties is printing applications for packaging, especially on flexible packaging. In this article the main challenges for inkjet printing are outlined.

Packaging and flexible packaging applications are widely spread and require different, partially combined or separated product, process and production conditions, such as:

- High print quality: a minimum of 600 x 600dpi; often >1,200 x 1,200dpi.
- Wide colour spectrum, mostly ≥4 colours, often up to 7/8 colours; even special brand colours.
- Different substrates, mainly polymer-based, often with limited or low thermal resistivity (well below 100°C or even less than 70°C).
- Wide range of substrate weights, from up to ≥500g/m² (corrugated boards and folding cards) down to <50g/m² (even down to 10gsm for flexible packaging goods).
- Broad range of formats from narrow, ≥600 mm, often even up to 1,700 mm; all either continuous or sheet by sheet.
- Special print processing configurations, such as reverse printing (black first), white base or last; pre-print processing (pre-primed) or post-print processing (overprint varnish, lamination).
- Food, health care or cosmetic applications often require FDA [Food and Drug Administration], Swiss ordinance or brand owner-approved certifications.

There are also considerations regarding specifically required or different inkjet technologies, (water-based) inks, substrate types and treatments; process systems (transport, drying, handling, finishing) and application/customer interfaces and boundary conditions. It is clear that a 'one size fits all' approach does not exist for such components or the way that they interact. Similarly, drying and pre and post-inkjet-processes cannot be selected and evaluated without considering all of these interacting influences.

CLASSIFICATION OF WATER-BASED INKJET INKS

Whilst adjustment of specific inkjet ink 'recipes' to an adapted inkjet system is recognised as an essential part of the process, making adjustments to the substrate to be printed on or the application process (e.g. R2R, R2Sheet, sheet to sheet, speed, …) can be neglected, perhaps even ignored – often driven by marketing messages such as 'We can print on all substrates' or 'We can print on all non-absorbent substrates'. However, this is still a requirement, even though different classes of inkjet inks are offered today.

In **table 1** the three major classes of available water-based inkjet inks are listed and their characteristics, which are publicly available, are outlined.

Class A inks contains a high to very high fraction (>50%) of high temperature boiling point alcohols. These are used to address or avoid the risk of nozzle blocking and therefore the ink can only be properly solidified (to produce a dried and durable ink layer) using either the porosity from the bulk substrate or with primer layers allowing the required absorption, at least from the humectants. Additionally, one can avoid lay-off and smear-off of the printed yet undried pattern through the use of an overprint varnish (OPV) or lamination film to seal the non 'dry' printed substrate.

Since Class A inks are for the most part

	Class A	Class B1	Class B2	Class C
Suppliers:	All major ink suppliers	e.g. Fujifilm, Memjet (DuraLink) Screen, Kao, …	e.g. Memjet (DuraFlex)	e.g. Actega, Sensient/Sun Chemical
Major components:	Water: ≳ 40 % Humectants: ≲ 50 % Solids: ≤ 10 %	Water: > 50 % Humectants: < 30 % Binder/solids: > 10 % thermal crosslinking at elevated temperature (≥ 80 °C)		Water: > 50 % Humectants: < 30 % Binder/solids: > 10 % crosslinking after water removal
Substrates:	Uncoated/porous substrates and partial coated	(partial)-coated, non-absorbent substrates		
Drying process (water removal):	Physical drying ≳ 50 – 60 °C	Physical dry at ≳ 50 – 60 °C, but tacky until durable (≥ 80 °C)	Physical dry at ≳ 50 – 60 °C, non-tacky, but durable at ≥ 80 °C	Physical dry **and** durable at 50 – 60 °C
Durability (lay off, smear resistant):	Through humectant penetration in substrate bulk	Must have thermal treatment 80 – 100 °C	Can be transported, but complete durability only by thermal treatment 80 – 100 °C	Given with completed drying process
Enhanced durability:	Additional thermal treatment or extended dwell time			Not necessary
(Enhanced) adhesion:	Eventual through pre-coating/pre-treatment (Corona, Plasma)			

Table 1 – characteristics of three major classes of water-based inkjet inks

	AC1: narrow web/label	AC2 A: industrial packaging	AC2 B: food/cosmetics/ health	AC3 A: High end/flexible packaging	AC3 B: Food/cosmetics
Width:	≤ 600 mm	≥ 600 mm		≥ 600 mm	
Speed:	≤ 30 m/min up to 60 m/min	≥ 60 m/min up to 200 m/min		≥ 60 m/min up to 150 m/min	
Substrates:	≥ 50 µm, up to 150 °C applicable	≤ 50 µm, up to 80 °C		≤ 30 µm, up to 60 °C	
				High print resolution: ≥ 1,200 dpi	
	Process colors + special customized colors	Process colors + special customized colors FDA approved/customer approved inks		Process colors + special customized colors FDA approved/customer approved	
	R2R, S2R	R2R, S2S, R2F		R2R	

Table 2 – classification of packaging applications

not suitable for non-absorbing substrates, Class B and Class C inkjet inks have been developed. In these inks the amount of high boiling point and low physical drying humectants has been reduced to a minimum fraction (≤20 %) in the liquid ink. For Class B inks, instead of humectants, binders are added, which avoid nozzle blocking (as long as they are not thermally heated, producing the molecule cross linking). The inkjet drops keep their original liquid composition until water evaporation and thermal cross linking takes place in the post-print dryer system.

The difference between Class B1 and B2 binder-based inkjet inks is that B1 ink layers stay tacky, even after water removal until the necessary temperature for binder cross linking is reached, typically >80°C – 100°C. B2 inks do not show any durability before the thermal cross linking (also ≥ 80 °C) is reached. B2 inks are not tacky after the physical water evaporation process so a final durable equivalent printed product can be reached by the application of an OPV or lamination, without a cross linking thermal step.

Class C inkjet inks, which have only recently been developed, are also based on low humectants, but these so called 'retarding inks' start cross linking with the applied binders after only (partial) removal of the water in the ink. So with the physical water evaporation, the solidification (due to cross linking) of the printed and dried layer is achieved along with durability without the need for a special thermal treatment for cross linking. And for the water evaporation, depending on the applied drying technology, a special minimum temperature is not required to achieve the final required properties.

"With current limitations a satisfying water-based inkjet solution for high-end/flexible packaging has not yet been developed"

These different ink properties clarify that for an intended substrate (especially for non-absorbent with maximum applicable substrate temperature) not every inkjet ink can be used. In addition, applied dryer technology and foreseen application may also affect the application of an ink type.

APPLICATION OPTIONS

The classification of packaging applications is outlined in **table 2**. Application Class AC1 (narrow web/label) is focused on label stock, lower speed and lesser print quality requirements, but very cost sensitive. The biggest market is probably industrial packaging (AC2), in which sufficient print quality, a large variety of substrates, geometries and high productivity are requested.

High-end packaging and especially flexible packaging (AC3) are the most demanding applications for print processing systems. High productivity and special substrates (low weight, low thermal resistance and environmentally-friendly) are often requested. Advanced and often technologically cutting-edge systems are necessary to establish water-based inkjet for these applications. For food, cosmetics and health applications a high functional performance and adequate compatibility is a must from all process components, even the inks.

Based on the above it is understood that with current limitations, a satisfying water-based inkjet solution for AC3 has not yet been developed and only limited inkjet print processing systems for industrial packaging applications are offered today. However, in the AC3 Application Class there have been successful applications, and several presently under development to be introduced to the market soon.

These successes, their capabilities and how they overcame former limitations will be outlined in the next issue of *Specialist Printing Worldwide*. ■

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