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Empirical Evaluation of Color Shift Caused by Ultraviolet Coatings on Offset-Printed Coated Substrates

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Abstract: In high-fidelity offset printing, maintaining colour accuracy is vital—particularly for applications such as illustrated books, packaging, and promotional materials. This study investigates the influence of post-print UV coatings—specifically UV-Gloss and UV-Matt—on colour stability across three types of coated media: Solid Bleached Sulfate (SBS) Coated One Side (C1S) paper, Gloss Art Paper, and Matt Art Paper. Using the CIE Lab* colour space and ΔE values as objective indicators of colour shift, printed samples of cyan, magenta, yellow, and black were analyzed before and after coating application. Pre-coated (Pre-Op) samples served as the baseline for comparison.

The findings reveal that UV-Gloss coatings generally produce lower and more consistent ΔE values, especially for cyan nd yellow, signifying better preservation of original colour tones. UV-Gloss was particularly effective on Matt and Gloss Art papers. Conversely, UV-Matt coatings consistently induced higher ΔE values across all paper types and colours, with black and yellow experiencing the most pronounced shifts. While UV-Matt coatings showed uniformity in their effects, their high ΔE readings suggest significant colour distortion.

This empirical analysis offers practical guidance for printers, designers, and production managers seeking to balance print durability with visual integrity. The results underscore UV-Gloss as the preferred coating for applications where colour fidelity is paramount, while UV-Matt coatings are better suited for less colour-critical projects. The study contributes to optimized coating selection in print workflows, aligning aesthetic goals with technical constraints in contemporary offset printing.

IndexTerms: *Offset Printing, UV Coating, Colour Shift, ΔE Value, CIE Lab, Coated Media, Colour Fidelity, Gloss Coating, Matt Coating, SBS C1S Paper, Gloss Art Paper, Matt Art Paper, Spectrophotometer Measurement, Print Quality, Post-press Finishing*

I. INTRODUCTION:

In the printing industry, achieving accurate color reproduction is essential for preserving the quality and visual appeal of printed materials. This becomes particularly critical in products such as illustrated books, magazines, marketing materials, and high-end packaging, where precise color matching is key to maintaining brand integrity and visual consistency(Anayath & Pandey, n.d.). Offset printing, known for producing sharp, high-resolution images, is widely used on coated media—a preferred substrate for vibrant colors and detailed imagery(Koivula et al., 2008). This technique's indirect ink transfer method minimizes image distortion, enhancing color accuracy. However, post-printing processes, especially the application of protective coatings, often introduce undesired color shifts. These shifts, measured by the ΔE value in the CIE Lab* color model, can alter intended colors, leading to inconsistencies in final output(Baumann & Timpe, 1994).

Coated media, including gloss, matte, and C1S (coated one side) papers, are commonly used to optimize image quality by enhancing surface smoothness, brightness, and ink retention. The non-porous surface of coated media prevents ink absorption, resulting in sharper images and more vibrant colors compared to uncoated alternatives. However, when UV coatings—typically gloss, or matt—are applied to improve durability and appearance, they interact with printed ink in ways that affect color perception. Gloss coatings tend to amplify color vibrancy through high reflectivity, while matte coatings, by diffusing light, create a more subdued color effect.

Previous research highlights how different coatings affect color shifts, with findings indicating that gloss and matte finishes distinctly influence colorimetric values(Tracton, 2006a). Gloss coatings can stabilize colors like cyan and black, while matte coatings are prone to variations in colors such as yellow and magenta due to their unique light-diffusing properties(Bhagya & Pai, 2017). Although several studies have examined these effects, few have comprehensively compared the color shift across different coated papers (C1S, gloss art, and matte art) when exposed to the two main coating types—UV gloss and UV matt(Hébert et al., 2021).

This study aims to fill this gap by evaluating how these UV coatings impact color stability across different paper types and process colors (cyan, magenta, yellow, and black) in offset printing. It seeks to identify which coating techniques offer the most consistent color retention for each color-paper combination, with the goal of minimizing undesirable color shifts that may compromise print quality. By addressing the role of specific coating methods in maintaining color fidelity, this research offers critical insights for printers, designers, and other stakeholders in selecting appropriate coatings to meet quality and aesthetic requirements(Hoffstadt, 2004). By systematically analyzing color shifts induced by various coating techniques on different coated media, this study provides valuable guidance on optimizing coating selection to achieve color stability in offset printing applications.

This study provides valuable guidance on optimizing coating selection to achieve color stability in offset printing applications. To understand the intricacies of this process, we will now explore the offset printing technique, its role in achieving precise color reproduction, the characteristics and advantages of different types of coated media, and the impact of various UV coating techniques(Dailliez et al., 2023). This foundation will set the stage for analyzing how these elements interact to influence color fidelity and print quality.

Offset Printing

Offset printing is an indirect method of printing which underlies on the principle 'Oil and Water do not mix with each other'. During printing image area is ink-accepting and non-image area water-receptive. Ink is applied on image area by inking unit and dampening solution is applied on image carrier by dampening unit. Then inked image in transferred on the blanket (rubber) cylinder which is further on to the substrate using suitable impression pressure by impression cylinder. Fig. 1 depicts working principle of Offset printing.

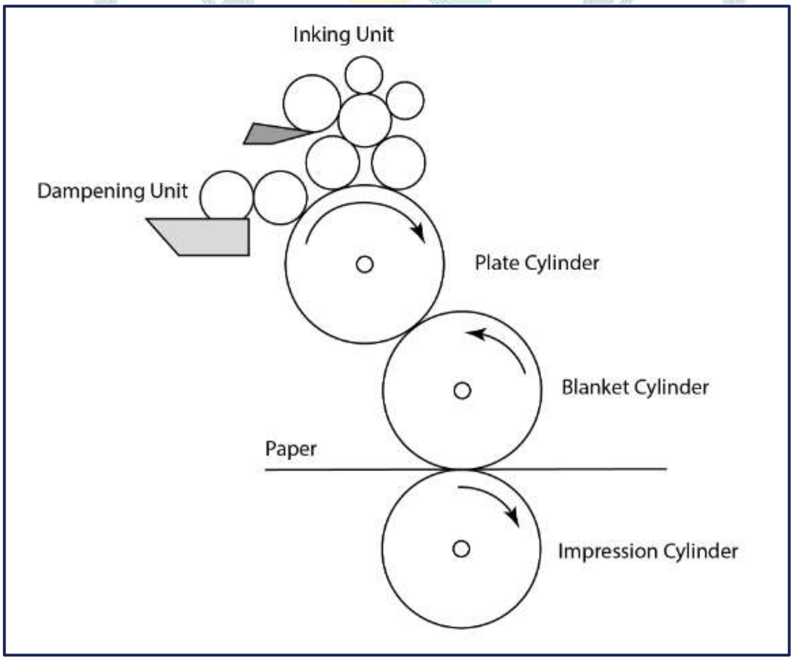

Figure 4.1-1 Offset Printing Principle

Colour accuracy and consistency are critical in the printing industry, where even slight deviations can impact the quality and marketability of printed materials. Colour accuracy is a critical performance specification of a printing device which is need of hour these days. But finishing operations which includes varnishing, coating and lamination can significantly alter the print appearance.

Colour shift is the colour difference commonly evaluated in terms of delta E (ΔE) using CIE L*a*b* Colour model. CIE L*a*b* colour space is composed of three dimensions which includes L* (Lightness/Darkness), a* (Green-Red axis) and b* (Blue-Yellow axis)(Lundström, 2013).

Lamination is a post-press finishing technique commonly used to protect any printed materials. In addition to this it enhances the aesthetic appeal of printed material. It also increases not only durability, but also the resistance of print media to various environmental aspects. Despite of so many advantages, lamination causes colour shift of printed media in terms of visual perceptions(Kipphan & Loffler, 1989).

Coated Media

Coated media, including coated paper and board, is widely used in offset printing to achieve high-quality, vibrant prints with excellent colour reproduction. Coated media is treated with a layer of coating—usually a mix of clay, calcium carbonate, and binders—that smoothens the surface, enhances brightness, and improves ink holdout. This coating allows for finer image detail, making it ideal for applications like magazines, brochures, packaging, and high-end marketing materials.

Composition and Interaction with Offset Inks

Coated media is typically composed of a paper or board base coated with a layer of minerals and polymers. This coating provides a smooth, non-porous surface, which interacts differently with **oil-based offset inks** than uncoated paper. Unlike uncoated paper, which absorbs ink, coated paper holds the ink on the surface, enabling sharper images and less ink absorption. This feature requires specific drying processes, as the ink must dry through **oxidation** and **evaporation** rather than absorption. In offset printing on coated media, the ink dries primarily through a combination of **oxidative drying** (reaction with oxygen) and **infrared or hot-air drying** to speed up evaporation. This controlled drying process ensures a smooth, glossy, or matt finish, depending on the media type(Tetsuya & Yosuke, 1998).

Types of Coated Media

SBS C1S (Solid Bleached Sulfate, Coated One Side) Art card/Paper

Chemical Properties

- **Composition**: SBS (Solid Bleached Sulfate) paperboard is made from 100% bleached virgin wood pulp, which gives it a bright, white base. The paperboard is coated on one side (C1S) with a layer of clay and/or calcium carbonate and a binder, usually a polymer such as styrene-butadiene or polyvinyl acetate.

- **pH Neutrality**: The use of bleached pulp makes SBS paperboard more pH neutral and resistant to yellowing over time, which is ideal for archival-quality prints and long-term storage.

Physical Properties

- **Brightness and Whiteness**: SBS C1S has a high brightness level, typically above 90 on the ISO scale, which enhances the vibrancy of printed colours.

- **Rigidity and Strength**: SBS C1S is known for its stiffness, rigidity, and good folding endurance. This structural strength makes it suitable for applications where durability and structural integrity are required.

- **Surface Smoothness**: The coated side provides a smooth, even surface that ensures excellent print quality, allowing for sharp images and vibrant colours.

- **Weight and Thickness**: SBS C1S is available in various weights (200 to 450 gsm) and thicknesses, making it adaptable for different applications, from thin card stock to thicker boards for book covers and packaging.

Gloss Art Paper

Chemical Properties

- **Composition**: Gloss art paper is typically made from a combination of wood pulp fibers and mineral coatings. The coating is often a mixture of clay, calcium carbonate, and other minerals, with a binder like polyvinyl acetate or styrene-butadiene. The binder secures the coating to the paper and contributes to a glossy finish.

- **Optical Brighteners**: Gloss art papers often contain optical brightening agents (OBAs) to enhance the whiteness and brightness of the paper, allowing colours to appear more vibrant.

- **pH Levels**: Gloss art papers are usually pH neutral or slightly alkaline, which helps maintain colour quality over time and prevents yellowing.

Physical Properties

- **High Reflectivity**: The glossy coating provides a highly reflective surface, which makes colours appear more saturated and vivid. This characteristic is beneficial for applications that require bright, eye-catching visuals.

- **Smoothness and Ink Holdout**: Gloss art paper has an exceptionally smooth, non-porous surface, which prevents ink from absorbing deeply into the paper. This feature ensures sharp detail and prevents ink bleed, resulting in high-resolution prints.

- **Brightness**: Gloss papers have a high brightness level, often over 90 on the ISO scale, which enhances the colour contrast and sharpness of images.

- **Weight and Thickness**: Gloss art paper is available in various weights (90 to 190 gsm) and thicknesses, making it suitable for different printing needs, from lightweight brochures, illustrated books, book jackets, multicolour books to heavyweight magazine covers.

Matt Art Paper

Chemical Properties

- **Composition**: Matt art paper is similar to gloss art paper in terms of its base material, with wood pulp fibers and mineral coatings. However, it has a different coating formulation that scatters light rather than reflecting it directly, resulting in a matt finish.
- **Binders and Additives**: The coating for matt art paper includes similar binders, such as polyvinyl acetate or styrene-butadiene, but may have additional matting agents or texturizers to reduce glossiness.
- **Absence of Optical Brighteners**: Some matt papers do not contain optical brighteners, which gives them a softer, more natural tone and reduces the starkness of colours.

Physical Properties

- **Low Reflectivity**: The matt coating diffuses light, resulting in a non-reflective surface that reduces glare. This property is advantageous for applications where readability is important, as it prevents reflections from affecting legibility.
- **Smooth but Less Glossy**: While still smooth, matt art paper lacks the high reflectivity of gloss paper. It provides an elegant, refined look that is more subdued and professional, suitable for materials that require a sophisticated appearance.
- **Brightness**: Matt art paper typically has a high brightness level, although it may appear less vibrant than gloss paper due to its non-reflective surface. This feature is desirable for applications where a subtle finish is preferred.
- **Ink Absorption and Image Quality**: Although matt paper is smooth, it absorbs slightly more ink than gloss paper, resulting in softer colours and a slightly less sharp finish. However, this is often preferred for fine art prints and luxury print materials where a muted, classic look is desired.
- **Weight and Thickness**: Matt art paper is available in various weights (90 to 190 gsm) and thicknesses, making it suitable for different printing needs, from lightweight brochures, illustrated books, book jackets, multicolour books to heavyweight magazine covers.

Property	SBS C1S Art card/Paper	Gloss Art Paper	Matt Art Paper
Composition	100% bleached virgin wood pulp with one-side coating	Wood pulp with glossy mineral coating	Wood pulp with matt mineral coating
Binders	Styrene-butadiene or polyvinyl acetate	Polyvinyl acetate, styrene-butadiene	Polyvinyl acetate, styrene-butadiene
Reflectivity	Moderate	High (Glossy, reflective surface)	Low (Non-reflective, matt finish)
Brightness	High (Above 90 ISO)	High (Enhanced by optical brighteners)	High, but with a softer, non-glossy appearance
Surface	Smooth, coated on one side	Smooth and very glossy	Smooth but non-glossy
Strength	High rigidity and stiffness	Moderate flexibility	Moderate flexibility
Ink Holdout	High, minimal absorption	High, sharp details due to low ink absorption	Moderate, slightly softer due to light absorption

Table I:1 : Comparison Chart of Various Coated Media

Coating

UV coatings are ultraviolet-curable coatings applied on printed papers and boards to enhance durability, appearance, and resistance to wear. Used extensively in packaging, brochures, book covers, and other printed materials, UV coatings are favored for their rapid curing time, superior gloss or matt finishes, and high durability. These coatings cure instantly upon exposure to ultraviolet light, providing efficient production and a robust protective finish(Simonot et al., 2018).

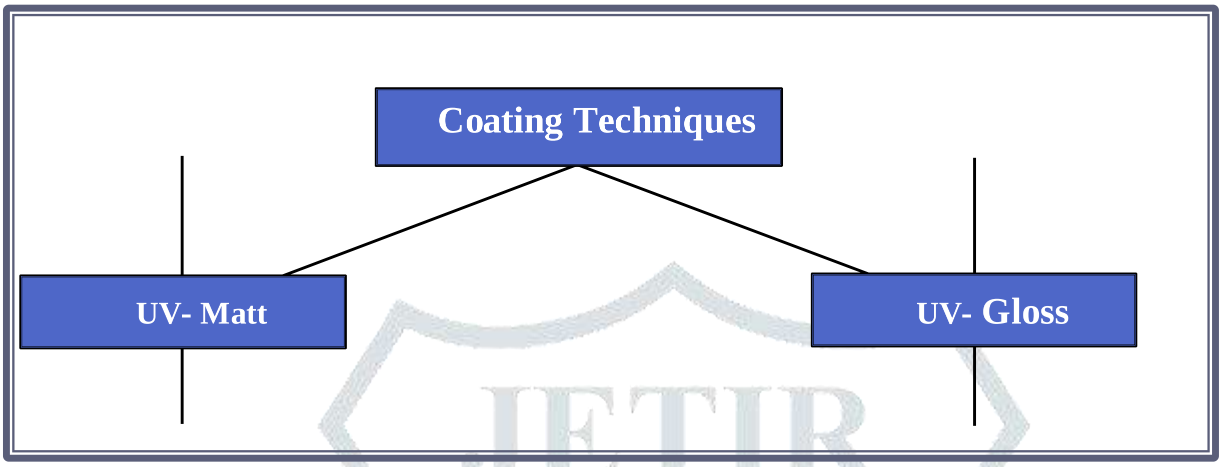

Fig I:2: UV Coating Techniques

Process

The UV coating process involves a chemical reaction triggered by ultraviolet radiation rather than mere physical drying. Upon exposure to UV light, photoinitiators in the coating formulation activate polymerization, forming a hard, protective film. This instantaneous curing creates a durable finish that significantly enhances appearance and protects the printed material.

Application of UV Coating

UV coating is applied using rollers or flexographic coaters directly onto offset-printed surfaces. The coating formulation typically includes oligomers, monomers, photoinitiators, and various additives such as waxes and leveling agents. The coating uniformly covers the printed surface without disturbing the underlying inks.

UV Curing Process

UV coating cures instantaneously when exposed to UV light emitted from high-intensity UV lamps. Photoinitiators absorb UV energy, initiating polymerization and crosslinking. This chemical reaction rapidly transforms the liquid coating into a solid, protective layer(Tracton, 2006b).

Polymerization and Crosslinking

Under UV light, photoinitiators produce free radicals, triggering rapid polymerization of oligomers and monomers. Crosslinking among polymer chains occurs swiftly, forming a dense network structure. This crosslinked structure provides superior durability, chemical resistance, and scratch resistance.

Film Formation

As polymerization completes, a continuous and solidified film forms over the printed substrate. The resulting film is robust, resistant to physical abrasion, and offers enhanced visual appeal. Additives such as waxes or leveling agents ensure smoothness, gloss or matt finish, and protection against wear.

Adhesion and Interaction with Offset Ink

Ink Compatibility: UV coatings are specifically formulated to adhere effectively over offset-printed inks, including oil-based and UV-cured varieties.

Adhesion Mechanisms: Strong chemical bonding and mechanical interlocking between coating polymers and printed ink layers ensure excellent adhesion and protective coverage.

Details of UV Coatings

Usage and Need: UV coatings provide superior protection and visual enhancement, offering resistance to fingerprints, smudges, and abrasions. The instant curing property also accelerates production speed.

Chemical Composition: Coatings consist primarily of acrylate-based oligomers, monomers, photoinitiators, and additives like waxes for abrasion resistance or leveling agents for smoothness(Menzel & Nickel, 1992).

Application Process: Applied using roller or flexographic coaters, the UV curing process occurs immediately after application under high-intensity UV lamps.

Thickness: Typically ranges from 2-5 microns, providing substantial protection without adding significant bulk.

Factors Affecting Effectiveness

UV Intensity: Proper intensity and exposure time are essential to achieve optimal curing and desired properties.
Machine Settings: Precise control of roller pressure, coating volume, and curing parameters ensure consistent application and finish quality.

Formulation Balance: The balance of oligomers, monomers, and photoinitiators affects curing speed, film properties, and durability.

Substrate Compatibility: Surface characteristics of printed media must align with coating formulation for ideal

	UV Matt	UV Gloss
Appearance	Non-reflective, smooth finish	High shine, reflective
Usage	High-end brochures, luxury packaging	Retail packaging, promotional materials
Chemical Additives	Matting agents to diffuse light	Gloss enhancers for brilliance
Application Process	Standard roller or flexo coat with immediate UV curing	Standard roller or flexo coat with immediate UV curing
Thickness	2-5 microns	2-5 microns
Sensitivity to UV Intensity	Moderate	High
Final Finish	Elegant, muted, sophisticated	Bright, vibrant, high-impact

Table I:2: Comparison Chart of UV matt and gloss coatings

II. OBJECTIVES OF STUDY :

Print enhancement is very crucial aspect for attractive and innovative print applications for which numerous post printing coatings are made on printed substrates are used for enhancing print quality now-a-days. But every coating technique has its unique effect on print enhancement in terms of colour shift or print quality parameter. The key objective of this study is to analyze the phenomenon of colour shift due to various UV coating techniques on Coated Paper media printed using offset printing.

III. RESEARCH METHODOLOGY :

To investigate the colour shift effects induced by different coating techniques on coated substrates post-offset printing, a systematic research framework was established. At the core of this methodology was the development of a Master Test Chart aligned with industry-standard printing parameters. The research workflow is illustrated in the following flowchart:

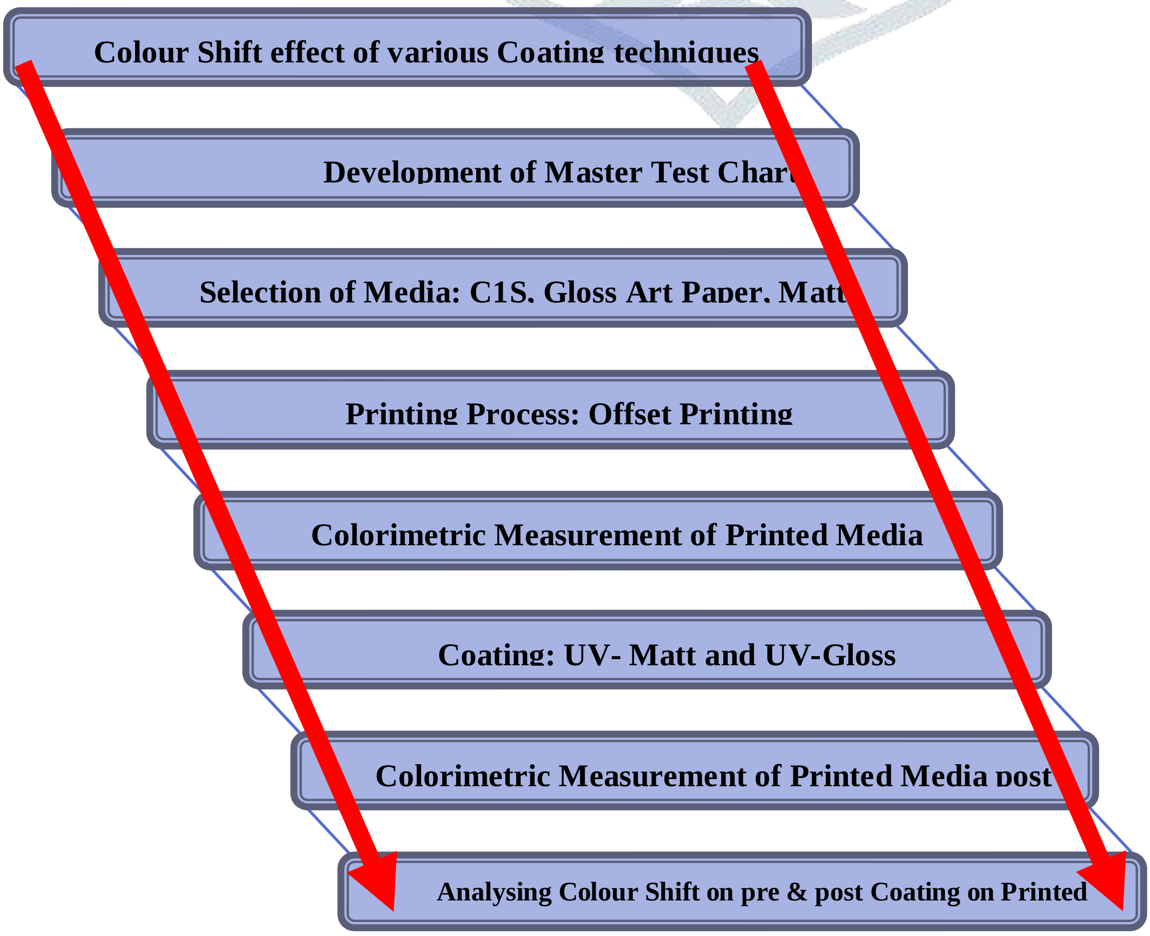

Fig III-1: Flowchart for attainment of research objective

Master Test Chart Development:

A dedicated Master Test Chart was designed incorporating a range of elements—such as solid patches, gradients, and registration marks—aligned with the research objective and printing standards.

Media Selection:

Three types of coated paper substrates were selected for the study:

1. Solid Bleached Sulfate (SBS) Coated One Side Art Card
2. Gloss Art Paper
3. Matt Art Paper

Printing Process:

Offset lithographic printing was employed to print the Master Test Chart on all selected media types under controlled and standardized pressroom conditions.

Colorimetric Measurement (Pre-Coating):

Colorimetric data of the printed samples were recorded using a spectrophotometer before the application of any coating. This served as the baseline for evaluating colour shift.

Coating Application:

Two ultraviolet coating techniques—UV Matt and UV Gloss—were applied to the printed samples. Coatings were applied under standard curing conditions to ensure uniformity and repeatability.

Colorimetric Measurement (Post-Coating):

After the coating application, the same samples were re-evaluated using the spectrophotometer. The comparison between pre- and post-coating colorimetric data allowed for quantifying the degree of colour shift induced by each coating type.

IV. RESULTS :

In order to analyze colour shift effect of various coating techniques (fig. 2) on Coated Media using Offset Printing process, colorimetric aspect colour difference (ΔE Value) was taken into consideration. The analysis of data (number of sample sheets measured on X-axis and their respective colorimetric value i.e. ΔE Value on Y-axis) is depicted as below:

4.1. <u>Colour Shift Due to UV Coating (Gloss and Matt) on C1S Paper:</u>

The colour shift (ΔE Value) of process colours—Cyan, Magenta, Yellow, and Black—during offset printing on C1S coated paper with UV-Gloss and UV-Matt coatings is shown in Fig. 4, 5, 6 and 7 *<u>respectively</u>*).

This study examined the colour shift (ΔE) across Cyan, Magenta, Yellow, and Black on SBS C1S paper with two types of UV coatings—Gloss and Matt —and compared them to uncoated samples.

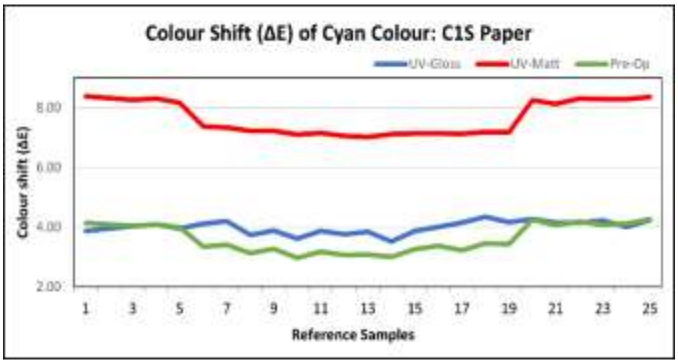

Figure 4.1-2: ΔE C on C1S paper – UV-Gloss, UV-Matt, No-Coat

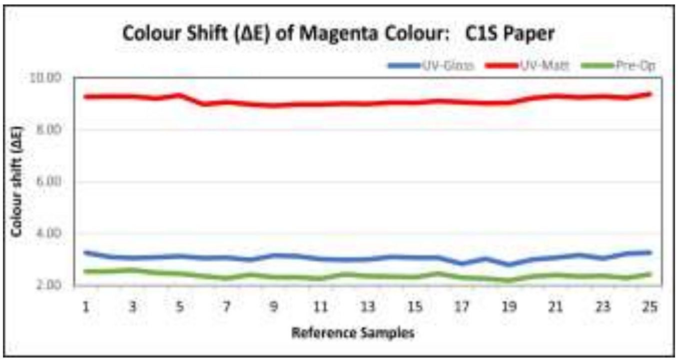

Figure 4.1-2: ΔE M on C1S paper – UV-Gloss, UV-Matt, No-Coat

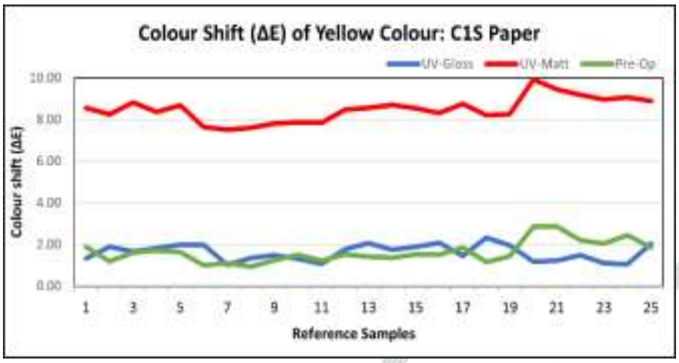

Figure 4.1-4: ΔE Y on C1S paper – UV-Gloss, UV-Matt, No-Coat

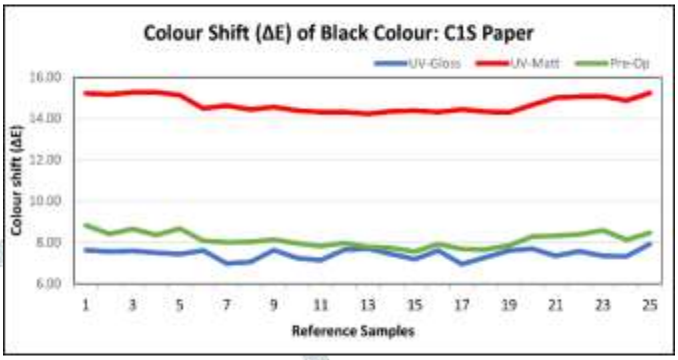

Figure 4.1-4: ΔE K on C1S paper – UV-Gloss, UV-Matt, No-Coat

1. **Cyan [**Fig. 4**]**: UV Gloss coating shows a **moderate and consistent colour shift** with ΔE values ranging between **3.8–4.5**, indicating **controlled deviation**. UV Matt displays **significantly higher ΔE values**, remaining above **7.0**, with most readings around **7.2–8.4**, suggesting a **strong and persistent colour distortion**.

2. **Magenta [**Fig. 5**]**: UV Gloss demonstrates a **low colour shift**, mostly within **2.9–3.4**, indicating **high visual stability**. UV Matt shows **very high ΔE values**, consistently between **9.0–9.5**, reflecting a **major colour alteration** from the intended shade.

3. **Yellow [**Fig. 6**]**: UV Gloss maintains **minimal ΔE fluctuation**, generally ranging from **1.0–2.3**, showing **excellent colour retention**. UV Matt causes **extensive colour shift**, with ΔE values between **7.5–10.0**, marking it as **unsuitable for accurate yellow tone preservation**.

4. **Black [**Fig. 7**]**: UV Gloss surprisingly **performs better than Pre-Op** in several instances, with ΔE values staying around **7.0–7.9**, denoting **moderate shift**. UV Matt, on the other hand, consistently records **very high ΔE**, from **14.5–15.5**, making it the **least desirable** coating in terms of black colour fidelity.

4.2. Colour Shift Due to UV Coatings (Gloss and Matt) on Gloss Art Paper:

The colour shift (ΔE Value) of process colours—Cyan, Magenta, Yellow, and Black—during offset printing on Gloss Art Paper with UV-Gloss and UV-Matt coatings is shown in Fig. 8, 9, 10 and 11respectively.

This analysis examined the colour shift (ΔE) for Cyan, Magenta, Yellow, and Black on Gloss Art Paper with — UV-Gloss and UV-Matt coatings — and compared them to uncoated samples.

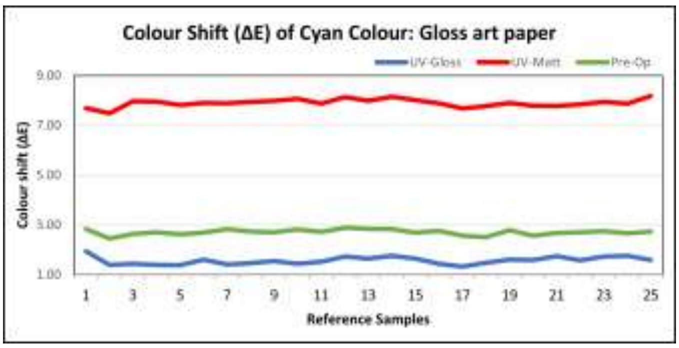

Figure 4.2-1: ΔE C on GAP – UV-Gloss, UV-Matt, No-Coat

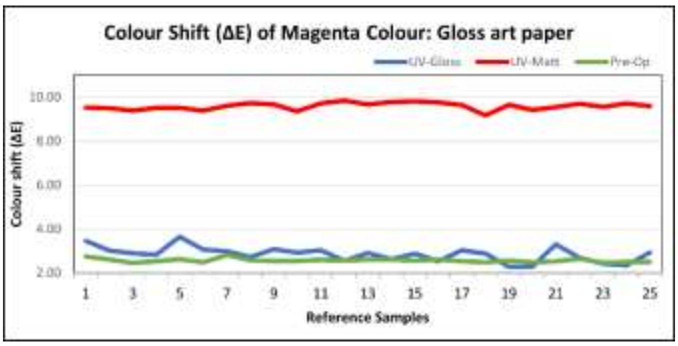

Figure 4.2-2: ΔE M on GAP – UV-Gloss, UV-Matt, No-Coat

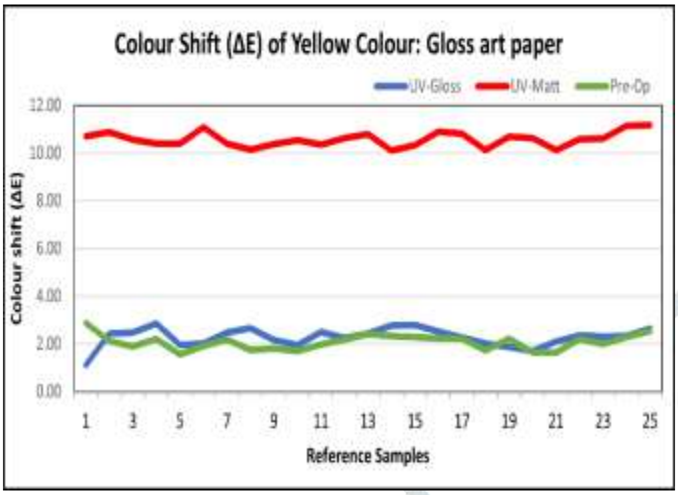

Figure 4.2-3: ΔE Y on GAP – UV-Gloss, UV-Matt, No-Coat

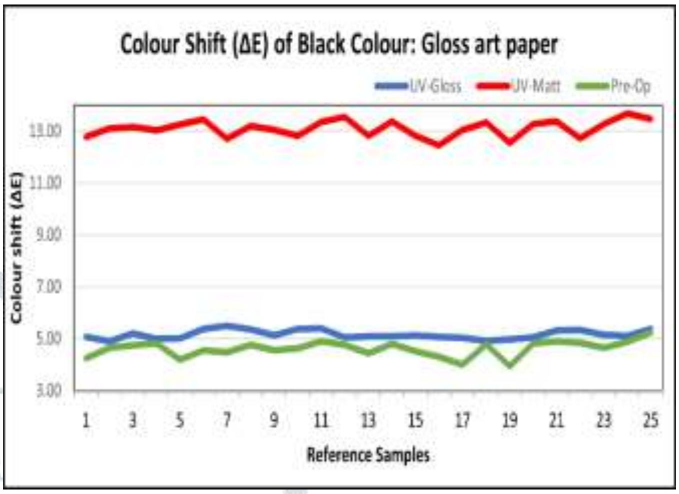

Figure 4.2-4: ΔE K on GAP – UV-Gloss, UV-Matt, No-Coat

1. **Cyan [**Fig. 8**]**: UV Gloss demonstrated a **significantly reduced ΔE** (approx. 1.2–1.8), indicating **very low colour shift** and **strong preservation of cyan** tone. UV Matt resulted in **very high ΔE values** (7.3–8.1), signifying a **major deviation in colour fidelity** from the intended output.

2. **Magenta [**Fig. 9**]**: UV Gloss displayed **moderate ΔE** (ranging from 2.8–3.7), suggesting **some shift** but within visually tolerable limits. UV Matt coatings yielded **high ΔE values** (9.3–9.9), pointing to **notable visual distortion** of the magenta tone.

3. **Yellow [**Fig. 10**]**: UV Gloss exhibited **low to moderate ΔE** (ranging from 1.2–3.0), with **occasional fluctuation**, indicating a **generally stable yellow tone**. UV Matt coatings caused **very high ΔE shifts** (10.1–11.5), confirming **substantial loss of yellow tone fidelity** under this coating.

4. **Black [**Fig. 11**]**: UV Gloss showed **consistently higher ΔE values** (approx. 4.9–5.9) compared to the baseline, suggesting a **moderate shift** in black. UV Matt resulted in **very high and stable ΔE** values (12.9–13.6), indicating a **substantial colour shift** and poor retention of black tonal accuracy.

4.3. Colour Shift Due to UV Coatings (Gloss and Matt) on Matt Art Paper:

The colour shift (ΔE Value) of process colours—Cyan, Magenta, Yellow, and Black—during offset printing on Matt Art Paper with — UV-Gloss and UV-Matt coatings — is shown in Fig. 12, 13, 14 and 15 respectively.

This analysis reviewed the colour shift (ΔE) for Cyan, Magenta, Yellow, and Black on Matt Art Paper with two coatings — UV-Gloss and UV-Matt — and compared them to uncoated samples.

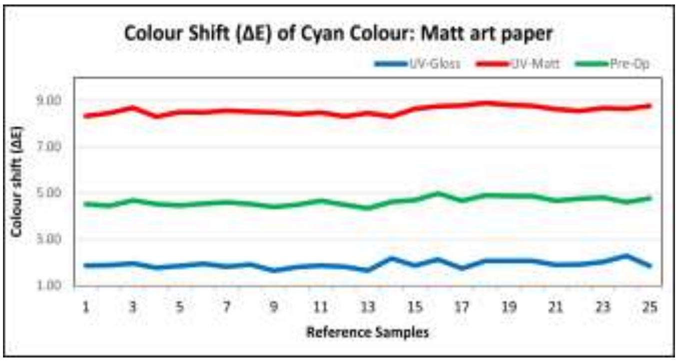

Figure 4.3-2: ΔE C on MAP – UV-Gloss, UV-Matt, No-Coat

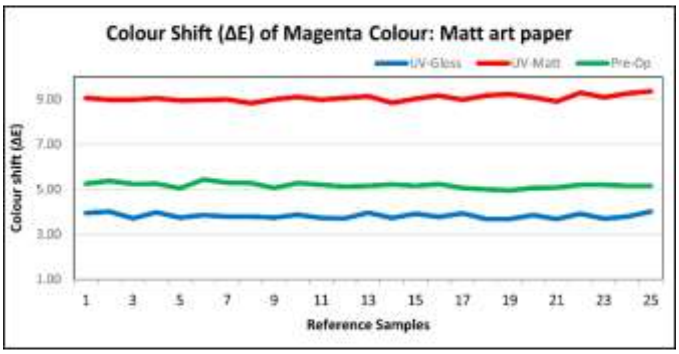

Figure 4.3-2: ΔE M on MAP – UV-Gloss, UV-Matt, No-Coat

1. **Cyan [**Fig. 12**]**: UV Gloss coating resulted in significantly **lower ΔE values** (1.5–2.2) compared to the baseline, indicating **excellent colour retention**. UV Matt, in contrast, produced **much higher ΔE values** (8.3–9.0), signifying a **substantial colour shift** from the original printed cyan.

2. **Magenta [**Fig. 13**]**: UV Gloss showed a **moderate reduction in colour shift**, with ΔE values between 3.3 and 4.1, implying **improved visual consistency**. UV Matt caused a **marked increase in ΔE** (8.8–9.4), reflecting a **strong deviation from the intended magenta tone**.

3. **Yellow [**Fig. 14**]**: UV Gloss displayed **minimal colour shift**, with ΔE values consistently in the 0.7–1.2 range, indicating **very high fidelity**. UV Matt led to a **pronounced shift** in colour, with ΔE ranging from 9.7 to 11.0, showing **significant impact** on yellow appearance

4. **Black [**Fig. 15**]**: UV Gloss produced a **reduced ΔE range** (6.5–7.7), suggesting **moderate improvement** in black tone

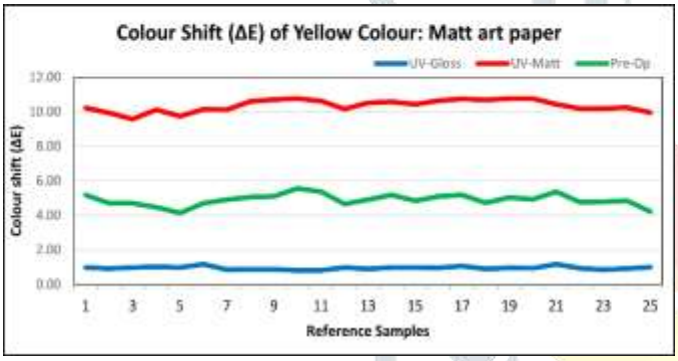

Figure 4.3-4: ΔE Y on MAP – UV-Gloss, UV-Matt, No-Coat

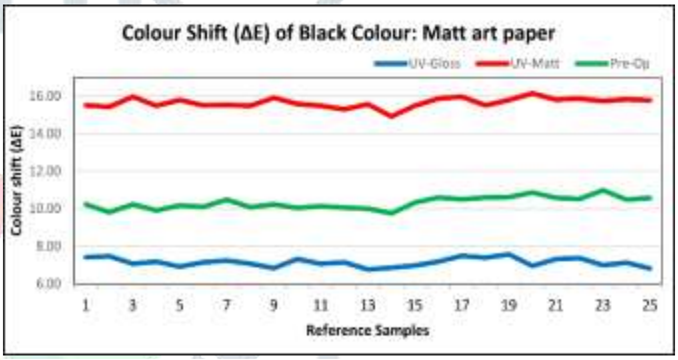

Figure 4.3-4: ΔE K on MAP – UV-Gloss, UV-Matt, No-Coat

consistency. UV Matt introduced a **major shift** with ΔE values between 15.2 and 16.3, making it the **least stable coating for black** on matt art paper.

V. DISCUSSION RESULT AND DISCUSSION

The detailed comparative analysis requires evaluating the ΔE values, depicting Colour shift, for each paper type (C1S Paper in Table 3, Gloss Art Paper in Table 4, and Matt Art Paper in Table 5) for each colour and each coating type. This approach will highlight how each coating type affects the colour shift when applied to different paper types and colours.

We'll go through each table individually, comparing the mean, standard deviation, minimum, and maximum ΔE values for each coating (UV- Gloss and UV- Matt) against the baseline no-coating ΔE values.

Colour Shift (ΔE Value) due to various Coating Techniques on C1S Paper

CIS					
Colour	Coating	Mean	Std_Dev	Min.	Max.
Cyan	UV-Gloss	4.01	0.21	3.52	4.35
	UV-Matt	7.66	0.57	7.02	8.39
	CIS Pre Op	3.62	0.47	2.98	4.26
Colour	Coating	Mean	Std_Dev	Min.	Max.
Magenta	UV-Gloss	3.06	0.11	2.78	3.26
	UV-Matt	9.12	0.14	8.92	9.37
	CIS Pre Op	2.37	0.10	2.18	2.59
Colour	Coating	Mean	Std_Dev	Min.	Max.
Yellow	UV-Gloss	1.61	0.39	1.02	2.32
	UV-Matt	8.49	0.59	7.51	9.92
	CIS Pre Op	1.64	0.52	0.92	2.87
Colour	Coating	Mean	Std_Dev	Min.	Max.

Black	UV-Gloss	7.44	0.25	6.95	7.93
	UV-Matt	14.70	0.38	14.22	15.27
	CIS Pre Op	8.13	0.35	7.56	8.83

Table V:1: Colour Shift (ΔE Value) due to various Coating Techniques on C1S Paper

Cyan

UV-Gloss: Shows a moderate mean ΔE of 4.01 with low variability (Std Dev 0.21), indicating a controlled and consistent colour shift.

UV-Matt: Records a significantly higher mean ΔE of 7.66, with a greater spread (Std Dev 0.57), implying a strong and inconsistent shift from the baseline.

Result: UV-Gloss coating provides better colour fidelity and stability for cyan on C1S paper, whereas UV-Matt leads to a larger and less predictable shift.

Magenta

UV-Gloss: Exhibits a low mean ΔE of 3.06 and minimal variability (Std Dev 0.11), indicating stable and limited colour shift.

UV-Matt: Has the highest mean ΔE of 9.12, with greater variability (Std Dev 0.14), suggesting substantial and inconsistent shift.

Result: UV-Gloss delivers superior colour retention and predictability, while UV-Matt introduces a pronounced and erratic deviation from the original magenta tone.

Yellow

UV-Gloss: Achieves the lowest colour shift among coatings, with a mean ΔE of 1.61 and a modest Std Dev of 0.39, showing high consistency and colour fidelity.

UV-Matt: Results in a very high mean ΔE of 8.49, with the highest standard deviation (0.59) among all yellow coating data, indicating both large and unstable shifts.

Result: UV-Gloss is clearly the most effective and consistent coating for preserving yellow hues, while UV-Matt yields severe and erratic discolouration.

Black

UV-Gloss: Produces a moderate colour shift with mean ΔE of 7.44, and excellent consistency (Std Dev 0.25).

UV-Matt: Generates the greatest colour distortion across all colours and coatings, with a mean ΔE of 14.70 and a relatively wide spread (Std Dev 0.38).

Result: UV-Gloss provides significantly better visual consistency and lower colour shift than UV-Matt for black. UV-Matt should be avoided where fidelity of black is crucial.

Colour Shift (ΔE Value) due to various Coating Techniques on Gloss Art Paper

Gloss art paper					
Colour	Coating	Mean	Std_Dev	Min.	Max.
Cyan	UV-Gloss	1.56	0.15	1.32	1.94
	UV-Matt	7.90	0.16	7.48	8.19
	Gloss art paper UV-Matt	2.71	0.11	2.45	2.88
Colour	Coating	Mean	Std_Dev	Min.	Max.
Magenta	UV-Gloss	2.85	0.34	2.28	3.64
	UV-Matt	9.59	0.16	9.17	9.85
	Gloss art paper UV-Matt	2.57	0.08	2.46	2.81
Colour	Coating	Mean	Std_Dev	Min.	Max.
Yellow	UV-Gloss	2.27	0.39	1.11	2.84
	UV-Matt	10.58	0.31	10.10	11.16
	Gloss art paper UV-Matt	2.07	0.32	1.56	2.87

Colour	Coating	Mean	Std_Dev	Min.	Max.
Black	UV-Gloss	5.16	0.17	4.91	5.50
	UV-Matt	13.11	0.33	12.45	13.69
	Gloss art paper UV-Matt	4.62	0.30	3.94	5.24

Table V:2: Colour Shift (ΔE Value) due to various Coating Techniques on Gloss Art Paper

Cyan

UV-Gloss: Exhibits a very low mean ΔE of 1.56 with low variability (Std Dev 0.15), indicating a stable and minimal colour shift.

UV-Matt: Results in a significantly higher mean ΔE of 7.90 with a slightly higher Std Dev of 0.16, suggesting a large and consistent colour deviation.

Result: UV-Gloss is highly effective in retaining cyan accuracy, while UV-Matt causes a substantial and uniform colour distortion.

Magenta

UV-Gloss: Shows a moderate mean ΔE of 2.85, with moderate variability (Std Dev 0.34), indicating visible but stable shift.

UV-Matt: Produces a very high mean ΔE of 9.59 with excellent consistency (Std Dev 0.16), reflecting strong and uniform discolouration.

Result: While UV-Gloss introduces a mild shift, UV-Matt leads to drastic colour change in magenta.

Yellow

UV-Gloss: Registers a mean ΔE of 2.27, with a higher standard deviation (0.39), indicating mild but somewhat variable shift.

UV-Matt: Causes the highest ΔE among all yellow samples at 10.58, with tight deviation (Std Dev 0.31), confirming strong but consistent shift.

Result: UV-Gloss provides better colour fidelity, while UV-Matt alters yellow tones significantly and uniformly.

Black

UV-Gloss: Yields a moderate colour shift with mean ΔE of 5.16 and good consistency (Std Dev 0.17).

UV-Matt: Shows a very high ΔE of 13.11, with low variability (Std Dev 0.33), indicating large and reliable black tone distortion.

Result: UV-Gloss is relatively safer for black colour reproduction, while UV-Matt introduces major and consistent discolouration.

Colour Shift (ΔE Value) due to various Coating Techniques on Matt Art Paper

Matt art paper					
Colour	Coating	Mean	Std_Dev	Min.	Max.
Cyan	UV-Gloss	1.91	0.16	1.64	2.29
	UV-Matt	8.58	0.17	8.31	8.90
	Matt art paper UV-Matt	4.64	0.17	4.34	4.98
Colour	Coating	Mean	Std_Dev	Min.	Max.
Magenta	UV-Gloss	3.82	0.11	3.68	4.01
	UV-Matt	9.06	0.13	8.83	9.36
	Matt art paper UV-Matt	5.18	0.11	4.96	5.44

Table V:3: Colour Shift (ΔE Value) due to various Coating Techniques on Matt Art Paper

Colour	Coating	Mean	Std_Dev	Min.	Max.
Yellow	UV-Gloss	0.95	0.09	0.81	1.18
	UV-Matt	10.35	0.34	9.57	10.77
	Matt art paper UV-Matt	4.90	0.34	4.14	5.56
Colour	Coating	Mean	Std_Dev	Min.	Max.
Black	UV-Gloss	7.15	0.23	6.78	7.57
	UV-Matt	15.65	0.26	14.90	16.14
	Matt art paper UV-Matt	10.32	0.32	9.76	10.99

Cyan

UV-Gloss: Shows a low mean ΔE of 1.91 with low variability (Std Dev 0.16), indicating a mild and stable colour shift.

UV-Matt: Exhibits a very high mean ΔE of 8.58 with moderate variability (0.17), pointing to a strong and consistent discolouration.

Result: UV-Gloss provides minimal and consistent shift, while UV-Matt leads to major distortion in cyan tones.

Magenta

UV-Gloss: Reports a moderate mean ΔE of 3.82 with very low Std Dev (0.11), suggesting a stable moderate shift.

UV-Matt: Has a high ΔE of 9.06 with excellent consistency (Std Dev 0.13), confirming strong magenta discolouration.

Result: UV-Gloss offers controlled shift, while UV-Matt produces substantial and consistent colour shift in magenta.

Yellow

UV-Gloss: Gives a very low ΔE of 0.95 with tight deviation (Std Dev 0.09), indicating a minimal and stable impact.

UV-Matt: Results in a very high ΔE of 10.35 with low variability (0.34), highlighting extreme and consistent shift.

Result: UV-Gloss ensures excellent colour stability, whereas UV-Matt causes severe yellow distortion.

Black

UV-Gloss: Produces a moderate ΔE of 7.15, with low variability (Std Dev 0.23), indicating some colour shift but reliable performance.

UV-Matt: Records the highest ΔE of all at 15.65, with very good consistency (Std Dev 0.26), reflecting significant black colour distortion.

Result: UV-Gloss is comparatively more stable, while UV-Matt causes major, consistent degradation of black tone.

VI. CONCLUSION

This study investigated the impact of UV coatings—Gloss and Matt—on the colour shift (ΔE) of four process colours (Cyan, Magenta, Yellow, Black) across three paper substrates: C1S, Gloss Art Paper, and Matt Art Paper. Pre-Op (uncoated state) served as the baseline reference for evaluating coating influence.

UV-Gloss Coating

UV-Gloss coatings demonstrated variable performance depending on paper type and colour:

C1S Paper: UV-Gloss exhibited a reduction in colour shift for Cyan and Black, providing moderate ΔE values (4.01 and 7.44 respectively) with good consistency, implying improved colour fidelity over Pre-Op. However, Magenta and Yellow showed slightly increased ΔE, though with low variability, indicating consistent but stronger colour deviation.

Gloss Art Paper: UV-Gloss showed very low ΔE for Cyan (1.56) and moderate values for Magenta and Yellow (2.85 and 2.27 respectively), confirming good colour retention for Cyan. Black showed slightly elevated ΔE compared to Pre-Op but remained within a moderate range.

Matt Art Paper: UV-Gloss provided excellent control over Yellow (ΔE 0.95) and stable Cyan performance (ΔE 1.91). Magenta and Black showed moderate shifts with low standard deviation, suggesting consistent performance.

Summary: UV-Gloss is highly effective for Cyan and Yellow, with generally controlled and consistent ΔE shifts. It performs best on Matt Art Paper, while slight elevation in colour shift may be observed for Magenta and Black on Gloss Art Paper.

UV-Matt Coating

UV-Matt coatings consistently introduced higher ΔE values across all paper types and colours, reflecting greater colour distortion compared to Pre-Op.

C1S Paper: Significant ΔE increases were recorded across all colours, especially Yellow (ΔE 8.49) and Black (ΔE 14.70), indicating major colour deviations and high variability in shift.

Gloss Art Paper: UV-Matt showed the highest ΔE for Yellow (10.58) and Black (13.11), with Cyan and Magenta also experiencing large shifts. Despite high ΔE, the standard deviations remained low, showing consistency in poor colour retention.

Matt Art Paper: UV-Matt registered extreme ΔE values, peaking at 15.65 for Black and 10.35 for Yellow, confirming major degradation of original tones. All colours exhibited high shifts, even though the variation remained tight.

Summary: UV-Matt is not suitable for applications requiring colour stability, as it consistently increases colour shift across all substrates. Its effect is most severe on Black and Yellow tones, with a strong negative impact across the board.

Overall Conclusion

The comparative analysis across three coated paper types establishes clear performance trends for the two UV coating types:

UV-Gloss: Demonstrates high colour retention and stability, especially for Cyan and Yellow on Matt Art and Gloss Art papers. While it may slightly elevate ΔE for Magenta and Black, it remains within consistent and visually acceptable limits. It is the most balanced and reliable coating across applications.

UV-Matt: Consistently induces the highest colour shifts (ΔE), particularly for Black and Yellow across all paper types. Though the results are uniform, they signify a substantial departure from original colour values, making this coating unsuitable for high-fidelity print jobs.

In conclusion, the study confirms that UV-Gloss coating is the optimal choice for maintaining colour integrity in offset printed media across coated paper substrates, while UV-Matt coatings, though consistent in behaviour, result in significant and undesirable colour shifts when compared to the Pre-Op baseline.

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