COMPARISION OF DRY ELECTROPHOTOGRAPHY (DEP), LIQUID ELECTROPHOTOGRAPHY (LEP) AND PIEZOELECTRIC INKJET (PIJ) PRESSES ON THE BASIC OF DENSITROMETRIC PRINT QUALITY ATRIBUTES ON PHOTO PAPER

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ABSTRACT

The present study considers a comprehensive comparative analysis of three prominent printing technologies: Dry Electrophotography (DEP), Liquid Electrophotography (LEP), and Piezoelectric Inkjet (PIJ) presses, focusing specifically on photo paper as the print medium. The investigation centres on the densitometric print quality attributes exhibited by each technology. Densitometry, as a quantitative measure of optical density, serves as a fundamental metric for assessing the precision and fidelity of printed images. Through a series of meticulously designed experiments and measurements, key densitometric parameters are evaluated, including but not limited to dot gain, colour accuracy, and overall image sharpness. The study aims to elucidate the strengths and limitations of each printing technology concerning these attributes, providing valuable insights into their performance on photo paper. The findings of this research contribute to a deeper understanding of the nuances in print quality across DEP, LEP, and PIJ technologies. Such insights are critical for industries and professionals seeking to optimize their printing processes, particularly when working with high-quality photopaper substrates. Ultimately, this research aids in informed decision-making for selecting the most suitable printing technology based on specific densitometric print-quality requirements in the context of photo paper applications.

KEYWORDS: - Dry Electro-photography, Liquid Electro-photography, Piezoelectric Inkjet, Solid Ink Density, Dot Gain, Print Contrast, Densitometer

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INTRODUCTION

In the realm of modern printing technologies, three distinct approaches have emerged as stalwarts in the reproduction of digital images and text: Dry Electro-Photography (DEP), Liquid Electro-Photography (LEP), and Piezo-Electric Inkjet Printing. Each method possesses its unique set of principles, mechanisms, and advantages, catering to diverse applications and industry needs.

Dry Electro-Photography, commonly known as laser printing, operates on the principle of electrostatic charges and toner particles. The process begins with a laser beam selectively charging a photoconductive drum, creating a latent image. Subsequently, toner particles adhere to the charged areas and are then transferred onto paper, fused through heat, producing the final print. DEP excels in high-speed, high-volume printing, making it a cornerstone in office environments and commercial printing applications. Liquid Electro-Photography, also referred to as digital liquid printing, distinguishes itself by utilizing liquid toners. In LEP, the photoconductive drum is coated with a liquid toner containing charged pigments. The charged liquid toner adheres to the photoconductive surface in response to the laser's modulation, transferring onto the paper and subsequently undergoing a fusing process. LEP is recognized for its vibrant colour reproduction and suitability for variable data printing, finding applications in marketing and packaging. Piezo-Electric Inkjet Printing relies on the precision of piezoelectric crystals to propel ink droplets onto the printing substrate. These crystals deform under an applied electric field, creating pressure waves that expel ink through microscopic nozzles. This technology offers exceptional versatility, accommodating a wide range of ink types and substrates. Piezo-electric inkjet printing is renowned for its capability to produce high-resolution prints with variable droplet sizes, making it an ideal choice for graphic arts, photography, and textile printing.

As we delve into the intricacies of these printing technologies, it becomes evident that each method brings its unique strengths to the table. This exploration aims to shed light on the operational principles, advantages, and limitations of Dry Electro-Photography, Liquid Electro-Photography, and Piezo-Electric Inkjet Printing, providing a foundation for informed decision-making in various printing applications.

RESEARCH OBJECTIVE

In the contemporary landscape, three main Dry Electro-photography (DEP), Liquid Electro-photography (LEP) and Piezo-electric Inkjet (PIJ) printing processes have gained significant traction, capturing market share, particularly for short-run jobs. However, a notable concern has emerged among printers and customers regarding the perceived disparities in print quality between Dry Electro-photography (DEP), Liquid Electro-photography (LEP) and Piezo-electric Inkjet (PIJ) printing presses. To gain a comprehensive understanding of print quality, samples from above mentioned printing methods have been generated, and their attributes quantified using a densitometer. This analysis focuses on key print-quality aspects including Solid Ink Density, Dot Gain, and Print Contrast, facilitating a thorough comparison of print quality on photopaper. The fundamental aim of this paper is to assess and contrast the print quality achieved through Dry Electro-photography (DEP), Liquid Electro-photography (LEP) and Piezo-electric Inkjet (PIJ) printing technologies on photopaper, employing densitometric measurements as a guiding metric.

RESEARCH METHODOLOGY

Creating an all-encompassing master test chart involved meticulous incorporation of line drawings, continuous tones, solid images, and tint patches representing cyan, magenta, yellow, and black. This meticulously designed test chart served as the foundation for subsequent printing exercises, employing both Dry Electro-Photography (DEP), Liquid Electro-photography (LEP) and Piezo-electric Inkjet (PIJ) printing presses readily available in the local market. The assessment process adhered to ISO 13660 standards, encompassing key print-quality attributes such as Solid Ink Density, Print Contrast, and Dot Gain (Figure 1).

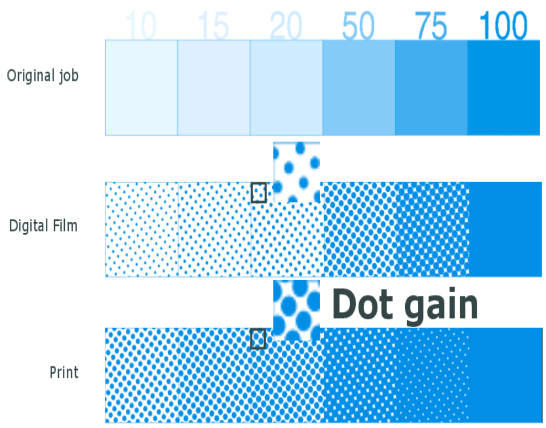

Figure.1. Dot gain (ESKO, 2012)

The evaluation of these print-quality attributes utilized a densitometer, an instrument specifically crafted for measuring the density of various materials. Typically employed to gauge the optical density of ink, pigments, films, and other printed materials, the densitometer plays a crucial role in sectors such as printing, photography, and film production. Accurate density and colour measurements are of paramount importance in these fields (Pritchard, 2010). A comprehensive set of 20 measurements was obtained from a sheet generated through Liquid Electro-photography (LEP) and Piezo-electric Inkjet (PIJ) printing presses.

DATA COLLECTION & ANALYSIS

Table 1. Print-quality Solid Ink Density on DEP, LEP & PIJ printing presses

	Cyan	Magenta	Yellow	Black
DEP	**1.50**	**1.53**	**1.10**	**1.75**
LEP	**1.54**	**1.58**	**1.13**	**1.79**
PIJ	**1.46**	**1.48**	**1.07**	**1.71**

It is observed in the table 1, that the Solid Ink Density values of Liquid Electro-photography are (1.54, 1.58, 1.13 and 1.79) on cyan, magenta, yellow and black respectively which are higher than values of Dry Electro-photography (DEP) and Piezo-electric Inkjet printing press on photopaper, but when we compare between Dry Electro-photography (DEP) and Piezoelectric inkjet press the values of SID are on higher side in DEP on all cyan, magenta, yellow and black.

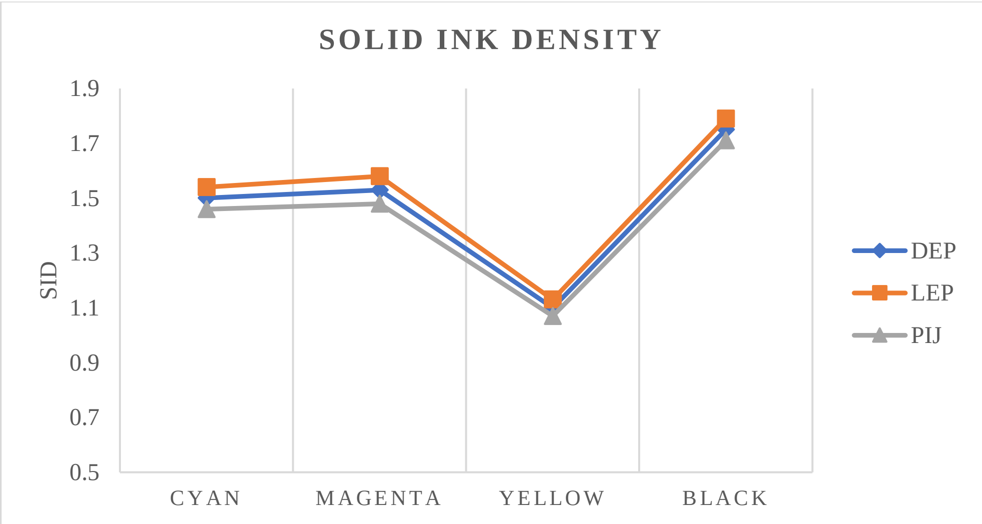

Figure 2. Comparative analysis of Print-quality Solid Ink Density on DEP, LEP & PIJ printing presses

Figure 2 is a graphical representation of collected data one of the most valuable attributes of print-quality check. And it is found that the solid ink density values of LEP (Liquid Electro-photography) on photopaper on the higher peak as compare to the Dry Electro-photography (DEP) and Piezoelectric Inkjet (PIJ) printing press.

Table 2. Print-quality Dot Gain on DEP, LEP & PIJ printing presses

	Cyan	Magenta	Yellow	Black
DEP	**12**	**13**	**10**	**15**
LEP	**09**	**11**	**08**	**13**
PIJ	**14**	**16**	**13**	**18**

Table 2 represent the print-quality dot gain values are on the higher side in piezoelectric inkjet press (14, 16, 13 and 18) on cyan, magenta, yellow and black respectively when compare with Der electro-photography (DEP) and Liquid electro-photography (LEP). But on the other hand, when compare the DEP and LEP the values of dot gain are on the higher side in case of Dry electro-photography (DEP) i.e., 12, 13, 10 and 15 on cyan, magenta, yellow and black respectively.

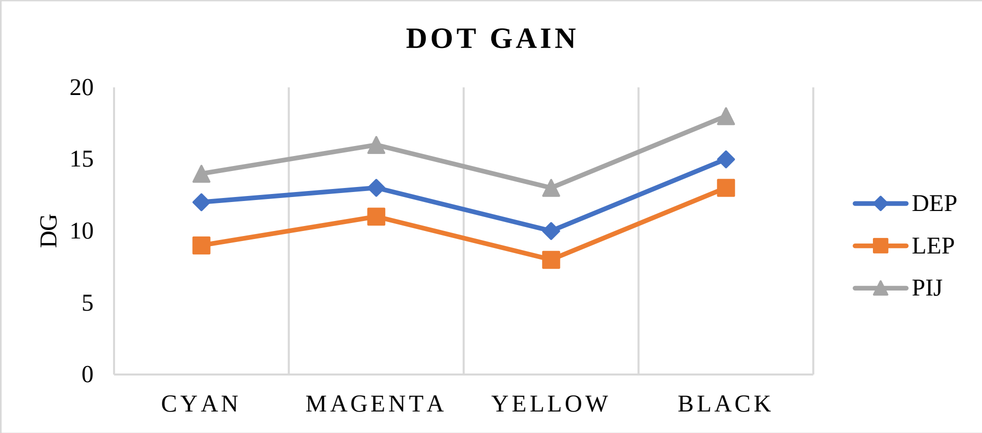

Figure 3. Comparative analysis of Print-quality Dot Gain on DEP, LEP & PIJ printing presses

Comparative analysis of dot gain is represented in figure 3 and it was found that on the photopaper the values of dot gain was higher in piezoelectric inkjet (PIJ) printing press as compare with the dry electro-photography (DEP) and liquid electro-photography (LEP).

Table 3. Print-quality Print Contrast on DEP, LEP & PIJ printing presses

	Cyan	**Magenta**	**Yellow**	**Black**
DEP	**41**	**41**	**38**	**43**
LEP	**44**	**45**	**41**	**47**
PIJ	**37**	**38**	**34**	**40**

Print contrast is playing a major role in print-quality attributes and when this attribute was compared on dry electro-photography (DEP), liquid electro-photography (LEP) and Piezoelectric inkjet printing presses it was found that the values of print contrast in Liquid electro-photography (LEP) are on the higher side (44, 45, 41 and 47) on cyan, magenta, yellow and black. On the other hand, when compare DEP and PIJ the values of print contrast in DEP are on the higher side and in PIJ the print contrast had least values i.e., 37, 38, 34 and 40 on cyan, magenta, yellow and black respectively.

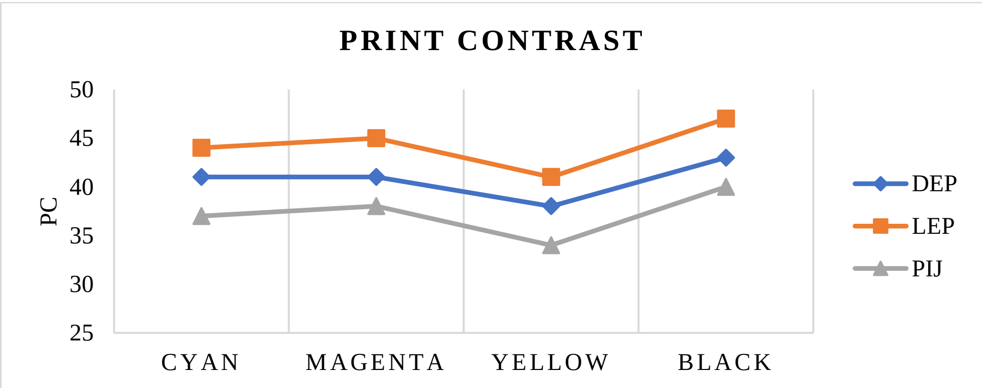

Figure 4. Comparative analysis of Print-quality Print Contrast on DEP, LEP & PIJ printing presses

Figure 4 illustrates that the print contrast exhibited higher values when utilizing the liquid electro-photography (LEP) printing press on photopaper, in contrast to the dry electro-photography (DEP) and piezoelectric inkjet (PIJ) printing press.

RESULTS & DISCUSSION

Solid Ink Density Analysis

Density of the printed ink is considered as one of the most important print qualities. Solid Ink Density (SID) refers to the optical density of a fully saturated and solid colour on a printed substrate. It is a critical parameter in print quality assessment, indicating the concentration of ink or toner deposited on the paper. Measured using a densitometer, SID values help evaluate the richness and intensity of colours in a print. High SID values suggest a denser and more vibrant colour, while low values may indicate insufficient ink coverage, potentially leading to faded or washed-out appearances. In the context of colour accuracy and consistency, Solid Ink Density serves as a fundamental metric for assessing the overall performance of printing technologies and their ability to reproduce vivid and uniform colours. When dry electro-photography (DEP), liquid electro-photography (LEP) and piezoelectric inkjet (PIJ) are compared it is found that the values of SID are on the higher side in case of liquid electro-photography (LEP).

Dot gain Analysis

Dot gain is a crucial print-quality attribute that measures the change in size or diameter of printed dots from the original intended size. It occurs during the printing process when dots on the printing plate or digital file appear larger on the printed material than initially designed. Dot gain can be influenced by factors such as ink absorption, paper characteristics, and the printing press itself. Measured using a densitometer, dot gain is expressed as a percentage increase in dot size. Understanding and controlling dot gain is essential for achieving accurate and consistent reproduction of images, especially in applications where fine details and image precision are critical. Excessive dot gain can result in a loss of image detail, reduced colour accuracy, and an overall decrease in print quality. Printers often employ various techniques, such as adjusting ink viscosity or using specialized printing techniques, to control and minimize dot gain. While it was compared in DEP, LEP and PIJ printing presses on photopaper as represented in table 2 it is found that the values of dot gain are on higher side in case of piezoelectric inkjet (PIJ) printing press.

Print-contrast Analysis

Print contrast is a key print-quality attribute that measures the difference in optical density between the printed image and the background or substrate. It is a crucial factor in evaluating the visual clarity and distinctiveness of printed content. Measured using a densitometer, print contrast values help assess how well a printing process distinguishes between image elements and the surrounding white space or background. High print contrast indicates a clear distinction between the printed image and the substrate, contributing to sharp and well-defined visuals. On the other hand, low print contrast may lead to a lack of differentiation between printed and non-printed areas, affecting the overall legibility and visual impact of the printed material. In table 3 print contrast was compared in DEP, LEP and PIJ printing presses on photopaper. It was found that the print contrast was on higher side in Liquid electro-photography (LEP) printing press on photopaper.

CONCLUSION

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

1. Solid Ink Density is found more on Liquid electro-photography (LEP) press as compared with the Dry electro-photography (DEP) and Piezoelectric Inkjet (PIJ) printing presses on photopaper.
2. Dot Gain was found more on Piezoelectric Inkjet (PIJ) printing press as compared with Dry Electro-photography (DEP) and Liquid Electro-photography (LEP) printing press on photopaper.
3. Print Contrast was found more in the case of Liquid electro-photography (LEP) press as compared with the Dry electro-photography (DEP) and Piezoelectric Inkjet (PIJ) printing presses on photopaper.

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