

# COMPARATIVE SID AND TVI ANALYSIS OF CHROMO AND COATED PE WHITE ON FLEXOGRAPHY PRINTING PROCESS

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**Abstract:** This study presents a comparative analysis of Solid Ink Density (SID) and Tonal Value Increase (TVI) on Chromo substrate and coated Polyethylene (PE) white substrate using the flexography printing process. The objective of this research is to evaluate the influence of substrate characteristics on ink transfer efficiency, color strength, and tonal reproduction, which are critical parameters for achieving high-quality flexographic prints. Printing trials were conducted under controlled production conditions using identical press settings, UV LED ink systems, anilox configurations and standardized measurement procedures to ensure consistent comparison between substrates. SID was measured to assess the amount and uniformity of ink transferred to the substrate surface, while TVI was analyzed to determine the increase in printed tonal values relative to original image data and its effect on print accuracy. The experimental results demonstrate that substrate composition and surface properties significantly influence print performance. Coated PE white exhibited different ink holdout and surface interaction characteristics compared with Chromo substrate, affecting achievable solid ink density and tonal reproduction behavior. Variations in SID contributed to differences in color intensity and print consistency, whereas changes in TVI affected dot gain, tonal gradation, and image detail reproduction. The findings of this research provide a deeper understanding of substrate-dependent print characteristics in flexography and offer practical guidance for substrate selection and process optimization to improve print quality, color consistency and production efficiency in packaging applications.

**Keywords:** NA

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## 1. Introduction

Flexographic printing has evolved into one of the most widely adopted printing processes in the packaging and label industry due to its versatility, high-speed production capability, and compatibility with a wide range of substrates (Kipphan, 2001). [1]

In recent years, increasing demand for improved print quality, sustainability, and energy efficiency has led to the adoption of advanced ink curing technologies, particularly UVLED curing systems (Bould, 2019). Alongside these technological developments, substrate selection has become a critical factor influencing final print appearance and performance. [2]

Paper-based substrates continue to dominate flexible packaging, labels, and commercial print applications because of their printability, recyclability, and cost-effectiveness (Mangin & Vähä-Nissi, 2018). [3]

Among these, \*chromo paper\* and \*coated paper\* are extensively used due to their differing surface characteristics and functional properties. Chromo paper typically features a semi-coated or pigmented surface with moderate smoothness and absorbency, whereas coated paper contains one or more coating layers that enhance surface uniformity, brightness, and gloss (Bristow, 2010). [4]

Print quality in flexographic printing is governed by a complex interaction between ink properties, printing parameters, and substrate surface characteristics (Hladnik & Muck, 2002). [5]



Parameters such as optical density, dot gain, tonal value increase, line sharpness, print contrast, and gloss are highly sensitive to substrate absorbency and surface roughness (Sharma, 2018). [6]

Multicolour printing exposes the substrate to water from the water containing ink. The emphasis was to investigate the relation between print quality and water-uptake of the paper surface with heat and water. Printing trials was carried out on substrates possessing a hydrophobic, and also a rather hydrophilic surface using a regular commercial water-borne ink. The favourable effect which water or surfactant solution had on the hydrophobic substrate with regard to print mottle could depend on its surface compressibility in combination with the hydrophobic nature of its surface that could affect the wetting properties.[7]

Flexography is widely used in the packaging industry because of its ability of print on various printing substrates and because of the use of digital platemaking technologies. However, there are some limits in the reproduction of smooth gradients which create the effect of sudden transition tones in the highlight area. Therefore, this research compares the parameters of print quality influenced by the dot geometry focusing on top dots shape, line rulings and printing pressures. The objective was to study how the various platemaking processes affect the dot geometry on the basis of influence of the most important variable parameters of flexographic printing. A test image was created and then printed with cyan UV ink on aluminum foil on the pre-printed opaque white ink. Based on the obtained research results, the guidelines and print conditions will be given about how to apply the studied influential parameters for better tone reproduction on aluminum foil that will result in a positive impact on the environmental sustainability of flexographic printing.[8]

This paper researches the issues related to the print quality in flexography, especially the influence of the print run and inadequate printing settings on dot deformation. Dot deformation can lead to inconsistencies in print quality, such as a loss of highlight tones or an unpredictable increase in tonal value. This research was conducted on two concrete examples of flexible packaging printed on transparent films. All significant parameters of dot deformation were evaluated, including dot coverage, dot sharpness and the uniformity of the ink density. The increase in the coverage values in the midtones was linear throughout the entire print run, while in the light tones, it was more logarithmic. The overall percentage deviations from the reference value were 6.3% in the midtones and 52.6% in the light area. The increase in dot coverage was due to the wear of the polymer plate, which caused the side shoulders of the dot to become a part of the printing surface. An analysis of the ink density showed a much more homogeneous shape of the dot at the beginning of the print run. The correct ratio of the anilox roller line screen to the line ruling of the printing plate is important in order to ensure a minimum dot size in print.[9]

This study characterizes and compares the parameters of the quality reproduction of fine elements in flexography on coated and uncoated paper as well as on OPP film (oriented polypropylene). A monochrome test form was created and printed using cyan UV ink. The analysis of results confirms the importance of interaction between the printing substrate and ink; it also indicates identical line and text deformations on the print. Quality reproduction on coated paper is higher in relation to OPP film for all the research parameters. The ink penetrates significantly more and with more irregularity into the pores and throats of the uncoated paper, which results in less homogeneous elements, and in such way that it loses its original shape. In coated paper and OPP film, the ink spreads more on the substrate area which gives it a significantly more homogeneous shape. However, due to the surface spread of the ink, the biggest changes in the size of fine elements are noticeable in the OPP film. The scientific contribution of this paper is based on the comparison of print quality parameters of fine elements, which can contribute to the optimization of the production process and quality of the final graphical product.[10]

## **2. Research Objectives**

This study aims to systematically evaluate and compare the print quality performance of chrome paper and coated paper when printed using the flexographic process. The objectives include examining how each substrate influences key print quality parameters such as color density, tonal value, grayness, print contrast and overall visual consistency. The research intends to identify the factors that contribute to performance differences between the two paper types and assess their suitability for various flexographic applications. Ultimately, the study seeks to generate evidence-based insights that can guide material selection and optimize print quality outcomes in flexographic printing

### **Research Methodology**

This study uses an experimental approach to compare the print quality of chromo paper and coated paper (PE white) using flexographic printing with UV-LED ink. A standard test chart with halftones, solids, and fine details will be printed on both substrates under the same printing conditions. Printed samples will be measured using tools like a

densitometer and spectrophotometer to check solid ink density, tonal value increase, print contrast, grayness. Visual observation will also be done to note any quality differences. The collected data will be compared and analyzed to identify how each substrate performs and which one provides better print quality in UV-LED flexography.

**Data Collection and Analysis**

*Average Solid Ink Density (SID) Comparison*

Table.1. Average Solid Ink Density (SID) Comparison of between Chromo and PE White Substrate

Averages	Cyan	Magenta	Yellow	Black
Chromo	1.54	1.06	1.17	1.74
PE White	1.59	1.10	1.11	1.55

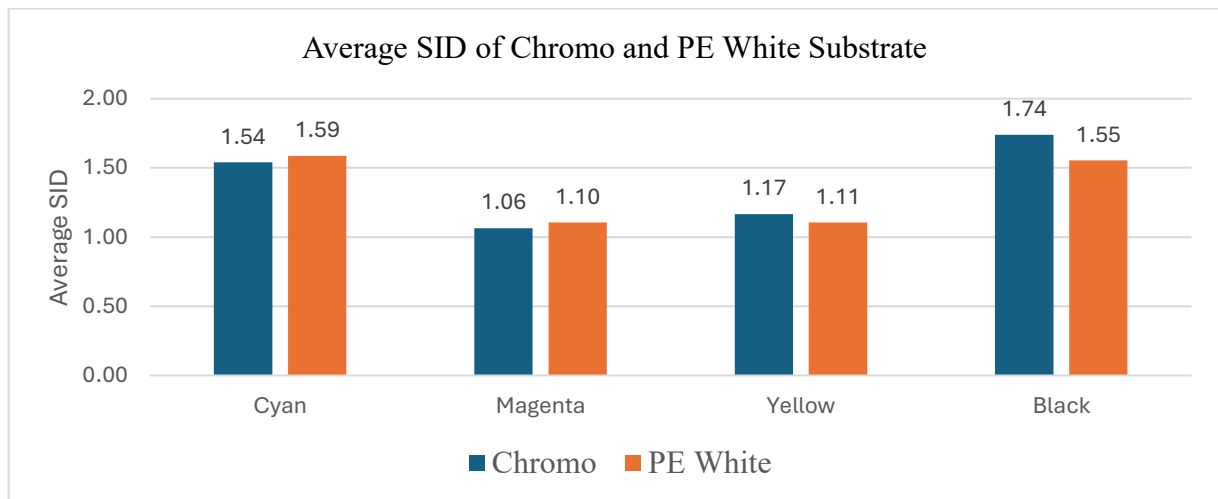


Figure.1. SID results of Chromo and PE White (Average 50 sheets)

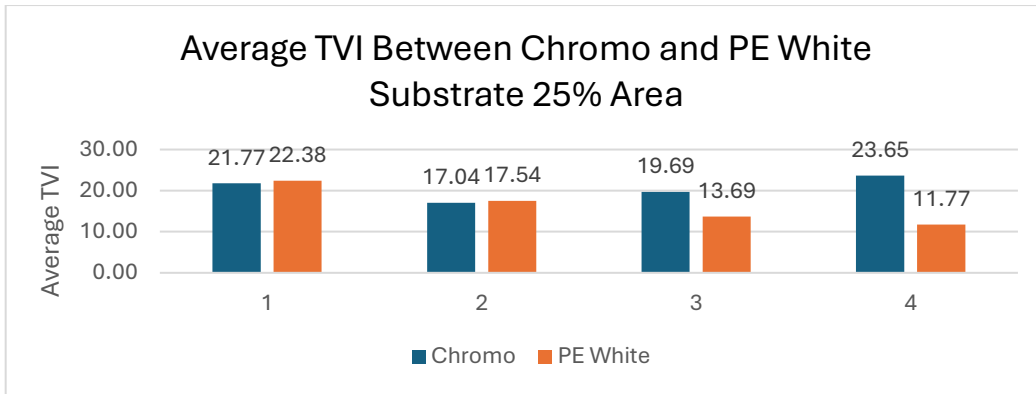
Table 1 presents the average Solid Ink Density (SID) values for the Cyan, Magenta, Yellow and Black (CMYK) process colors printed on Chromo and PE White substrates using the flexographic printing process. The PE White substrate exhibited slightly higher SID values for Cyan (1.59) and Magenta (1.10) than the Chromo substrate which recorded values of 1.54 and 1.06 respectively indicating superior ink transfer efficiency and enhanced color strength for these process colors. In contrast the Chromo substrate demonstrated higher SID values for Yellow (1.17) and Black (1.74) compared with PE White (1.11 and 1.55) suggesting more effective ink deposition and stronger substrate ink interaction. These results indicate that the surface characteristics and printability of the substrate have a significant influence on solid ink density thereby affecting color reproduction ink transfer performance and the overall print quality achieved in UV LED flexographic printing.

**TVI (%) Average Comparison at 25%, 50% and 75%**

The Average of Dot gain / TVI results of chromo and PE White substrate were analyzed at 25%, 50% and 75% tonal Values to evaluate tonal reproduction performance in the Flexography printing process. The measurements were obtained from the average of 50 printed sheets using a densitometer through the Master test chart. The testing conditions were maintained constant to ensure consistency and reliability of results.

Table.2. Average comparison of Dot Gain (TVI %) of Chromo and PE White Substrate at 25% Area

Average	Cyan	Magenta	Yellow	Black
Chromo	21.77	17.04	19.69	23.65
PE white	22.38	17.54	13.69	11.77

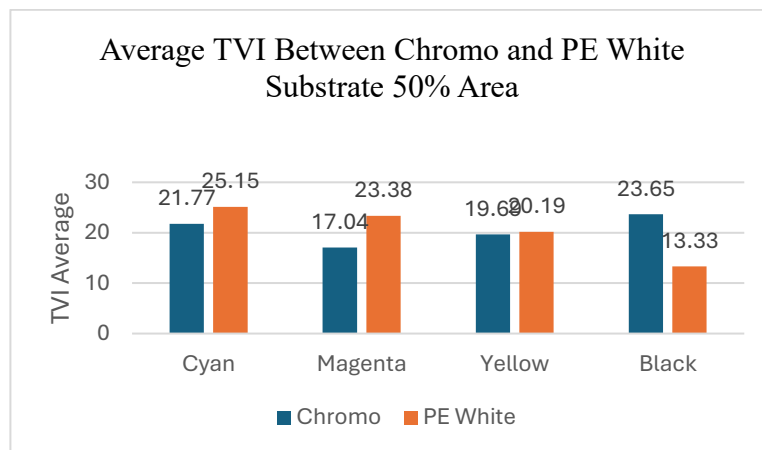


**Figure.2. Dot Gain (TVI %) results of Chromo and PE White Substrate (Average 50 Sheets)**

Table 2 presents the average Tonal Value Increase (TVI) values for the Cyan Magenta Yellow and Black (CMYK) process colors printed on Chromo and PE White substrates using the UV LED flexographic printing process. The PE White substrate exhibited slightly higher TVI values for Cyan (22.38) and Magenta (17.54) compared with the Chromo substrate which recorded 21.77 and 17.04 respectively indicating greater dot gain for these process colors. In contrast the Chromo substrate demonstrated substantially higher TVI values for Yellow (19.69) and Black (23.65) than the PE White substrate which recorded 13.69 and 11.77 respectively suggesting increased tonal value expansion on the Chromo surface. These findings indicate that substrate characteristics have a significant influence on tonal value increase which directly affects dot reproduction tonal accuracy and the overall print quality in UV LED flexographic printing.

**Table.3. Average comparison of Dot Gain (TVI %) of Chromo and PE White Substrate at 50% Area**

Average	Cyan	Magenta	Yellow	Black
Chromo	21.77	17.04	19.69	23.65
PE White	25.15	23.38	20.19	13.33



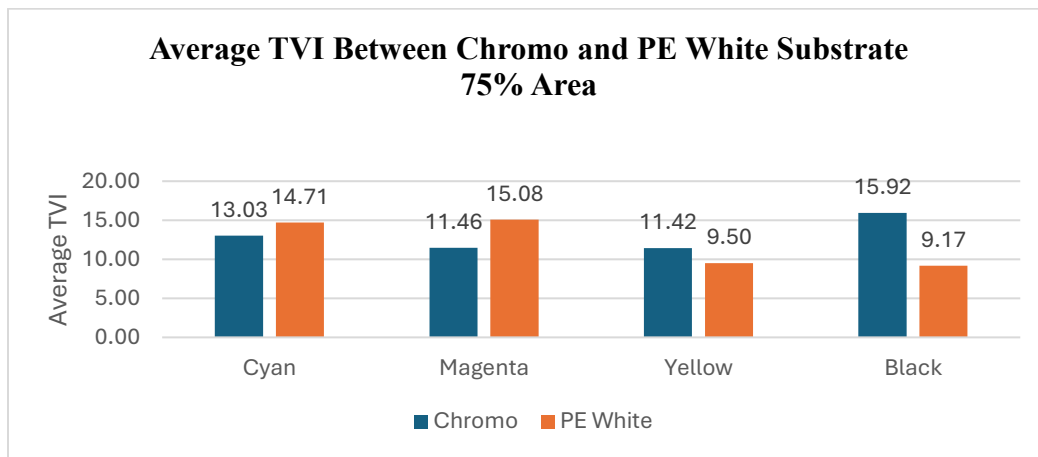
**Figure.3. Dot Gain (TVI %) results of Chromo and PE White Substrate (Average 50 Sheets)**

Table 3 presents the average Tonal Value Increase (TVI) values for the Cyan Magenta Yellow and Black (CMYK) process colors printed on Chromo and PE White substrates using the UV LED flexographic printing process.

The PE White substrate exhibited higher TVI values for Cyan (25.15) Magenta (23.38) and Yellow (20.19) compared with the Chromo substrate which recorded 21.77 17.04 and 19.69 respectively indicating greater dot gain and increased tonal value expansion for these process colors. Conversely the Chromo substrate demonstrated a significantly higher TVI value for Black (23.65) than the PE White substrate (13.33) suggesting more pronounced dot gain and stronger ink–substrate interaction for the black ink on the Chromo surface. These findings indicate that substrate properties have a considerable influence on tonal value increase thereby affecting dot reproduction tonal accuracy and the overall print quality achieved in UV LED flexographic printing.

**Table.3. Average comparison of Dot Gain (TVI %) of Chromo and PE White Substrate at 75% Area**

Average	Cyan	Magenta	Yellow	Black
Chromo	13.03	11.46	11.42	15.92
PE White	14.71	15.08	9.50	9.17



**Figure.4. Dot Gain (TVI %) results of Chromo and PE White Substrate (Average 50 Sheets)**

Table 4 presents the average Tonal Value Increase (TVI) values for the Cyan Magenta Yellow and Black (CMYK) process colors printed on Chromo and PE White substrates using the UV LED flexographic printing process. The PE White substrate exhibited higher TVI values for Cyan (14.71) and Magenta (15.08) compared with the Chromo substrate which recorded 13.03 and 11.46 respectively indicating greater dot gain and tonal value increase for these process colors. In contrast the Chromo substrate demonstrated higher TVI values for Yellow (11.42) and Black (15.92) than the PE White substrate which recorded 9.50 and 9.17 respectively suggesting improved dot stability and greater tonal value expansion on the Chromo surface for these inks. These results indicate that the substrate characteristics significantly influence tonal value increase thereby affecting dot reproduction tonal accuracy and the overall print quality achieved in UV LED flexographic printing.

This study evaluated the influence of substrate type on Solid Ink Density (SID) and Tonal Value Increase (TVI) in UV LED flexographic printing by comparing Chromo and PE White substrates. The results demonstrated that both substrates exhibited distinct printing characteristics due to differences in their surface properties and ink–substrate interactions. PE White generally achieved higher SID values for Cyan and Magenta, indicating improved ink transfer and color strength, while Chromo exhibited superior SID values for Yellow and Black. Similarly, variations in TVI were observed across the CMYK process colors, with PE White showing greater dot gain in certain colors and Chromo demonstrating higher tonal value increase in others.

Overall, the findings confirm that substrate selection has a significant impact on ink density, tonal reproduction, and print quality in flexographic printing. The differences in SID and TVI values highlight the importance of optimizing printing parameters according to substrate characteristics to achieve consistent color reproduction and improved print performance. Therefore, understanding the relationship between substrate properties and print quality

metrics is essential for enhancing process control and ensuring high-quality output in UV LED flexographic printing applications.

### 3. Results and Discussion

#### Solid Ink Density (SID)

The Solid Ink Density (SID) analysis revealed that both Chromo and PE White substrates produced satisfactory ink density values, although their performance varied across the CMYK process colors. The PE White substrate recorded higher average SID values for Cyan (1.59) and Magenta (1.10) compared with the Chromo substrate, which achieved 1.54 and 1.06, respectively. These results indicate improved ink transfer efficiency and greater color strength for Cyan and Magenta on the PE White substrate. In contrast, the Chromo substrate exhibited higher SID values for Yellow (1.17) and Black (1.74) than the PE White substrate, which recorded 1.11 and 1.55, respectively, suggesting more effective ink deposition and stronger ink–substrate interaction for these colors.

Overall, the SID results demonstrate that substrate characteristics significantly influence solid ink density in UV LED flexographic printing. PE White provided better ink density for Cyan and Magenta, whereas Chromo performed more effectively for Yellow and Black. These findings indicate that selecting an appropriate substrate is essential for achieving optimal ink density, consistent color reproduction, and high-quality print output.

#### Dot Gain (TVI)

The Tonal Value Increase (TVI) analysis indicated that both Chromo and PE White substrates exhibited variations in dot gain across the CMYK process colors, reflecting the influence of substrate characteristics on tonal reproduction. The PE White substrate generally produced higher TVI values for Cyan and Magenta, indicating greater dot gain and tonal value expansion for these process colors. Conversely, the Chromo substrate demonstrated higher TVI values for Yellow and Black, suggesting enhanced ink–substrate interaction and increased dot gain in these inks. These differences highlight the effect of substrate surface properties on ink spreading and dot reproduction during the UV LED flexographic printing process.

Overall, the TVI results confirm that substrate selection plays a critical role in controlling tonal value increase and maintaining print quality. Appropriate optimization of printing parameters based on substrate characteristics is essential to minimize excessive dot gain, improve tonal accuracy, and achieve consistent color reproduction in UV LED flexographic printing.

### 4. Conclusion

The present study demonstrates that substrate type has a significant influence on Solid Ink Density (SID) and Tonal Value Increase (TVI) in UV LED flexographic printing. The experimental results revealed that the PE White substrate exhibited higher SID values for Cyan and Magenta, indicating improved ink transfer and color strength, whereas the Chromo substrate achieved higher SID values for Yellow and Black, reflecting stronger ink–substrate interaction. Similarly, the TVI analysis showed noticeable variations between the two substrates across the CMYK process colors, confirming that substrate surface characteristics affect dot gain and tonal reproduction. Overall, neither substrate consistently outperformed the other for all process colors, as each demonstrated specific advantages depending on the ink. These findings emphasize that substrate selection and process optimization are critical for achieving consistent ink density, controlled tonal value increase, accurate color reproduction, and superior print quality in UV LED flexographic printing. The outcomes of this research provide valuable guidance for improving process control and substrate selection in commercial packaging and label printing applications.

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