PRINTHEAD NOZZLE STATUS DETECTION

Sebastian Filliger of iPrint, discusses the development of a solution for printhead nozzle status detection, in partnership with STEINEMANN DPE and Polytype AG

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iPrint is a digital printing research institute affiliated with the School of Engineering and Architecture of Fribourg, Switzerland (HEIA-FR), member of the University of Applied Sciences and Arts Western Switzerland (HES-SO). The institute collaborated with STEINEMANN DPE (a KURZ company) and Polytype AG.

iPrint developed and tested specialised sensing hardware and analysis software that Polytype AG integrated into their printhead drive board. This technology enables the evaluation of jetting performance in individual nozzles without the need for image processing. The system was tested extensively under real industrial-printing conditions by STEINEMANN DPE. Results show that significant reductions in production costs can be achieved.

PRINTHEAD NOZZLE STATUS DETECTION

Thanks to its high productivity rates and compatibility with a variety of fluids and substrates, inkjet is increasingly becoming the solution of choice for digital production. The heart of the inkjet system is the printhead, a sophisticated device capable of depositing ink accurately and on demand through thousands of independent nozzles. However, this complexity makes printheads somewhat delicate and difficult to service. By developing a more efficient way to detect the status of individual nozzles, iPrint and its partners are addressing the industry's need for better printhead maintenance and error-detection systems.

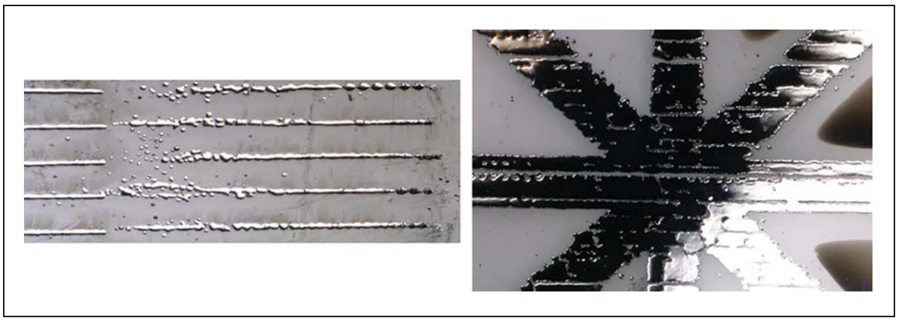

Figure 1: Printing defects caused by the loss of a nozzle

"Results show that significant reductions in production costs can be achieved"

A common issue with printheads is the loss or deviation of a nozzle during printing, which often results in visible product defects (see Figure 1).

CURRENT COSTLY SOLUTIONS

The error-detection solutions, presently available to the industry, are expensive and inefficient. Most systems are based on optical inspection of the printed product and are thus limited to specific printing patterns. Inspection also requires production halts and lengthy maintenance cycles that cause production loss, ink wastage and printhead wear and tear. Not surprisingly, few companies actually employ such systems. Most prefer to rely solely on operator observation.

SENSING SYSTEM

The innovative sensing process uses the nozzle's piezo-actuator as a sensor. The driving of the actuator creates pressure waves within the fluid. These waves bounce back and forth inside the nozzle chamber, exerting pressure back onto the actuator. This results in a small, but measurable, current that is directly proportional to the change of pressure (see Figure 2).

In addition to identifying defective nozzles, the sensing system is able to determine the likely cause of the failure. This is made possible by the fact that different nozzle malfunctions change the reflection pattern in a variety of ways (see Figure 3).

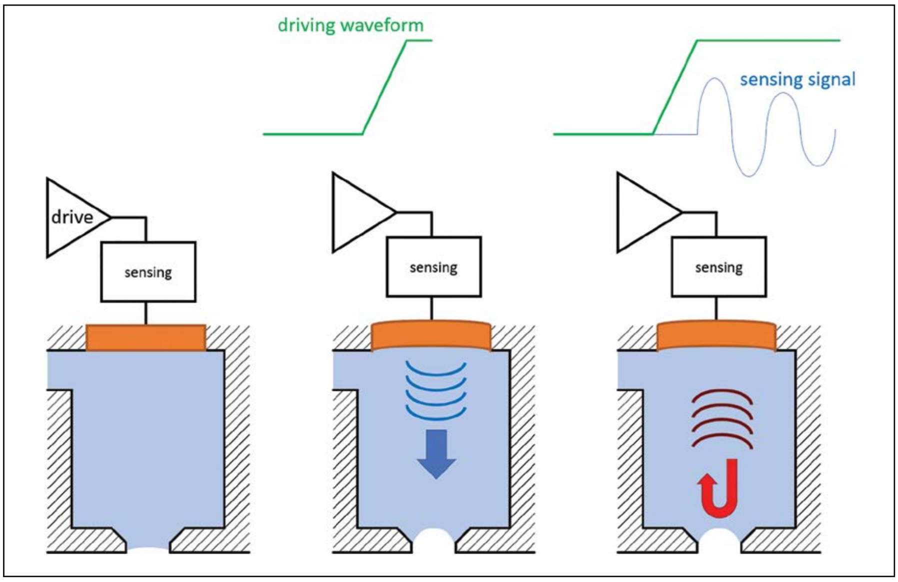

Figure 2: Illustration of the sensing process. The actuator is driven, inducing pressure waves. After activation, the current is measured, yielding a sensing signal

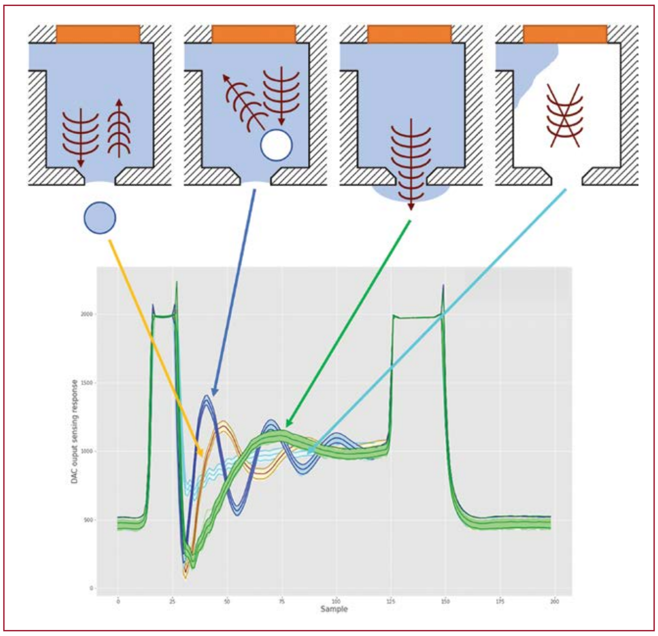

Figure 3: The reflection patterns and corresponding sensing system outputs caused by normal jetting (yellow), an air bubble in the nozzle chamber (dark blue), nozzle plate wetting (green) and nozzle chamber drying (light blue)

PROJECT CONTRIBUTIONS

The feasibility of nozzle-status detection, based on pressure waves, had been scientifically established prior to the start of the project. The main contribution, made by iPrint and its partners, was to successfully industrialise the system. To be able to test the experimental sensing system on a real printer, a transparent intermediate system had to be developed. Placed between the existing print system and the printhead, the intermediate system remains passive during printing and has no impact on the print process. Upon activation, it disconnects the print system and independently tests the printhead. The results are sent to a database and presented to the operator.

"iPrint and its partners are addressing the industry's need for better printhead maintenance and error-detection system"

The project's second key contribution was to reduce the time of measurement significantly, using field-programmable gate array (FPGA) acceleration. A measurement time below 50ms was required to avoid interference with the sheet-to-sheet (STS) process and allow for sequential testing of all nozzles.

NOZZLE CLASSIFICATION

The pressure exerted on the piezo produces a measurable signal which serves as a fingerprint for jetting performance. An algorithm calculates a fitness value for each nozzle by comparing it to various benchmark waveforms for known failure cases. If significant deviations occur, an alert is sent to the machine indicating the probable cause of failure.

All nozzles are classified as well performing, poorly performing or missing. After receiving a complete overview of the printhead, operators can rely on their own experience to decide whether or not to perform maintenance or resume printing. Automation of this decision-making process is a work-in-progress at iPrint.

OPERATION TESTING

Evaluation of the sensing system, under real industrial conditions, was carried out over a six-month period on STEINEMANN DPE's DM-MAXLINER 3D single-pass, digital-varnishing print system. Four printheads were equipped with the system. Operators regularly conducted manual nozzle checks with time stamps on the same

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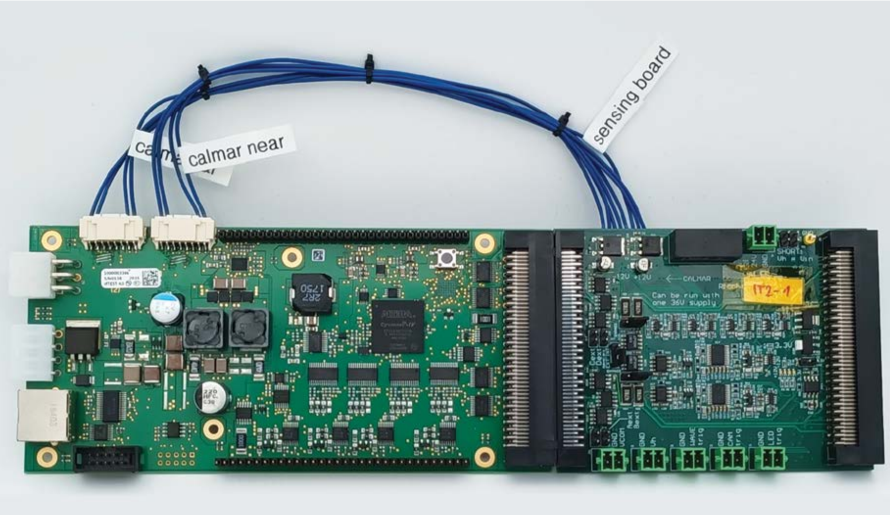

Figure 4: Existing printhead driver board on the left and additional sensing board on the right

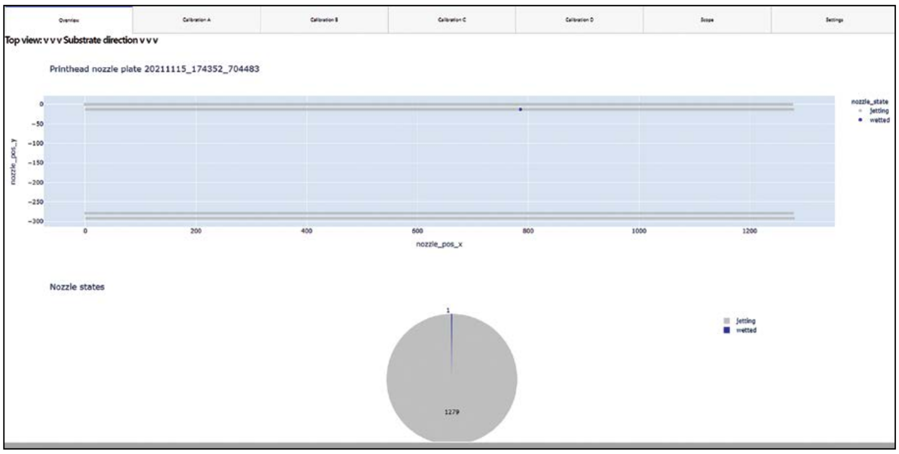

Figure 5: HMI-indicating statistics and positions of missing nozzles

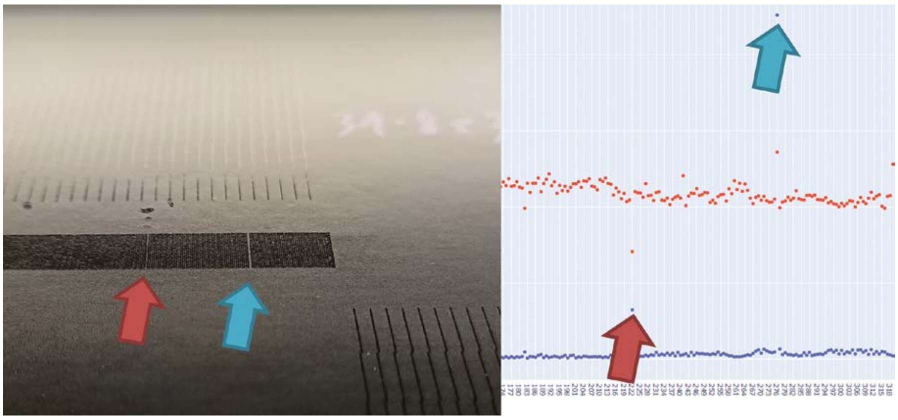

Figure 6: On the left, printing defect caused by a missing nozzle (blue arrow) and by a deviated nozzle (red arrow). On the right, the sensing system's output showing the corresponding outlying fitness values

printheads. At the end of the testing period, the classification produced by the sensing system was analysed statistically against data from the manual nozzle checks.

The results were impressive – the sensing system correctly identified 98.4% of poorly performing nozzles without producing a single false positive. Only 1.6% of poorly performing nozzles went undetected (false negatives).

"The innovative sensing process uses the nozzle's piezo-actuator as a sensor"

As shown in Figure 6, the system's output is easy to interpret. The values produced by well-performing, poorly performing and missing nozzles can be distinguished using simple thresholds.

CONCLUSION

The system can detect poorly performing and missing nozzles in an STS process within 20ms between prints. This amounts to a gap of 3.3cm at 100m/min. The detection rate of missing nozzles is 98.4% and the detection of deviated nozzles is also possible. Although, not enough data is currently available for statistical analysis. The system was tested on an industrial printer for over 6 months, without any deterioration in print quality or machine reliability.

This innovative sensing system removes the need for manual checks and makes printhead maintenance much more efficient. By relying on physical signals from the nozzle, rather than on optical inspection of the printed product, the system is able to work independently of print pattern and ink colour, and can even provide error detection for transparent inks. ■

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