Experiences with Paper and Board Substrates for Digital Printing

Petri Sirviö
Stora Enso Oyj Research Centre
Imatra, Finland

Abstract

A testing environment has been built to gain first hand experiences on digital printing on board substrates. The testing environment includes an electrophotography based web fed digital printing machine, equipped with an unwinder that can handle up to 132 cm diameter reels. Because of the possibility of being able to adjust the printing process parameters from the user interface, different parameter combinations can be easily created for research purposes. The aim of the testing environment is to learn about the requirements that dry toner electrophotographic processes place on board grades, and to develop grades that enable the optimal print result.

Case studies have been done where actual packaging designs have been printed and post processed, to learn in practice about the requirements that the substrates and the technology must meet to enable a properly functioning production chain. The print quality meets the requirements of many packaging applications in these case studies, when the substrate used is suitable for the process, enabling good print quality. Based on the feedback, there is a great interest on the possibilities that small and personalized production series can give to the packaging industry.

Introduction

A testing environment had been built to study the requirements that the electrophotographic printing process places on packaging materials. Earlier, another Xeikon based machine, Agfa Chromapress 32i, had been installed in this environment, and used for studying paper properties in electrophotography. To investigate what is required from packaging materials in this type of web fed electrophotography, a digital production printing press, Xeikon DCP/50-SP, was installed in the controlled laboratory environment.

This electrophotographic printing press prints four colors on one side of a 50 cm wide web with 7,35 m/min speed. It can pull through thicker and stiffer packaging substrates than the earlier installed Chromapress 32i, due to the machine being designed for packaging applications.

The installation includes also an unwinder, which can run up to 132 cm diameter reels, needed for thick board substrates in production printing. Later also a rewinder will be installed, which makes it possible to print from reel to reel, giving possibilities for many applications in the post processing area.

The operator of the machine is able to optimize the print quality for different substrate types mainly by adjusting the moisture level of the web, transfer currents and the fuser roll temperatures from the user interface. This gives also possibilities to make controlled studies of the effects of the board properties on print quality and on printing process parameter levels required.

An illustration of the trial printing machinery is shown in figure 1.

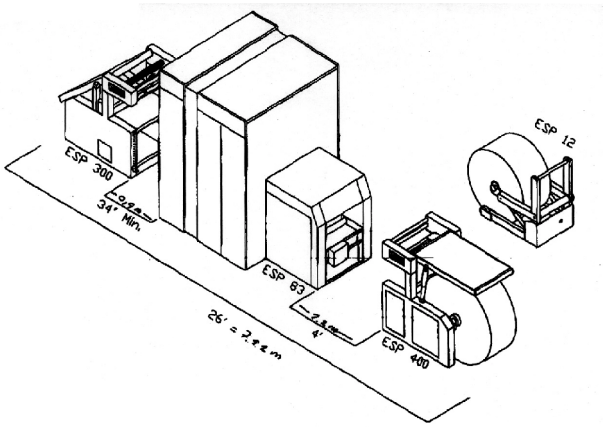

Figure 1. The trial printing machinery

Case Studies

A set of packaging materials was produced to investigate the applicability of the dry toner electrophotographic printing systems in making real packages in packaging processes. The packages produced were a candy box, liquid packaging disposable cup, lid for that liquid packaging cup, and a pasta package cover. In all these designs variable data was used, to test the production in such a way that the benefits of the digital printing production could be demonstrated in full extent. The production chain was tested from the creation of the master page (constant background data) and variable data elements in the advertisement agency, to the final finished packaging. The different production phases of making digitally printed packages can be seen to create their own expertise areas, which need to be linked to have a successful end result:

- File preparation, especially the use of variable data elements
- Printing press operations and the suitability of the board substrates for the printing process, both print quality and process stability aspects
- Post processing operations and the behavior and endurance of the printed material in the post processing

The Designs and the File Preparation

This case project included an advertisement agency that made the art design of the master pages, and the design of the variable data elements. The actual print ready file, in which these elements were combined, was prepared in the SE Digital Printing Laboratory. The designs contained one or several variable data areas.

The candy box was made so that the only variable data area was the name of the person receiving it as a gift. The sequence we printed contained a group of 200 names. The design is illustrated in figure 2.

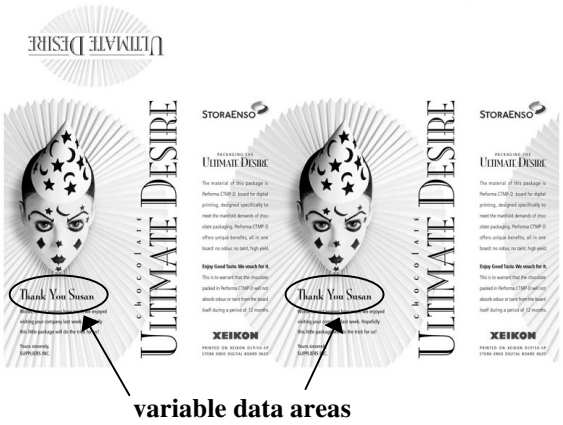

Figure 2. The candy box design

The liquid packaging cup design is shown in figure 3. The material used was one side PE coated, having suitable functional properties for this type of a product.

Lids were printed on suitable moisture barrier material, to be able to make also closed cups. Lid production added one variable field to the cups closed with these lids, as a number code was printed on the lids using variable information (figure 4).

The pasta cover was printed on one side plastic coated material suitable for this type of applications. This design contained several variable information areas. The design is illustrated in figure 5.

When designing and utilizing in practice the variable data designs in these packaging printing cases, the experience was that efficient building of the final data files that combine the static and variable information requires good file preparation and data management capabilities. This applies to both the advertisement agency making the components, and to the personnel making the final print ready file.

Figure 3. The cup design

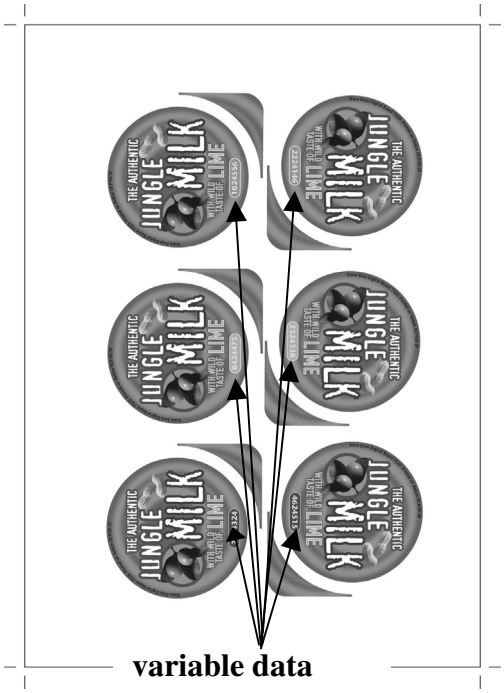

Figure 4. The lid design

Figure 5. The pasta cover design

Printing and Substrate Requirements

The print quality optimization process followed the procedure that was developed based on the earlier experiences with the laboratory's Xeikon DCP/32D_SEC type of Agfa Chromapress 32i printing machine[2]. The print quality optimization procedure naturally differs with the simplex machine to some extent from that of the duplex machine (table 1).

Table 1. The optional process parameter adjustments to optimize the print quality, duplex machines[1,2]

	U2 voltage	Transfer currents	Duplex currents
HFC	⇑	⇓	⇑
LFC	⇓	⇑	⇓
Duplex lines	⇑	⇓	⇑
Banding	⇓	⇑	⇓
⇑ = increase needed, ⇓ = decrease needed			

The most common defect types related to unsuitable process settings or unsuitable substrate type are named here as high frequency cloudiness (HFC) and low frequency cloudiness (LFC).[1,2] HFC is normally graininess in size area of ~3…5 mm, and LFC defects are normally low density areas of 5…10 mm size area. High frequency cloudiness can be noticed more often with standard board substrates, which are of higher moisture level compared to the substrates normally used in electrophotographic printing. This is normal as this defect type occurs when the moisture level or conductivity of the web is too high, or when the transfer currents are set too high. Low frequency cloudiness appears when the substrate is too dry or resistive, or when the transfer currents are set too low. The adjustments of duplex currents were in many cases unnecessary due to their limited effect in the simplex machine, the most important parameters used in optimizing the toner transfer being then the transfer currents and web moisture control. The web should not be dried more than what is required with the optimized transfer currents, in order not to make the board unnecessarily dry. In case board is very dry, post processing problems like cracking will occur in some post processing applications.

The candy box design was printed on 260 gsm folding box board, material type normally used for this type of packaging. The liquid packaging material that was used to produce the cups, was one side PE coated cupstock, the grammage being 225 gsm, and the lids were printed on high barrier multilayer laminated 90 gsm material. The pasta cover was printed on one side PET coated 270 gsm material.

The actual substrates were selected from the possible materials available by evaluating their physical properties that have significance on print quality and runnability in electrophotographic processes. Based on the earlier investigations using the Agfa Chromapress 32i with paper substrates it was known that the electrical properties of the substrate should be on a suitable level, and that the surface properties contribute to both succesfull toner transfer and good fusing result.

The print quality optimization of those grades that are not plastic coated, is more or less analogous to the normal print quality optimization that is done for substrates being qualified for the web fed dry toner electrophotographic duplex presses. The contact fuser temperatures need to be adjusted to a level where the toner fixation is optimal without any hot or cold offset. But when the substrate has a plastic coating on it, for example PE, that can endure only mild temperatures, problems can occur in any hot roll contact fusing process. Also the toner transfer process adjustment may require more experience when using that type of substrates, as the electrical properties of plastic coated materials differ greatly from those of the non-plastic coated substrates.

Using the guidelines described, the print quality of all the substrates used could be optimized to a good or to an exellent level.

Post Processing Operations

The post processing operations require in many cases robustness from the printed surface due to the friction and possible heat impact applied on the material.

The production of the cups requires relatively high temperatures, when the cup is formed using heat sealing. This may create concerns of smearing of the printed surface. In this case study we were able to adjust the cup machine so that these problems were eliminated. We have investigated different varnishing types that can be applied on the printed cupstock material before post processing, to eliminate this type of potential problems.

The lids were heat sealed on the cups to form closed packages. One point that was taken into consideration in the graphical design of the lids was that the area that is exposed to the heat sealing process was left unprinted (figure4).

The pasta package covers were heat sealed onto the filled trays. The packaging operations in this case were done manually. A deepfreezing test and tests of heating in a microwave oven were performed.

The candy box forms were cut, creased and glued using normal industrial machinery. The amount of candy boxes printed and post processed was approximately 20000 pieces, as this design was used to test a relatively large production lot with a digital printing process. The filling of some sample boxes was done manually. No special critical post processing issues could be noticed in this product case. This was influenced also by the possibility to use only moderate drying of the web during the printing process with the board type used.

Discussion

The case studies that were performed when producing four different packaging items could be successfully carried out. The final print and package quality made it possible to use the produced packages in substantiating the possibilities of digital printing to the partners that have had a great interest in the possibilities of the digital printing in general.

However, there are issues that need to be taken into consideration when making digitally printed materials. One area requiring new skills is naturally the use of variable images and texts beyond bar codes and address data, and the construction of the required databases. When making small series, and especially when making personalized printing where every piece is unique, the material used in printing and the process have to perform reliably. It is impossible to use a substantial share of the machine time and materials in small batch production trying to enhance bad print quality related to unsuitable material. Also the possible restrictions that the present post processing machinery may cause on some digitally printed materials need to be considered. Some of the problem areas can be avoided for example by using varnishing when the added value of the product justifies this.

Digital printing makes it possible to save costs on obsolete packages and also on logistics and inventory costs. There are also great possibilities for example in small batch test marketing and in personalized packaging. Therefore we have proceeded further on the area of developing substrates for different digital printing processes, and are at the moment involved in several pilot projects that will utilize digital packaging printing in practice.

References

1. F. Goris, Unpublished instruction, Agfa Gevaert N.V., 1997
2. P. Sirviö, The Effects of the Process Parameter Adjustments on Print Quality in a Web Fed Electrophotographic Color Printing Process, Proc. IS&T NIP16, pg. 293-296. (2000).

Biography

Petri Sirviö received his M.Sc. degree in Graphic Arts Technology from the Helsinki University of Technology, Finland, in 1996 and joined Stora Enso Oyj. His work as a research scientist of digital printing in Stora Enso Research involves research, testing and method development activities in the Digital Printing Laboratory, established in 1996. The aim of this laboratory is to collect and generate knowledge for developing paper and board grades for the digital printing processes.