Volume 25 Issue 03, 2022 ISSN: 1005-3026 https://dbdxxb.cn/ Original Research Paper

ANALYSIS OF PRINT-EDGE OF DRY ELECTROPHOTOGRAPHY (DEP) AND INKJET PRINTS AS PER ISO13660 PRINT QUALITY ATTRIBUTES

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ABSTRACT

To adapt to the dynamic demands of printers and customers, a variety of printing processes have emerged in the printing industry. Among these, digital printing stands out as the most rapid and advancing technique in contemporary times. Two prominent components of digital printing, employed for printing on cellulosic substrates, encompass the Dry Electro-photography (DEP) and Inkjet technologies. This paper aims to juxtapose the print-edge characteristics between Dry Electro-photography (DEP) and Inkjet technologies using the Human Standard Observation Method. In order to accomplish this objective, a comprehensive test chart was generated using Corel Draw Graphic Suite 20, integrating diverse test image elements such as line drawings, continuous tones, and solid images. Subsequently, this test chart was printed using available Dry-toner Electrophotographic and Inkjet printing presses within the local market, employing uncoated, matte coated, and gloss coated papers. The assessment of print-edge attributes encompassed Graininess, Mottle, Voids, and Fill, all in accordance with ISO 13660 standards. The evaluation of print-edge qualities was conducted through the participation of Standard Human Observers who successfully passed the Ishihara Test. By averaging the outcomes from twenty observers, the results were collated and subjected to further analysis and discussion.

KEYWORDS: - DEP (Dry Electro-photography), Inkjet printing press, Human Standard Observer, Graininess, Mottle, Voids, Fill, Ishihara Test, Digital Printing process.

INTRODUCTION

Dry Electro-photography (DEP) constitutes a digital printing approach wherein ink is deposited onto a photoconductive drum in a dry powder state. Subsequently, the ink is fused onto the intended substrate through the application of heat and pressure. This process is employed for imprinting images onto substrates like Cellulose Papers (Barney Smith, E. H., 2010). Conversely, the Inkjet printing process utilizes a printhead to accomplish printing tasks. The printhead, a pivotal component, incorporates minuscule nozzles responsible for expelling ink droplets onto the target surface. During printhead movement, it receives directives from the printer's control system regarding the precise locations and timings for ejecting ink droplets. Within the printhead, the nozzles experience heating, leading the ink to vaporize and generate tiny bubbles. These bubbles exert pressure, propelling individual droplets of ink from the nozzles onto the substrate. The resultant image resolution and quality are determined by factors such as droplet size and the quantity of droplets distributed within a designated area (M. Hwsam & B. Volfango, 2020).

Submitted: 08/06/2022 **Accepted**: 27/07/2022

Numerous research endeavours have already been conducted to assess the disparities in quality between the Dry Electro-photography (DEP) and Inkjet printing processes. These investigations have focused on several print quality aspects, including Solid Ink Density, Dot Gain, and Print Contrast, among others. ISO 13660 serves as a framework defining diverse print quality parameters for Electro-photography office printers, encompassing attributes pertinent to Line drawings, such as Graininess, Mottle, Voids, and Fill. These attributes serve as valuable metrics for printers to effectively gauge and compare the quality of print edges between the aforementioned printing technologies.

RESEARCH OBJECTIVE

Both Dry Electro-photography (DEP) and Inkjet printing methods have gained extensive usage in the current landscape, gradually capturing market share even for short-run print jobs. However, a notable concern has emerged among both printers and customers concerning the perceived disparities in print quality between Dry Electro-photography (DEP) and Inkjet printing presses. To achieve a clearer comprehension of print quality, an exploration of ISO 13660 standards has been conducted, with a focus on relevant factors for facilitating a comparative assessment of print-edge quality. This paper's primary objectives revolve around employing the Human Standard Observer Method to systematically compare the print-edge qualities inherent to Dry Electro-photography (DEP) and Inkjet printing technologies.

RESEARCH METHODOLOGY

A comprehensive master test chart was meticulously created, encompassing an array of visual elements such as line drawings, continuous tones, solid images, and tint patches for the cyan, magenta, yellow, and black color channels. This meticulously designed test chart underwent printing using both the Dry Electro-photography (DEP) and Inkjet printing presses available within the local market. Subsequently, an in-depth analysis incorporated the print quality attributes defined by ISO 13660, namely Print-edge Graininess, Mottle, Voids, and Fill (refer to Figure 1).

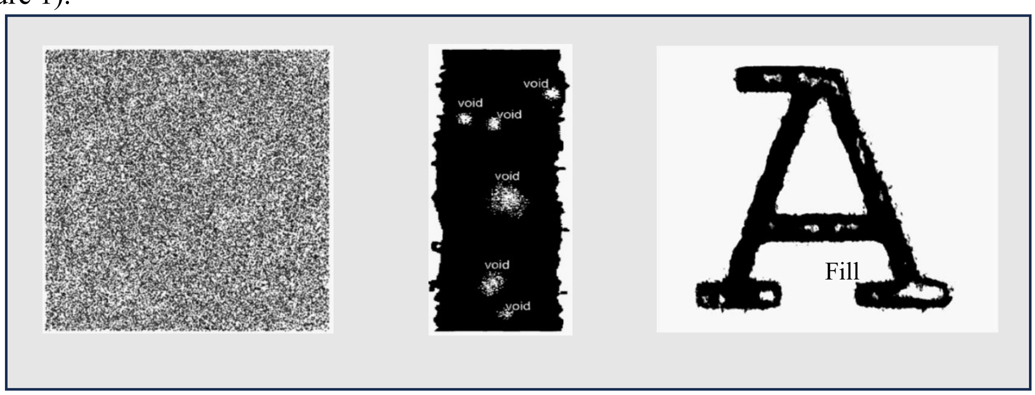

Figure.1. Various print-edge quality attributes as per ISO 13660 (ISO 13660)

The evaluation of these print-edge quality attributes was conducted employing the established standard human observer method. Participants aged 18 and above, who demonstrated the capability to pass the Ishihara Test for color blindness (refer to Figure 2) and achieved scores below 2, were designated as human standard observers. A total of 20 observers were provided with assessment sheets to evaluate and analyze the print-edge quality, rating it on a scale from 1 to 10. In this scale, a score of 1 indicated the lowest quality, while a score of 10 denoted the highest print-edge quality attribute.

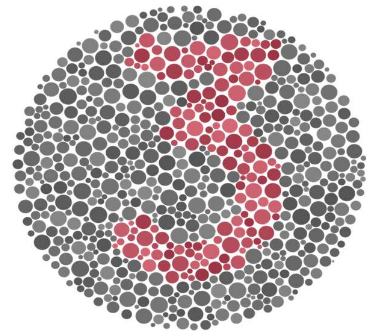

Figure 2. Ishihara Test (Colour blindness test)

Observations were facilitated using a 10x zoom eye-lens, with readings taken from a standardized distance of 30 cm. Subsequently, the average rating from these 20 observers was calculated, and standard deviations were determined. To elucidate the findings, the collected data was organized through tabulation and visual representation using bar charts, thus enabling thorough analysis and discussions on the outcomes.

DATA COLLECTION & ANALYSIS

Table 1. Print-edge Graininess on DEP and Inkjet presses

	Uncoated	Matte Coated	Gloss Coated
DEP	6.45	5.30	4.45
Inkjet	7.60	5.65	5.20
SD1	0.6863	1.1743	0.9445
SD2	0.8208	1.0400	1.1965

Table 1 highlights a discernible trend where the graininess values for Dry Electro-photography (DEP) (6.45, 5.30, and 4.45) are consistently lower compared to the values obtained from the Inkjet press (7.60, 5.65, and 5.20), across all paper types namely Uncoated, Matte Coated, and Gloss Coated. In the context of Dry Electro-photography data, SD-I signifies the standard deviation, while SD-II represents the standard deviation in the Inkjet press data.
The compiled data notably reveals that the prints produced by the Inkjet press exhibit a higher degree of graininess when juxtaposed with those created using the Dry Electro-photography process.

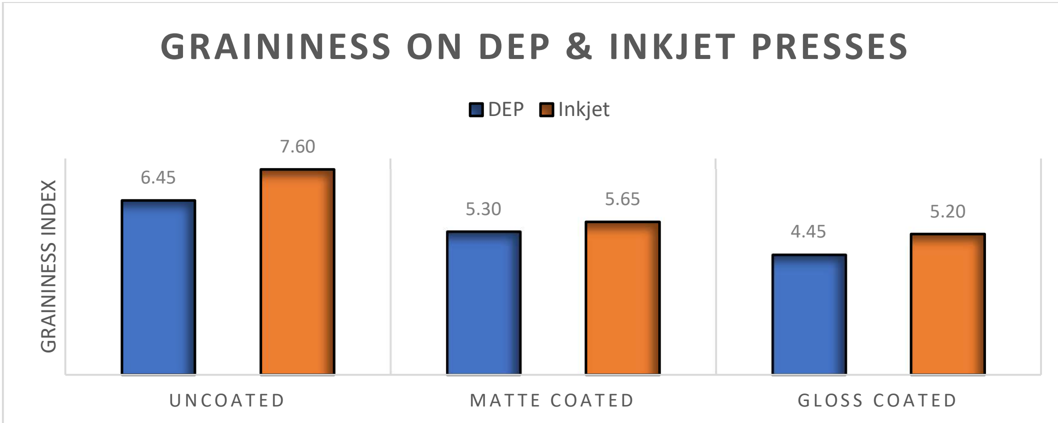

Figure 2. Comparative analysis of Print-edge Graininess on DEP and Inkjet presses

Figure 2 serves as a graphical depiction of the accumulated data, illustrating one of the pivotal attributes in the evaluation of print edge quality. The graphical representation distinctly highlights that the graininess values obtained from the Inkjet press exhibit a prominent peak on Uncoated, Matte Coated, and Gloss Coated papers. In contrast, the graininess values originating from the DEP (Dry Electro-photography) process exhibit comparatively lower peaks across the same paper types.

Table 2. Print-edge Mottle on DEP and Inkjet presses

	Uncoated	Matte Coated	Gloss Coated
DEP	6.25	5.10	4.40
Inkjet	7.45	6.10	5.45
SD1	0.9665	0.9679	1.0463
SD2	0.9445	0.9679	1.0501

Table 2 represent the Print-edge Mottle values are on higher side in Inkjet press i.e., 7.45, 6.10 and 5.45 on Uncoated, Matte coated and Gloss coated papers respectively but on the other hand these values are 6.25, 5.10 and 4.40 in Dry Electro-photography. Standard deviation is ranged between 0.9445 to 1.0501 in case of Inkjet press and in case of DEP press it is ranged between 0.9665 to 1.0463.

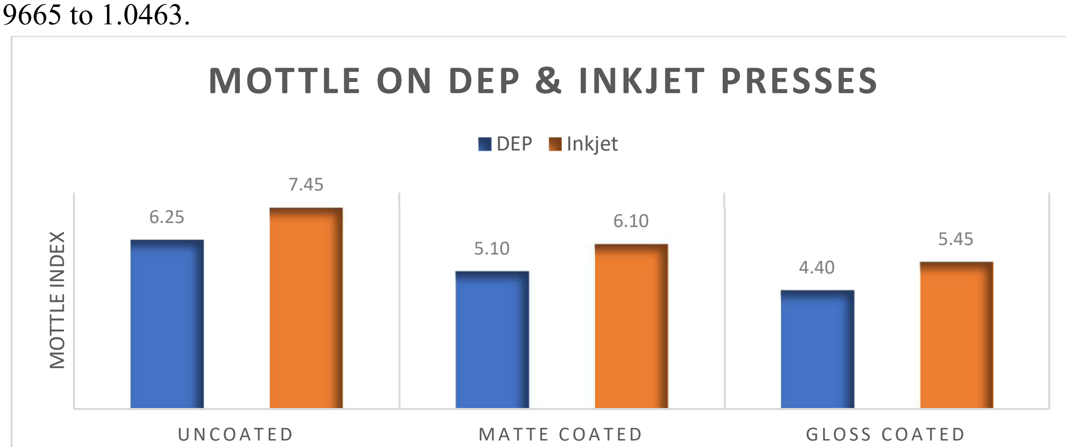

Figure 3. Comparative analysis of Print-edge Mottle on DEP and Inkjet presses

Figure 3 effectively demonstrates the impact of mottle on print-edge quality. It is evident from the graphical representation that the mottle effect is more pronounced in prints produced by the Inkjet press when compared to those created through the Dry Electro-photography process. This observation holds true across various paper types, including uncoated, matte coated, and gloss coated papers.

Table 3. Print-edge Voids on DEP and Inkjet presses

	Uncoated	Matte Coated	Gloss Coated
DEP	7.80	6.90	5.55
Inkjet	7.20	6.00	4.45
SD1	0.7678	0.9119	0.8256
SD2	0.7678	1.1239	0.9445

Print-edge contrast is Voids a major role in print quality attributes and when this attribute was compared on dry electro-photography and inkjet presses it was found that the result based on the types of papers. It was represented in the table 3 that in case of the DEP press the values of print-edge mottle on higher side i.e., 7.80, 6.90 and 5.55 on Uncoated paper, Matte Coated and Gloss Coated compared with the Inkjet press.

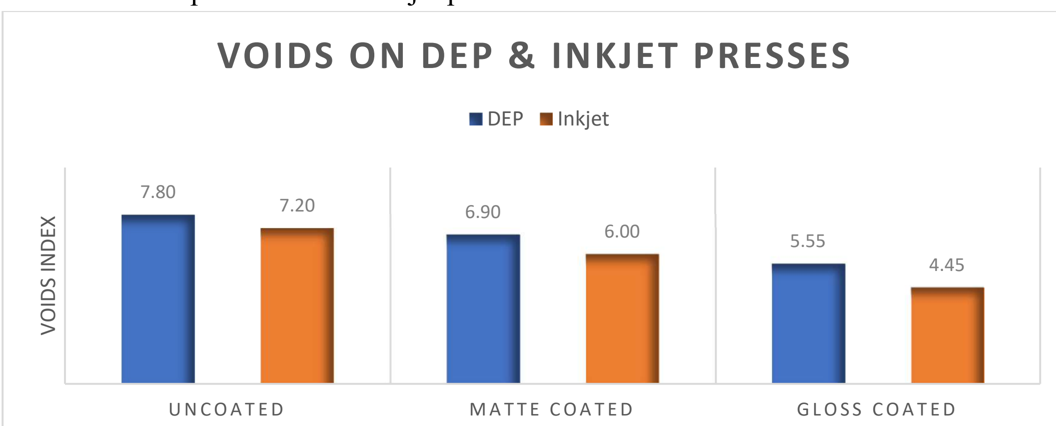

Figure 4. Comparative analysis of Print-edge Voids on DEP and Inkjet presses

Figure 4 provides a comparative analysis of print-edge contrast, showcasing the differences between the two printing methods. Notably, the data reveals that on uncoated, matte coated, and gloss coated papers, the values of print-edge mottle were higher in the context of the DEP press when contrasted with the Inkjet press. This observation underscores a distinct characteristic of the print-edge quality across these paper types between the two printing technologies.

Table 4. Print-edge Fill on DEP and Inkjet presses

	Uncoated	Matte Coated	Gloss Coated
DEP	6.10	7.50	8.10
Inkjet	6.50	7.80	8.30
SD1	0.7182	0.8272	0.7881

SD2	1.0000	0.9515	0.8013

The print-edge fill data is presented in table 4, revealing an insightful perspective on this attribute. The analysis highlights that the values associated with print-edge fill are notably higher in the case of the Inkjet press on uncoated, matte coated, and gloss coated papers, with recorded values of 6.10, 7.50, and 8.10 respectively. In comparison, the values derived from the DEP press are comparatively lower. This suggests a distinct variance in the print-edge fill quality between the two printing technologies across these different paper types.

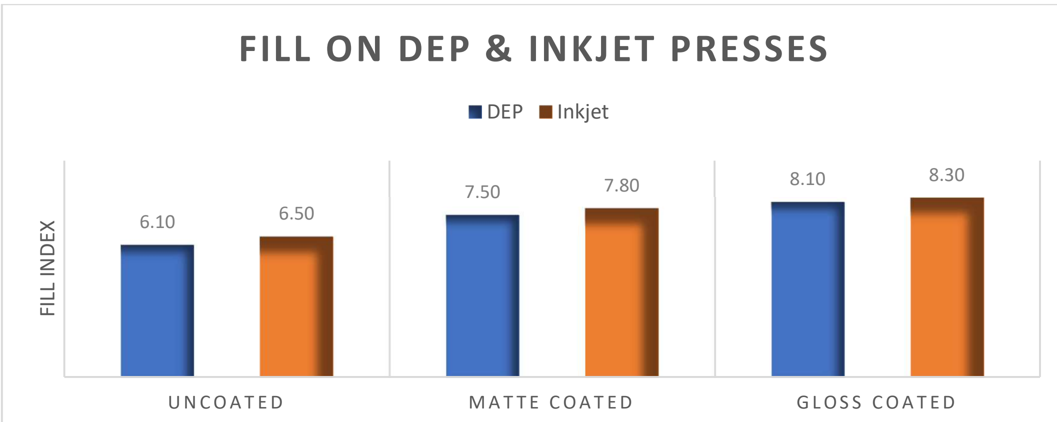

Figure 5. Comparative analysis of Print-edge Fill DEP and Inkjet presses

Figure 5 vividly illustrates the relationship between print-edge fill values across different paper types. The graphical representation distinctly shows that the values of print-edge fill are noticeably higher when using the Inkjet press, specifically on uncoated, matte coated, and gloss coated papers, as compared to the results obtained from the Dry Electro-photography (DEP) press. This visual representation underscores the disparity in print-edge fill quality between the two printing technologies across the various paper substrates.

RESULTS & DISCUSSION

Print-edge Graininess Analysis

Print-edge graininess in printing pertains to a perceptible occurrence wherein an image or text exhibits a rough texture composed of tiny dots or pixels. This phenomenon has the potential to diminish the overall quality and distinctness of the printed content. Graininess tends to be particularly conspicuous in images featuring gradual color transitions or delicate tonal variations, especially in photographic prints. When this aspect was examined through a comparison between DEP and Inkjet presses on different paper surfaces i.e., uncoated, matte coated, and gloss coated as depicted in table 1, it became apparent that the graininess was more pronounced in the results obtained from the Inkjet press.

Print-edge Mottle Analysis

Print-edge mottle in printing signifies an undesirable visual occurrence wherein uneven, patchy, or blotchy regions of color emerge on a printed material. These irregular color patches can disrupt the overall coherence and quality of the printed image. Upon comparing the instances of print-edge mottle between DEP and Inkjet presses across various paper types i.e., uncoated, matte coated, and gloss coated, as outlined in table 2, an interesting observation emerges. The data reveals that the values associated with print-edge mottle are notably higher in the context of the Inkjet press, indicating a more pronounced presence of this unwanted effect in prints produced by the Inkjet technology.

Print-edge Voids Analysis

Voids in printing refer to areas on a printed material where the ink or toner did not properly adhere to the surface, resulting in gaps or blank spots. These gaps can disrupt the intended image or text and lead to an incomplete or flawed appearance. In table 3 print-edge voids was compared in DEP and Inkjet presses on uncoated, matte coated and gloss coated papers. It was found that the voids are on higher side in DEP press on uncoated paper as compare with Inkjet press, because of uncoated paper absorbed more ink and the image area was formed denser.

Print-edge Fill Analysis

Print-edge fill pertains to the uniformity of darkness within lines, images, and characters on a printed material. It is quantified as the ratio of the area with a 75% relative reflectance value within the inner boundary to the total area encompassed by that boundary. In table 4, a comparative analysis of print-edge fill is presented between Dry Electro-photography and Inkjet presses on different paper types i.e., uncoated, matte coated, and gloss coated.

Upon careful examination of the values presented in table 4, a notable trend becomes apparent. The data indicates that the print-edge fill values are notably higher in the case of the Inkjet press, across all the considered paper types i.e., uncoated, matte coated, and gloss coated. This suggests that the Inkjet press tends to exhibit a higher degree of darkness uniformity within the specified boundaries compared to the Dry Electro-photography process.

CONCLUSION

The following points are concluded on the basis of results and discussions.

1. The phenomenon of print-edge graininess is more pronounced in Inkjet presses when compared to Dry Electro-photography presses across uncoated, matte, and gloss coated papers.
2. Print-edge Mottle was found more in the case of Inkjet printing press as compared to the Dry electro-photography printing press on uncoated, matte coated and gloss coated papers.
3. In the context of uncoated, matte coated, and gloss coated papers, a higher occurrence of print-edge voids was observed in DEP presses as opposed to Inkjet printing presses.
4. The inclination towards print-edge fill was more noticeable in Inkjet presses while considering uncoated, matte coated, and gloss coated papers, as compared to Dry Electro-photography printing presses.

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