IMAGE-IN: Improved Ink-Jet Printing by Control of Ink-Media Interactions

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Abstract

Digital ink-jet printing has huge potential as an alternative printing technology for many packaging and decorative applications. By its very nature, ink-jet printing provides high added value since it meets the needs for short run production demands of today's industrial and commercial markets. These are summed up by the phrase 'mass customisation'. In order to capture and exploit this huge potential capability, short comings of the industrial ink-jet printing process must be overcome. Perhaps the most demanding of these factors is associated with adaptation and tuning related to the key physical inputs: ink, media and media treatment. The introduction of new media or ink requires reformulation of the industrial printing parameters, which is both time consuming and wastes material and chemicals in setting up. Waste chemicals alone amount to approximately 29M€ annually.

By studying the whole digital ink-jet printing process the IMAGE-IN project[1] is using a synergistic approach to develop both a complete understanding of the generic science that underpins the printing processes, together with extending the capability to satisfy the commercial, economic and environmental requirements of industrial ink-jet printing. To achieve these objectives the IMAGE-IN consortium consists of 7 partners (5 industrial companies and 2 universities) who collectively posses core expertise in all the key components of the printing process (inks, materials, benchmarking and characterization, modelling). The project is funded through the Framework 5 'Promoting Competitive and Sustainable Growth' program.

Introduction

Use of UV cured inks is a rapidly developing technology in ink jet printing processes, and is making significant progress into areas until recently dominated by aqueous based ink formulations. However, despite this rapid adoption of UV cure inks in industrial processes, there is a lack of fundamental understanding in their behaviour at the media interface. Because of their historic and widespread adoption, aqueous based inks are much better understood in terms of process parameters. However, there is still significant scope for research to produce insights into the ink-media interaction behaviour that can lead to improvements in aspects of ink and media coatings.

The IMAGE-IN research program is therefore addressing this whole issue with the ultimate objective of producing a fundamental understanding of ink-media interactions. This will enable generic ink and media treatments to be quantified and parameter sets to be derived. For selected print media substrates trial industrial print tests will be conducted.

The IMAGE-IN Consortium

The consortium is a well-balanced pan-European partnership covering the entire technological and scientific chain in 4 countries. The consortium consists of:

- *SunJet* – ink manufacturer and developer
- *AGFA-Gevaert N.V.* - media manufacturer and developer
- *Dotrix N.V.* - manufacture and development of printing technology
- *Ardeje SARL* - SME specialising in high-speed visualisation technology,
- *Teich AG* - industrial printer,
- *Department of Rheology, Universite Joseph Fourier*,
- *Departments of Materials and Physics, University of Oxford.*

The overall aim of this project is to add intelligence into the ink jet printing process. To achieve this, two totally synergistic objectives are being pursued by the consortium:

- Development of ink jet printing processes capable of satisfying the commercial, economic and environmental requirements described above.
- A complete understanding of the generic science that underpins the key aspects of the ink jet process.

Results and Discussion

Some of the key industrial substrates we are initially targeting are polyesters, polyolefins, and metals. The general approach to improving both print quality and adhesion of the ink to the media is to modify the surface chemistry either with a suitable surface layer coating, i.e. lacquering, or by pre-treatment, i.e. plasma, corona, flame treatment. Surface coatings can be either absorbing or non-absorbing and a great variety of formulations have been tried in the industrial context. Although surface property modification by either coating or pre-treatment techniques has been widely employed, the

exact nature of the ink-media interaction is not fully understood. To be able to exploit the technological and economic advantages of ink-jet printing we are developing a generic understanding of the ink-media interaction. This requires a careful and detailed systematic investigation of well defined systems, where key parameters can be tested independently.

High quality commercial ink jet printing presents unique technical challenges to jet ink formulation. Commercial applications require high fastness properties and therefore we are developing pigmented systems based on high solids ink chemistry. These systems have to be stabilised at very low viscosities over long periods, which can adversely affect penetration and spreading on substrate surfaces, as well as its curing behaviour. These problems can be understood and eliminated by studying and modifying the physico-chemical properties of the inks and how these are affected by surface modification or treatment of the media.

Several UV jet-ink formulations have been developed for application to a variety of substrates. These inks have been focused toward piezo drop on demand print-heads with both wetting and de-wetting face plate surfaces. Key industrially important substrates have consisted of aluminium foils with various lacquers developed by Teich and polyester substrates with different surface treatments such as corona and plasma pre-treatments as well as a number of coatings technologies.

When pre-treated the surface energy of the film plays an important role on how dot size and therefore print quality varies. Surprisingly, high surface energy substrates such as silica and fluoro-treated PET give much smaller printed dot size than lower surface energy equivalents, thereby suggesting chemical interactions are predominant over dynamic wetting characteristics. Figure 1 shows an example of how a printed dot size varies with substrate surface energy for a surfactant containing 100% UV ink formulation (UGE5529) and a model fluoro-surfactant free formulation (U3285). In the absence of surfactant, static surface tension of the ink increases from 28.0 dyn/cm to 35dyn/cm and when printed onto the above substrates, gives comparatively large droplet spread, even on fluoro-treated PET. Similar analysis of droplet behaviour on other modified substrates shows that control over dot size is possible by a combination of ink chemistry and media surface modifications. The exact relationship between the parameters that dictate the ink and media behaviour in these industrial formulations is being investigated by looking at the fundamental aspects of the ink-media interaction. These studies are using a combination of experimental methods on model systems and computational modeling by the Universities of Joseph Fourier and Oxford.

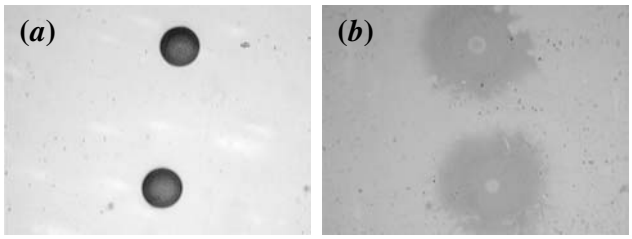

Figure 1. Optical micrographs (x100) of ink-jetted droplets on fluoro treated PET (Agfa). (a) surfactant containing jet ink (UGE 5529) with average drop diameter of 161 μm, (b) model jet ink (U3285) without surfactant with average drop diameter of 424 μm.

Conclusion

Through a strong collaborative program funded by the EU under the Framework 5 Growth Programme (G1RD-CT-2002-00663) the IMAGE-IN consortium are pursuing a fundamental understanding of the ink-media interactions to provide a full parametric basis for improving inkjet printing.

References

1. see www.imagein.org for further details.

Biography

David Bucknall gained his PhD in polymer physics in 1991. Since this time he has specialised in studies of surfaces and interfaces, in both government research and academic institutes. He is currently a lecturer at Oxford University studying aspects of polymers and biomaterials. He is also co-ordinator of the multinational European funded IMAGE-IN research project to study and develop a better understanding of ink-media interactions for improved industrial ink-jet printing.