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Abstract T-44

T-44: Long Distance Jetting: Digital Printing on Non-Planar Shapes

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Abstract

The inkjet printing technology plays a major role in the digital printing field. Having the possibility to digitally and selectively print or coat areas offers a great advantage. Usually inkjet was limited to flat substrates but nowadays with modern printheads and advanced waveform tuning, it is possible to extend the jetting distance and print on non-planar shapes. This paper will compare different printheads and the strategies used to increase the jetting distance.

Keywords*: inkjet technology, long distance jetting, direct to shape, selective coating*

1. Introduction

Inkjet printing technologies have been consistently growing over the last years. Digital printing has been extensively used in the graphical printing field, but the number of applications is constantly increasing. Inkjet printheads can nowadays be used for digital coating applications where they shine thanks to their flexibility and their low ink wastage. However, such coating techniques were often limited to flat or slightly curved substrates due to the low jetting distance required by the printheads (3). Manufacturers have now greatly improved the design and manufacturing of printheads to deliver higher quality products achieving superior jet straightness, and with advanced waveform tuning, opening the door to higher distance jetting. In this context, three different printheads offering a native resolution of 600 DPI were evaluated in order to find the most suitable candidate for long distance jetting. The jetting straightness measured on printed samples was considered as criterion in order to compare different printheads.

2. Theory

One of the important aspect to reach a high-quality print is the drop placement on the substrate. A good placement will have an impact on the color reproduction for graphical printing or on the wetting behavior in coating applications. Firstly, the nozzle will influence the droplets trajectory. The shape (4) or the accuracy in the drilling or manufacturing of the nozzle may affect the jetting straightness of the droplets. A lot of progress has been accomplished in the manufacturing technologies using MEMS manufacturing techniques to etch accurate geometries in silicon. Moreover, as soon as the droplet exits the nozzle, external factors may change the trajectory of the droplet. Air molecules will have the most impact by slowing down droplets and given their small size, airflows will deviate the droplets (1-2). The challenge of the airflow on the droplet flight is a well-studied phenomenon and the airflow changes with the gradient of speed between the printhead and the substrate (the printing speed), ink discharge (productivity) or even the printhead design (row-to-row distance). The flow of ink jetted by the printhead creates eddies between the nozzle rows. Some strategies were implemented to mitigate this problem by trying to control the airflow, but a preferred workaround is to spend the least amount of time in the printing gap by having a fast and heavy droplet that will be less carried around by airflows because of its higher momentum.

3. Experimental procedure

The evaluation of each printhead was performed in two steps. The process started with a waveform optimization using dropwatching to have droplets with a high kinetic energy. Black UV inks were chosen considering the specified viscosity range of each printhead. All inks had a viscosity around 8-10 mPas at 45°C. A set of waveforms were selected for each printhead to be tested during printing tests. The droplets had a volume ranging from 25 up to 60 pl and a velocity between 7.5 and 10 m/s measured at 1 mm away from the nozzle plate. The following image shows the drop formation of a 6-pulses waveform with six individual sub-droplets that merge into a single droplet and increase the speed and the volume of the droplet.

Figure 1. Drop formation for a 6-pulses waveform resulting in a 30 pl droplet.

To evaluate the jetting straightness of each printhead, a set of images containing a grid was used while the printing quality was visually assess using a standard pattern. All prints were done on inkjet paper to remove all wetting behaviors that could impact the result. A printed grid of dots was used to measure the drop placement on the substrate using a digital microscope. The position of each dot on the substrate was computed and the data points were processed to fit a theoretical straight line pattern. The deviation of the dot from this line could be quantified. The steps are illustrated on the following figure.

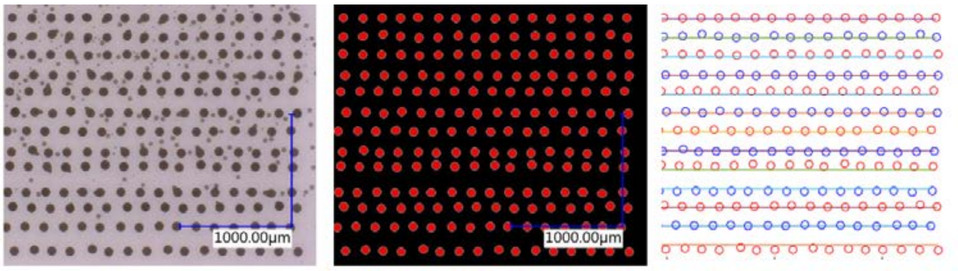

Figure 2. Scanned printed grid, drop position and fitting of each printed line

The deviation from the theoretical position follows a normal distribution law and it is therefore possible to fit a gaussian curve to the data points to compute the printed resolution that the printhead achieved at the given jetting distance. A criterium of two sigmas corresponding to half the nozzle pitch was used to fit the gaussian curve. Using this criterium for a 600 DPI printhead, 95.4% of the drop should land within a ±21µm error from the theoretical position.

4. Results and discussion

A set of three native 600 DPI printheads were tested and the drop placement was measured. Under these conditions, one printhead was still able to maintain a 600 DPI printing resolution up to an 8-mm jetting distance. All printheads showed an exponential decrease in the accuracy according to the distance.

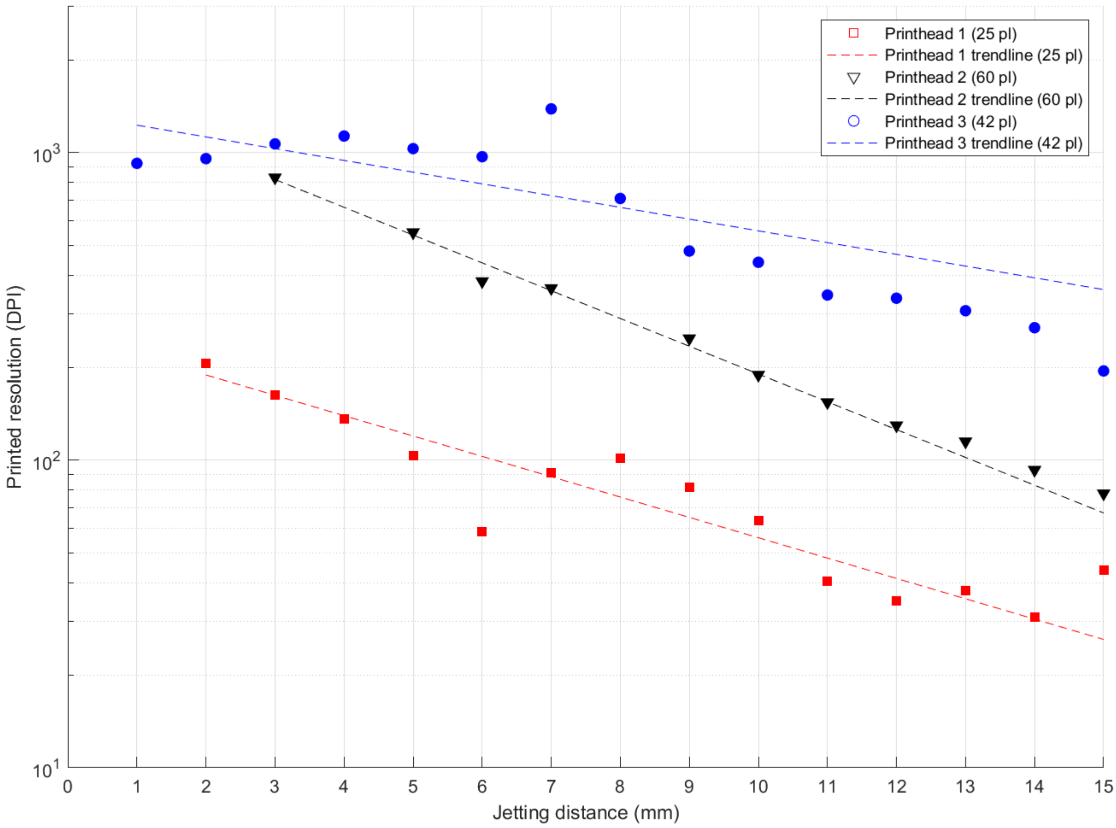

Figure 3. Printed resolution according to the jetting distance for three different printheads.

Nonetheless, these results show the potential to print using piezo inkjet printheads at greater distances than the industry standard of 1 to 2 mm. An increase in the printing gap opens the doors to non-planar substrate for decoration or functional printing.

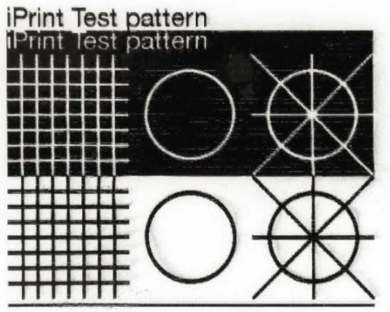

Figure 4. Pattern printed at 8 mm (the grid has 1 mm square)

The printed images show a decent quality perfectly suitable for selective coating applications or lower resolution graphical printing.

5. Conclusions

We have compared different inkjet printheads to measure the jetting straightness and the achievable printing resolution for a given jetting distance ranging from 1 up to 15 mm. One printhead was able to maintain a 600 DPI printing resolution up to 8 mm and over 300 DPI up to 12 mm. These results show the possibility to extend the range of applications toward curved shapes while still maintaining a decent printing quality.

6. References

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