International Journal of Science and Technology (IJST)
ISSN: 3049-1118, Volume- 3, Issue- 2 (April - June 2026)

Comparative Print Contrast and Colour Difference Analysis of Coated and NTR Papers on Liquid Electrophotography (LEP) Printing Process

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Abstract

This study presents a comparative analysis of Print Contrast (PC) and Colour Difference (ΔE) between Coated and NTR (non-tearable paper) used in the liquid electrophotography (LEP) printing process. LEP is a high-quality digital printing technology known for its superior image reproduction and colour accuracy. But substrate characteristics significantly influence print performance. In this research print samples were printed on both Coated and NTR papers under same printed conditions and their print quality was evaluated using standard measuring methods. The measurements will be carried out under M-1 measurement conditions. Print contrast was analyzed to understand tonal quality and image sharpness while colour difference (ΔE) was measured to check colour accuracy and variation from the original colour. The results indicated noticeable variations in print behavior due to difference in surface properties ink absorption and paper texture.

Keywords: Liquid Electrophotography (LEP), Print Contrast (PC), Delta E (ΔE), Colour Difference, Coated Paper, NTR Paper (non-tearable paper), Print Quality, Digital Printing.

Introduction

Printing has been one of the major inventions in the history of mankind. Printing refers to the reproduction of 'N' number copies similar to each other, close to original by using any mechanical and digital technologies [1]. In the earlier time, hand writing was used as a printed medium but with the invention taking impression has been faster and more efficient alternative to handwriting or drawing especially when printed materials requires to be produced on a larger scale [2]. In digital printing, a different approach is taken in which each image is assembled from a complex set of numbers and mathematical formulas. Images are captured from a matrix of dots generally referred to as pixels and this process is known as digitizing. The digitized image is then used for the digitally controlled deposition of ink, toner or exposure to electromagnetic energy such as light, through which images are reproduced. Digital printing is also popularly known as Non-Impact Printing (NIP). A number of NIP techniques are made

Published: 30 June 2026
DOI: https://doi.org/10.70558/IJST.2026.v3.i2.241296

available in the market and they are generally named after the physical or chemical principles on which they are based [3].

Electrophotography is also commonly known as "Xerography" and it is one of the oldest forms of the non-impact printing technologies. It was invented in the mid 1930's by Chester Carlson. Electrophotography is the most complex digital printing technology which basically consists of two critical materials and seven process steps. In this process an electrical image of the original is created on the photoconductive drum and covered with toner particles. When the copier paper passes over the photoconductive drum the toner is transferred to it [4].

Liquid Electrophotography (LEP) is a highly advanced digital printing technology that blends the principles of traditional electrophotography with the precision of liquid based inks. The toner particle size is in the 1-2 μm range. Because of the small particle size the ink provides high resolution, uniform gloss, sharp image edges and very thin ink films [4]. Since the basic material of the liquid electrophotography ink is a novel resin material rather than oily material curing is not dependent on the drying time of the ink film on the medium when it is in contact with the paper or other medium it can immediately cure and produce a clear printed images the edges do not blur and bleed. The biggest difference between Indigo ink and conventional ink is HP ElectroInk technology which directs the ink electronically using charged particles in the ink. Unlike conventional printing that uses a fixed plate, HP indigo digital presses use a light sensitive photoconductor that attracts ink in charged areas It is most widely recognized through HP Indigo presses which transformed modern commercial printing by offering offset like print quality but with the versatility of digital workflow. LEP stands at a unique intersection of chemistry, physics and printing science, enabling extremely fine image reproduction, smooth gradients, sharp text and a broad colour gamut across various substrates. In simple words LEP is a digital printing process where charged liquid ink particles are attracted to an electrostatically created image on a photoconductor transferred to a blanket and then fused onto the substrate like paper, films, plastics or metallic sheets [5]. Unlike conventional toner-based laser printing that uses dry powder LEP uses liquid toner also called Electrolnk which consists of pigment particles dispersed in a carrier fluid. The liquid form allows the toner particles to be extremely small typically around one micron which is much finer than dry toner grains. This microscopic size contributes to its extremely high resolution, precise colour reproduction and smooth surface finish. Traditional digital printing methods often struggle with non-porous materials like plastic films, metalized surfaces and synthetic papers. LEP on the other hand uses a heated blanket transfer mechanism that helps the liquid ink form a thin, uniform layer. This enables printing on porous as well as non-porous substrates, making the technology extremely valuable for luxury packaging, folding cartons, flexible packaging, shrink sleeves and high-end labels [6]

Research Objectives

Liquid Electrophotography (LEP) printing is widely used for high quality digital printing due to its ability to reproduce sharp images, smooth tones and stable colours. However, the print quality in LEP printing is greatly influenced by the type of substrate being used. Different substrates such as porous, semi-porous and non-porous surfaces show variations in toner adhesion, dot formation and surface finish. After considering these differences it becomes

necessary to study how various substrates affect the overall print quality on LEP printing process.

1. To compare key print quality parameters such as Print Contrast (PC) and Colour difference (ΔE) on Coated and NTR printing substrates on LEP printing process.

Research Methodology

A quantitative experimental approach will be used to compare the print quality performance of Coated Paper and NTR Paper in the Liquid Electrophotography (LEP) Printing Process. Controlled printing trials will be conducted to evaluate and compare the print behavior of both substrates under print conditions. Print Contrast (PC) and Delta E (ΔE) where Selected parameters are tested on the average of 50 printed sheets at a time to maintain consistency of results and to allow reliability. To perform PC and ΔE testing, a master test chart was used. The PC and ΔE measurements were carried out using a densitometer and total fifty printed sheets were tested to ensure consistency and reliability of the results.

Data Collection and Analysis

The collected print quality data will be systematically analyzed to compare the performance pf Coated Paper and NTR Paper. Parameters such as PC and ΔE Values will be measured and recorded for each colour channel (CMYK). The average measured values will be represented using tables and graphical analysis to evaluate substrate performance.

Average Print Contrast (PC) Comparison

Table.1. Average Print Contrast (PC) Comparison of between Coated and NTR Paper

Average	PC % Cyan	PC % Magenta	PC % Yellow	PC % Black
NTR Paper	45.54	45.79	41.60	54.47
Coated Paper	42.0	41.7	37.8	51.7

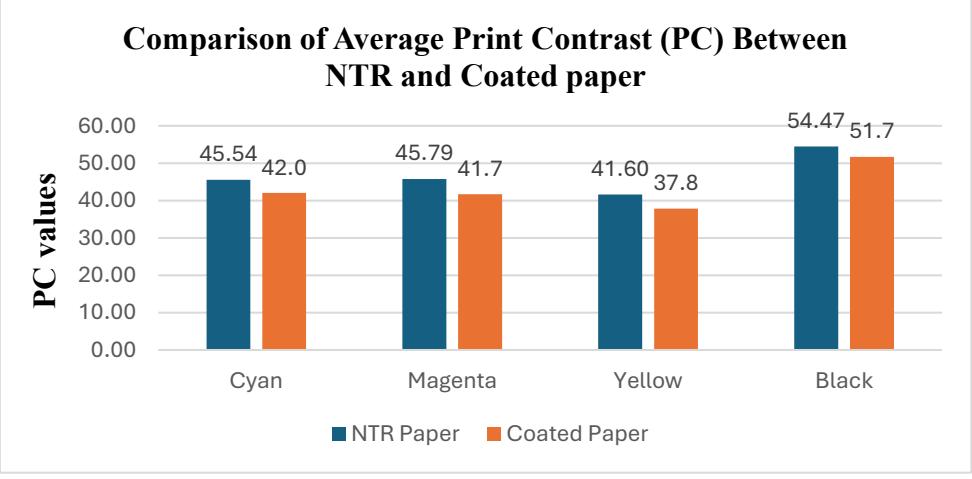

Figure.1. Print Contrast (PC) results of NTR and Coated Paper (Average 50 Sheets)

The average print contrast values obtained for NTR and Coated Papers indicate that ntr paper achieved slightly higher print contrast than coated paper across all process colour (C, M, Y, K). Cyan 45.54, Magenta 45.79, Yellow 41.60 and Black 54.47 were recorded as ntr paper. Coated paper showed comparatively lower values of Cyan 42.0, Magenta 41.7, Yellow 37.8 and Black 51.7. the highest print contrast was observed in black ink for both substrates while yellow showed the lowest values.

Table.2. Average Colour difference (ΔE) Comparison of between Coated and NTR Paper

Average	Cyan	Magenta	Yellow	Black
NTR Paper	5.94	8.04	6.15	4.85
Coated Paper	3.06	1.57	5.39	3.80

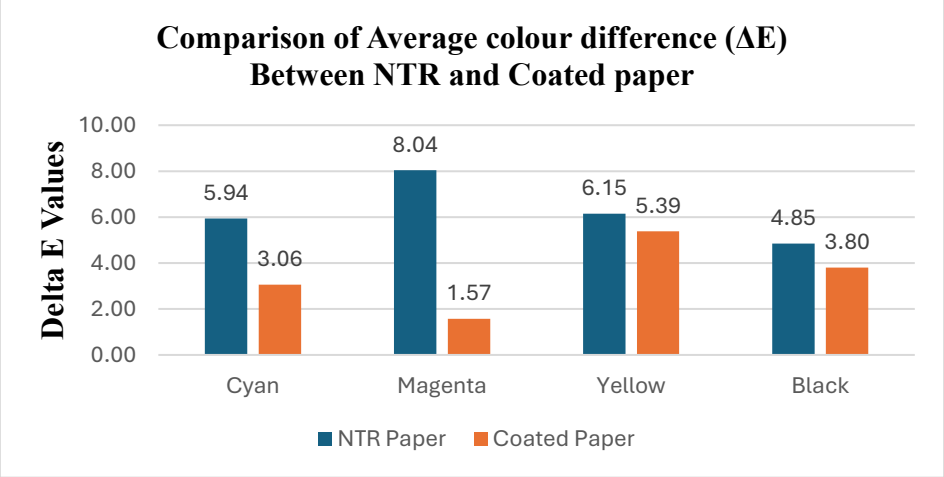

Figure.2. colour difference (ΔE) results of NTR and Coated Paper (Average 50 Sheets)

The Colour difference (ΔE) refers to the differences between the target colour and the printed colour. The average print contrast values obtained for NTR and Coated Papers, the Coated paper obtain values such as Cyan 3.06, Magenta 1.57, Yellow 5.39 and black 3.80. whereas NTR paper showed comparatively higher values such as Cyan 5.94, Magenta 8.04, Yellow 6.15 and Black 4.85. the Colour difference (ΔE) results indicates that coated paper exhibited lower colour difference values compared to ntr paper across all process colour (C, M, Y, K). Lower delta E values indicate that printed colours were closer to the target and the coated paper achieved that the target.

Results and Discussion

Print Contrast (PC)

The higher print contrast observed on NTR paper compared to Coated paper may be attributed to better tonal differentiation during the LEP printing process. The ink on ntr paper produced a clearer distinction between solid and halftone areas, resulting in improved tonal clarity and

sharper image reproduction. In contrast, coated paper coated paper showed slightly lower print contrast due to reduced tonal separation caused by the surface characteristics of substrate. So that Ntr paper provided better print contrast and sharper image quality as compared to coated paper.

Colour Difference (ΔE)

Colour difference (ΔE) refers to the colour differences between original colour and the printed colour. It is used to measure colour accuracy in printing. The results showed that the Coated paper exhibited lower colour difference values compared to NTR paper. The NTR paper result shows the high colour difference. A lower colour difference (ΔE) value indicates better colour accuracy that means the printed colour is close to original colour, whereas a higher delta E value indicates greater colour variation or deviation from the original colour.

Conclusion

Based on the analysis of both parameters it can be concluded that the print contrast and delta E (ΔE) both NTR and Coated paper exhibited different print performance characteristics during LEP printing process. NTR paper achieved higher print contrast values compared to Coated paper, indicating better tonal differences, improved distinction between solid and halftone areas and sharper image reproduction. On the other hand, Coated paper exhibited lower delta E values indicating better colour accuracy, consistency and closer reproduction to the original colour target. So it can be concluded that NTR paper performed better in terms of print contrast and tonal clarity, whereas coated paper showed superior colour reproduction and print stability.

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