Improvement of Piezoelectric Ink Jet Printhead For Higher Throughput.

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Abstract

A prototype of monolithic piezoelectric line ink jet printhead, which has 108 mm print width, was proposed at NIP21 by one of the authors. It enables variable volume drop ejection at 20 kHz frequency from 2,656 nozzles arranged in 108mm x 16.8mm area. And it achieved 600 dpi x 600 dpi single pass printing at 847 mm/s. Then, its' highest drive frequency was raised up to 24 kHz for faster printing (reported at NIP 23).Again, it is raised further up to 30 kHz by modifying ink viscosity as well as channel design. The latest mode 1 enables 600 dpi single pass printing at 1,269 mm/s with variable drop volumes between 5 and 12 pl. The drop velocity trend against firing frequency becomes more consistent up to 30 kHz. Also, drop deviation is improved for better image quality by modification with nozzle plane.

Introduction

As the first prototype model, a monolithic piezoelectric line ink jet printhead was proposed by one of the authors as a product of cooperative development work between Kyocera Corporation and Brother Industries LTD., at NIP 21 [1]. This printhead realized single pass print at 847 mm/s with 600 dpi x 600 dpi resolution across 108 mm width by its unique design. Since then, it has been evolved for industrial applications that require higher productivity and reliability.

Then, as an intermediate step, it was attempted to raise the drop ejecting frequency from original 20 kHz to 24 kHz for faster single pass print [2]. The modified model achieved 1,016 mm/s single pass print.

However, it was needed to achieve 30 kHz or 1,270 mm/s to be more competitive in the market for such an application as high speed variable data press (transaction printer). From technical view point, higher print speed also requires more accuracy in drop placement.

In order to achieve the drive frequency target, studies are made on channel design together with influence of ink viscosity. Also, non-wet coating of nozzle plane is modified for better dot placement accuracy.

This paper introduces latest status of the printhead and technical approach to realize it.

Printhead Specifications

Following table summarizes specifications of latest model of Kyocera piezoelectric ink jet printhead KJ4 series for aqueous ink. Comparing with previous prototypes, it has not changed a lot in its appearance but it is improved in printing performance as referred above. In addition, it is more focused on industrial applications by employing stiffer connectors and couplers. Appearance of the printhead is shown in figure 1.

Table 1: Representative Specifications of the Print Head

1. Model Code	KJ4B-HD06MHG-STDV
2. Dimension (WxDxH)	200 mm x 25 mm x 60 mm
3. Print Width	116.54 mm
4. Effective print width	108.25 mm (600 dpi)
5. Nozzle No.	2,656
6. Effective nozzle No.	2,558 (600 dpi)
7. Std. resolution	600dpi x 600 dpi
8. Drop Volume	5 – 18 pl*1
9. Max. Drive Frq.	30 kHz for 5 – 12 pl 20 kHz for 5 – 18 pl
10. Optimum viscosity	5 - 6.5 mPa*s
11. Drop velocity	7 – 8 m/s
12. Data input pin No.	51
13. Temp. control	Thermistor and film heater

Figure 1 *Appearance of the printhead.*

Technical improvements

Dependency on driving frequency

Figure 2 shows a summary of 12 pl drop behavior against drive frequency. In case of the former model, drop volume and velocity is fallen by insufficient ink supply over 24 kHz.

In order to provide sufficient ink to a nozzle at higher rate, it was required to reduce flow resistance inside an ejector. However, it could increase influence of residual oscillation after drop ejection at each period and drop behavior could be suffered at high frequency driving, i.e. drop speed could be varied periodically along with drive frequency. Having optimized channel design and ink viscosity, drop behavior could be stabilized up to 30 kHz. It was achieved by increase of ink viscosity from 4.5 mPa*s to 6.0 mPa*s with expanded restrictor (see figure 3). In total, flow

resistance of the restrictor part is reduced to 71% of former prototype design that achieved 24 kHz drop ejection.

On the other hand, in order to compensate more damping by increasing ink viscosity, it is required to generate more pressure by the actuator. It was achieved by increasing cavity area so that more volume displacement can be generated.

As a result, constancy of drop behavior is improved up to 30 kHz with the printhead.

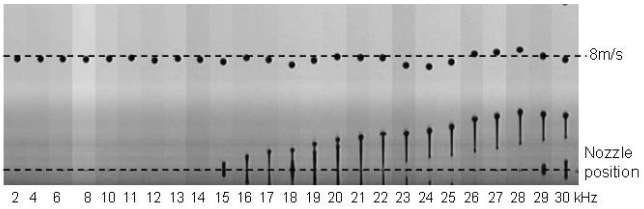

Figure 2 *Trend of drop velocity against drive frequency.*

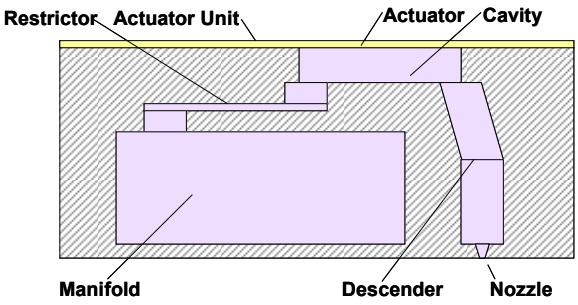

Figure 3 *Cross sectional view of a drop ejector.*

Drop placement accuracy

Figure 4 shows examples of dot deviation of both models, which represents dot placement error from each designed nozzle position with 1 mm gap between a media and nozzle plane.

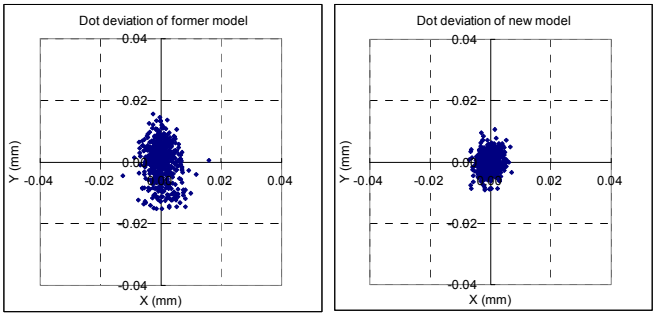

Figure 4 *Comparison of typical dot placement accuracy.*

As shown in figure 4, number of dispersive drops is reduced in case of the new model. It much owes improvement in non-wettability of nozzle plane, which made much contribution to reduce the deviation angle as well as irregular dots. By reducing misaligned dots, image appearance is much improved.

Single pass print

Figure 5 shows an example of full width single pass print image by using the new printhead driven at 30 kHz. Other printing conditions are summarized in table 2. As shown in the magnified views, there is no visible satellite. Also, regarding horizontal lines, straightness is secured. Hence, new printhead shows capability for high speed printing applications.

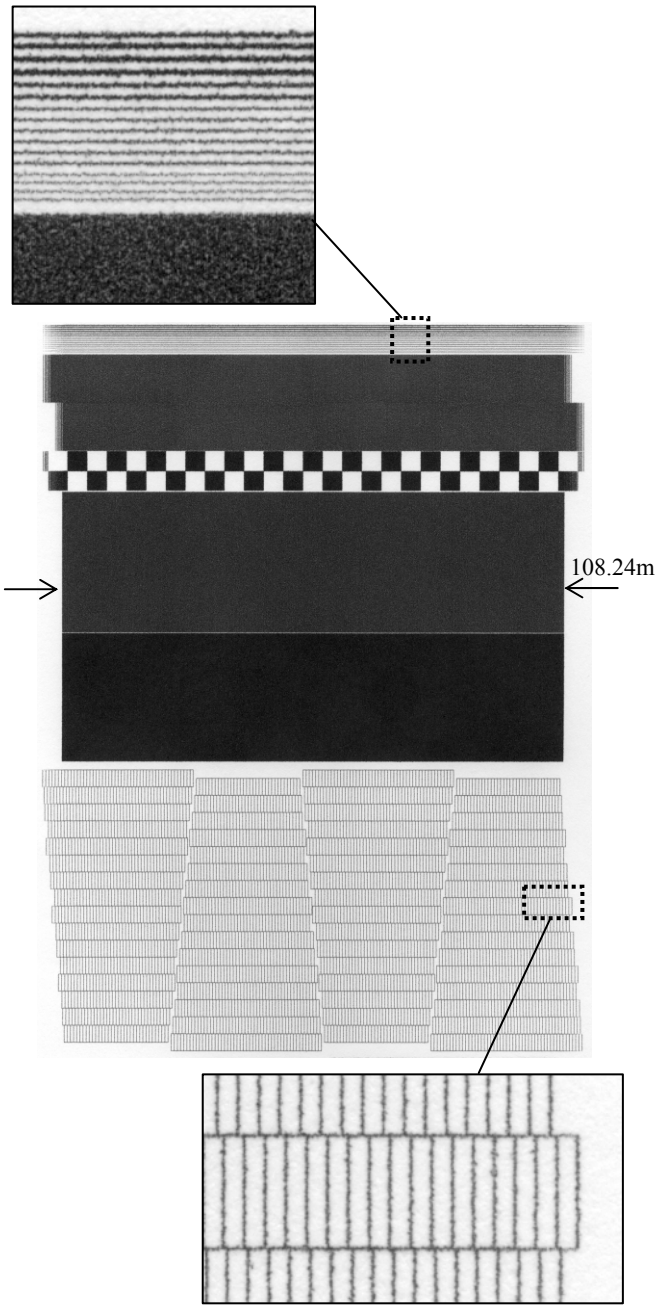

Figure 5 Print sample.

Table 2: **Summary of printing conditions.**

Resolution	600 x 600 dpi
Print gap	1.5 mm
Scanning speed	1,270 mm/s
Media	Plain paper by OJI
Ink type	Aqueous pigment

Conclusion

Drop ejection frequency of a piezoelectric ink jet printhead is raised from 24 kHz to 30 kHz, which made 25% improvement in printing productivity. It enables single pass print at 1,270 mm/s with 600 dpi x 600 dpi resolution.

It is achieved by increase in viscosity of ink from 4.5 mPa*s to 6.0 mPa*s together with less restrictive channel and more compliant actuator.

Drop placement accuracy is improved by employing new non-wet coat. The deviation angle is reduced 33% from former model in terms of statistical deviation angle.

There is no visible satellite in a single pass print image, obtained by using this printhead driven at 30 kHz. Also, horizontal lines are straight enough even for high speed printing applications.

References

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

[2] S. Ishikura, A. Matsumoto, "Development of Drop - on - Demand Piezoelectric Line Ink jet 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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Kentaro Mori received his B.Eng. and M.Eng degree in electronics engineering from Kyushu University in 2008. In this year, he joined Kyocera Corporation and has been working for jetting behavior analysis.