

# Hybrid printing: paper media for combined flexographic and inkjet printing

Petru Niga, Jonas Örtengren, Viviane Alecrim, Marianne Klamann, Erik Blohm, Jon Lofthus

**KEYWORDS:** Inkjet, flexography, print quality, line width, print density, aqueous inkjet ink.

**SUMMARY:** Hybrid printing combining inkjet technology with flexography can be used to add customer specific information into the production of packaging and print. However, in order to improve print quality, a comprehensive understanding of the mechanisms governing print quality is required. In this work, inkjet printing using three aqueous inkjet inks was performed on top of flexographic printouts on four paper substrates. For comparative reasons, inkjet printouts were made on the four papers as well. The flexographic film contained tone values ranging from 0 to 100% ink coverage. Line width and print density of the inkjet printouts were evaluated. It was found that paper characteristics such as surface energy, porosity, absorption coefficient and surface roughness play an important role in defining the final print quality. These findings are further supported by micrograph images.

## ADDRESSES OF THE AUTHORS:

**Petru Niga** (petru.niga@miun.se),

**Jonas Örtengren** (jonas.ortengren@miun.se),

**Viviane Alecrim** (viviane.alecrim@miun.se): Digital Printing Center, Mid-Sweden University, SE-891 18 Örnsköldsvik, Sweden,

**Marianne Klamann** (marianne.klamann@innventia.com),

**Erik Blohm** (erik.blohm@innventia.com),

**Jon Lofthus** (jon.lofthus@innventia.com): Innventia AB, Box 5604, SE-114 86 Stockholm, Sweden.

**Corresponding author: Jonas Örtengren**

## Introduction

The rapid development in the field of inkjet technology in recent years manifests itself as an increase in inkjet printing speed and a narrowing of the gap to the traditional printing technologies in terms of print production speed (Kettle et al, 2010, Rehberger et al, 2009). This opens up new market segments as producers of print products find novel users of customized information. Inkjet printing is a flexible, digital, non-impact printing method which can be integrated directly in the production line or utilized in a subsequent print production step (Viström 2008). Over the years, paper media for high volume print production has been developed and continuously improved to suit traditional printing technologies such as offset and flexography. Inkjet, with its inherent prerequisites on the ink concerning low viscosity and a suitable surface tension interval in order to avoid clogging of the ink at the nozzles of the print head and to certify stable jetting and drop formation over time, concerns printing of ink with a relatively large amount of carrier liquid and a small amount of colorants as compared to the traditional

printing technologies. This puts severe and contradictory constraints on the media and the ink in the inkjet printing process; the carrier liquid should rapidly vanish from the surface to avoid color-to-color bleeding, wicking, and coalescence of droplets. The colorant, on the other hand, should stay close to the surface in order to reproduce a large color gamut volume, but at the same time exhibit good durability towards mechanical wear, moisture and light. Optimization of the paper surface properties for more than one print technology is not straightforward.

Here, the inkjet print quality on paper and on flexography preprinted paper was evaluated. Flexographic printing in conjunction with inkjet printing gives the possibility to individualize packaging print or to customize the print to the target group. The work aims at improved understanding of the mechanisms governing print quality when combining flexographic printing and inkjet printing.

## Materials and methods

### Paper media

Four paper webs were selected for print trials. Papers 1-3 were uncoated graphic papers with paper weights of 80 gsm (paper 1) and 100 gsm (papers 2 and 3). Paper 4 was an uncoated kraft liner with a paper weight of 125 gsm.

### Paper analysis

The porosity and the surface roughness of the papers were determined by the Bendtsen method. The surface energy of the papers and the printed areas was determined by static contact angle measurements in a Fibro DAT1100, using water and diiodomethane, and analyzed according to TAPPI T 558 om-97. Liquid absorption capacity of the papers was measured with a Bristow absorption tester.

### Flexographic Printing

The test form for the flexographic printing trials is shown in Figure 1. The test form contains tone values corresponding to 0 and 100% of ink coverage in steps of 10%, as well as lines and text for assessment of line quality and visual impression. The paper samples were printed with aqueous yellow ink (Sun Scanverse FJ14, Sun Chemical) in a Fischer & Krecke flexographic press using an anilox roller (Secher) with a resolution of 280 lines cm<sup>-1</sup> and a printing plate with a resolution of 42 lines cm<sup>-1</sup> and a screen angle of 37°.

### Inkjet Printing

**Inkjet printing:** Inkjet printing was performed on the flexography preprinted samples in two experimental set-ups. The first set-up consists of a belt rig with appended inkjet print heads and control systems (Gepp et al 2009). The paper to be studied is cut accordingly and rolled around the two cylinders of the belt rig. The rotational

speed of the cylinders is controlled by an engine. The paper runs over a plate of stainless steel to which one or several print heads are attached. Print heads from Konica Minolta (KM 512 MAY) with a printing resolution of 360 dpi, and commercial aqueous pigmented inks from two different suppliers were used for the inkjet print trials on the preprinted paper samples. The test form used contained features for evaluation of line quality, dot quality, mottling and optical density. In the second set-up, the reel-to-reel Linda machine at Innventia, with an integrated inkjet printing module, was used. The set-up is described elsewhere (Klaman et al, 2011).

## Print Analysis

The inkjet printouts were analyzed in terms of line quality and dot quality by scanning of the print samples using an Epson expression 10000XL flatbed scanner and own written software for evaluation of the line width. Print density measurements on Inks A and B was performed using an X-rite spectroscan and the magenta channel, ISO-E settings, without polarizer.

## Results and Discussion

The surface properties of the papers, with and without flexographic preprint, were determined in order to find explanations to variations in inkjet print quality parameters. Measurements are ongoing, although some statements can be done already at this early stage.

Interestingly, preliminary measurements show that the total surface energies for the flexography print samples (PIY-P4Y) all lie within a small surface energy range, implying that the flexographic film is determinant in regulating the surface energy.

Bendtsen porosity data shows that flexographic printing corresponding to 100% of ink coverage results in only a minor decrease in the porosity (samples PIY-P4Y). Neither was the surface roughness strongly influenced by flexographic printing, as determined by the Bendtsen surface roughness method. With exception for paper 1, the change in Bendtsen surface roughness before and after printing was within experimental accuracy.

The absorption coefficient of both P1 and P1Y is remarkably higher than for the other samples as determined by the Bristow Absorption Test (B.A.T). Data from Cobb60 measurements confirms the high water absorption capacity of sample P1. The absorption coefficient is lower on the flexographic printed areas for papers 1,2 and 3. On the contrary, for paper 4 the absorption coefficient is higher on the printed area.

Line width data (not shown) reveals that the line width slightly increases when inkjet printing on a flexography preprinted sample, as compared to an unprinted sample. Figure 1 shows micrographs of inkjet printed lines using ink A on unprinted and flexographic preprinted papers. Visual inspection of inkjet printed lines printed with magenta inks A and B, and black ink C, are consistent with the line width data, in that the differences in line width are small but detectable, when comparing a large number of samples. It may be possible that the influence on the porosity by the flexography preprinted film has an effect on droplet spreading.



Fig 1. Micrographs of inkjet printed lines using Ink A, on unprinted samples (left) and flexography printed samples (right) of, from top to bottom, papers 1, 2, 3, and 4.

The inkjet print density showed a tendency to decrease slightly with increasing flexography print coverage, as depicted in Figure 2 for Inks A and B. The difference is however relatively small in most cases. Furthermore, when studying the samples in an optical microscope, it is clear that the inkjet printed area is not entirely covering the flexography preprinted surface and that the underlying yellow flexographic print is observed between the inkjet dots.

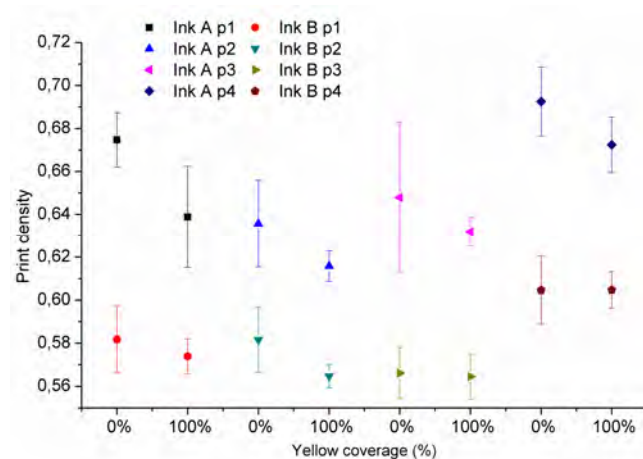


Fig 2. Print density of inkjet printed magenta ink A and B on papers 1, 2, 3 and 4. The paper substrates were covered with 0% (unprinted) and 100 % of yellow flexographic print.

The first results are encouraging in the sense that the reported inkjet print quality parameters only are affected to a minor extent by the flexographic ink film. This opens up for combined flexographic and inkjet printing.

## Conclusions

Inkjet printing with aqueous inks was performed in two different setups on four papers, preprinted in a flexographic press, as well as unprinted. From print quality measurements of inkjet ink printed on the unprinted papers and the preprinted papers, it is concluded that the line width of the inkjet printed lines increased with increasing flexographic ink coverage, whereas the inkjet print density decreased with increasing flexographic ink coverage.

---

## Acknowledgements

The authors gratefully acknowledge financial support from VINNOVA (project number 2007-02402), the Kempe Foundations, Swedish agency for economic and regional growth (project number 140591), and from Länsstyrelsen, Västernorrland.

---

## Literature

**Gepp, S., Örtengren, J., Hägglund, J.-E., Alfthan, E., (2009)** Measuring cockling on-line in high speed inkjet printing, Proc. of

NIP 25: 25<sup>th</sup> international conference on digital printing technologies, 521-524

**Kettle, J., Lamminmaki, T., Gane, P.:** (2010): A review of modified surfaces for high speed inkjet coating, Surface & coatings technology,, 204 (12-13), 2103-2109.

**Klaman, M. , Blohm, E., Johansson, P.-Å., Lofthus, J., Alecrim, V., Örtengren, J.,** (2011), Hybrid printing - print quality mechanisms when offset and inkjet are combined, Advances in printing science and technology, **38**, xxx,.

**Rehberger, M., Glasenapp, A., Örtengren, J.** (2010): VDP on packaging - elementary velocity study on inkjet-printed papers for corrugated board production, Proc. of TAGA (Technical Association of the Graphic Arts) the 62<sup>nd</sup> Annual Technical Conference, San Diego, USA, 188-212.

**Viström, M.,** (2008), Aspects of the Impact of Technology Integration on Agility and Supply Chain Management - the Potential of Digital Packaging Printing, PhD Thesis, Lund University, Lund, Sweden.