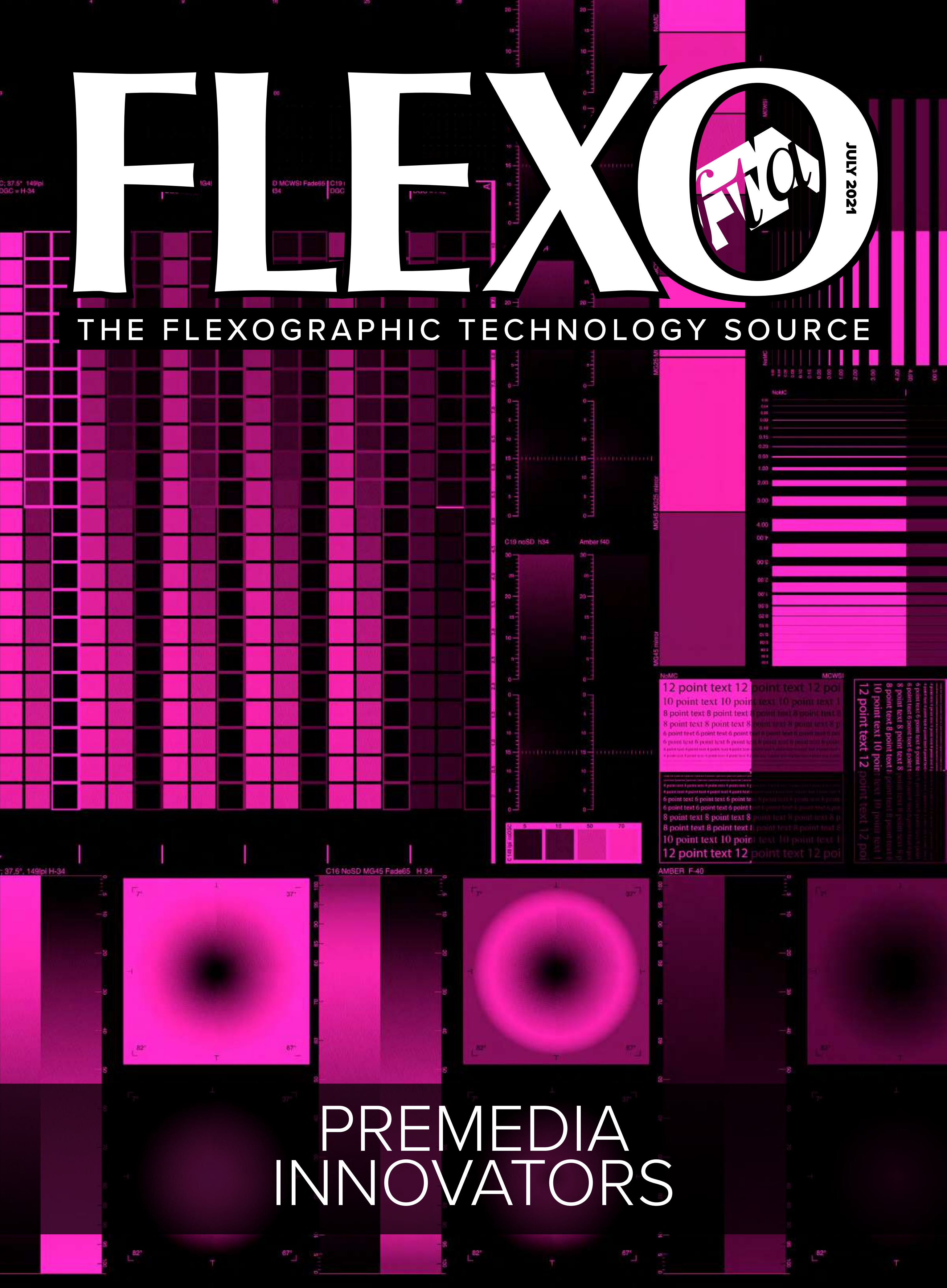
FLEXO

THE FLEXOGRAPHIC TECHNOLOGY SOURCE

JULY 2021



PREMEDIA INNOVATORS

JULY 2021 VOLUME 46, NO. 7

CONTENTS

60

54

FLEXO
THE FLEXOGRAPHIC TECHNOLOGY SOURCE

FTA
3920 Veterans Memorial Hwy Ste 9
Bohemia, NY 11716-1074
Phone: 631-737-6020

PUBLISHING DIRECTOR & PRESIDENT
Mark Cisternino, ext. 125
markc@flexography.org

ASSOCIATE PUBLISHING DIRECTOR & VICE PRESIDENT
Brad Pareso, ext. 131
bpareso@flexography.org

PUBLISHER
Robert Moran, ext. 117
rmoran@flexography.org

DIRECTOR OF EDUCATION
Joe Tuccitto, ext. 147
jtuccitto@flexography.org

DIRECTOR OF MEMBERSHIP & BUSINESS DEVELOPMENT
Jay Kaible, ext. 120
jkaible@flexography.org

CREATIVE SERVICES MANAGER
Katie Dubois, ext. 151
kdubois@flexography.org

FLEXO Magazine (ISSN-1051-7324) is published monthly by the Foundation of Flexographic Technical Association. Address all correspondence to FLEXO Magazine, 3920 Veterans Memorial Hwy Ste 9 Bohemia NY 11716-1074. Telephone: 631-737-6020. Fax: 631-737-6813. Subscriptions: 1 year: $55 U.S./$76 foreign; 2 years: $92 U.S./$125 foreign; 3 years: $125 U.S./$170 foreign. Single copies: $7 U.S./$10 foreign. Periodicals postage rates paid at Bohemia, NY 11716, and at additional mailing offices. POSTMASTER: Send address changes to FLEXO Magazine, 3920 Veterans Memorial Highway, Suite 9, Bohemia, NY 11716-1074, USA. Printed in USA. Publications Mail Sales Agreement No. 1558153. FLEXO Magazine is the official journal of the Foundation of Flexographic Technical Association, devoted to education, technical and research support to advance flexographic technology.

Excellence Via Viscosity Control

A LOOK INSIDE RHEONICS' FTA TECHNICAL INNOVATION AWARD-WINNING INKSIGHT

Dr. Joe Goodbread, Dr. Sunil Kumar & Bert Verweel

A central goal of flexographic printing is to produce the best possible print quality, most economically. In today's brand-conscious market, high print quality is of paramount importance in attracting customers and maintaining a loyal customer base.

Brand owners require the highest possible color accuracy for packaging, as brand identity is closely linked to color accuracy. Consider Coca-Cola red or Heineken green—these are emblematic for a whole range of global products. In today's world of rapidly changing and diversifying packaging for similar products, it is essential this color accuracy and consistency be maintained despite frequent and necessarily fast setup job changes.

Although much has been written about objective criteria for color quality, most boils down to reducing the Delta E value to less than 2, which is a generally accepted criterion for job approval. This approach has two shortcomings[1]:

- First of all, there is no direct path for translating spectrophotometer measurements to specific actions that either the operator or the machine can execute to correct a too-high Delta E value
- Perhaps the more serious problem is that the Delta E value is not the ultimate judge of the print's quality—it is the customer who finally decides whether or not the color is acceptable. A satisfied customer ensures better economy through less returned waste and promotes long-term business relationships through repeat orders

"ColorLock locks in the initial match of the printed color to the master; InkSight ensures this match is maintained over the entire printrun, no matter how long, and no matter how many times fresh ink must be added."

Rheonics' InkSight Viscosity Control System, a 2021 FTA Technical Innovation Award recipient in the prepress/pressroom category, was developed in cooperation with one of this article's authors, Bert Verweel, who had tried a variety of viscosity sensors and control systems and was dissatisfied with the results[2]. Among the most common shortcomings were lack of stability, reliance on cup measurements for frequent and necessary calibration, and sensitivity to contamination by ink deposits.

The Rheonics SRV viscometer, a key component in the InkSight system, answered the need for a stable, accurate and robust sensor; the InkSight was developed to support the goal of color excellence—beyond Delta E 2000—to enable the highest, most consistent color quality, both initially during job setup and throughout the longest runs, by tight, accurate and reliable viscosity control.

In this article, we will show how and why accurate control of ink viscosity is one of the most important factors contributing to the final quality of the printed image. We will start by offering experimental evidence for the link between ink viscosity and Delta E 2000 values, and how these experiments enable us to quantify the permitted viscosity variation for a given limiting value of Delta E 2000.

From this information, we can evaluate the advantages and limitations of available ink viscosity measurement systems. This will permit us to demonstrate how the measurement and control technology that forms the core of the InkSight system enables tight control of Delta E 2000 values on even the longest printruns, while minimizing setup times and operator intervention.

COLOR & VISCOSITY CONTROL

Delta E 2000 can be measured, but not controlled—In conventional flexographic printing, there is no direct way of correcting Delta E 2000, either by hand or by a control system. Therefore, the operator must have a method for translating Delta E 2000 values—as well as deviations from color master on visual inspection—into concrete actions that can improve and maintain good color matching.

Delta E 2000 can be directly linked to viscosity through color density—There is an established link between Delta E values and other printing parameters[1]. Once the operator knows how the required inks behave on the given substrate and the flexographic machine, color density emerges as the most important predictor of color accuracy. And color density, in contrast to Delta E value, is controllable by clear and explicit actions that are available to the operator.

Color density is dependent of the way that the ink film is deposited and dries on the substrate. And against intuition, more is

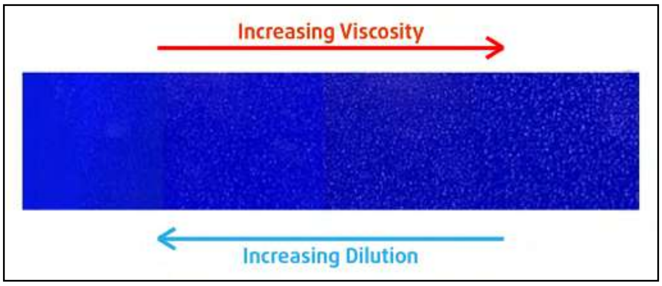


Figure 1: Color density variation with ink dilution and viscosity

ALL FIGURES AND GRAPHICS COURTESY OF RHEONICS

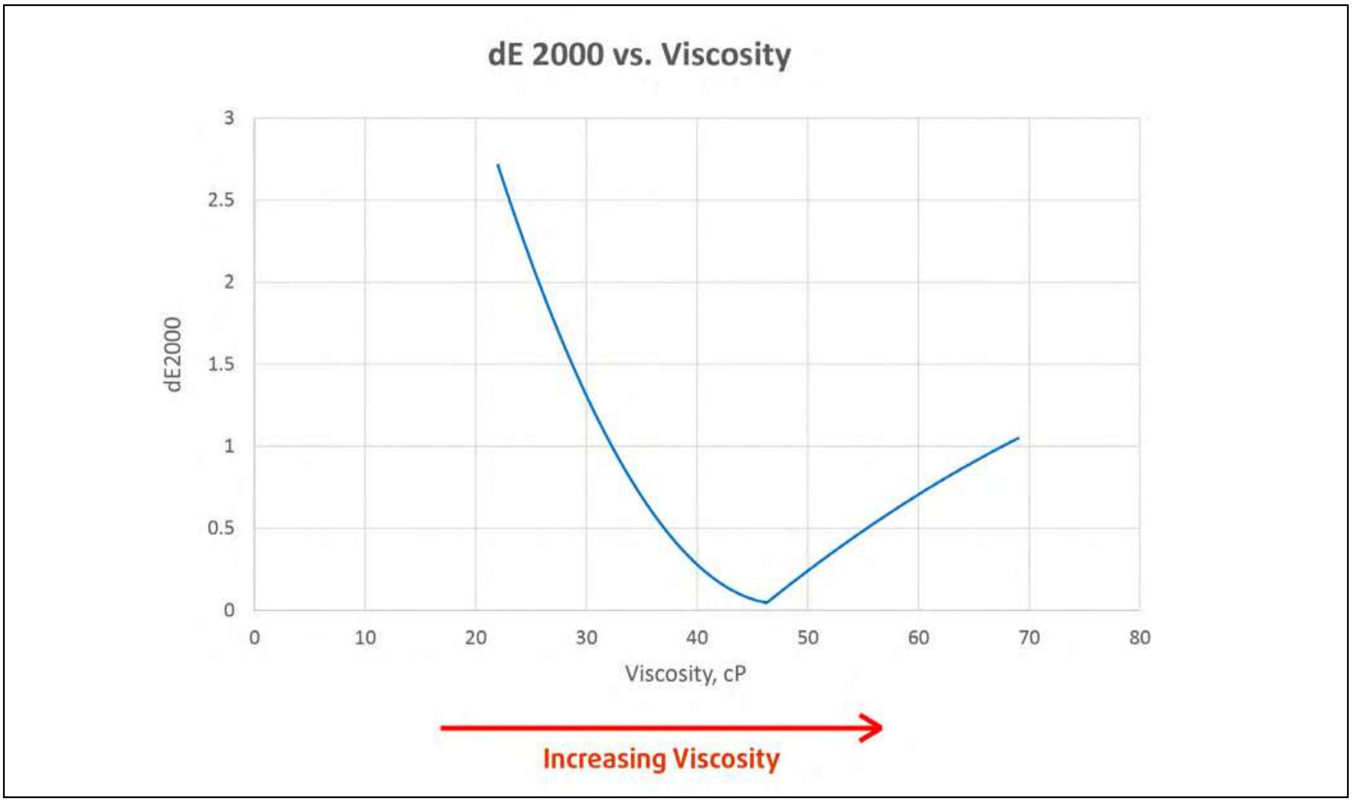


Figure 2: Delta E 2000 values as a function of ink viscosity (referred to a digital PMS reference)

not necessarily better. This is demonstrated by an experiment that is described later in this article.

VISCOSITY CONTROL IS THE KEY

Bert Verweel, one of the authors of this article, conducted a series of experiments to explore the potential of viscosity measurement and control as a means for optimizing color quality. While Delta E 2000 was one of the criteria for judging the results, visual inspection proved to be a far more sensitive test for color quality and showed the true value of accurate viscosity control.

We performed a series of experiments on the effects of ink dilution on print quality and measured ink viscosity. We will see how this then allows estimating the required accuracy of viscosity measurement in order to maintain Delta E 2000 < 2 for an entire run. In a first experiment, 10-kg. ink was diluted by 10 percent. The press was run at 200 meters/min, the polyester film was marked and the press was stopped. Ink was diluted with a further 3 percent of solvent, then circulated until the viscosity stabilized and the process was repeated a total of 15 times. The film was removed, and all 15 segments were measured with a spectrophotometer, and photographs of the film segments were made for subjective visual evaluation. *Figure 1* shows the visual appearance of the printing quality at a series of dilutions.

At the lowest dilution (highest viscosity), too much ink is deposited and does not flow properly. Pinholes develop and overall quality is poor. Although the color between the pinholes is quite dense, the measured density is low, due to the high reflectivity of the pinholes. As dilution increases, viscosity decreases and the flow improves, but pigment loading decreases and the color becomes lighter. Each sample was measured with a spectrophotometer and compared with the digital PMS reference. *Figure 2* shows the Delta E 2000 as a function of viscosity. The Delta E 2000 values are referred to a digital PMS reference.

On one end of the scale, the pigment loading is insufficient to produce the desired color density; on the other end, the viscosity is too high, leading to poor flow and pinholes in the ink layer. Between these two extremes is an optimum viscosity that produces both the optimal pigment loading flow characteristics, and therefore the desired color quality. What determines the pigment loading and viscosity of an ink? There are two contributing factors:

» The first is the ink's initial composition, the "recipe" that is used to prepare the ink as delivered by the supplier to make it ready for the printrun

» The second factor is degree of dilution—the amount of solvent added to the ink, both in the initial preparation and in later additions to keep the pigment loading and flow properties constant throughout the printrun

Both of these factors have a direct link to an easily measurable and controllable quantity: ink viscosity.

There are two takeaways from this experiment. First, Delta E 2000 isn't everything! Despite the densitometer readings indicating that the color is well within normal tolerance limits, there is a tremendous range of visual appearances that can make the difference between an acceptable print and a truly great print. Secondly, the SRV's stability and accuracy, when backed up by the InkSight control system and ColorLock software, can make this kind of color accuracy part of the routine workflow in any flexographic system. It is a solid, easy-to-use tool; not a laboratory curiosity.

When setting up a run, ink viscosity can be measured and adjusted during the mixing phase, where relative quantities of ink, varnish and solvent can be added to give the ink the desired body and color density. Once the proper viscosity has been reached, it is necessary to check the performance of the ink during the setup process, in which a sample is printed and the color compared with a master for the print. At this point, adjustments to viscosity can be made by changing the setpoint and letting the system add solvent in order to reach the desired color.

Once the proper viscosity has been established by test prints, maintaining this viscosity throughout the print job ensures constant color quality, despite the fact that ink concentration is varying as a result of evaporation. Maintaining constant ink viscosity throughout a run is the key to color consistency. Since it is measurable and controllable with high accuracy, it offers a simple and direct method for maintaining high and consistent color quality throughout even the longest printruns.

COLORLOCK

Although the Delta E value can put the strength of each color in the right ballpark, the operator's experienced eye is the last word on overall color quality. The operator makes the decision, "Good to print." Having mixed an ink recipe, the operator makes test prints to check against the print master, so that final adjustments can be made before the run is started. Once these adjustments have been made, the operator pushes a single button and InkSight takes control of color quality by adjusting the viscosities of each ink color, despite variations caused by evaporation or addition of a fresh batch of ink.

This process is called ColorLock, a feature baked into the predictive tracking control system and the operator interface of the InkSight. ColorLock locks in the initial match of the printed color to the master; InkSight ensures this match is maintained over the entire printrun, no matter how long, and no matter how many times fresh ink must be added. *Figure 3* offers a look at a ColorLock interface screenshot.

Let's take a look inside the InkSight to see how all the parts work together to give truly great color quality.

UNDER THE HOOD

InkSight is built on three pillars: Rheonics' SRV viscosity sensor, the predictive tracking control system, and the ColorLock display and user interface. These three subsystems work in concert to give the finetuned viscosity control that is essential for accurate and consistent color.

The first pillar on which InkSight rests is the Rheonics SRV viscometer. Based on patented[3] symmetric resonator[4] technology, the SRV unites the essential characteristics of accuracy, reproducibility, and robustness in a small and easily installed viscometer probe (see *Figure 4*).

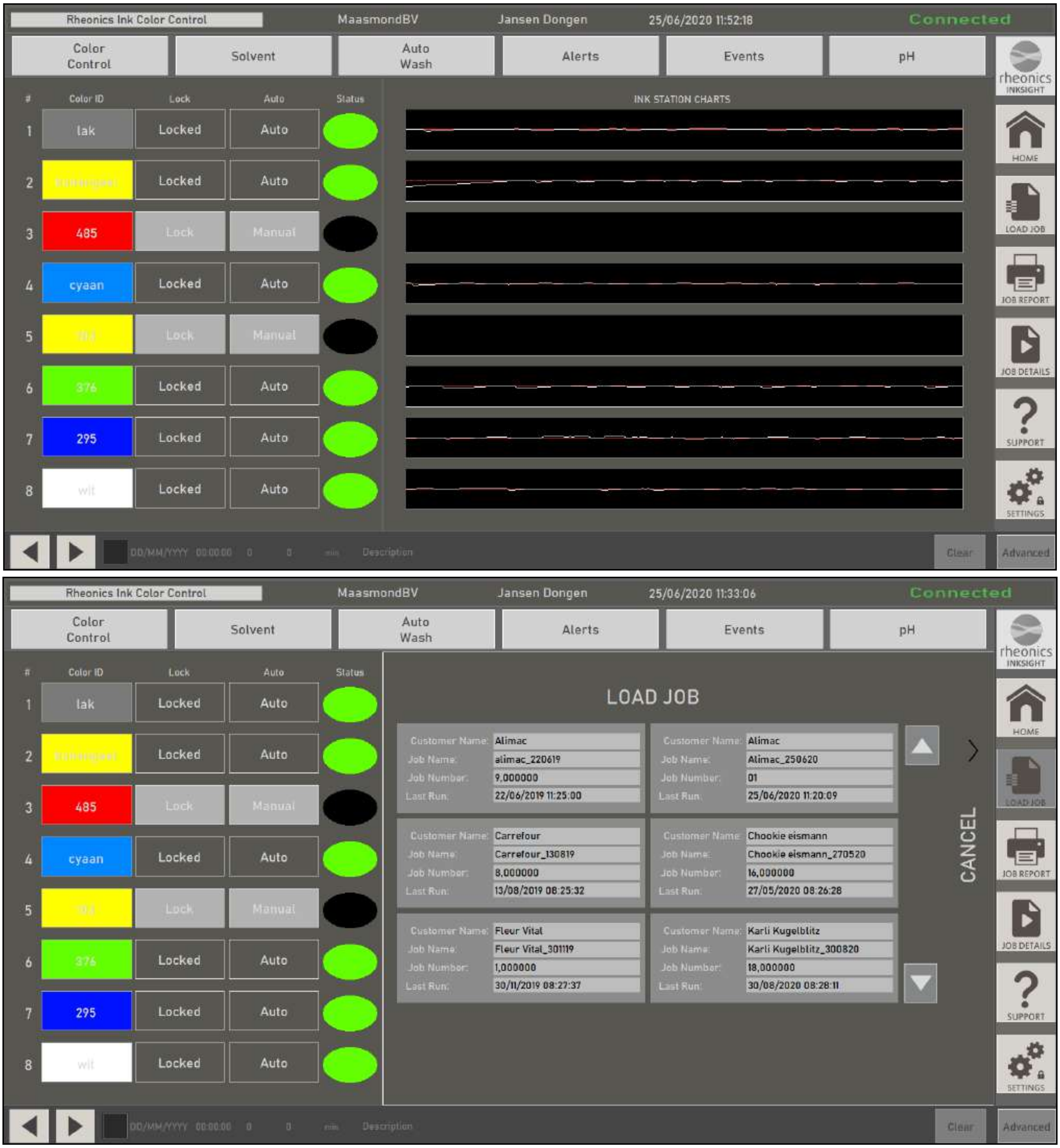


Figure 3: ColorLock interface screenshot (top) showing 8-station press with six stations active and (bottom) loading a pre-existing job for repeat run

Figure 4: Inline viscometer, a Rheonics SRV

Sensor accuracy enables drastically shortened setup times. Once an ink recipe has been established for a given job, it can be filed for re-use, whenever the customer order is repeated. The SRV's accuracy ensures InkSight will set precisely the same viscosity, from the beginning of a run, through reel changes and ink additions, through any number of re-orders of the same job. This means that after the initial setup the first time a job is run, the operator can check and lock the color from a simple and intuitive user interface, each time the job is loaded. Instead of hours, setup time is reduced to minutes, with exact matches to the job master.

The ability of the sensor to deliver the same measurement for the same ink, no matter how long the run, removes the necessity for re-calibrating the viscosity sensors each time a job is set up and run.

The SRV is self-checking; it automatically detects any deposits of dried-on inks that may have accumulated during downtime of the machine. If deposits are detected, the sensor can be easily removed and cleaned with a solvent-soaked wiper, without any danger of damaging the sensor or changing its calibration. However, in normal use, the sensor seldom needs cleaning. The SRV is only 5-in. long and 1-in. in diameter, and weighs less than one pound. Despite its compact size, it is stable, with no need for calibration, no matter how and where it is mounted on the press. It installs directly in the ink hose eliminating the need for additional space on press (see *Figure 5*).

While the SRV measures the viscosity of the ink, the controller keeps it constant. The InkSight control system compares the measured viscosity to a value set during the ColorLock process and uses a predictive tracking control method to maintain this

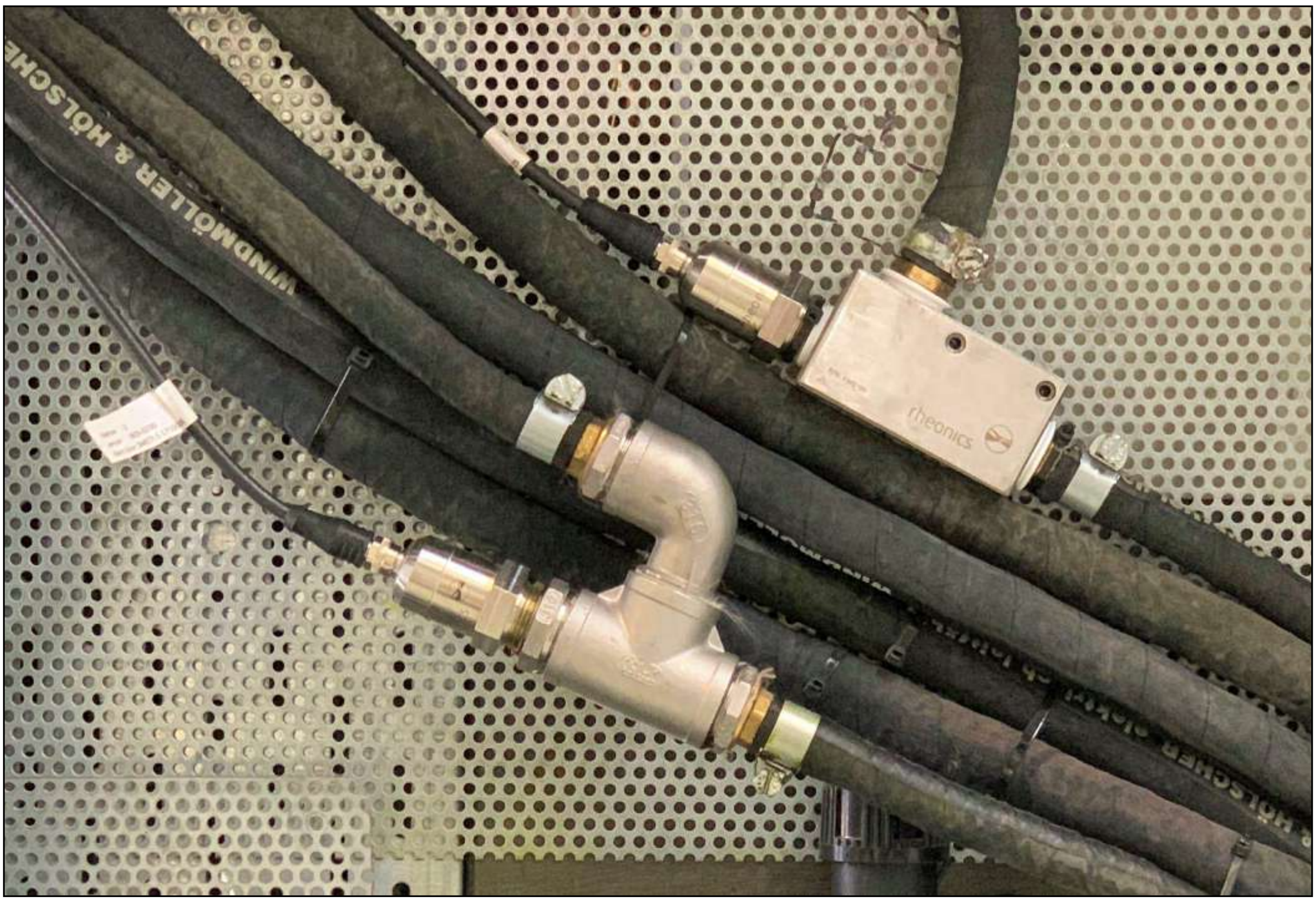


Figure 5: Two SRV inline viscometers installed on the ink hoses from pump to the doctor chamber

Figure 6: (a) InkSight predictive tracking controller and (b) W&H Primaflex CS 8-station with InkSight system integrated in the press as a modular unit

viscosity, regardless of evaporation, temperature or addition of fresh batches of ink.

Through a system of valves, it controls the addition of solvent to the ink circuit to keep viscosity constant, despite solvent loss through evaporation. Thanks to the accuracy of the control system and the stability of the SRV, viscosity variation can routinely be held to ± 0.2-cP., or about 0.04 cup seconds. Such fine variation cannot even be measured with an efflux cup; in contrast when the sensors in a viscosity control system must be calibrated using cups, achieving this level of repeatable accuracy is out of the question.

And even the most accurate sensors calibrated against an unreliable standard cannot deliver the short setup times offered by the InkSight (see *Figure 6*).

The third pillar of InkSight is the ColorLock user interface. This enables the operator to match the printed color with the master, and lock on to it with a single button on the ColorLock touch-screen interface. Generally, the ink recipes for use with InkSight are prepared with less than the final amount of solvent, so that the dilution can be increased to the desired level by the control system. That way, the system recognizes that the ink is too viscous, and doses solvent according to a built-in algorithm to bring the ink to the correct working viscosity.

This takes only minutes and is done fully automatically, thanks to the "turbo" mode, which can add larger doses of solvent just after fresh ink is added, and switch into the normal fine-control mode, as soon as the ink comes to the proper working viscosity. It eliminates the danger of over-dilution, which could require remixing of the entire contents of the bucket, and saves valuable time for operators by eliminating need for exact ink dilution. This is possible only with a fast, stable, accurate viscometer like the Rheonics SRV.

INKSIGHT IN USE

InkSight has two basic modes: startup and run. During startup, the ink recipe is mixed and added to the ink bucket. The system is started and an initial viscosity set point is selected. If this is a re-run of a job, then the previous job specification is selected and loaded through the ColorLock touchscreen (see *Figure 7*).

The InkSight takes over viscosity control. In the screen shot from a startup process seen in *Figure 8*, the viscosity is about 9-cP. higher than the initial setpoint, calling for a large addition of solvent. The operator confirms switching to turbo mode,

Figure 7: Inksight Colorlock HMI co-located with the main press console

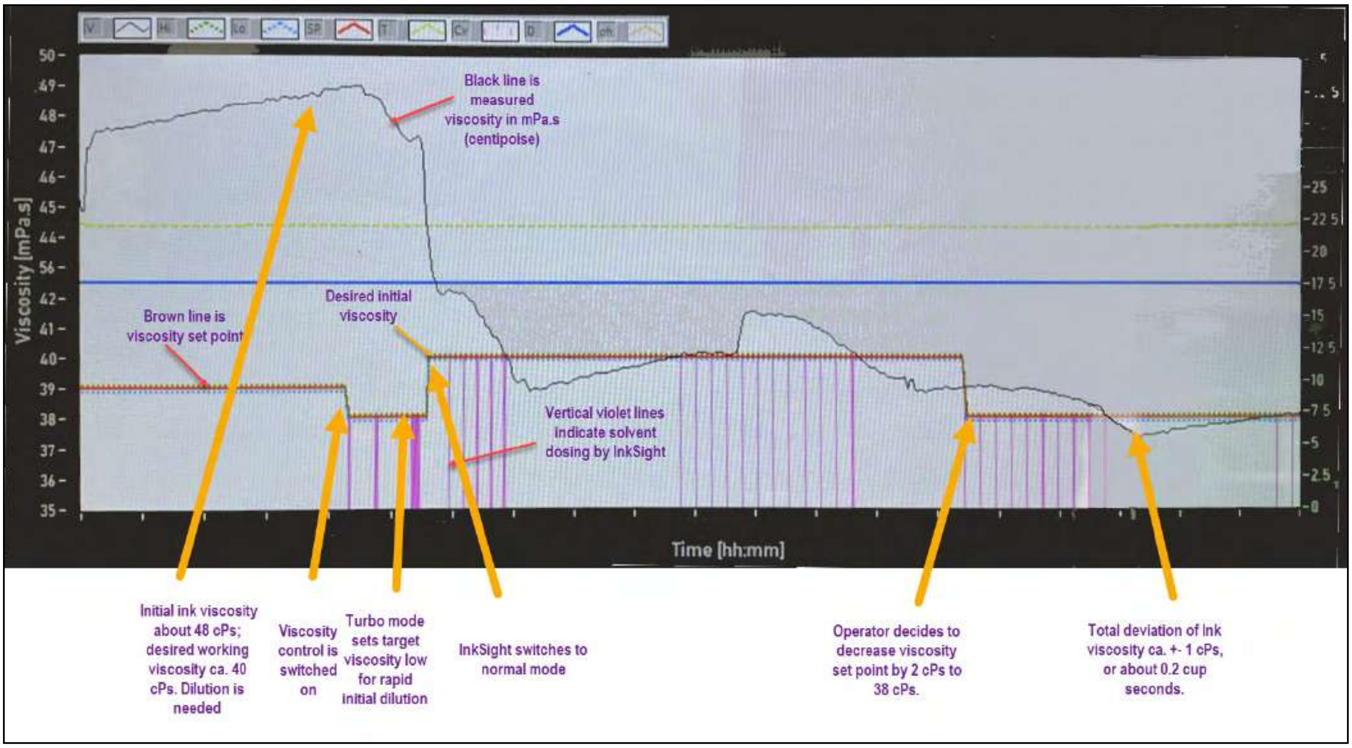


Figure 8: Startup process showing fast, autonomous stabilization of ink viscosity to set point

which adds larger doses of solvent to quickly bring the viscosity into the correct range. When the viscosity approaches the proper setpoint, turbo mode disengages, and the viscosity stabilizes to within about ± 1-cP. (about 0.2 cup seconds) of the new set point. The operator examines the sample print and decides (in this case) that a slightly lower viscosity is needed to match the master. The set point is bumped down by about 2-cP., the operator pushes the ColorLock button and the run proceeds.

Figure 9 shows the viscosity of an ink before and after addition of fresh ink to the bucket (taken from a log file generated by InkSight). Notice that the viscosity fluctuates between about 38.7 and 39.2, or ± 0.5-cP. before and after ink is added. This corresponds to a viscosity of about ± 0.1 cup seconds! Such small variations are impossible to measure with a cup[5]—and therefore, are meaningless when applied to a sensor that has been calibrated against a cup, as is necessary with many other ink viscometers.

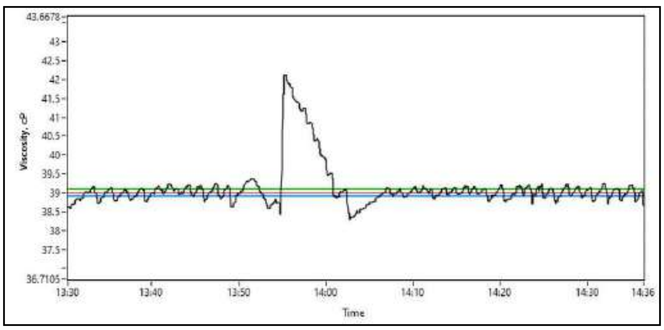


Figure 9: Response of InkSight system to addition of fresh ink during a run—within five minutes, the system brings freshly added ink to operational viscosity setpoint

Finally, *Figure 10* is a series of measurements taken from a print job of 24,500 meters, and 13 reels. The run was interrupted several times, and so was printed on five different days, and in part at different speeds (at around 150 meters/minute). Despite the long time span and the interruptions, the Delta E 2000 value never exceeded 1.8.

Over the entire course of this print job, the SRV viscometers were never re-calibrated, nor were they cleaned. The individual runs were simply loaded from the ColorLock screen and continued from where it last left off. The ink recipe remained the same throughout the run. It should be pointed out that over three years of operation of InkSight on the press, the sensors have never needed removal for external cleaning. This has been confirmed by other customers using InkSight on their presses. InkSight was built to work in the background without requiring any maintenance or intervention. Its sophistication is purposely hidden behind a simple, intuitive, single-click interface.

The data speaks for itself. This control process is backed up by a multi-faceted data storage and reporting system. A real-time view allows monitoring the printrun and issues alerts to the operator when process parameters are outside of preset limits, as when a solvent bucket unexpectedly runs dry. It prepares a job report to keep the production supervisor informed about the

Figure 10: (a) Delta E 2000 for a run of 24,500 meters spread over five days and 13 reels, (b) sample of print

progress of the run. In addition, it supplies a data stream to feed back to the factory IoT systems for full traceability of every job.

This is the InkSight approach to ink viscosity control in flexographic printing. We have shown how the Rheonics system offers both greater agility—through reduced setup times—and high color consistency over the longest runs. But perhaps the greatest advantage is the system's ability to deliver this performance with only minimal operator intervention. This leads operators to place their trust in the system—from initial setup, to consistent runs, to re-loading of repeat jobs. It also has the side effect of encouraging operators to use greater care in the initial ink mixing process, since they know this effort will be accurately supported by the InkSight system's reproducible accuracy.

The end effect is that higher quality color can be delivered to discriminating brand owners with less effort, lower cost and greater operator satisfaction. And pride in the finished product has always been a hallmark of the printing industry. ■

UPCOMING FTA MEMBERNAR

Listen to Rheonics' Dr. Joe Goodbread discuss the InkSight Viscosity Control System at the September 16 FTA Membernar—free to attend for FTA members.

Learn more and register at www.flexography.org/membernars

REFERENCES

1. Team Flexo. 'Running to Delta E (dE)' Objectively Quantify Pressroom Color. [Online]. Available from: www.spoton-color.com/pdf/sof_white_paper_11-18_final.pdf [Accessed: July 7, 2021]

2. Verweel B. and Goodbread J. Viscosity Standardization: One printer's approach to controlling a critical variable in label & flexible package production. FLEXO Magazine, February 2021, pp. 52-59.

3. Hausler K. and Goodbread J. Fluid properties measurement device having a symmetric resonator. US9267872B2 (Patent) 2011.

4. Rheonics. Whitepaper: Rheonics vibrational sensor technology demystified. [Online]. Available from: https://rheonics.com/whitepapers/ [Accessed July 7, 2021].

5. Hebert V. Beyond the Zahn Cup. Paint & Coatings Industry Magazine. [Online] October 1, 2008. Available from: www.pcimag.com/articles/88259-beyond-the-zahn-cup [Accessed July 7, 2021].

ABOUT THE AUTHORS: *Dr. Joe Goodbread, chief technology officer at Rheonics, is a founding member of the team that developed the firm's core technologies over the past 30 years. He established and directed the Experimental Mechanics Laboratory at the Institute for Mechanics, ETH Zurich. He has developed substantial IP in the field of fluid properties sensors with 11 granted patents and several more pending. He has a B.S. in aerospace and mechanical engineering Science from Princeton University, a M.S. in biomechanics from Stanford University, and a Dr. Techn. Sc. in biomechanics from the ETH Zurich.*


Goodbread

Dr. Sunil Kumar, chief executive officer at Rheonics, has extensive experience in the sensors and energy sector, having worked in a variety of roles in engineering and research in his early career. Most recently Sunil worked at Baker Hughes, where he led global engineering for drilling services. He graduated with a bachelor's in aerospace from Indian Institute of Technology, Kharagpur, and holds a master's in mechanical engineering from University of California, Irvine and a Ph.D in electrical engineering from Imperial College, London, where he developed the Seis-SP seismometer that is part of the main payload for the NASA Insight mission to Mars.


Kumar

Bert Verweel is the owner of Maasmond Papierindustrie bv Oostvoorne in the Netherlands. He earned his bachelor's degree in mechanical engineering from TU Delft, and has 25 years' experience in flexographic printing, laminating, engineering, and biological treatment of air emissions. Over the years, he has tested multiple types of inline sensors for ink viscosity monitoring and control. Maasmond is a family-owned company with 50 years of experience in converting of paper and plastics. For the converting of food and non-food packaging and labels, it houses a broad range of modern narrow and wide web flexographic printing presses, laminating, and slitting, diecutting and perforating machines.


Verweel

The authors would like to acknowledge the contributions of Maybemar Hernandez and Manpreet Dash in preparing this article, as well as those early adopters who generously put their trust in early versions of InkSight.