Comparison Between Inline and Offline Color Management Processes for Digital Presses

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Keywords: color management, inline measurement, digital printing

Abstract

Digital presses have become one of the most efficient ways to create short-run or personalized print products. Compared to traditional printing presses, it is also easier and quicker for digital presses to make changes in color management, especially with inline measurement systems. Inline color management can not only perform automated registration and real-time color density adjustments, but also create custom ICC profiles for different substrates under different environmental and press conditions. This inline process can be added into an automated workflow to ensure color matching or G7 conformance. However, it would be interesting to know whether the color measurement accuracy of the inline process using cameras is comparable to that of the offline process using spectrophotometers.

In this study, a Konica Minolta AccurioPress C2070 at Ball State University was used to compare inline and offline profiling processes. An inline IQ-501 Intelligent Quality Optimizer installed on the press along with EFI Fiery™ Color Profiler Suite was used to create custom profiles for eight paper substrates, three uncoated and five coated. The G7 method was used for calibration and then 1,617 patches (CGATS IT8.7/4) were printed and measured inline. The offline process was the same as the inline one except that an offline EFI ES-2000 spectrophotometer was used for color measurements. The inline process took about 5 - 10 minutes to create one profile, while the offline process took about 35 - 40 minutes, which confirmed that the inline process could greatly increase efficiency.

Profiles created using inline and offline processes were evaluated and compared in CHROMiX ColorThink™ Pro. It was found that the differences in gamut volume between profiles created by inline and offline processes were less than 1% for the three uncoated substrates, while the differences ranged from 0.66% to 4.58% for the five coated substrates.

Ball State University

Introduction

Digital presses have become one of the most efficient ways to create short-run or personalized print products. Compared to traditional printing presses, it is also easier and quicker for digital presses to make changes in color management, especially with inline measurement systems. Inline color management can not only perform automated registration and real-time color density adjustments, but also create custom ICC profiles for different substrates under different environmental and press conditions [1]. This inline process can be added into an automated workflow to ensure color matching or G7 conformance [2]. Therefore, inline color management has many advantages, such as faster makeready, better process control, process improvement, proof of conformance, and reduced costs [3].

Offline measurement systems utilize spectrophotometers, which can obtain accurate color measurements, but allow for spot measurements only. Inline measurement systems currently used in printing presses typically use RGB cameras to capture color information [4]. It would be interesting to know whether the color measurement accuracy of the inline process using cameras is comparable to that of the offline process using spectrophotometers.

Experimental Procedure

In this study, a Konica Minolta AccurioPress C2070 at Ball State University was used to compare inline and offline profiling processes. An inline IQ-501 Intelligent Quality Optimizer has been installed on the press, which includes a spectrophotometer to measure the front side, and two scanners, one for the front side and one for the back side [1], as shown in Figure 1. An offline handheld EFI ES-2000 spectrophotometer is also available for measuring colors and densities. The printing process control software is EFI Fiery™ Command Station 6.8, while the color management software is EFI Fiery™ Color Profiler Suite 5.0.

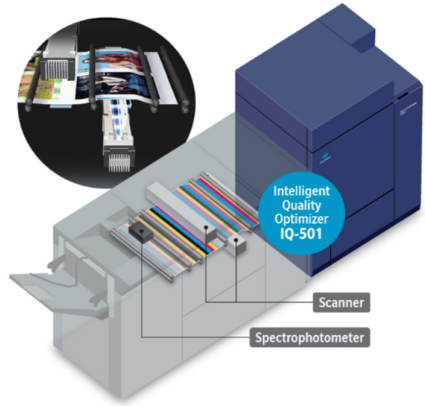

Figure 1: *Schematic of the IQ-501 Intelligent Quality Optimizer (credit: Konica Minolta)*

A total of eight different paper substrates from different manufacturers were used in this study, three uncoated and five coated, as listed in Table 1. Their basis weights ranged from 90 g/m^2 to 270 g/m^2.

Brand	*Manufacture*	*Type*	*Weight (g/m^2)*
Cougar Text	Domtar	Uncoated	118
Bold Digital	Xerox	Uncoated	105
Platinum Digital	Navigator	Uncoated	90
Flo Gloss Cover	Sappi	Coated	216
Everyday Digital	Mohawk	Coated	270
Kromekote Gloss Cover	CPI Paper	Coated	170
Sterling Gloss Cover	Verso	Coated	216
Tango Digital Cover	WestRock	Coated	195

Table 1: *Paper substrates used*

For each paper substrate, color profiles were created using both inline and offline processes. The inline profiling process included the following steps:

1. CMYK calibration: After 10 warmup pages were printed, a test chart with 51 random patches for each process color was printed and measured by the inline IQ-501 Intelligent Quality Optimizer. Measurement results were applied to calibrate CMYK curves.
2. G7 gray balance calibration: The P2P51 target was printed and measured by the inline IQ-501 Intelligent Quality Optimizer. Measurement results were applied to correct both CMY and K neutral print density curves (NPDCs), and iterate if needed.
3. ICC profiling: The CGATS IT8.7/4 target with 1,617 patches were printed and measured by the inline IQ-501 Intelligent Quality Optimizer. Measurement results were used to create an ICC profile.

The offline profiling process was the same as the inline one except that color measurements were performed manually using the EFI ES-2000 spectrophotometer, as shown in Figure 2.

Figure 2: *Offline measurement using the EFI ES-2000 spectrophotometer*

Profiles created using both inline and offline processes were analyzed in CHROMiX ColorThinkTM Pro 3.0.9. Their 2D and 3D graphs as well as gamut volumes were compared to find out their differences.

Results and Discussion

The operation time is compared first. Considering several factors such as how familiar an operator is with the process and how many iterations are needed to achieve G7 conformance, the inline process took about 5-10 minutes to create one profile, while the offline process took about 35-40 minutes, as listed in Table 2. It confirmed that the inline process could greatly increase efficiency.

Inline	***Offline***
5-10 minutes	35-40 minutes

Table 2: *Operation time comparison between the inline and offline processes*

The 2D and 3D graphs of profiles created by the inline and offline processes are compared for each substrate, as shown in Figures 3-10. In each of these figures, The profile created by the inline process is shown in red, while the one created by the offline process in green; the profile with a higher gamut volume is shown using a wireframe surface, while the one with a lower gamut volume using a solid surface.

Figure 3 shows the comparison for Cougar Text, which is an uncoated substrate. The profile created by the offline process is a little bigger, with small differences in the yellow and red-blue regions.

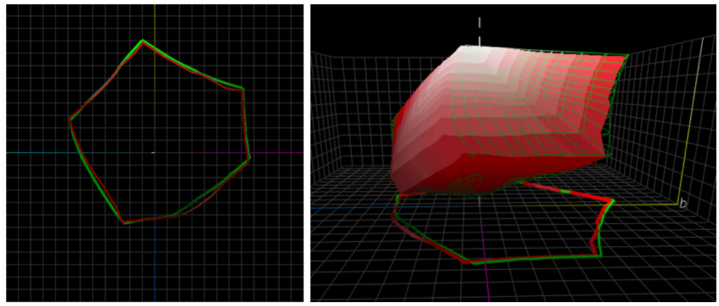

Figure 3: *Comparison between Cougar Text profiles created using the inline (red) and offline (green) processes*

Figure 4 shows the comparison for Xerox Bold Digital, which is also an uncoated substrate. The profile created by the offline process is also a little bigger, with small differences in the yellow region.

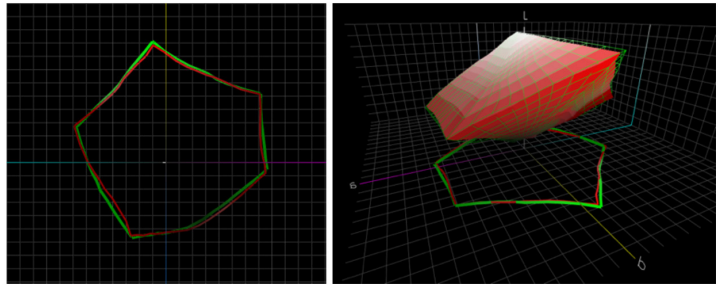

Figure 4: *Comparison between Xerox Bold Digital profiles created using the inline (red) and offline (green) processes*

Figure 5 shows the comparison for Navigator Platinum Digital, which is also an uncoated substrate. However, the profile created by the inline process is a little bigger, with differences in the yellow and red-blue regions.

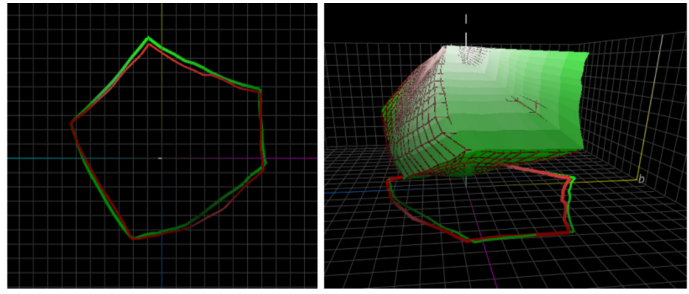

Figure 5: *Comparison between Navigator Platinum Digital profiles created using the inline (red) and offline (green) processes*

Figure 6 shows the comparison for Sappi Flo Gloss Cover, which is a coated substrate. The profile created by the offline process is a little bigger, with small differences in the yellow and green-blue regions.

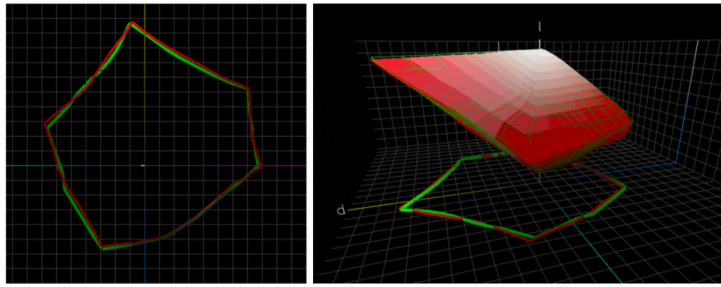

Figure 6: *Comparison between Sappi Flo Gloss Cover profiles created using the inline (red) and offline (green) processes*

Figure 7 shows the comparison for Mohawk Everyday Digital, which is also a coated substrate. However, the profile created by the inline process is a little bigger, with small differences in the green-blue region.

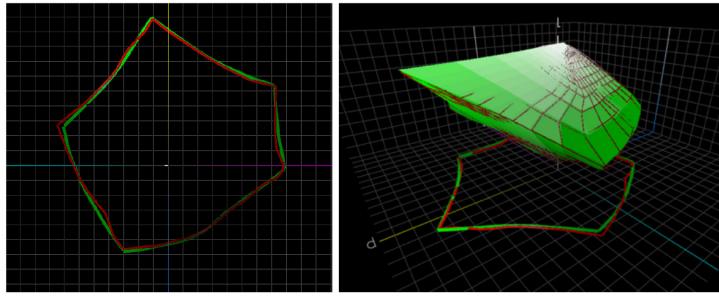

Figure 7: *Comparison between Mohawk Everyday Digital profiles created using the inline (red) and offline (green) processes*

Figure 8 shows the comparison for Kromekote Gloss Cover, which is also a coated substrate. The profile created by the inline process is a lot bigger, with very big differences in the yellow-green region.

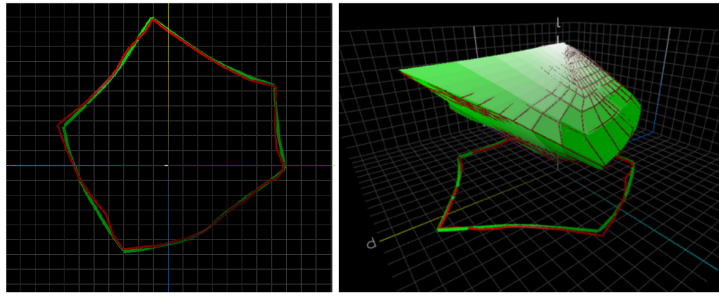

Figure 8: *Comparison between Kromekote Gloss Cover profiles created using the inline (red) and offline (green) processes*

Figure 9 shows the comparison for Sterling Gloss Cover, which is also a coated substrate. The profile created by the offline process is bigger, with big differences in the red-yellow region.

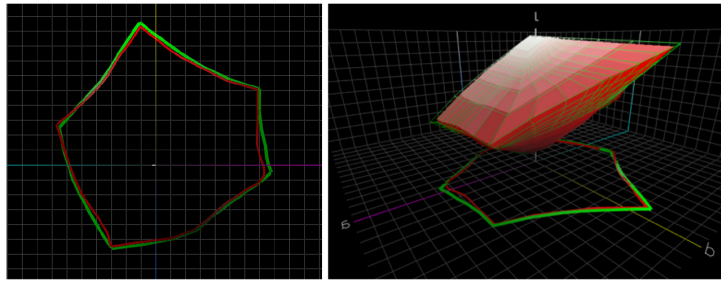

Figure 9: *Comparison between Sterling Gloss Cover profiles created using the inline (red) and offline (green) processes*

Figure 10 shows the comparison for Tango Digital Cover, which is also a coated substrate. The profile created by the offline process is a little bigger, with very small differences in the red region.

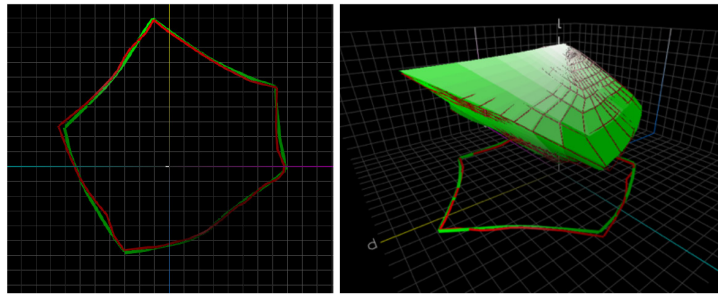

Figure 10: *Comparison between Tango Digital Cover profiles created using the inline (red) and offline (green) processes*

The difference between the two profiles created by the inline and offline processes for each substrate can be better illustrated quantitatively by the difference in gamut volume, as listed in Table 3. Since the offline process using a spectrophotometer can obtain more accurate color measurements, the gamut volume of a profile created using the offline process is regarded as the baseline to calculate the difference in percentage. A negative value means a smaller profile created by the inline process, while a positive value means a bigger one.

Substrate	**Gamut Volume**		***Difference***
	Inline	Offline	
Cougar Text	451,552	455,390	-0.84%
Xerox Bold Digital	446,759	448,916	-0.48%
Navigator Platinum Digital	386,156	382,705	0.90%
Sappi Flo Gloss Cover	437,163	442,142	-1.13%
Mohawk Everyday Digital	481,476	478,210	0.68%
Kromekote Gloss Cover	455,706	435,746	4.58%
Sterling Gloss Cover	422,435	433,831	-2.63%
Tango Digital Cover	452,295	455,282	-0.66%

Table 3: *Gamut volume comparison between profiles created using the inline and offline processes*

For the first three uncoated substrates, the absolute differences in gamut volume were less than 1%, while the absolute differences ranged from 0.66% to 4.58% for the remaining five coated substrates. The reason might be that uncoated substrates are more similar between different manufacturers, but coated substrates have various factors such as finish, brightness, and gloss that could affect color information captured by RGB cameras used in the inline process and thus measurement accuracy.

Conclusions

In this study, a Konica Minolta AccurioPress C2070 was used to compare inline and offline color management processes. Compared to the offline process which took 35-40 minutes, the inline process only took 5-10 minutes, which confirmed that the inline process could greatly increase efficiency.

In order to better understand if the color measurement accuracy of the inline process using cameras is comparable to that of the offline process using spectrophotometers, eight paper substrates, three uncoated and five coated, were used to create profiles using both processes. It was found that the differences in gamut volume between profiles created by inline and offline processes were less than 1% for the three uncoated substrates, while the differences ranged from 0.66% to 4.58% for the five coated substrates. Future studies will look at how paper properties such as coating, finish, brightness, and gloss affect inline color measurements.

References

[1] Konica Minolta, "IQ-501 Intelligent Quality Optimizer," 2019. [Online]. Available: https://kmbs.konicaminolta.us/products/production-industrial-printing/digital-press/iq-501-intelligent-quality-optimizer/. [Accessed March 2023].

[2] M. Bohan, "Automation in Color Management," The Magazine, vol. 11, no. 6, pp. 18-19, 2019.

[3] M. Sisco, "Advantages of Inline Colour Measurement: Benefits for the Printer and Brand Owner," Journal of Applied Packaging Research, vol. 8, no. 4, p. Article 8, 2016.

[4] C. Godau, M. Klammer, T. Eckhard, M. Schnitzlein, D. Nowack, B. Frei and P. Urban, "Evaluation of a multi-spectral camera system for inline color measurement.," 2013.

Acknowledgement

The author would like to thank Konica Minolta for press and material donations.