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# Comparative study of ΔE on Different Label Stock on Digital Dry Toner Electrophotography and Inkjet Digital Printing Technique

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**Abstract:** The printing and packaging industries grow fastest across the world, as well as in India. Printing labels have made a major contribution to the growth of the printing and packaging industries. In the printing industry, labels are printed using different printing techniques. In the modern era, digital printing has rapidly grown across the world. In this research, comparisons were made between different label stocks printed by dry-toner electrophotography and inkjet printing technology. After the data analysis, the print quality of chromo paper was fine as compared to PP white paper in the case of chromo paper and PP white paper printed by dry-toner electrophotography. The print quality of PP white paper is better as compared to chromo paper in the case of both substrates printed by inkjet printing technology.

***Keywords:*** *Electrophotography, Inkjet, Colour control, Lab value, Delta E etc.*

## Introduction:

In recent years, digital printing has been the fastest-growing segment in the printing industry across the world. In 2022, the value of digital printing was 25.28 bn in the Indian printing industry. Printing processes have two types: impact and non-impact printing technology. In the impact printing process, the substrate and image carrier have contact with each other. Letterpress, flexography, offset, screen, and gravure printing processes. In this research, print quality comparison between different label stock (PP white and chromo paper) on digital electrophotography and inkjet digital printing technology. In the printing sample added some printing technical element like a colour control bar of pressSIGN software, density patch, and subtractive colour theory image.

## Electrophotography

Electrophotography, sometimes referred to as xerography, is a sophisticated imaging technology that is widely employed in copiers, fax machines, and digital printers. It starts with a digital file and uses a photoreceptor, light source, electrostatic principles, and toner to produce the printed output. Prior to its widespread use in digital printing, electrophotography was primarily employed in analogue copiers, which used a lamp to illuminate the page being copied and a series of mirrors to reflect the page directly onto a drum. In digital copiers, the direct light path was replaced with a sensor that converted the analogue image into digital information, after which a laser or an LED array wrote the image onto the drum.(Medeiros, 2015)

As the name implies, electrophotography is the method of reproducing an image using light and electricity. Electrophotographic process instances have been documented in the literature since the early 1920s. Using electro-sensitive paper that could be activated by photocurrents was the mainstay of early attempts to build photo-electrical imaging technologies (Gairns, 1996; US, 2013). The development of the method now widely referred to as xerography was the most important commercial invention in the field of electrophotography. The word "xerography," which is Greek for "dry writing," originated with Chester Carlson's initial discoveries (SCHAFFERT & OUGHTON, 1948).

Toner is an extremely thin, dry powder media used in electrophotography and xerography. It is mostly made of resin and contains pigment, wax, and additives that improve the process. The term xerography, in fact, is derived from the Greek terms xeros, ‘dry’ and graphia, ‘writing,’ reflecting how toner rather than ink is employed in the imaging process. Triboelectric effect causes toner particles to become electrically charged upon stirring or agitation. The toner's composition affects both its image qualities and its capacity to regulate and preserve its charge properties. The toner's capacity to charge is also influenced by its shape. The toner

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can be precisely adjusted during the process thanks to this electrical charge (Medeiros, 2015).

### Inkjet Printing

Using liquid phase materials, inkjet printing is a non-contact direct-writing deposition process. A solute that has been dissolved or otherwise distributed in a solvent makes up these materials, often known as inks. The procedure is best described as the discharge of a specific amount of ink. As a slug in a chamber, via a nozzle to an abrupt, quasi-adiabatic piezoelectric chamber volume reduction (Kumar & Baral, 2023). The application of an external voltage causes a liquid-filled container to constrict. A liquid drop is ejected out the nozzle as a result of this abrupt reduction creating a shockwave in the liquid (Kumar & Kumar Baral, 2022). The reader is provided with a detailed description of this method along with citations to current review studies (Singh et al., 2010). The ejected drop flows at the velocity attained during motion and is helped in its flow on the surface by surface tension as it descends under the effect of gravity and drag until it strikes the substrate (Kumar, 2023). After that, the drop evaporates the solvent and dries. According to recent studies, drop spreading and the final printed shape Current research shows that viscosity, which is closely correlated with the polymer's molar mass, has a significant impact on drop spreading and the final printed shape. Interestingly, the same group also noticed that the polymer concentration and printing height affected the final dried drop diameter (Kumar & Baral, 2022; Kumar & Sharma, 2022).

### Print Label

A sheet of paper, plastic film, fabric, metal, or other material with printed information or symbols regarding a product or item is called a print label, and it is attached to a container or object. Direct printing of information onto a container or item is another option.(Schroeder, 2014) Additionally, print labels serve as a company's main means of client communication. When it comes to how a consumer views a product and the impression it leaves on their mind, labels play a significant role.

Chromo paper, also known as C1S, is a one-side coated specialty packaging paper that offers exceptional printability, superior tear resistance, and excellent lay-flat for all of your coated one-side applications. It can be used to lower basis weights while maintaining comparable strength characteristics. It offers unparalleled consistency for filling and converting efficiency in a variety of applications (What Is C1S Chromo Paper and Where It Is Used?, n.d.). It is frequently used in the food industry to make food pouches, including mouth freshener bags, coffee pouches, tea bags, theatre popcorn bags, and pan masala bags. Other than this, it's frequently used to create labels, business cards, and greeting cards.

A polypropylene (PP) label is a piece of plastic that has been distributed for use on products and printed with your product's information. Synthetic plastics like polypropylene are widely used in many different industries. Owing to its exceptional barrier qualities against gases like carbon dioxide and oxygen, as well as its resilience against chemicals, oil, and moisture, it is frequently utilized in the production of food labels. Waterproof and heat-resistant to 180°C (356°F), polypropylene labels are also resistant to acids and alkalis, UV-stabilized for outdoor use (up to 5 years), recyclable, and have low gas permeability, which helps prevent produce spoilage during shipping. Additionally, they are soft enough not to break delicate items like flowers but sturdy enough not to chip off when handled roughly in retail stores & supermarkets (What Are Polypropylene Labels | Label Solutions, n.d.). They are long-lasting, waterproof, and suitable for usage in a range of conditions. There is an enormous variety of colours available for our polypropylene labels.

The Print Process divides the Print Label Market into categories such as Offset lithography, Gravure, Flexography, Screen, Letterpress, Electrophotography, and Inkjet; Label Format (Wet-glue, Pressure-sensitive, Linerless, Multi-part tracking, In-mold labels, Shrink and Stretch Sleeves); End-User Industry (Food, Beverage, Healthcare, Cosmetics, Household, Industrial, Logistics)

### Print Quality

#### L*a*b*

Hunter's Lab has been upgraded and is now available through CIELab. While some applications and equipment refer to it as L, A, B, or Lab, the proper pronunciation is “CIE-L*a*b*”. It is important to know what L*, a*, and b*stand for: L*: Lightness; a*: Red/Green Value; b*: Blue/Yellow Value.

The chromaticity's a* and b*, as well as the axis of lightness L*, must be appropriately quantized if colours are represented by the CIELab space. It is necessary to specify the axes' restrictions and colour range as a result. While no restrictions are listed for a* and b*, the standardized CIELab definition (CIE 1986a) provides a limit just for the L* axis ($0 \leq L^* \leq 100$). Regarding object colours, a theoretical limit is provided by the so-called optimal colours, which are obtained using a specific illuminant in conjunction with the limited spectrum reflectance or transmission curves. (Hill et al., 1997)All of the smaller colour gamut's found in technical reproductions are included in a colour space with the surface of ideal colours.

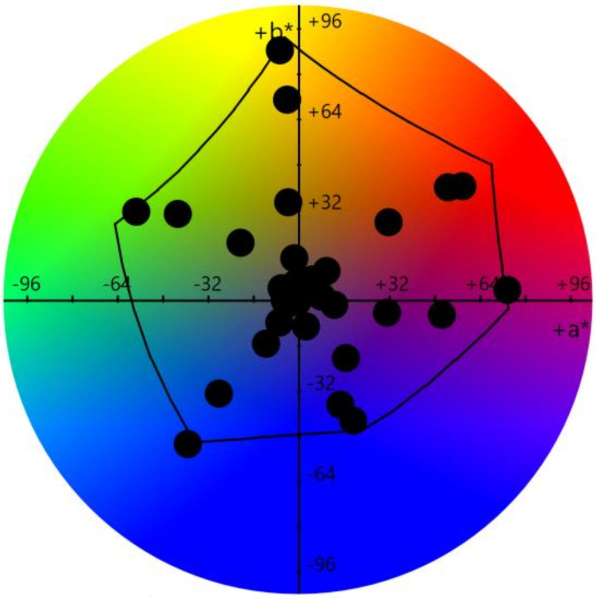


**Figure 1:** Colour Gamut

**Delta E (ΔE)**

The 'distance' between two colours is represented by the single number delta-E (ΔE) (Wyszecki & Stiles, 2000). The theory states that the smallest colour difference perceptible to the human eye is a ΔE of 1.0. It follows that any ΔE greater than 1.0 should be obvious (as in, put on the coffee; we're going to be here for a while), and any ΔE less than 1.0 should be undetectable (as in, switch off the lights and head to the pub). Sadly, and perhaps not unexpectedly, it's not that easy. It's permissible to have certain colour differences - up to and including undetectable - that are bigger than 1. Furthermore, there are other locations where the same ΔE colour difference between two yellows and two blues can fall and may not appear to the eye to be the same (Green & MacDonald, 2002).

**Research Problem**

Digital printing techniques like Electrophotography and inkjet printing are the novel approach to print paper stocks. These novel printing techniques are also used in packaging and label industry due to their high potential. Print consistency is the prime factor to control the print quality. Therefore, delta E on label paper stock was the thrust area that needs attention.

**Research Objective**

Digital printing technique and label-based printing are the fastest-growing segments in the printing industry. The aim of this research is to compare ΔE analysis between different label stock and technology-based digital processes.

**Research Methodology**

During this research, to compile the research objective, a test chart was prepared using CorelDraw DTP software. In the test chart, colour patch tools was designed, such as a pressSIGN colour control bar, a solid density patch, a grey image, a halftone image, circle-based subtractive colour theory diagram, etc. After that, the test chart was printed under standard printing conditions on chromo paper and polypropylene by Kolors-Smart plus the UV inkjet digital label production machine and AccurioLabel 230. The EFI-based i1pro scans the colour control bar strip. Get the output data in the form of lab value, delta E, and density of primary and secondary colours from subtractive colour theory. The print quality between chromo paper and polypropylene paper was analysed in the inkjet digital printing process and dry toner electrophotography.

### Data Collection and Analysis

In this research, chromo paper and PP white paper were printed with an inkjet and dry-toner digital printing machine with a test chart design. Both papers have been printed in ten samples using inkjet printing and dry toner digital printing machines. All printed samples have been scanned by EFI i1 Pro to get an output report for each sample. Collect data of delta E from all the sample reports. The delta E value of cyan, magenta, yellow, and black ink was measured. These values are mentioned below.

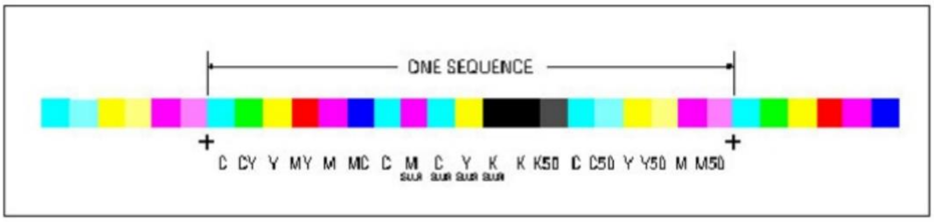


**Figure 2:** Colour control strip

**Table 1:** Average value of 10 sample of chromo paper and PP white paper on electrophotography and inkjet digital printing process

| | CHROMO PAPER | | PP WHITE | |
|---|---|---|---|---|
| **Delta -E** | **INKJET** | **DRYTONER** | **INKJET** | **DRYTONER** |
| **CYAN** | 9.4 | 7.0 | 6.0 | 9.0 |
| **MAGENTA** | 9.4 | 5.0 | 12.1 | 8.0 |
| **YELLOW** | 6.0 | 9.0 | 4.9 | 15.0 |
| **BLACK** | 7.4 | 2.0 | 7.0 | 8.5 |

In this research, get the value of delta E from each machine, inkjet and dry-toner electrophotography digital printing machines. Calculate the value with a single average value for each colour on different paper from different digital printing machines. Here is a comparison of both paper on the same machine and the same paper on different digital printing machines.

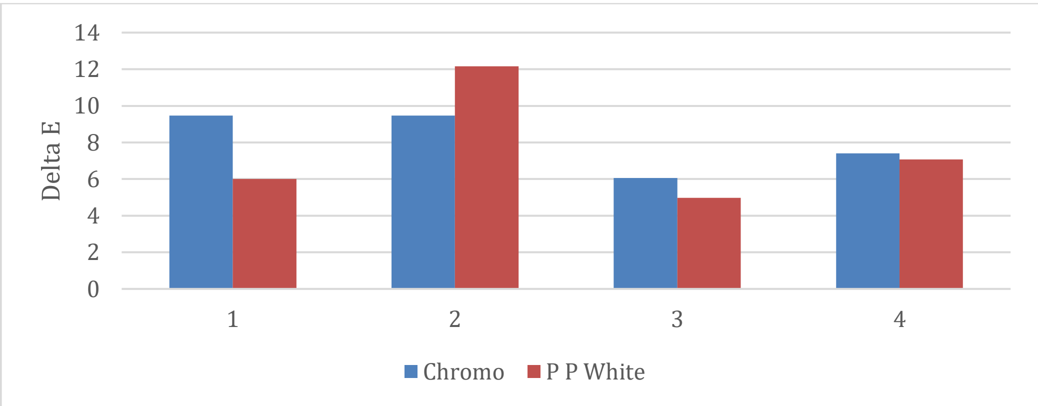


**Figure 3:** Delta E comparison between PP white and Chromo Paper printed by inkjet printing technology.

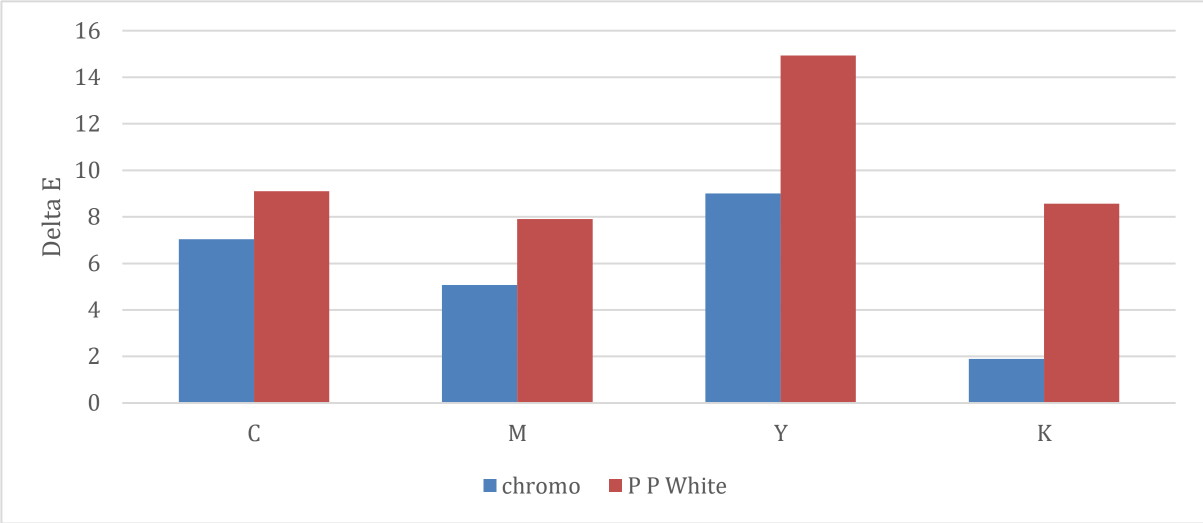


**Figure 4:** Delta E Comparison PP white and Chromo paper printing by dry toner electrophotography digital printing technology.

To accomplish this research paper the data of inkjet and dry toner digital printer was recorded. For the inkjet printer print on chromo paper reading of CMYK colour gamut were recorded respectively 9.4, 9.4, 6 and 7.4 meanwhile the dry toner printer prints on the chromo paper reading of CMYK colour gamut were recorded respectively 7, 5, 9 and 2. For the inkjet printer print on PP White reading of CMYK colour gamut were recorded respectively 6, 12.1, 4.9 and 7 meanwhile the dry toner printer prints on the PP white reading of CMYK colour gamut were recorded respectively 9, 8, 15 and 8.5.

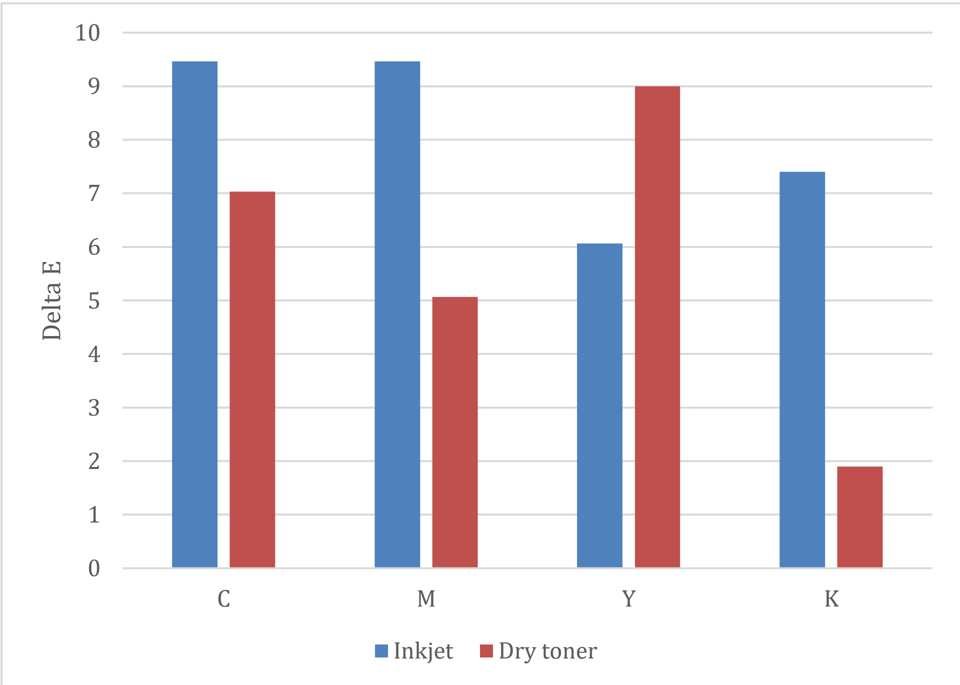


**Figure 5:** Delta E comparison on chromo paper printed by dry toner electrophotography and inkjet printing technology.

## Result and Discussion

In this research, a comparison between chromo paper and PP white paper printed by a dry-toner electrophotography machine was made. The PP white and chromo paper was printed by DoD inkjet digital printing process. The figure 3 shows the comparative analysis of delta E value on above mentioned printing substrates. The value of delta E of cyan colour was 9.4 on chromo paper and 6.0 on PP white paper as shown in figure 3. The value of delta E of magenta colour was 9.4 on chromo paper and 12.1 on PP white paper. The value of delta E of yellow colour was 6.0 on chromo paper and 4.9 on PP white paper. The value of delta E of black colour was 7.4 on chromo paper and 7.0 on PP white paper. The overall value of delta E of cyan, magenta, yellow and black colour on PP white paper was low as compare to chromo paper when printed with inkjet.

The PP white and chromo paper was printed by dry toner electrophotography digital printing process. The figure 4 shows the comparative analysis of delta E value on above mentioned printing substrates. The value of delta E of cyan colour was 7.0 on chromo paper and 9.0 on PP white paper as shown in figure 4. The value of delta E of magenta colour was 5.0 on chromo paper and 8.0 on PP white paper. The value of delta E of yellow colour was 9.0 on chromo paper and 15.0 on PP white paper. The value of delta E of black colour was 2.0 on chromo paper and 8.5 on PP white paper. The overall value of delta E of cyan, magenta, yellow and black colour on chromo paper was low as compare to PP white paper.

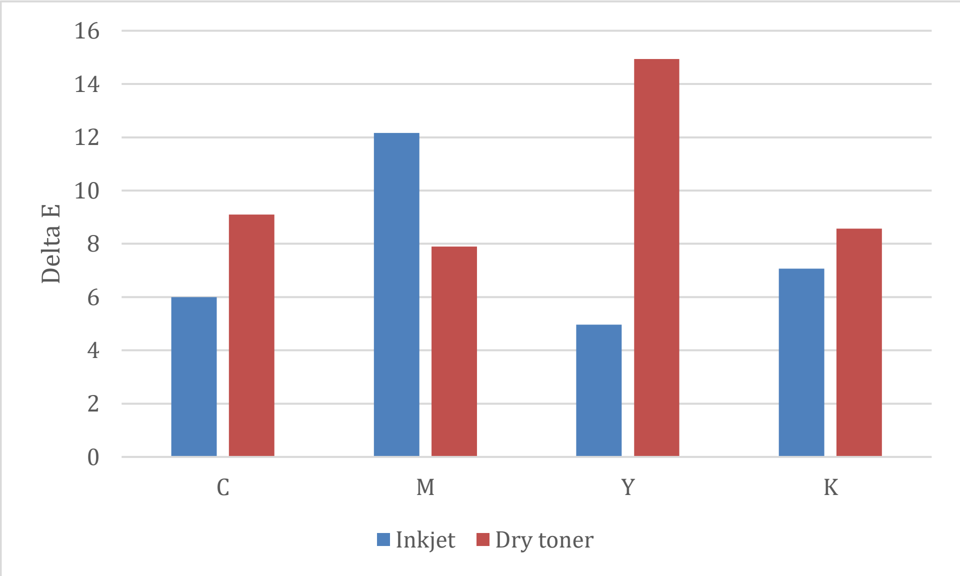


**Figure 6:** Delta E comparison between on PP paper printed by dry toner electrophotography and inkjet printing technology.

The chromo paper was printed by dry toner electrophotography and DoD inkjet digital printing process. The figure 5 shows the comparative analysis of delta E value on above mentioned dry toner electrophotography and DoD inkjet printing techniques. The value of delta E of cyan colour was 9.4 by DoD inkjet and 7.0 by dry toner electrophotography on chromo paper as shown in figure 5. The value of delta E of magenta colour was 9.4 by DoD inkjet and 5.0 by dry toner electrophotography on chromo paper. The value of delta E of yellow colour was 6.0 by DoD inkjet and 9.0 by dry toner electrophotography on chromo paper. The value of delta E of black colour was 7.4 by DoD inkjet and 2.0 by dry toner electrophotography on chromo paper. The overall value of delta E of cyan, magenta, yellow and black colour on chromo by dry toner electrophotography printing process was low as compare to DoD inkjet printing process.

The PP paper was printed by dry toner electrophotography and DoD inkjet digital printing process. The figure 6 shows the comparative analysis of delta E value on above mentioned dry toner electrophotography and DoD inkjet printing techniques. The value of delta E of cyan colour was 6.0 by DoD inkjet and 9.0 by dry toner electrophotography on PP white paper as shown in figure 6. The value of delta E of magenta colour was 12.1 by DoD inkjet and 8.0 by dry toner electrophotography on PP white paper. The value of delta E of yellow colour was 4.9 by DoD inkjet and 15.0 by dry toner electrophotography on PP white paper. The value of delta E of black colour was 7.0 by DoD inkjet and 8.5 by dry toner electrophotography on PP white paper. The overall value of delta E of cyan, magenta, yellow and black colour on PP white by DoD inkjet printing process was low as compare to dry toner electrophotography printing process.

## Conclusion

The findings of this study indicate that poor print quality was produced using chromo paper with a high delta E value during the inkjet process. Since PP white had a low Delta E value in the Inkjet, the print quality was superior to that of Chromo paper. Print quality is higher on chromo than PP white with dry toner, as indicated by the high delta E value on PP white and low delta E value on chromo paper. When compare to inkjet and electrophotography, inkjet has shown better colour consistency on PP white paper whereas electrophotography shown on chromo paper.

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