Versatile Ink-Jet Printer

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Abstract

We have designed and built a printer on the basis of a commercially available drop on demand (DOD) print-head. In this presentation we will focus on the primary objectives (versatility, cost) and how these have been met. We will detail some of the technical solutions which go from a perfectly controlled pressurized ink tank to specific algorithms for representing special characters. Finally we will emphasize the industrial applications and insist more particularly on the applications in the tags and labels and packaging area.

Introduction

With increasing demands of industrial printing the ink-jet printing market is growing rapidly. The key technologies in this field are continuous ink-jet and drop on demand. The advantages associated to the latter technology are, at least on the paper, better resolution and lower cost. However the components have to be put together to constitute a versatile and reliable printing system. This is the main objective of this work and we will show how this has been fulfilled for a printing system which is essentially directed towards the tags and labels and packaging area.

The paper is organized as follows. The second section discusses the printing system. The following section gives sample results with different inks and makes some comparison with continuous ink-jet printing. The final section concludes the paper and introduces some of the future work.

Printing System

The printing system can be split into two parts: the printing module and the electronic printing controller. The latter is integrated in a rack as shown in figure 1 and the global architecture of the system can be found on figure 2. The system is able to print all types of files (image, text, barcode) with a width of 16 mm at a maximum velocity of 1m/s on various substrates. The resolution is 200 dpi and can reach 360 dpi with a slanted or tilted head.[1]

The rack includes the following components:

- A Compact PCI which is a communication bus including various circuit boards (GIOB, DPB).
- An interface circuit board called IEB.
- A main ink reservoir with a capacity of 2 liters.

This part is of course coupled to the external sensors (web velocity, ink level, presence of sample, etc…), the printing module and finally to the supervisor through an Ethernet link.

Electronic Circuit Boards

The GIOB (General I/O Board) is in charge of collecting the different signals coming from the ink level sensor, the one providing information on the velocity (Tachy) as well as the signal indicating the beginning of printing (Btop). The GIOB then feeds the Tachy and Btop signals to the DPB board.

The DPB (Data Path Board) is the supervisor unit of the printing module. It stores the data to be printed and manages both the ink circuit and the printing module through the IEB circuit board. The signals fed by the DPB to the interface circuit board are in RS 422 in order to be as much immune as possible to electromagnetic noise which may be either internal or external.

The IEB (Interface Embedded Board) links the DPB and the printing module. It’s essential function is to transmit data from the DPB to the module. It also includes the power supply for the module and other various components.

Printing Module

The printing module which is shown in figure 3 comprises the following components:

- An electronic circuit which supervises the print-head.
- An auxiliary ink circuit equipped with an ink level indicator.
- The print-head which is the heart of the system.

A specific mechanical support has been designed for the printing module so that the full assembly is well protected and can be positioned quickly for printing as it can been seen on figure 1. Note in figure 3 that at the bottom of the assembly is the XAAR 128 nozzle print-head. Next to the print head is a thermal sink which is appropriate for evacuating the heat generated during printing. It is well known that different printing schemes are available so that the temperature distribution in the print-head is made independent of the image to be printed.[2] Above the thermal sink are the auxiliary ink reservoir and the specific electronic board which is the supervisor for the print-head.

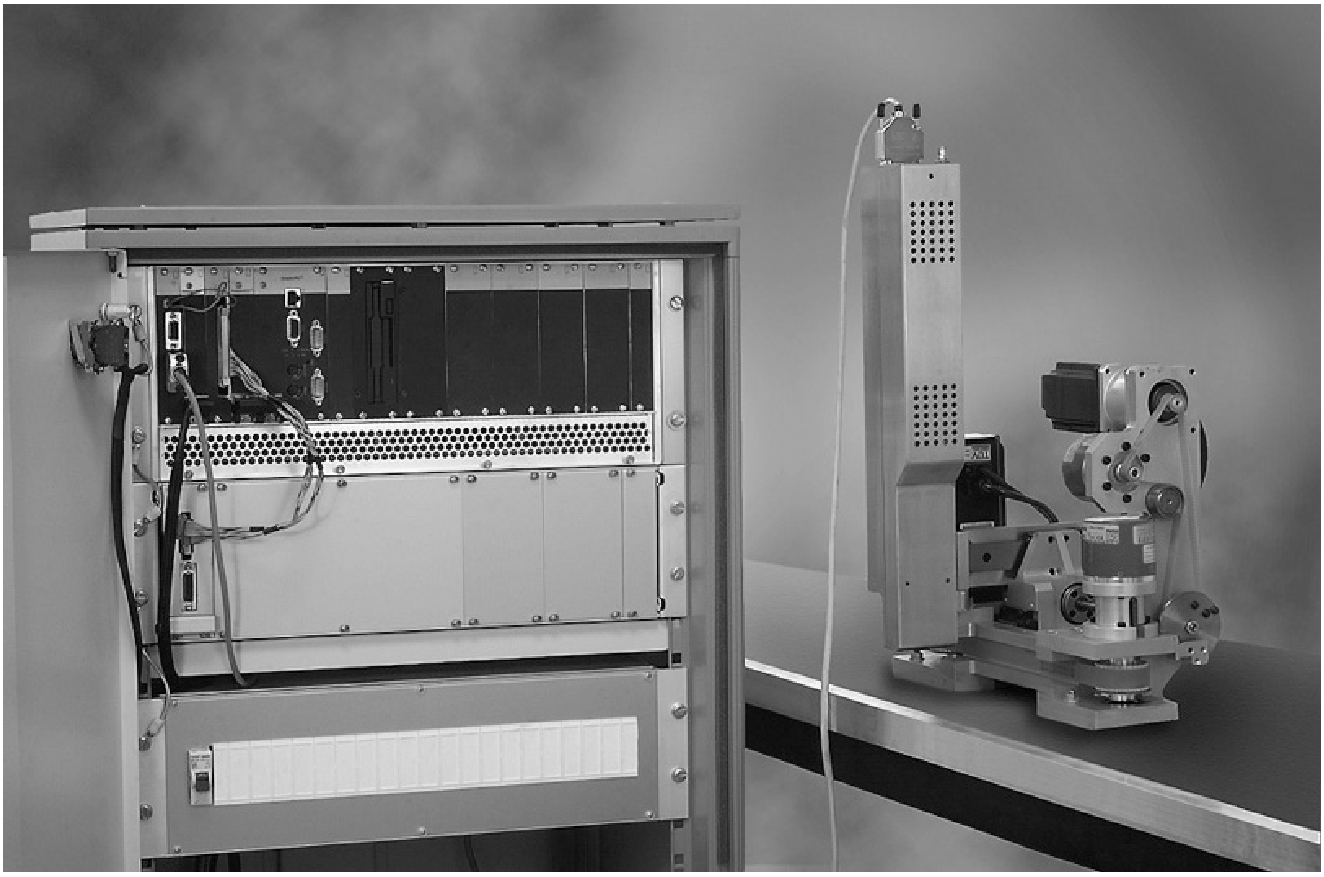

Figure 1.Global view of the printing system

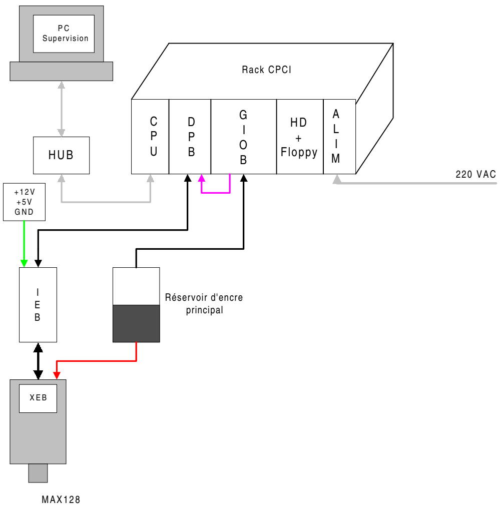

Figure 2. Architecture of the printer

Ink-Circuit

The ink-circuit is a smart mixture of pneumatic and hydraulic control. It allows to have the pressure necessary for performing purge operations on the print-head as well as to maintain a negative head during printing.

The purge operations are deemed necessary before starting to print or in the case of change of colors. The negative pressure can be maintained well within +/-10^3 Pa whatsoever the change in the atmospheric pressure during the printing process. This is especially helpful when several modules are put side by side for large width printing and constitutes one of the main features of the printing system.

Figure 3. Overview of the printing module

Software

A specific software is available to convert images from .tiff format into files which are ready to be printed i.e. in form of binary bitmaps. During the conversion process it is also possible to modify the file so as to have an enhanced resolution with the slanted position of the print-head.

At this time, the size of the message cannot exceed 1024 pixels long by 128 pixels wide but of course this can be changed quite easily. The mode of printing is CMYK color so there is a ripping which is performed in order to have the original image converted into each of the process colors. The conversion of the files is rapid enough to allow the printing of a different file for each sample if the velocity of the conveyor belt is lower or equal to 1 m/s.

Sample Printing

In this section we will show some selected examples of printing which have been performed on an impervious substrate using the printing system. The examples which are discussed in this section are essentially focused on the following two points:

- Resolution differences between the actual printing system and a continuous ink-jet printer.
- Wetting differences between a thermoplastic and a UV ink on the same impervious substrate.

Resolution

In figure 4, we show chinese characters printed with the actual system. One can note that the characters are quite well rendered.

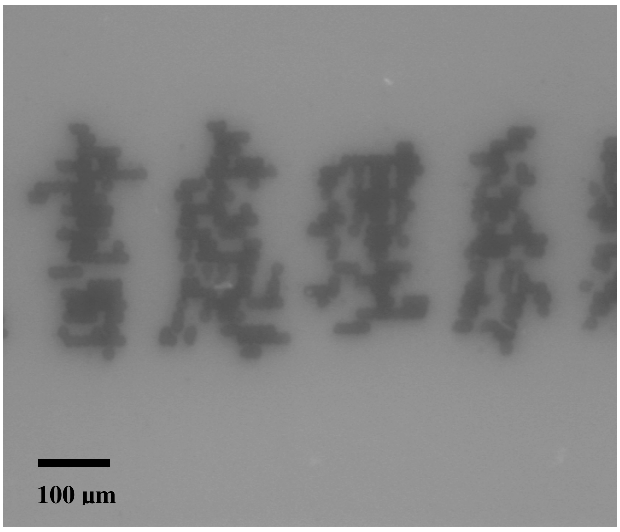

Figure 4. Chinese characters printed with actual printing system

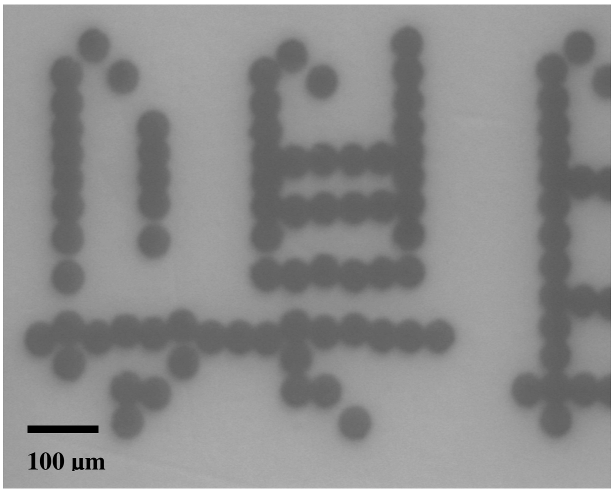

Figure 5. Chinese characters printed by Continuous Ink Jet.

We give in figure 5, the same characters printed using a continuous ink-jet (CIJ) printer. First of all, the dots are quite large because of the limited resolution of the printer but most importantly the rendering is far from being satisfactory. This is due to the fact that in the CIJ printer the rasters which are especially studied for each given character are not accurate enough compared to the technique used in the actual system where the characters are processed like an image. It is important to note here that the velocity of the conveyor was the same for both samples.

Wetting

In figures 6 and 7, we present printed samples on the same substrate but using two different inks. The first figure considers printing done with a thermoplastic ink. The printed pattern does not present any topographical fluctuations since all the ink seems to have penetrated the substrate. Due to the coalescence of the drops, the rendering of the pattern on this substrate is matte.

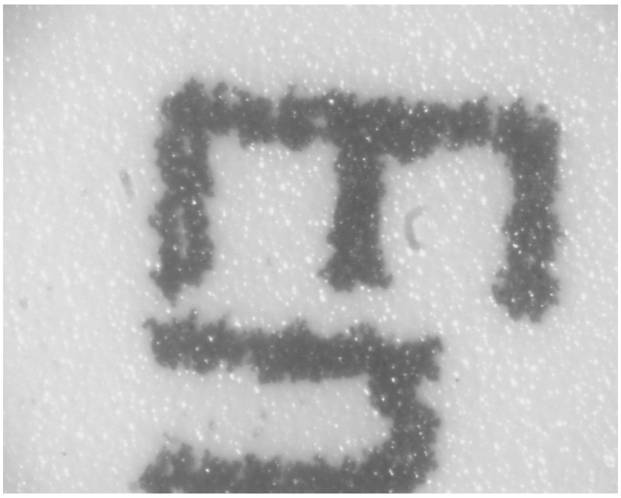

Figure 6. Printed pattern with the thermoplastic ink.

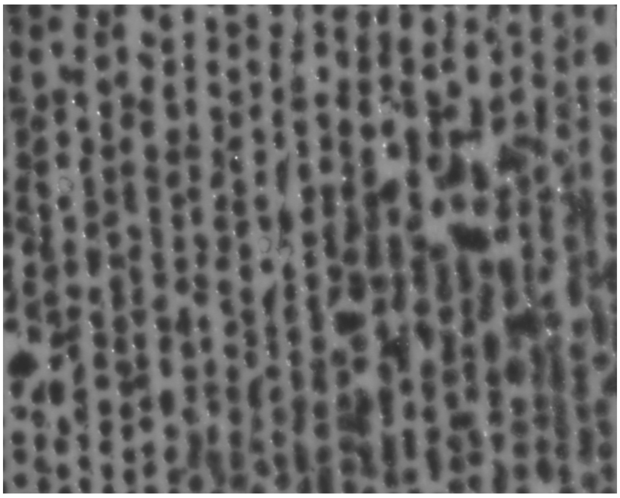

Figure 7. Printed pattern with the UV ink.

In contrast to the thermoplastic ink, the coalescence of the drops is quite limited with the UV ink as it can been seen in figure 7. This leads to well defined drops sitting on the substrate and allows for enhanced image quality. This situation is comparable to drops obtained with hot melt inks.[3]

One drawback with this ink is the limited scratch resistance due to the hemispherical shape of the drop on the substrate. This can probably be taken care by different processes.

Conclusion

In this paper we have detailed the design and performances of a printing system based on a commercially available print-head. Some of the specific developments include the proprietary controller electronics and ink circuit. The print module such as it is assembled should facilitate the installation on industrial webs. We have shown with the help of several selected examples that the system is quite optimized for packaging applications and compares very favourably with existing CIJ printers. The future work will concentrate on the extension of the present system to several print-heads in order to be able to cover large width printing applications.

References

1. J. Kretschmer and G. Beurer, *Design Parameters of a Shear Mode Piezo Print-Head for a given Resolution,* IS&T, NIP 13, 1997, pg. 626.
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Biography

Cyril Schlemer is Project Leader at Ardeje for packaging applications. He is in charge of the electronic development of printing systems.