54.3: Drop Landing Accuracy Improvements in Inkjet Printed OLED Displays

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Abstract
Producing high quality full colour polymer OLED displays by inkjet printing requires accurate placement of ink droplets into predefined pixel well structures. Recent improvements in inkjet printer design have significantly increased the drop landing accuracy, making it possible to inkjet print higher resolution displays

1. Introduction
One opportunity for inkjet printed polymer OLED (P-OLED) displays is in the manufacture of high resolution displays (160-200ppi). This requires inkjet printed drop placement of better than 5 microns. High quality inkjet printheads have typical directionality errors of up to10mRad which equates to a 3 micron placement error with a 300 micron throw distance from printhead to substrate. As a result, the maximum printhead positional error for all the printhead nozzles over the entire substrate is ±3 microns.

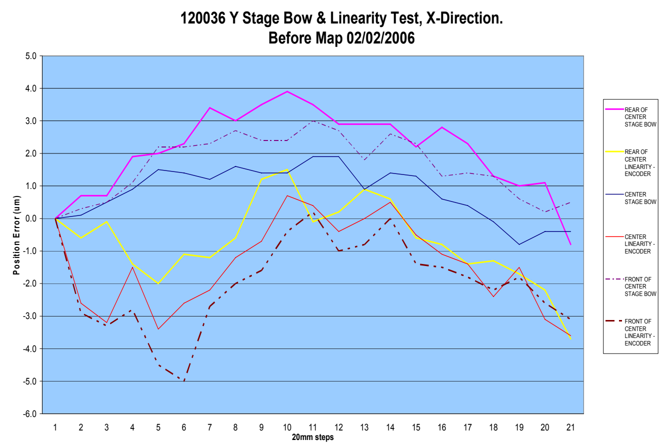
In addition, the task of achieving this accuracy must not be too onerous or time consuming for the printer operator, so the printer has to employ systems that allow this level of accuracy to be achieved consistently, and to compensate for dynamic errors caused by variation in temperature, or machine wear over time.

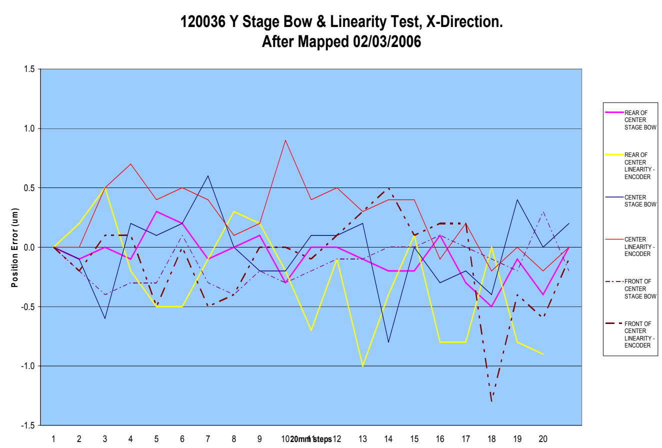
2. Isolation of Error Sources
In the practice of building a series of inkjet printers which have grown in active area over 2 orders of magnitude, Litrex have narrowed and isolated the error sources in inkjet printing from over 250 individual sources into conceptual groupings to be addressed systematically.

Many of the sources identified, and their impact on drop placement accuracy, are used in the design review process to refine and improve system stability and precision on adjustments. This includes design of stages, head positioning mechanisms, and metrology subsystems.

In practice, the error sources can be broken down in to key subsets:

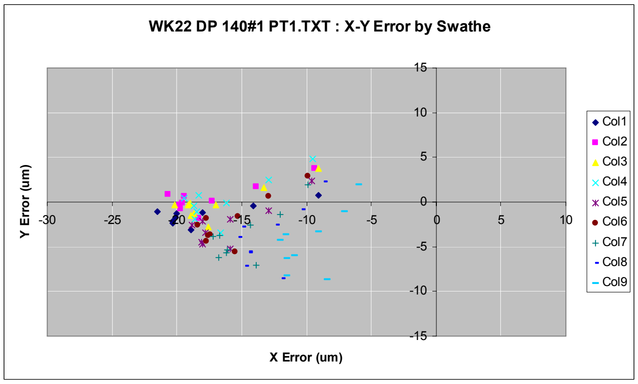
- Static mechanical errors – these are error sources that can be measured at any point in the active area of interest and compensated prior to processing. The figures below show the effect of analyzing and compensating one such source of these errors (stage straightness and linearity).
- Dynamic mechanical errors – these are error that result in shifting mass centers under motion as well as the influence of acceleration of mass on the supporting structures of the printer. These can only be characterised post printing to develop a compensation strategy.
- Statistical process error sources – these are error sources which inherently exist in some distribution which must be accounted for in the residual, un-compensated budget allotment. Recognizing the impact of these can have influence the process parameters and operation of the printing process to minimize their effect.



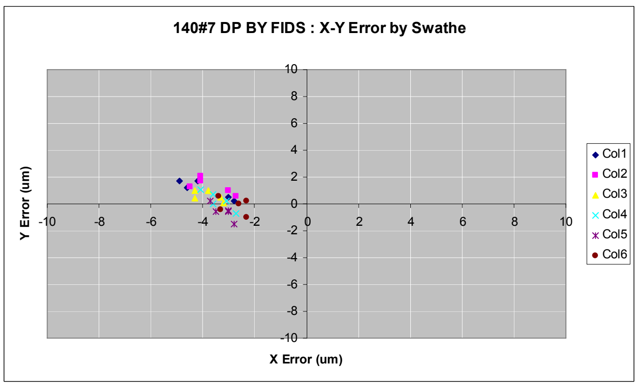


3. Results
CDT has used Litrex 140 & 142 Gen2 printers to perform the drop placement, and a calibrated Mitutoyo metrology system for automated measurement of the placement of single drops with a resolution of ±2 microns. In order to ensure that maximum accuracy is achieved, the drop placement substrate is pre-coated with a moderately non-wetting material, allowing the drop to pin to the surface where it lands but prevents the drop spreading. This results in a small circular drop whose centre can be accurately defined and measured relative to both the pixel edge and the substrate fiducial or alignment marks.

Previous drop placement results – Litrex 140 Printer



Latest Drop Placement Results - Litrex 142 High Resolution Printer

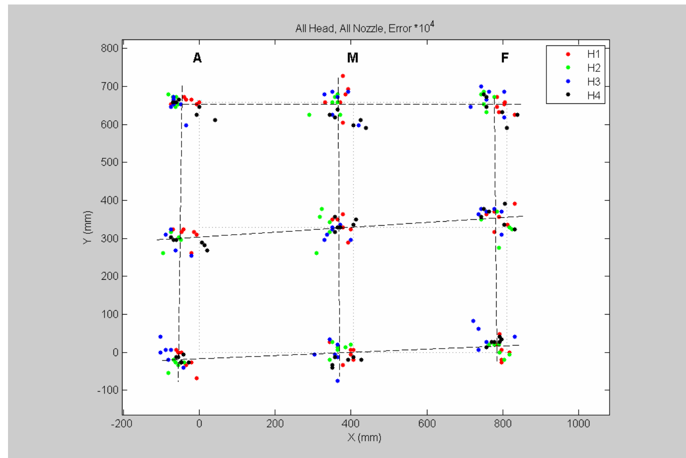


4. Application

This work demonstrates that the drop placement accuracy required for inkjet printing high resolution displays can be attained from a well designed printer, that the isolation and reduction of error sources within the printer is an essential part of the design process, and that this understanding is likely to be applicable to large multi-head printers.

In the application of inkjet printing to large format, high resolution displays, the magnitude of each error source tends to grow due to the larger travel dimensions and the more complex alignment systems necessary for multi-head printing. The increased mass of the larger subsystems and higher accelerations required to meet demanding tact times mean higher dynamic deflections of the system. In this case, additional characterisation work must be done in order to compensate for error sources occurring under actual process conditions. The figure below illustrates such a characterisation study on a Gen 5 printer. The plot shows errors by geographic location across the entire active area of the printer. Breaking this data down by specific location isolates the error sources to stage movement, head alignment, internal head errors, substrate alignment and droplet ejection timing errors. These errors can then be compensated in the print strategy.

Drop placement error across a Gen5 substrate



5. Conclusion

A detailed analysis of the drop placement of inkjet printed drops has allowed the major error sources to be identified and removed. In a Litrex 142 printer, the contribution to drop placement error from the printer is now below that of the placement error caused by the angular deviation of drops ejected from the printhead. Future reductions in drop placement error in the 142 printer will therefore be focused on printhead rather than printer performance.

6. Acknowledgements

Our thanks to Dr Mark Bale at CDT for providing and analyzing the drop placement data .

7. References

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