Inkjet single pass color printing with UV curable ink.

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Abstract

Studies on an inkjet printhead, capable of 847 mm/s printing rate with 600 dpi single pass resolution for 108 mm print swath, were reported by one of the authors. In this study, the printhead is applied to UV curable inks for color prints on non absorbable media. Four of the printheads are arranged for a color printing system using Y, M, C and K UV curable inks accompanied with a UV lamp. Studies are made on effects of printing and curing procedure for image quality achieved by the printer. As a general tendency, it is confirmed that the faster a print speed becomes, the image quality got improved in terms of sharpness. The results reveal dependency of image quality upon a time that allows drops to be driven on a media by surface tension before the curing. Also, the images obtained by the single pass printing with a certain pass speed shows potential for practical applications in terms of image quality as well as productivity although it is limited in a certain application area that uses relatively simple images.

Introduction

Since the public presentation of the piezoelectric drop on demand line inkjet printhead with 108 mm print width and 600 dpi single pass resolution in year 2005 [1], the authors have been working to expand its capability for industrial applications.

As a part of the achievements, it was reported in NIP23 that the printhead was modified in the firing frequency to 24 kHz from the original specification of 20 kHz [2]. On basis of the improvement, further refined model with firing frequency of 30 kHz was developed and has been employed for a high-speed transaction press.

On the other hand, having taken into account of demands for UV inkjet printing, which can be used for wider range of media, studies on the printhead have been made to apply it to printing with UV ink although it was developed for aqueous inks originally. This report summarizes latest status of a printhead model for UV curable ink and studies on effects of printing and curing procedure on image quality.

Printhead Specifications

In case of a print with aqueous inks, absorbability of a media plays more or less important role to fulfill the coverage on a media. However, it is expected to cover a non-absorbable media in case of a UV print. Therefore, the printhead is required to increase drop volume. In addition, UV inks require more energy to be fired than aqueous ones because of their higher viscosity in general.

In order to satisfy the requirements above, the printhead designs were optimized in actuator, cavity and nozzle dimensions. The specifications attained by the optimizations are summarized in table 1 as those of a model KJ4A with comparisons to KJ4B that is optimized for aqueous inks.

1. Model Code	KJ4A	KJ4B
2. Ink Type	UV	Aq.
3. Dimension	200(W) x 25(D) x 60(H) mm	
4. Number of Nzl.	2,656	
5. Print Width	108 mm (4.25 inches)	
6. Resolution	600dpi (print width direction)	
7. Drop Volume	4 - 18 pl[*1]	5 - 20 pl
8. Max. Drive Frq.	20 (30)[*1] kHz	20 kHz
9. Viscosity	5 - 6.5 mPa*s	6.5 - 8.0 mPa*s

*1: Up to 12 pL in case of 30 kHz

Table **1: Representative Specifications of the Print Head**

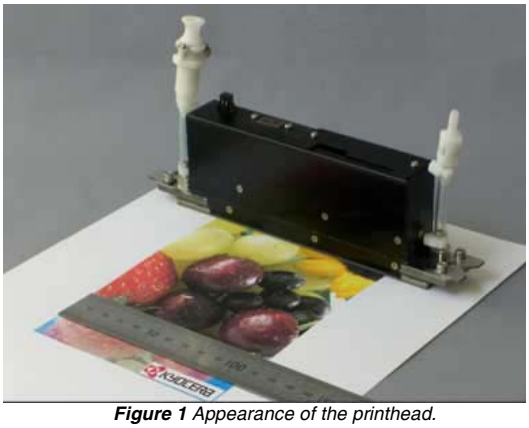


Figure 1 *Appearance of the printhead.*

Printing Tests

Equipment

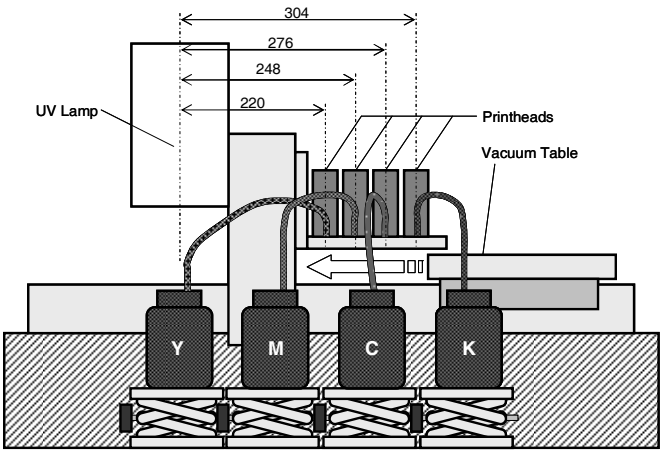


Figure 2 *Test Printer.*

Figure 2 shows a schematic expression of a printer used for the tests. As shown in the figure, a substrate fixed on the table passes under the four printheads aligned with a UV lamp.

Conditions

By using the test printer above, effects of printing speed on image quality are examined in following conditions. Of these conditions, characters are printed with black ink only whereas color picture and photo-like images are obtained with Y, M, C and K inks.

Also, impact of printing and curing procedures on image quality is examined by comparing ones obtained by sequential four pass prints for each color with those printed in single pass print with four colors. Drops of ink are cured in each color one by one for the former case, which is so called sequential color printing in this paper, but four colors are cured together as a batch in the latter, which is named as batch color printing hereafter.

Table **2: Printing Test Conditions**

1. Image	7 Pt. Character, Picture, Photo-like
2. Fire Freq.	5/ 10/ 15/ 20 kHz (Corresponding to following feeding rate respectively.)
3. Feeding Rate.	211.6/ 423.3/ 635/ 846.7 mm/s
4. Method	Sequential/ Batch
5. Ink and Lamp	Curing Energy: 60 mJ/mm Lamp Power: 120 W/cm
6. Media	Gross Coat Paper

Results and Discussions

Of the images obtained at test conditions above, figure 3 shows magnified views of characters printed at 5 kHz (211.6 mm/s) and 20 kHz (846.7 mm/s) respectively. As it is shown in the figure, the profiles of the character become sharper so as the feeding rate is higher. It can be thought that drops attached on non-absorbable substrate surface could be moved or deformed by surface tension by the time it is transported to the UV lamp, or cured. This result implies that an inkjet printhead capable of fast printing is rather suitable for single pass UV applications.

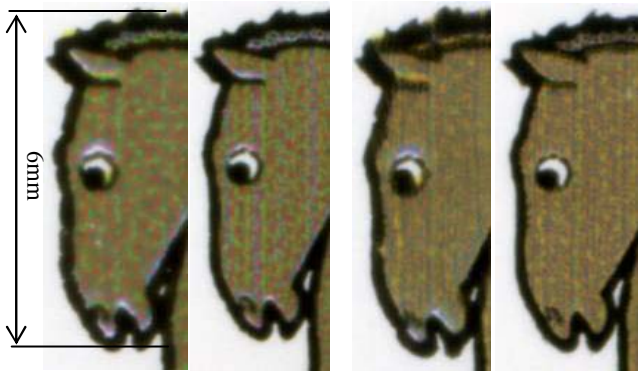
(a) 5 kHz (211.7 mm/s) (b) 20 kHz (846.7 mm/s)

***Figure** 3 7 Points Character*

Figure 4 shows color picture obtained by sequential, batch color printing at 5 kHz (211.6 mm/s) and 20 kHz (846.7 mm/s).

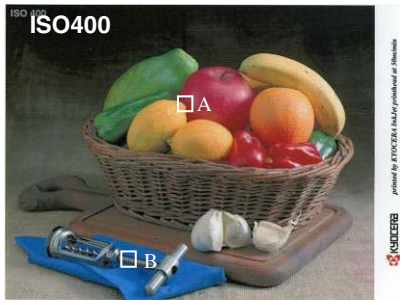
As shown in the figures below, images obtained by batch color printing look less granular than ones by sequential printing. It implies that drops of different colors are more or less got together before fixed on the substrate by UV exposure in case of batch printing. That makes an image look even smoother in a sense without spoiling color quality itself. In addition, batch color printing cannot be suffered by inaccurate paper positioning whereas sequential printing could.

As to the feeding rate effect, profiles and boundaries of different color regions are sharper as it becomes higher, so as in the case of the character printing. However, it also makes an image more granular, especially for a sequential color printing. These results indicate that an image quality could be adjusted by a time between firing and curing on a substrate accompanied with drive frequency or distance between printheads and a UV lamp.

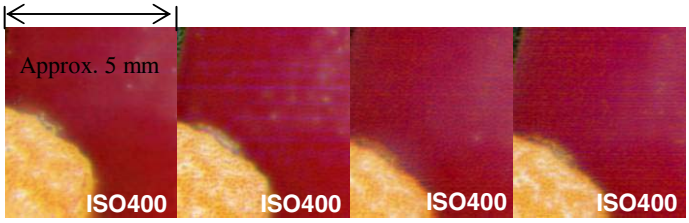


(a) 5 kHz Sequential (b) 20 kHz Sequential (c) 5 kHz Batch (d) 20 kHz Batch

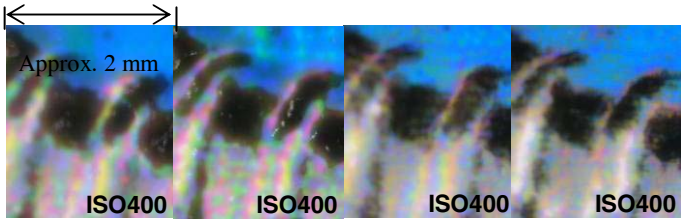
***Figure** 4 Picture Image*



(A) Apple and lemon



(B) Corkscrew



(a) 5 kHz Sequential (b) 20 kHz Sequential (c) 5 kHz Batch (d) 20 kHz Batch

***Figure 5** Photo-like Image*

Figure 5 shows magnified views of color photo-like images (ISO400) at an apple, lemon surfaces named area “A” and a part of a corkscrew, so as area “B”, which are obtained in same conditions as pictures in figure 4.

As a general tendency, tiny pattern on apple surface and lemon calyx seen in area A are more or less vague other than picture (b), which is obtained by sequential color printing at 20 kHz firing frequency. Especially, it is even looked flat in a region of a high coverage rate with multiple colors in pictures (c) and (d), which are obtained by batch color printing. Hence, it might be an incapable method for printing of fine photo-like images.

In addition, shadow edges of screw part in area B look unclear in cases of prints at 5 kHz firing frequency whichever the print methods are. As discussed above, the results indicate that time between dot placements on a substrate and curing could have much impact on sharpness in an image.

Conclusion

A line inkjet printhead, which was originally designed for aqueous ink, is modified for UV curable ones. Four of the printheads and a UV lamp are built into a single pass color printer to examine effects of printing procedure on an image quality.

Firstly, effects of a media feeding rate, or time between the dot placement and UV exposure, are examined by character printing with black ink solely. Generally, as the rate becomes lower, or the time become longer, character edges get thicker and dull. It could be due to mechanical interaction of ink drops with media and/or other drops. A printhead capable of high-speed printing could be a solution to reduce the influence, as well as close arrangement between printheads and a UV lamp.

Secondly, effects of printing procedures are examined by comparing picture images obtained by sequential (four pass for each) and batch (one pass for four) color printings. In case of a relatively simple picture image, batch color printing seems to be effective from commercial view point because of its productivity. Whichever the procedures, a time by the curing for the drops on a media could have much impact on a trade off between granularity and sharpness in an image.

Thirdly, photo-like images are obtained by the both printing procedures. It reveals limitation of batch color printing in terms of image quality especially for complex ones like photograph. Fine patterns, curvedness and sharpness in an image could not be represented so well as sequential color printing.

References

[1] A. Hirota, S. Ishikura, "Development of Drop - on - Demand Piezoelectric Line Inkjet Printhead", Proc. NIP21, IS&T, p257 - 263 (2005).

[2] S. Ishikura, A. Matsumoto, "Development of Drop - on - Demand Piezoelectric Line Inkjet Printhead", Proc. NIP23, IS&T, p257 - 263 (2006).

Author Biography

Shin Ishikura joined Kyocera Corporation in 1995. Since then, he has been in development section for print heads and their components. He received his degrees of M.S. and M.Eng. from Liverpool John Moores University and Kanazawa University respectively.

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Wataru Ikeuchi received his B.Eng. and M.Eng degree in electronics engineering from Oita University in 2006. Then, he joined Kyocera Corporation in 2006 and have been experiencing manufacturing, evaluation and designing of inkjet printhead.