Sustainability Benefits of Expanded Gamut Printing

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Abstract

Expanded gamut printing is a relatively new technology that allows print companies to move away from spot colors and require an inventory of them on hand or order them from their ink supplier whenever a print job requires a spot color. With expanded gamut printing, the same seven colors remain in the printing units, and only the printing plates and the substrate get changed. This leads to less frequent ink changes and print unit wash-ups and allows the so-called ganging of jobs, resulting in less use of organic solvents and lower paper consumption. Also, the target printing ink densities for the seven colors were established during the characterization press runs. In turn, the press operator knows which target densities must be achieved to obtain optimum color balance, resulting in shorter make-ready times. The savings mentioned above make the operation of a print company more sustainable.

A list of currently used Pantone colors will be compiled and converted to their expanded gamut version in cooperation with a local print company. The color difference to the digital Pantone library will be determined so brand owners know there might be a color difference.

This study focuses on the sustainability aspects of expanded gamut printing. The main goal of this project is to quantify these savings so that expanded gamut printing will achieve broader acceptance in the industry based on its advantages and enhanced sustainability of the print operation.

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Introduction

Since 2019, expanded gamut printing has been the topic of many presentations at TAGA conferences. Ten presentations and papers have been published in the TAGA proceedings in the last five years [Chu, 2022] [Desphande, 2023] [El Asaleh et al., 2020] [Habekost, 2019] [Habekost, 2021] [Hoffstadt, 2019] [Joshi et al., 2021] [Lankinen, 2023] [O'Hara et al., 2019] [Quian et al., 2023]. These papers address the various aspects of expanded gamut printing with flexographic and offset printing. Expanded gamut replaces the standard four-color printing with CMYK by adding Orange, Green and Violet, expanding the ink set to CMYKOGV. These seven process colors allow printing a wide range of Pantone colors without needing spot colors.

Procedure for expanded gamut printing

For this project, the authors of this paper partnered with a local print company that wants to venture into the packaging market. The benefits of expanded gamut printing are as follows:

- No need for spot colors
- Keep the ink sequence the same in the press
- Change only the substrate and the printing plates
- Less time spent washing up print units with spot colors
- Use of less solvent
- Less time spent between press run washing up → more press runs per shit → better utilization of the press

The print company wanted to use a Heidelberg CX102 press with six print units and a coating unit for this project. Expanded gamut software is required to convert spot colors to an expanded gamut ink set, and since the press has only six printing units, CMYKOV was agreed upon as the ink set. Before spot colors can be converted to a combination of some of the expanded gamut ink set, a test chart needs to be created, printed and measured in the expanded gamut software. GMG's OpenColor software was used for this project. In a previous project by one of the authors, it was determined that this software is very efficient in the test chart creation and calculating the build of spot colors from the expanded gamut ink set [El Asaleh et al., 2020]. The first page of the test chart can be seen in Figure 1. The test chart was measured with an X-Rite iSiS in M1 mode.

Figure 1. *First page of the test chart*

The following figures show the original jobs and their converted versions.

Figure 2. *First test job with P0821 blue and P2091 violet*

Figure 3. *Converted test job in expanded gamut*

Figure 4. *Second test job with P180 orange and P247 light purple*

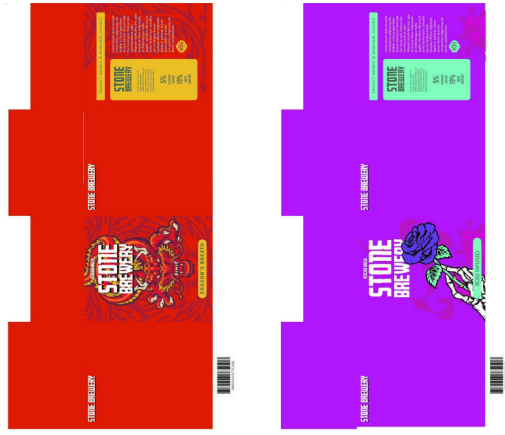

Figure 5. *The second test job converted to expanded gamut*

It must be said that this paper's color representation does not reflect the actual printed colors.

A comparison between the standard colors and the achieved colors can be seen in Figure 6.

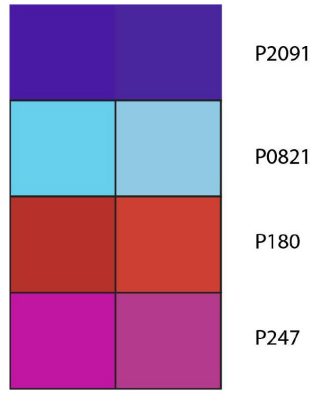

Figure 6. *A visual representation of the standard colors on the left and the achieved colors on the right*

The DE00 values predicted by OpenColor and the actual DE00 values are shown in Table 1.

	P2091	**P0821**	**P180**	**P247**
Predicted DE	1.20	3.70	0.0	5.20
Achieved DE	3.42	4.74	2.97	7.76

Table 1. *Predicted and actual DE00 values of the tested colors*

The achieved DE00 values are not bad, and these deviations were expected. Another item looked at was the tone value increase or TVI curves for the six process colors. The test chart in Figure 1 contains an area in the middle that shows the process colors in various tint percentages from 2 to 100%. These tint percentages were measured with an X-Rite eXact using the Murray-Davies equation for CMYK and SCTV for orange and violet. Figure 7 shows how these various tint percentages were distributed.

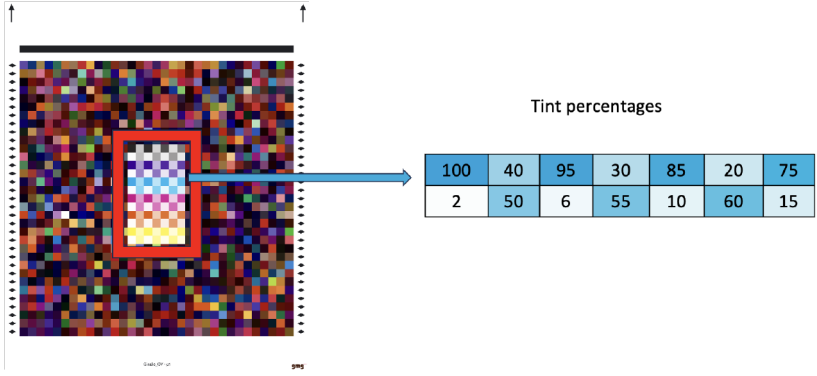

Figure 7. *The test chart area contains the process color's tint percentages.*

The TVI curves were plotted from the measurements of the tint percentages and are shown in Figure 8.

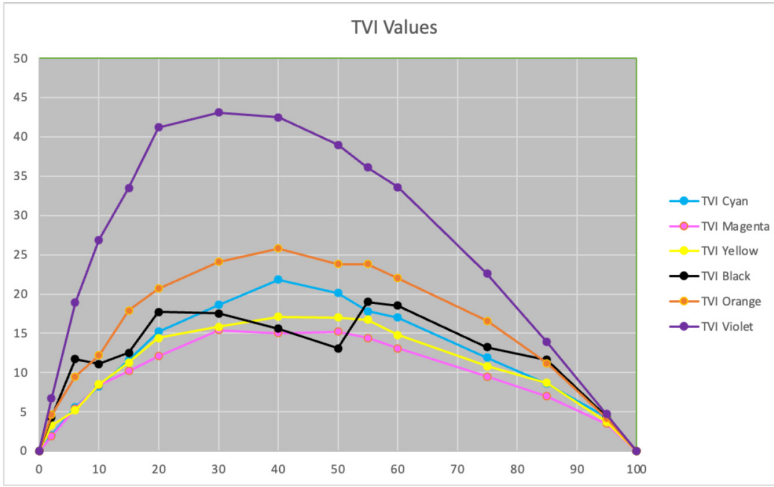

Figure 8. *TVI curves of the six process colors used in the test run*

The TVI curves for yellow, magenta, cyan and orange are more or less within a normal range of TVI. These curves show a maximum at the 40% tint when it should be at the 50% tint. The curve for the orange tint shows more gain than magenta, yellow and cyan and has a maximum gain at the 40% tint. The normal tone value increase should be between 18 and 22% for coated paper, as stated in ISO 12647-2:2013 [ISO, 2013]. The TVI curve for violet shows too much TVI overall and has a maximum of 30%. The black TVI curve shows some erratic behavior with the highest TVI at 55%.

Given these printing conditions, it is unsurprising that the DE00 values shown in Table 1 were achieved. On the other hand, it is remarkable that the expanded gamut software worked with these printing conditions to achieve somewhat desirable results.

Sustainability aspects of expanded gamut printing

Sustainability terms and the printing industry have been in the circle of awareness nowadays. Printing processes are related to pre-media processes, using printing presses and other machinery in the process, according to the product's specification and consumables like substrates, inks & varnishes. Nowadays, sustainability in the printing industry is considered an environmental issue, like using more ecological paper, inks, and chemicals and using more renewable energy. There were many activities taken in the case of application above aspects. Still, Expanded Color Gamut (ECG) is a new approach, not present widely in scientific papers. Still, there were many case studies and industry presentations during the main conferences and events like TAGA, Label Expo, and INFOFLEX.

In many research papers [Lankinen, 2023] and conference presentations, one of the main aspects of sustainability benefits of implementing the ECG in the printing company was ink savings. Typically, changing the Pantone Matching System (PMS) with thousands of mixed colors into only seven process colors like CMYK, Orange, Green, and Violet gives printing companies very profitable outcomes.

It's necessary to look deeper into the ink management system in a real-life scenario to find how substantial savings could be obtained from the inks. In a selected printing company using flexographic printing technique and 13 narrow and mid-narrow web presses and implementing a modern ink mixing station/ink kitchen, there were from 30% to 50% of inks leftovers from presses daily (Figure 9). It was related to the different construction of the ink fountains, and some of the presses needed from 2000 to even 5000 grams to start transferring the ink from the ink fountain to the anilox roller.

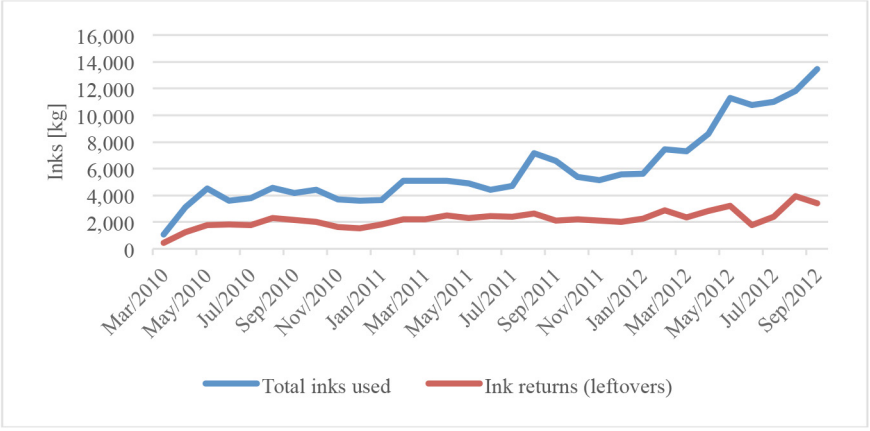

Figure 9. *Total inks prepared for production vs leftovers*

The modern ink mixing station aims to properly manage dispensed inks and – even more important – leftovers, inks returning from the presses. There were always inks returned from the press due to ink fountain construction allowing ink transfer from a certain amount of ink in the fountain.

Also, when all operation times in the ink mixing station are considered, it was seen that around 30% of operating time is consumed by handling ink leftovers (see Figure 10).

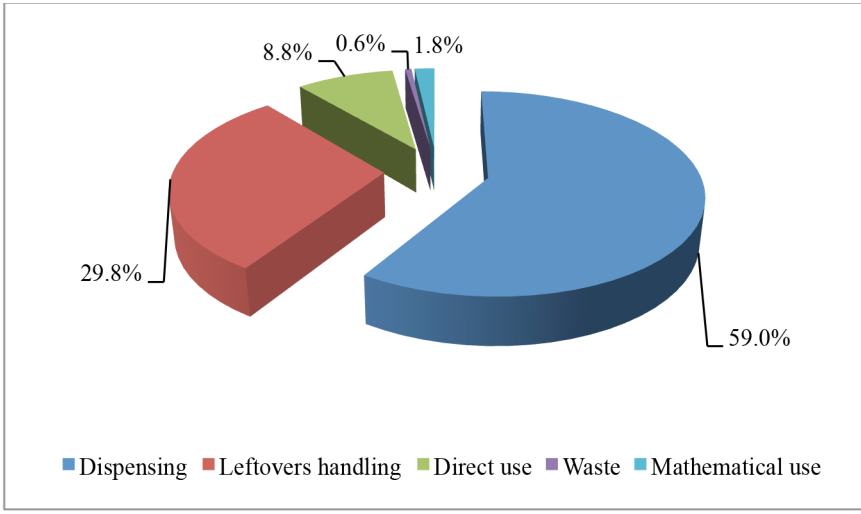

Figure 10. *Operation times in the ink mixing station*

A simple simulation of two offset job orders, the standard one with CMYK and two PMS colors and the second one with CMYK plus OGV—full ECG project, was prepared. The main aim of this simulation was to calculate operation times during press setup, make-ready, and cleaning. Printing time wasn't in the scope because it does not influence this simulation.

Operation	CMYK + 2 PMS [min]	CMYK + OGV [min]
Substrate installation	5	5
Plate mounting	5	6
Inks adding	5	0
Scenario[1]	*30*	*30*
Scenario[2]	*60*	*30*
Cleaning (PMS inks)	*20*	*0*
SUM[1]	***65***	***41***
SUM[2]	***95***	***41***

Table 2. *Operation time simulation of two offset job orders*

Scenario[1] – make ready time for each job order type.
Scenario[2] – make ready time for each job order type, with adding of 30 minutes more for PMS correction (CMYK + 2 PMS).
SUM[1] – sum of all times without adding 30 minutes more for PMS correction.
SUM[2] – sum of all times with adding of 30 minutes more for PMS correction (CMYK + 2 PMS).

As shown in Table 2, there are a few benefits in this comparison. One is related to the inks adding time – in ECG, no inks are being added because there are still seven colors in the ink fountains for every job order. But it's not the main benefit of the ECG. The main asset in this simulation shows that there could be a huge time difference if there is a need for the color correction of inks. In this simple example, Make Ready2 requires 30 minutes more to correct one of the PMS colors. This comparison was made based on the author's experience. Assuming more than two PMSs and more than one PMS needs to be correct, more time could be consumed, which is even less beneficial than the ECG job example. Another significant difference is when the PMS inks must be removed from the ink fountains for the next job requiring PMS colors. The above example assumed 20 minutes for cleaning two printing units, but according to the printer's experience, it could be sometime even more time wasted.

To summarize this simple simulation, at least 24 minutes for setup/make-ready can be saved in very simple mode, up to even 54 minutes if PMS inks need to be corrected and physically adjusted for color - not by the press instruments.

Assuming this elaboration, here are listed selected main pros of the ECG implementation, which have a real impact on the sustainability of printing:

- No ink kitchen, ink mixing processes.
- Less storage & positions.
- Fastest setup/make-ready process.
- Higher overall production efficiency.

As every method has pros and cons – below are listed selected cons of the ECG implementation:

- Limitations to printing techniques and types:
  - Gravure.
  - Screen.
  - Narrow web in-line presses.
- Still no coverage of 100% of the PMS gamut.

Despite all limitations described above, the positive impact of sustainability, such as fewer inks in the ink kitchen, fewer storage and positions on the list, faster setup/make-ready processes, and higher overall production efficiency, may be decisive in making decisions about implementing the Expanded Color Gamut into an offset printing company.

Adopting this method in almost every printing company using offset printing technology could be beneficial not only in operational and economical aspects but

also in sustainability and environmental areas, which are crucial for current and next decades not only for the printing industry.

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