Development of Image Quality and Reliability Enhancing Technology for 29 × 23 Size Digital Inkjet Press "KM-1"

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Abstract

We have developed a Single-pass inkjet digital press AccurioJet KM-1, which can achieve off-set like high image quality with high productivity, 3,000 sheets per hour.

To success in the commercial printing field, high image quality and high consistency are required to be achieved.

For achieving high image quality, undesirable image defect such as banding should be improved. Therefore we have classified image banding into two, narrow banding (streak) and wide banding.

To solve the narrow banding issue, we developed a unique halftoning and a nozzle compensation techniques by means of image simulation process. We also improved the wide banding issue by adjusting the dot size and the dot density.

As for the high reliability, we developed a streak detection system, which scans images on every sheet, checks the existence of streaks, and feed-backed the results to the above mentioned image compensation systems.

Introduction

Recently commercial printing field has started to shift from analogue printing to digital printing, because of increasing job number of "small lot", shortening of lead time, personalization and so on.

Aiming for entering into this market, we tried to satisfy the requirements in this field such as high productivity, media flexibility, high image quality and high reliability, with our inkjet technology.

In terms of high productivity, we adopted a single-pass printing technology and a gripper-type paper transport system which can realize duplex printing with high stability. In terms of high image quality, we developed a new print head, KM1800i, which can deposit ink-dots in high frequency with high accuracy.[1] We also developed a new UV curable inkjet ink which could realize the high image quality and media flexibility. [2]

The single-pass inkjet printing technology, one of the key technology for the high productivity, is still a big challenge for image processing. There is no redundancy which can hide a undesirable image defect so-called "banding". It is essential to solve the banding issue for achieving high image quality accordingly. We developed various image compensation/correction techniques and achieved the high image quality. We will report what we achieved in the development.

Technological achievement

Outline of the AccurioJet KM-1

Figure 1 illustrates the structural outline of AccurioJet KM-1. Media, set in the sheet feeder, are transferred to the main cylinder. Inkjet heads jet the ink to form the image on the media, and the deposited ink dots are fixed by UV light emitted from the LED lamps. A page-wide inline image sensor is installed between the LED UV array and the sheet delivery output. The

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image sensor scans a printed “streak detecting” chart. The scanned results transferred to the image correction system to solve the banding issue.

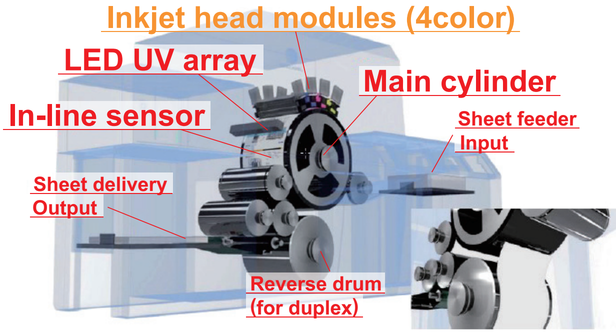

Figure 1 Structural illustration of AqurioJet KM-1 system.

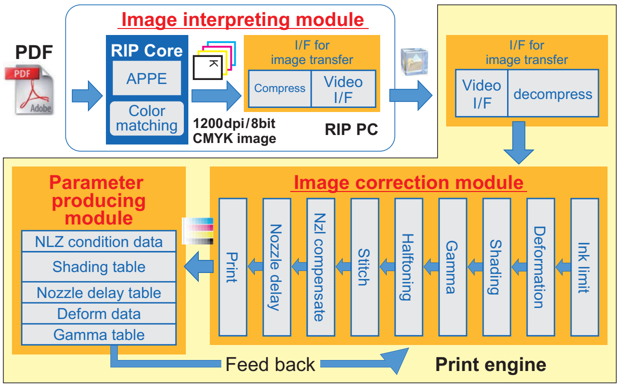

Figure 2 Outline of the image correction data flow.

Figure 2 illustrates the outline of the image correction data flow. To solve the banding issue, the halftoning, the nozzle compensation, and the shading correction are processed by this flow.

Approach to offset like image quality

To improve the banding issue, we have classified the image banding into two, “narrow banding (streak)” and “wide banding.”

We investigated their structure and mechanism thoroughly, and we found new techniques to improve them. We solved the narrow banding by adopting unique halftone technique and nozzle compensation technique developed by using image simulation process. The wide banding, on the other hand, was improved by using dot size adjustment and dot density adjustment.

Halftone screen pattern optimization Print Image simulation

On the first to think of the halftone pattern, we examined the impact of image-processing parameters on the image quality. We utilized a simulation technology of image for the study. Focusing on dot deposition patterns seen in images printed by KM-1, we quantified the dot shape tendency relationship as a function of a distance and overlapped amount between adjacent deposited dots. Figure 3 is an example of a printing pattern which was performed to obtain a simulation parameters. We found that a coalescence of deposited dots proceeded in non-linear manner; the line width and the center of gravity of deposited dots were affected by the dot deposition pattern.

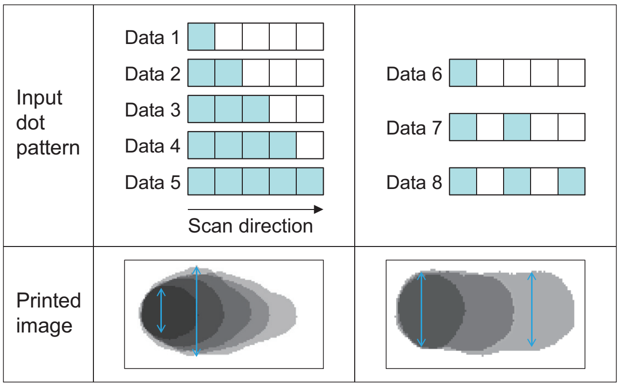

Figure 3 Example of obtaining the parameter for dot pattern simulation. Line width and line length change depending on variable input data patterns.

Figure 4 is an illustration of a comparison between the actual printed image and the predicted image by the simulation. We found a good correlation in dot displacements and dot patterns.

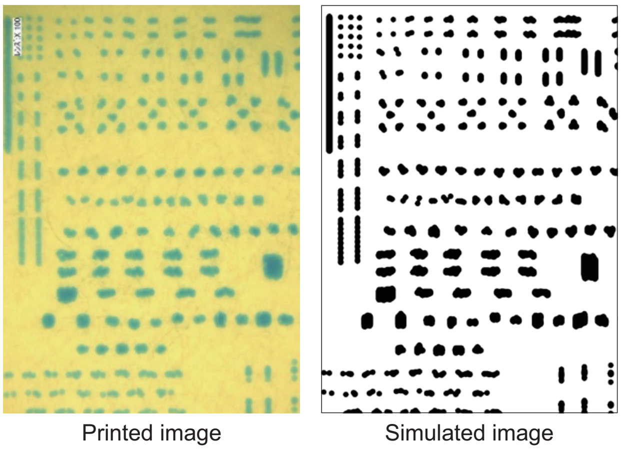

Figure 4 Comparison between a printed image and the estimated image.

Halftone screen pattern optimization - Optimization of Halftoning

We optimized the halftone pattern by using the aforementioned image simulation technique then. We simulated the impact of dot displacement in the main- and sub-scanning directions on the generation of the “narrow banding” (streak). We varied the extent of the displacement in the nozzle array direction (x-axis) and the paper feeding direction (y-axis) independently and predicted images.

In the dot pattern generated with a conventional half-toning technique, we found that the "streak" was very sensitive to the displacement along the x-axis. The non-linearity, which was found in the dot coalescence process, enlarged the input deviation of the center of gravity of dots to larger displacement of dot deposition and yielded the "streak" as shown in Figure 5-1. Considering the results, we developed a new halftoning technique that did not enlarge the deviation of input to larger deposition displacement. Figure 5-3 shows the result based on this new technique. Introducing a unique algorithm, we found that it could suppress the enlargement of the "streak."

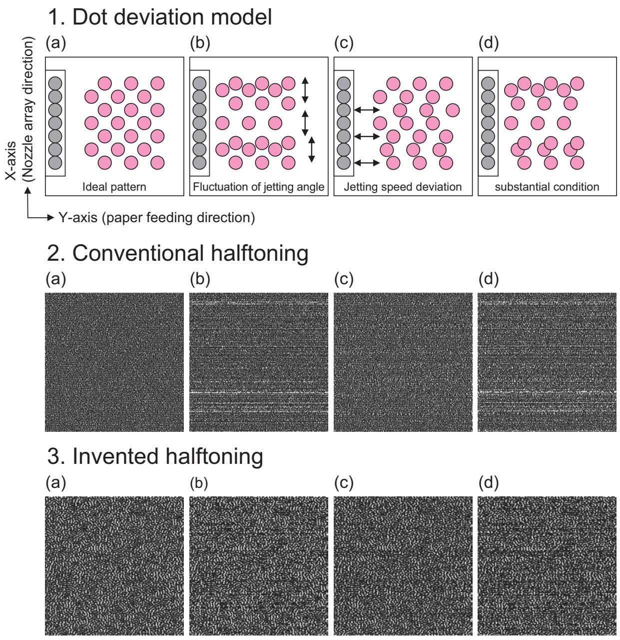

Figure 5 Simulated example of dot patterns under dot position's deviation.
x-axis and y-axis are defined as nozzle arrangement direction and media convey direction respectively. 1(a)-1(d) indicate dot position deviation models. (a) Dot positions are in an ideal position (b)dot positions are deviated along only x-axis, (c)dot positions are deviated along only y-axis, (d) dot positions are deviated along both x-axis and y-axis. 2(a)-2(d) show simulated images based on a conventional halftoning pattern and 3(a)-3(d) show simulated images based on a invented halfoning pattern.

Nozzle compensation

In a single pass inkjet printer, streaks can be recognized even one deviated nozzle is exist. For achieving offset image quality, those kind of streaks should be compensated.

In order to compensate this issue, we have focused the coalescence of deposited dots to design a compensation pattern.

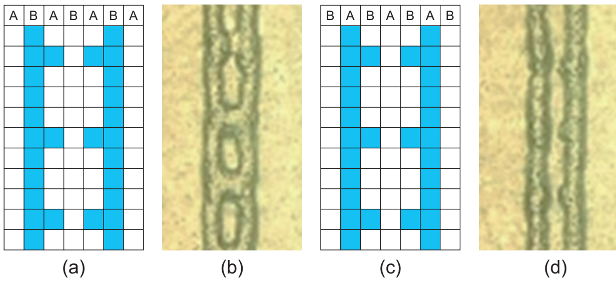

Figure 6 Differences of coverage depending on a differences of dot placement order. (a) (c) indicate input images and (b), (d) indicate printed results. Data for column A is printed before data for column B is printed.

A print head module of KM-1 consist of 2 heads, each head has 600 nozzle per inch resolution, for achieving 1200 nozzle per inch. In this case, two heads are located apart from each other along paper feeding direction. Accordingly we found a unique phenomenon that dot coalescence condition is changed depending on the deposited order.

Figure 6 shows the difference between dot placement order. Pint pattern of Figure 6 (a) and print pattern of Figure 6 (c) is almost the same. However there are big differences between Figure 6 (b) and Figure 6 (d) because of dot coalescence of adjacent dots. As a result, a performance of the nozzle compensation become unstable. In order to keep a good performance, suitable compensation patterns which suppress the coalescence are developed.

Precise adjustment

Precise adjustment are very important subject for suppressing streaks and bandings. Imaging problems are not solved without fine adjustment even any image correction method are applied.

Head module skew adjustment is one of the most important adjustment process. If the adjustment is not good enough, droplets from the nozzles cannot be deposited at right position and various parameters such as coverage, gloss value, hue and so on) can be changed. Some result are shown at Figure 7.

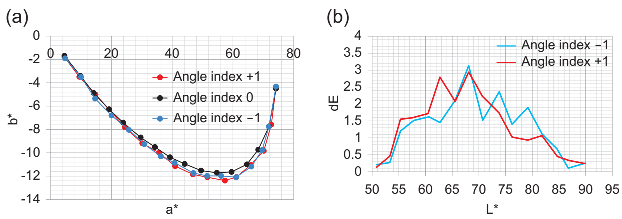

Figure 7 (a) indicates a* and b* variations between 0% to 100% dot percent of Magenta under different skew angle. (b) shows lightness(L*) vs color difference(dE). color difference at angle index +1 and -1 are calculated between angle index 0 and each angle index.

Image coverage and density of a printed sample is different depending on the head skew even single color is used. This phenomena can be explained by optical dot gain. Therefore it is no longer correctable. Accordingly fine angle adjustment method are introduced for realizing almost same color between adjacent heads.

For head module skew adjustment, suppressing of streak is taken into account.

Shading Correction

In terms of a density correction for inkjet, there are two way of correction, changing size and changing a number of dot.

Gloss of an image depends on a percentage of dots. Therefore it is preferable to realize same density at the same percentage of dots. (Figure 8)

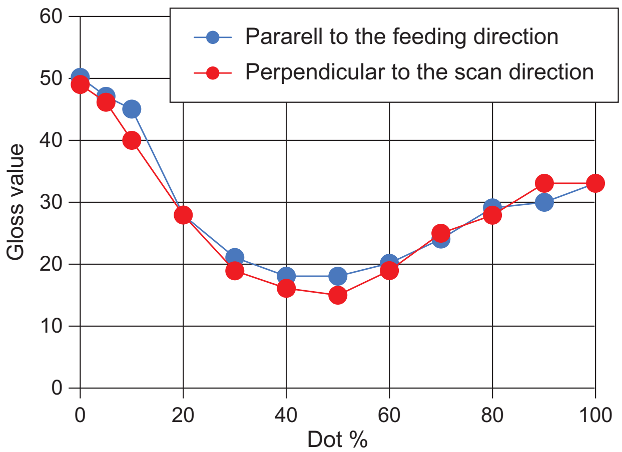

Figure 8 60° Gloss value dependence of dot % in a coated paper.

Accordingly voltage of each head need to be adjusted, because each head has each voltage sensitivity. So the head voltage adjustment process by using in-line sensor is introduced to compensate the voltage sensitivity.

Inter-head banding is suppressed to apply the head voltage adjustment. On the other hand, intra-head bandings are still remain. This intra-head bandings will be caused by jetting volume deviation and jetting angle deviation. In this case, unevenness depends on a density level. Therefore a two-dimensional look up table (i.e. nozzle positions vs. density level) is used for correcting this unevenness.

Streak Detecting System

Image corrections for pre-printing have been discussed. But image corrections during printing are also important, because jetting condition is easy to change. So simple streak detection pattern is added at the end of every sheet. This pattern is applied with any kind of correction such as stitching correction, shading correction, nozzle compensation and so on for avoiding detection failure.

After detecting streaks, nozzle detecting pattern is printed for detecting nozzle information for nozzle compensation.

Conclusion

We have developed image correction systems for achieving offset image quality. Main points is to understand a printed dot behavior on the substrate for suppressing unwanted effect.

We will make effort to provide a power from analogue to digital by the newly developed UV-curable inkjet technology.

References

[1] Development of the 23”×29.5” Sheet-fed Inkjet Press KM-1, M. Obata, T. Sugaya, T. Mizutani, H. Watanabe, T. Takabayashi, and H. Iijima, Proceedings of NIP 30 and Digital Fabrication 2014, p. 372 - 374, (2014).

[2] Newly developed UV-curable inkjet technology for Digital Inkjet Press “KM-1”, T. Takabayashi, H. Iijima, K. Goi, M. Obata, T. Mizutani, and H. Watanabe, Proceedings of NIP 31 and Digital Fabrication 2015, p. 251 - 255, (2015).

Acknowledgment

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