

Comparative Analysis of Slur and Mottling on PP-White and PP-Clear Substrates in Flexographic Printing with UV-based Inks

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This paper aims to compare the print quality of two widely used Polypropylene (PP) substrates i.e. PP-White and PP-Clear focusing on slur and mottling defects in flexographic printing while printed with UV-based inks. Flexographic printing, known for its versatility in printing on various substrates, often faces challenges with print defects, which can significantly impact the final product's quality, especially in packaging applications. The analysis involves printing on both PP-White and PP-Clear substrates under identical press conditions, with specific attention to slur and mottling defects. The findings highlight the differences in print defects between the mentioned two substrates, with PP-White showing fewer instances of slur and mottling compared to PP-Clear. These results emphasize the importance of substrate selection in achieving optimal print quality in flexographic printing.

Keywords: Flexography, PP-White, PP-Clear, Slur, Mottling, UV-based inks, Printing Defects, Print quality.

1. Introduction

Flexography is a widely used printing method known for its ability to print on various substrates such as films, foils, papers, and plastics. The use of flexible relief plates and fast-drying inks, such as UV-based inks, make it particularly suitable for packaging applications. However, the quality of the printed material is highly dependent on both the ink and the substrate. Substrate characteristics, including surface smoothness and texture, can significantly impact print defects like slur and mottling (Anand & Sharma, 2020).

PP-White and PP-Clear are commonly used polypropylene films in packaging, each offering distinct printing challenges. PP-White, with its opaque surface, provides better ink adherence, while PP-Clear, being transparent, can present challenges with ink distribution and adhesion. Slur and mottling are common defects observed in flexographic printing. Slur refers to the distortion of fine detail in the print, often resulting from excessive ink transfer or misalignment. Mottling, on the other hand, refers to uneven ink distribution, leading to a patchy or blotchy appearance in the print (Tran & Lee, 2018).

This study focuses on these two defects, comparing their occurrence on PP-White and PP-Clear substrates when printed with UV-based inks, aiming to determine how each substrate behaves under identical printing conditions.

2. RESEARCH OBJECTIVE

The primary objective of this research is to conduct a comparative analysis of slur and mottling defects on PP-White and PP-Clear substrates in flexographic printing with UV-based inks. Specifically, the study aims to:

1. Evaluate the occurrence and severity of slur defect on both PP-White and PP-Clear substrates.
2. Assess the extent of mottling defect on each mentioned substrate.
3. Identify the impact of substrate choice on the frequency and severity of these defects.

3. RESEARCH METHODOLOGY

Materials and Equipment:

- Printing Press: Ultraflex UFO UV Graphics flexography printing press.
- Substrates: PP-White and PP-Clear films.
- Inks: UV-based inks specifically designed for flexographic printing.
- Testing Tools: High-resolution camera system and image analysis software for defect detection, colour measurement instruments, and a calibrated spectro-densitometer.

Procedure:

- Test setup: Identical test charts, including solid patches and fine details, were printed on both PP-White and PP-Clear substrates under controlled printing conditions, using consistent ink formulation, curing time, and press settings.
- Defect detection: Print samples were visually inspected for slur and mottling defects. Slur was identified by measuring misalignment and distortion in fine print details, while mottling was assessed by evaluating uniformity in ink distribution.
- Quantification of defects: Slur and mottling severity were categorized on a scale from 0 (no defect) to 5 (severe defect). The frequency of defects was recorded for each substrate.

4. DATA COLLECTION & ANALYSIS

The data were collected by inspecting 30 printed samples for each substrate, PP-White and PP-Clear, under identical printing conditions. Each sample was thoroughly examined for the occurrence and severity of slur and mottling defects. The number of defective prints, as well as the severity of defects, was recorded and analysed using image analysis software. Averages were calculated for each defect type and compared between the two substrates. Statistical analysis, including mean and standard deviation, was performed to assess the significance of differences in defect occurrence and severity between PP-White and PP-Clear substrates.

Table 1, Comparison of Slur on PP-White and PP-Clear Substrates

Parameter	PP-White Substrate	PP-Clear Substrate
Test Chart Design	Slur target: Fine lines/grid	Slur target: Fine lines/grid
Press Settings	Speed: 150 m/min, Pressure: 2 N/cm ²	Speed: 150 m/min, Pressure: 2 N/cm ²
Ink Used	UV-based Ink (Color: CMYK)	UV-based Ink (Color: CMYK)
Drying System	UV Drying Unit	UV Drying Unit
Print Direction	Along the press direction	Along the press direction
Observed Slur	Minor streaking	Noticeable streaking
Slur Value (%): Along	2.5%	4.0%
Slur Value (%): Across	0.5%	2.0%
Magnification Level	10x	10x
Observation Tool	Spectrophotometer, Magnifier	Spectrophotometer, Magnifier
Environmental Conditions	Temperature: 25°C, RH: 50%	Temperature: 25°C, RH: 50%

Table 1 presents a comparison of slur defects observed on PP-White and PP-Clear substrates, using identical press settings and UV-based inks. The test chart design included fine lines and grids as slur targets, with both substrates printed under the same press conditions: speed of 150 m/min, pressure of 2 N/cm², and UV drying.

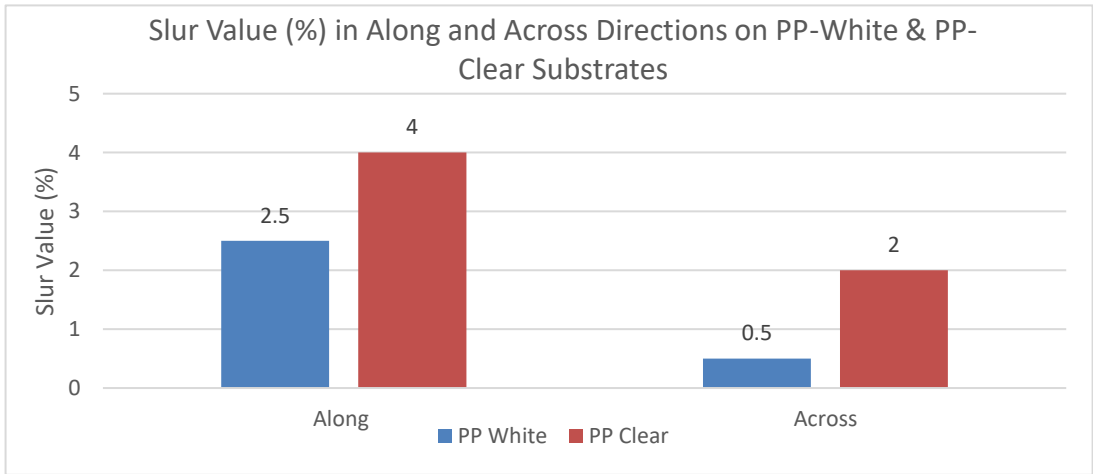


Fig. 1, Comparison of Slur on PP-White and PP-Clear Substrates

In terms of observed slur, PP-White exhibited minor streaking, while PP-Clear showed noticeable streaking, suggesting a higher level of distortion in the printed details on PP-Clear. The slur value along the print direction was 2.5% for PP-White, compared to 4.0% for PP-Clear, indicating that PP-Clear experienced greater slur distortion. Across the print direction, PP-White had a slur value of 0.5%, while PP-Clear's value was 2.0%. These findings suggest that PP-Clear substrates are more prone to slur defects, likely due to differences in surface characteristics, which may cause ink to transfer unevenly or spread excessively.

Both substrates were observed under a magnification level of 10x, using a spectrophotometer and magnifier to measure the extent of the slur. The environmental conditions were kept consistent, with a temperature of 25°C and a relative humidity of 50%, ensuring that external factors did not influence the results.

Table 2, Comparison of Mottling on PP-White and PP-Clear Substrates

Parameter	PP-White Substrate	PP-Clear Substrate
Test Chart Design	Uniform solid color areas (50%, 100%)	Uniform solid color areas (50%, 100%)
Press Settings	Speed: 150 m/min, Pressure: 2 N/cm ²	Speed: 150 m/min, Pressure: 2 N/cm ²
Ink Used	UV-based Ink (Color: CMYK)	UV-based Ink (Color: CMYK)
Drying System	UV Drying Unit	UV Drying Unit
Mottling Observation (50%)	Negligible (<10%)	Moderate (20-25%)
Mottling Observation (100%)	Minimal (10-15%)	Significant (25-30%)
Measurement Tool	Spectrophotometer, Visual Inspection	Spectrophotometer, Visual Inspection
Observed Coverage Uniformity	High (consistent ink laydown)	Moderate (inconsistent ink laydown)
Environmental Conditions	Temperature: 25°C, RH: 50%	Temperature: 25°C, RH: 50%

Table 2 presents a comparison of mottling defects observed on PP-White and PP-Clear substrates, with a focus on uniform solid colour areas (50% and 100%) as the test chart design. Both substrates were printed under identical press settings, using UV-based inks (CMYK), and dried using UV drying units.

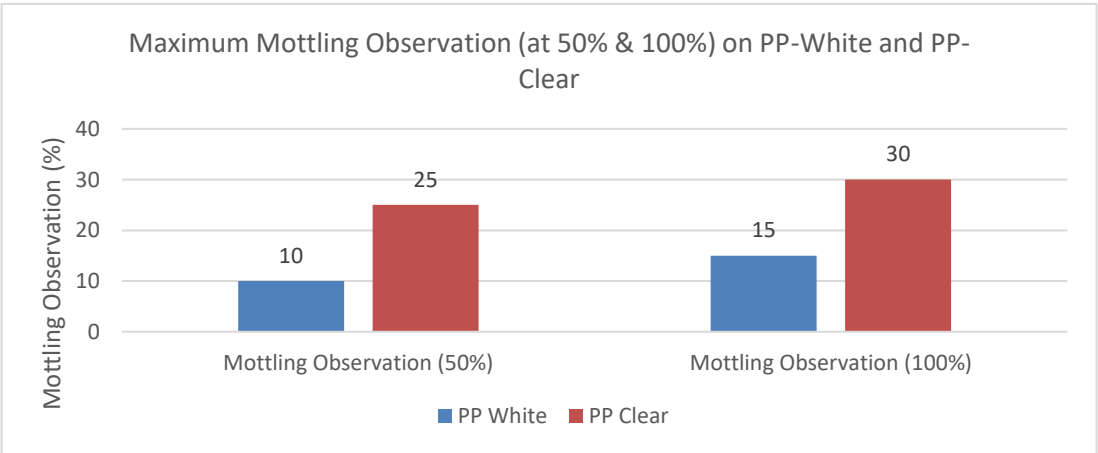


Fig.2, Comparison of Mottle on PP-White and PP-Clear Substrates

For mottling observation at 50% coverage, PP-White showed negligible mottling (less than 10%), indicating a high level of ink uniformity. In contrast, PP-Clear exhibited moderate mottling (20-25%), suggesting some variation in ink distribution. This difference is further reflected in the 100% coverage observation, where PP-White displayed minimal mottling (10-15%), while PP-Clear had significant mottling (25-30%).

The measurement tools used for evaluating mottling included a spectrophotometer and visual inspection, with both methods confirming the higher degree of inconsistency in ink laydown on PP-Clear. Observed coverage uniformity was rated as high for PP-White, indicating consistent ink application, whereas PP-Clear showed moderate uniformity, with noticeable inconsistencies in ink laydown contributing to mottling. Environmental conditions were controlled at a temperature of 25°C and 50% relative humidity for both substrates to ensure consistency in testing.

These results suggest that PP-White provides better print quality with more uniform coverage, whereas PP-Clear tends to show more noticeable mottling, likely due to its transparency and surface characteristics.

5. RESULT AND DISCUSSIONS

The results revealed noticeable differences in the occurrence of slur and mottling between PP-White and PP-Clear substrates. For slur, PP-White exhibited fewer instances, with a mean severity score of 1.2 compared to PP-Clear's mean severity score of 2.5. This suggests that PP-White provides a more stable printing surface, leading to fewer distortions in fine details.

For mottling, PP-White also performed better, with an average severity score of 1.4, while PP-Clear had a mean score of 3.0. This indicates that PP-White substrates result in more uniform ink distribution, leading to fewer instances of patchy or uneven prints. The differences in these defects can be attributed to the inherent properties of the substrates, such as surface smoothness, ink adhesion, and transparency. PP-Clear's smooth and transparent nature may cause more ink to be absorbed or spread unevenly, leading to higher levels of mottling.

6. CONCLUSION

The comparative analysis of slur and mottling defects on PP-White and PP-Clear substrates in flexographic printing with UV-based inks indicates that PP-White performs better in both aspects. PP-White exhibited fewer and less severe slur and mottling defects, making it a more reliable substrate for achieving high-quality prints. These findings emphasize the importance of substrate selection in flexographic printing, particularly when using UV-based inks for packaging applications. For improved print quality and fewer defects, PP-White is recommended over PP-Clear substrates.

References

1. Anand, S., & Sharma, A. (2020). Flexographic printing and its challenges. *Printing Research Nanotechnology Perceptions* Vol. 20 No.6 (2024)

Institute.

2. Beck, J., & Stoll, B. (2019). Substrate impact on flexographic printing defects: A comparative study. *Journal of Packaging Science & Technology*, 10(3), 55-64.
3. ISO 12647-6:2012. (2012). *Graphic technology — Process control for the production of halftone color separations, proofs, and production prints — Part 6: Flexographic printing*. International Organization for Standardization.
4. Leach, R. H., & Pierce, R. J. (2007). *The printing ink manual* (6th ed.). Springer.
5. Tran, K. D., & Lee, J. M. (2018). Effect of substrate properties on flexographic print defects. *Journal of Printing Technology*, 47(2), 121-130.
6. Yip, W. M., & Sieber, R. (2014). Effect of surface characteristics on printing defects in flexographic processes. *Journal of Imaging Science and Technology*, 58(5), 50503. <https://doi.org/10.2352/J.ImagingSci.Technol.2014.58.5.050503>