Enhancing Quality and Standardization in Flexographic Printing: the need to embrace Big Data

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Abstract

The most valuable asset of a printing company lies in the optimal technical performance of the printing machine, which must be given the highest priority in ensuring quality. Whilst flexographic (flexo) printing for flexible packaging has seen significant growth, notably with the integration of ECG, itself reducing costs by minimising the need for spot colour inks and supporting sustainability by reducing ink waste, many companies still lack the in-house expertise to manage the complexity of Big Data required for ECG implementation, often relying on third-party advisors. This article explores advancements and challenges in flexographic (flexo) printing, particularly those related to managing quality and achieving standardization requirements when implementing Extended Colour Gamut (ECG) printing, often reverting to third-party support. The core challenge lies in the plethora of variables reported by the flexo printing machine, forming the record of long-term running performance, effectively summing to constitute a repository of Big Data. In the context of this paper, Big Data refers to the extensive array of physical and chemical variables recorded by the flexographic printing machine throughout its operational lifecycle. Big Data, in this sense, provides the foundation for process optimization, predictive maintenance, quality assurance, and colour standardization across production runs. Other variables, such as printing plates, double-sided adhesive tapes, and anilox rollers, play an essential role in the process. They are regarded as consumables with significantly shorter lifespans than the printing machine itself, and their impact on quality can be more readily judged and corrected in real time. Unlike other printing methods like offset, which benefit from clear ISO guidelines to achieve standardization, flexo printing, in comparison, lacks a formal standardization process, making it difficult to maintain consistent control of image quality and colour reproduction arising from factors such as pressure settings and image raster adjustment. To eliminate this contradiction, a corresponding process has been initiated in cooperation with market leaders and FOGRA, which will be launched in 2025.[3] Companies must tackle these challenges by establishing internal capabilities for handling their machine-reported Big Data, including machine fingerprinting and monitoring critical variables within the production process. To adopt ECG effectively, companies must assess data availability, internal plate production, and compliance with quality standards. The significance of skilled in-house engineers who are experts in colour management, quality control, and data analysis cannot be underestimated. As digitalization advances in flexo printing, the role of these professionals becomes vital for maintaining consistent quality and operational efficiency through the control of Big Data, requiring a comprehensive understanding of the entire value chain and precise control over all variables in the printing process. The article concludes that with appropriate standards and in-house expertise, companies can successfully implement ECG, ensuring the quality and consistency of their printed products worldwide. This is reflected in those cases where companies successfully implement ECG printing systems.

Introduction

Modern technologies in flexible packaging printing have reached new heights with the implementation of an extended colour gamut. The latest digital inkjet technology streamlines this process, as advanced printhead nozzles enable precise pixel manipulation and complete control over process colour ink application on various substrates.

Adhering to ISO 12647-2 [6] and Process Standard Offset (PSO) [7] requirements has ensured high-quality process monitoring for advertising

and publications printed using offset technology. These standards outline comprehensive value-chain datasets and colorimetric values specific to each printing technology.

In contrast, this standard-based advantage is absent when discussing meeting the quality requirements in gravure and flexographic (flexo) printing. This is particularly evident in how well print providers can control image raster Colour Value Increases (CVI) and their relation to the applied pressure on printing forms and substrates. We are consistently confronted with the challenge of assessing how effectively these processes can be standardized to ensure a unified value chain and repeatable production outcomes in daily manufacturing. While these ongoing challenges are often disregarded, flexo printing for flexible or corrugated packaging continues to lack progress in standardizing processes, leaving many companies to depend on in-house management and external expertise to analyze and define suitable colour spaces for their key investments, including those for new printing machines. Only a few major players in the global flexible packaging market appear to be positioned to value their assets fully by controlling their flexo printing machines, as reported by Big Data, thereby minimizing risks associated with third parties.

This article discusses the advancements and challenges in flexographic (flexo) printing technology, particularly those related to managing Big Data to provide complete process control when implementing Extended Colour Gamut (ECG) printing.

This article aims to address the following issues:

1. Do flexo printing companies manage their value chain and printing machine reporting Big Data, and if so, how?
2. Are flexo printing companies fully aware of their most critical assets—specifically, printing machine fingerprint conditions—and able to control them daily?

During the undersigned's visits to various flexographic printing providers, it was observed that data management is frequently outsourced to third-party reproduction houses. Historically, reproduction house services were convenient for supplying flexographic printing plates; however, with the digitalization of printing processes, in-house expertise has become essential for monitoring and adjusting printing variables daily.

With the digitalization of printing processes and the advent of high-tech flexographic standard impression cylinder (CI) presses (or modular presses), in-house expertise is essential to monitor and adjust printing variables daily. Therefore, having skilled printing technology engineers on-site is becoming a critical asset for any significant print service provider. These professionals must possess comprehensive knowledge of colour management and the entire value chain, as well as the ability to analyze data and implement corrective measures to eliminate issues and maintain or improve quality. Use of the Simplex method to optimize CMYK input values so that, after printing, the measured TVI matches a target TVI curve (such as ISO 12647-2 and 12647-6 standards). The Simplex Search is based on the Nelder-Mead Simplex Method, is a direct search method used to find the minimum (or maximum) of a function in a multi-parameter (n-dimensional)

space.
Notably, parallel to the analytical needs of the print service provider sector, many flexo machine manufacturers now operate their own repro and plate-making departments—a further indication of the growing importance of pan-industry Big Data control.

Factors to consider before adopting ECG in flexographic printing

In the early 2000s, the undersigned participated in a project at a world-leading flexo print service provider that pioneered the Extended Colour Gamut (ECG) printing process using the Opaltone system. This company successfully implemented ECG across all group operations by controlling their entire value chain's Big Data. This innovation significantly reduced costs, mainly by minimizing the need for spot colour inks, and supported sustainability by reducing the leftovers of waste inks. Due to the implementation of ECG technology in flexo technology and cooperation with creative agencies, the aforementioned printing service provider did not have to deal with mixing spot colours and could leave ECG printing inks in the machine. As a result, machine downtime due to wash time for colour changes was reduced and production throughput increased.

Implementing ECG in flexographically printed packaging has become a significant trend, yet many companies lack in-house expertise and turn to third-party advisors. There are many consulting companies, but the standardization process and continuous quality improvement require daily presence.

Before adopting ECG, factors to consider include the availability of comprehensive Big Data, in-house production of flexographic plates, adherence to quality standards, and expertise in colour management.

Approximately 25 years later, the implementation of ECG in flexo-printed packaging has become a significant trend. Still, often many companies feel compelled to give up the quest because of the lack of access to in-house competence. This has led to a growth in resorting to third-party advisors offering ECG implementation services. Despite specific expertise residing with such advisors, the essential connection between raw materials, machine design, parameters and reproducibility of graphic requirements is, by definition, lacking when the expertise is not physically in-house and on board daily. Especially in the case of remote monitoring, the parameter input remains insufficient, whilst the quantity becomes overwhelming.

Before implementing ECG (Extended Colour Gamut) printing, companies must carefully evaluate the following factors, grounded in logical reasoning and deductive analysis by the Nelder-Mead Simplex Method.

Applying the first stage Nelder-Mead method to a 4-colour printing process:

a. Start with 5 CMYK combinations;
b. Simulate or measure the TVI response from each;
c. Compute the sum of squared errors to the target;
d. Iterate via reflection, expansion, contraction, or shrinkage;
e. Stop when ΔTVI is minimized.

1. The **availability** of a comprehensive printing machine for Big Data for four-colour process printing

a. A **critical challenge** in four-colour process printing is maintaining stability daily. The in-house quality department must monitor the following key variables:

b. **Pressure setting** based on the ma chine fingerprint data, which directly affects colour reproduction during printing

Figure 1 Four colour printing control patches. [1] [3]

c. **Achieving stable pressure values** to establish a correlation between the pressure settings during the finger printing process and the optimal colour shades on the substrate.

d. Accuracy in the secondary colours is required to monitor consistent print quality in four-colour process printing.

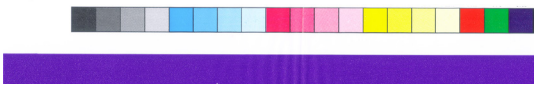

Figure 2 Four colour printing control patches with overprint control patches [1] [3]

2. **Consistency** in the in-house production of flexographic printing plates [2]

a. Producing flexo plates internally offers advantages such as increased speed, security for proprietary processes, and intellectual property protection.

b. In-house production allows for faster resolution of non-conformities, minimizing interruptions to manufacturing processes.

3) Adhering to four-colour process print ing quality standards (i.e. ISO 12647-6)

a. The correlation between ink pigmentation and printing ink viscosity. Defining the ink pigmentation percentages and their relationship to ink viscosity settings is essential for standardizing the print process.

b. The correlation between the chosen anilox rollers and press performance. Using the appropriate anilox roll specification (lines per cm or lines per inch) ensures optimal ink performance and consistent ΔE values.

Table 1 List of optimal ΔE values during the print process [3]

Substrate ΔE_{00}	All patches ΔE_{00}		Maximum ΔC_h composed grey
	Mean	95% quantile	
A.0	B.5	C.0	D.5

c. When monitoring critical variables, the colorimetric tone value (CTV) needs to align with the pressure settings (1 b.) and stability measures (1 d.).

d. Ensuring compatibility between the smallest dot size and the chosen anilox roller results in effective print repro duction and avoids dot dunking.

4) In-house colour management expertise

a. Establishing in-house standards that align with international requirements (ISO 12647-6) ensures print uniformity.

b. Having the necessary tools available for daily quality assurance, like spectrophotometers, dot size and dot shape evaluation devices, and ICC profiling tools, ensures consistent print quality.

c. The quality control personnel should possess expertise in optical phys ics and colour theory to perform logi-

cal and deductive analysis of the daily manufacturing data.

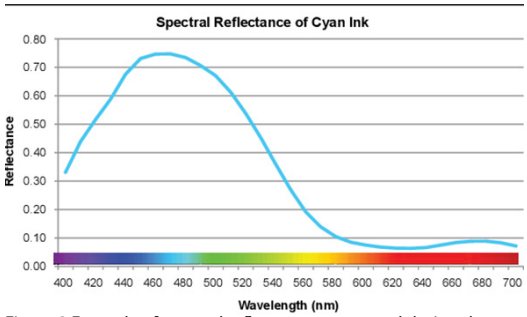

Figure 3 Example of spectral reflectance curve used during the quality control process [8]

5) Control of key variables

a. Clear decision-making rules for material procurement and quality control need to be established.

b. Changes in materials, such as inks or adhesives, require thoroughly evaluating variables, including supplier data on ink pigmentation levels.

c. Decisions should not only be cost-driven. Reduced ink costs must be evaluat ed against pigmentation percentages (changes in ΔE towards the standard ink profile) and print mileage per kilogram.

6) Stability across shifts and over time

a. All shifts must maintain uniformity in process management, especially in multinational enterprises.

b. Key parameters must be recorded and documented during shift handovers to ensure continuity.

c. Quality control teams and manage ment staff should effectively track and analyze logged data inputs.

d. The printing company's engineers must be able to continuously improve the printing machine's printing and speed setting curves in their daily routine.

7) Current percentage of non-conformities

a. Recorded non-conformities should undergo a systematic case-by-case analysis using logical and deductive methodologies to determine the root cause of the problem.

b. Findings must be communicated to the shop floor personnel and documented by key quality management stakeholders.

c. Critical technological and quality risks should be clearly defined and methodically assessed.

8) Additional operational risk considerations

a. The process of onboarding and off boarding employees must be well-organized to ensure the continuity of in-house quality requirements.

b. Training and mentoring processes should be thoroughly recorded and updated regularly.

c. Ongoing training programs, both in-house and from third-party providers, are essential for theoretical and practical advancements.

By employing inductive reasoning, which derives conclusions from observed data, and deductive analysis, which validates these conclusions against logical frameworks, companies can make informed decisions about adopting ECG in their printing operations while guiding customers on best practices to optimize material usage in manufacturing.

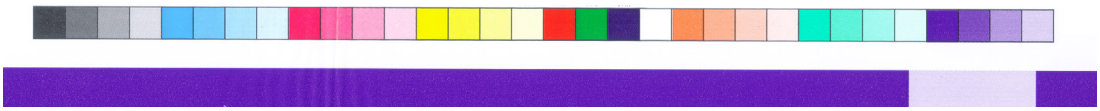

Figure 4 Colour control bar used in expanded gamut (ECG) printing

Conclusions

Companies can use inductive reasoning and deductive analysis, the Nelder-Mead Simplex Method, to make informed decisions about adopting ECG in their printing processes while advising customers on best practices to optimize material usage. Implementing ECG should not be difficult if companies adhere to clearly defined printing standards and develop in-house expertise.

If these requirements are met, implementing ECG should not be overly challenging. The key factors are installing or adhering to existing, well-defined printing standards, building in-house expertise with technology engineers' support, and adopting best practices throughout. With consistent efforts, customers and brand owners will appreciate knowing that their trademarks are safely and reliably printed using flexographic technology worldwide.

The next time you consider standardizing flexographic printing processes, don't hesitate to say, **"Yes!"** Standardization becomes a valuable investment. You can ensure your company's long-term success and competitiveness by controlling your big data and monitoring all printing variables daily.

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