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COMPARATAIVE ANALYSIS OF PRINT QUALITY: DRY TONER AND LIQUID TONER DIGITAL PRINTING TECHNIQUES ON VINYL SUBSTRATE

Dushyant[1], Satish[2] , Saurabh[3], Anil Kumar[4] Department of Printing Technology, GJUS&T, Hisar, Haryana, India

Abstract
The digital printing is emerging sector and rapidly replacing to other print processes. The digital prints have easy customization, effective cost and fast production. In order to increasing demand of digital print processes study of the digital techniques are essential for the modern printing and packaging market. In current era of digital print processes are using two different type of inks i.e. liquid toner and dry toner. Liquid toner and dry toner both are the two different types of inks and have different characteristics. The study of Liquid toner and dry toner inks is priority of this research project. The modern market of printing and packaging is completely depended on fast and quality production. The print quality refers to verities of print quality parameters like as L*a*b*values, delta E, Solid-Ink density, LCH values, Hue error, and Grayness etc. The vinyl is most common plastic substrate for the digital print process. Vinyl substrates are mostly used in interior design and coated with acrylic type polyvinyl chloride (PVC) used in decorative wallpapers. This research project deals with study of vinyl substrates and verities of print quality parameters like as L a*b* values, delta E, Solid-Ink density, Hue error, and Grayness etc.

Keywords: Liquid toner and dry toner inks, digital printing, L*a*b* values, delta E, Solid-Ink density, Hue error, Grayness etc.

Introduction

The Printing and Packaging industries widely use offset [1] and digital printing processes. The printing and packaging industries generally use holographic polyester films for their attractive look and special security purposes. The offset and digital machines can both print on holographic polyester film substrates. But the film is directly laminated with the paperboard for the base. The printing and packaging industries use a variety of print quality parameters such as l*a*b* values, colorimetric values of colour and grey components, etc.

Ink Technology: The ink technology is the branch of the color management and fluid mechanics. In the digital printing processes toner inks [2] are used. The ink toners of the digital printing are classified into two main types one is liquid toner and another one is dry toner. Both the toner has own characteristics and excellent print quality.

Thus, digital printing has revolutionized the printing industry with its ability to print on a wide range of substrates with high accuracy, speed, and quality. Two popular digital printing [3] techniques are dry toner-based printers and liquid toner-based printers. Both techniques employ a toner, but the toner is either dry or liquid.

The brief description about both toner inks of digital printing are mentioned below:

Liquid toner or fluid inks: These inks are costly as compare to other inks. Liquid toners are always available in liquid form [4]. Liquid toner or fluid inks can print glossy substrates as well as non-porous substrates. Liquid toner or fluid inks are not useful on the pours/paper substrates. Because of liquid form it may penetrates into pours/paper substrates. Liquid toner or fluid inks gives excellent print quality as compare to dry toners. The Liquid toner or fluid inks are more fluent and less viscosity fluid [5], [6].

[1]M.Tech. Scholar, Department of Printing Technology, GJUS&T, Hisar, Haryana, India.
[2]Assistant Professor, Department of Printing Technology, GJUS&T, Hisar, Haryana, India. Corresponding Author
[3]M.Tech. Scholar, Department of Printing Technology, GJUS&T, Hisar, Haryana, India.
[4]M.Tech. Scholar, Department of Printing Technology, GJUS&T, Hisar, Haryana, India.

Liquid toner-based digital printing technique is used in printers such as HP Indigo, Kodak, and Konica Minolta, among others. In this technique, the toner is in the form of liquid droplets that are electrostatically charged and transferred to the substrate. The substrate is then passed through a fuser that melts the toner onto the substrate, creating a permanent print. Liquid toner particles are smaller, leading to smoother gradients and color transitions.

Dry toner or powder inks: These inks are costly as compare to other inks. Dry toners are always available in powder form. Dry toner or powder inks can print glossy substrates as well as porous and non-porous substrates. Dry toner or powder inks are useful on the porous/paper substrates. Because of solid form it cannot penetrates into porous/paper substrates. Dry toner or powder inks results as good print quality [5] [6] [7].

Dry toner-based digital printing technique is used in printers such as Xerox, Canon, and Ricoh, among others. The toner is in the form of dry powder, which is transferred to the substrate using heat and pressure. The substrate is then passed through a fuser that melts the toner onto the substrate, creating a permanent print. Dry toner particles are more significant, leading to higher resolutions and sharper lines.

Vinyl substrates: The vinyl substrates are very useful for material in the interior decoration and wallpaper designs. It is most durable wallpaper of the modern market. The vinyl is directly referring to carbohydrates or ethane group while vinyl chlorides are addition of chloride group into ethane or vinyl group. The major applications of the vinyl in the printing and packaging industries are used as stickers, wallpaper, interior designing and packages etc.

Print Quality: The print quality means "how to maintain standard of a given print as per the requirement." In various cases the print quality is directly refers to print comparison between the digital images or other standard images. Spectrophotometer is a device which is used to measure SID, TVI, Lab Values and dot trap etc. The major printing standards are SID, TVI, L*a*b* Values and dot trap etc. [1], [5], [6].

Print quality standards: The major printing standards are SID, Lab Values and dot trap etc. The brief description about the SID, TVI, Lab Values and dot trap are given below:

Solid-Ink density: Solid-Ink density of the colour or any print provides information regarding the solid patches or solid tint of the color.

L*a*b*values: CIE (Commission International de l'Eclairage), the*a*b* color space was modeled, L*a*b* values of the print quality are main parameter. The L* is tends for lightness and darkness while a* is tends for the (+) redder and (-) greener. Similarly, the b* tends for the (+) yellower and (-) bluer of the colour.

Delta for L* (ΔL*), a* (Δa*) and b* (Δb*) may be positive (+) or negative (-). The total difference, **Delta E** (ΔE*), however, is always positive.

- **ΔL*** (L* sample - L* standard) = difference in lightness and darkness (+ = lightness, – = darkness)
- **Δa*** (a* sample - a* standard) = difference in red and green (+= red, – = green)
- **Δb*** (b* sample - b* standard) = difference in yellow and blue (+ = yellow, – = blue)
- **Delta E:** The delta E is the difference between two different colour values. Or, Delta E can define as difference between the two colour-spaces [8].

$$\textbf{Delta E } (\Delta E) = [(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_1)^2]^{1/2}$$

Hue error: The hue error is the major parameter for the print quality. The hue error defined as measure of the larger contamination portion of an ink.

Grayness: The grayness is available in the all the colour. The presence of the grayness gives information colour percentage.

Objectives

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This research work is based on the main objective which is mentioned below:
Comparative Analysis of Print Quality: Dry Toner and Liquid Toner Digital Printing Techniques on Vinyl Substrate.

Research Methodology

To accomplish the above-mentioned objectives, this is given below:
With the use of graphic design software, a master chart was created and printed in standard quality using digital equipment. All of the instruments, including the spectrophotometer, illuminants, and densitometer, were calibrated prior to the reading. Following instrument calibration, observations were made. The L*a*b* values, delta E, Solid-Ink density, hue error, and grayness of both prints were measured and assessed in accordance with the requirements of the research project.

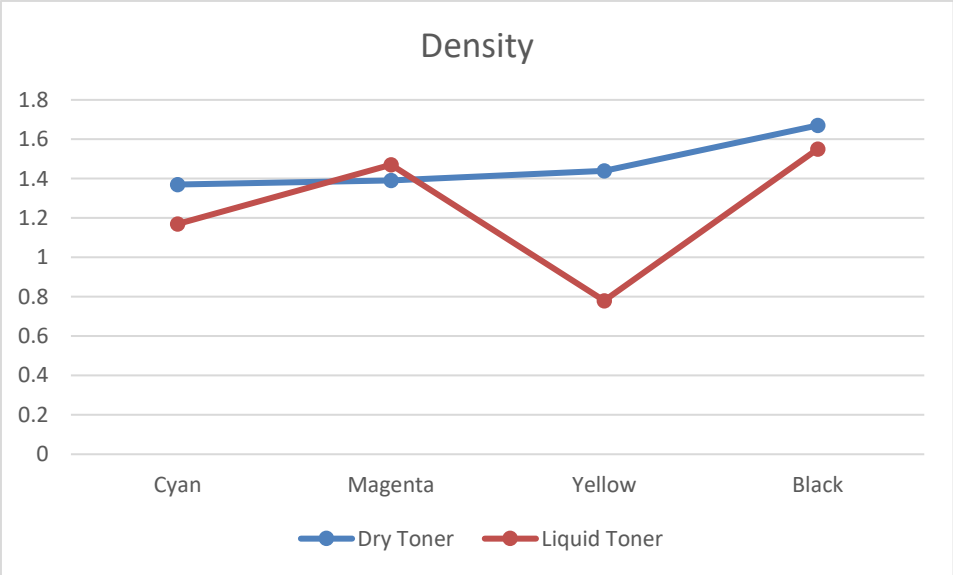
Data Collection and Analysis

The data conclusion of the compassion between of offset and liquid toner digital print is given below:
Solid-Ink density: The Solid-Ink density of all four colour cyan, magenta, yellow and black for the digital print are discussed below in table number 1 and Graph number 1.

Table no.: 1 Solid-Ink density

Density (SID)	Cyan	Magenta	Yellow	Black
Dry Toner	1.37	1.39	1.44	1.67
Liquid Toner	1.17	1.47	0.78	1.55

The average Solid-Inkdensities of dry toner digital of cyancolour were found 1.37while magenta, yellow and black colours were recorded 1.39, 1.44 and 1.67respectively.
The average Solid-Inkdensities of liquid toner digital of cyancolour were found 1.17 while magenta, yellow and black colourswere found 1.47, 0.78 and 1.55respectively.



Graph 1: Solid-Ink Density

Delta E: The delta E is the difference between two different colour values. Or, Delta E can define as difference between the two colour spaces. The delta E of all four colour cyan, magenta, yellow and black for the digital print are discussed below in table number 2 and Graph number 2.

Table no.: 2: Delta E

Delta E	Cyan	Magenta	Yellow	Black
Dry Toner	15.4	8.66	10.73	3.28

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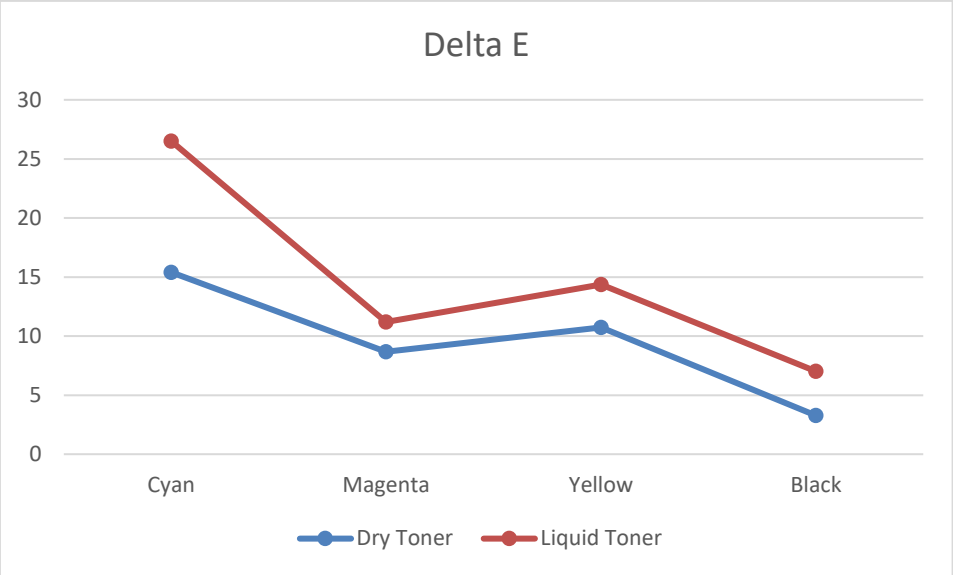
Liquid Toner	26.5	11.18	14.36	7.02

The delta E of dry toner digital of cyancolour were found 15.40 whilemagenta, yellow, and black colours were recorded 8.66, 10.73and 3.28 respectively.
The delta E of liquid toner digital of cyancolour were recorded 26.50 whilemagenta, yellow, and black colours were found 11.18, 14.36 and 7.02respectively.



Graph2: Delta E

Grayness: The grayness is available in the all the colour. The presence of the grayness gives information colour percentage. The grayness of all four colour cyan, magenta, yellow and black for the digital print are discussed below in table number 3 and Graph number 3.

Table no.: 3: Grayness				
Grayness	Cyan	Magenta	Yellow	Black
Dry Toner	11.78%	15.13%	0%	99.65%
Liquid Toner	18.70%	14.33%	3.78%	95%

The grayness of dry toner digital of cyancolour were found 11.78 whileyellow, magenta and black colours were recorded 15.13%, 0% and 99.65% respectively.
The grayness of liquid toner digital of cyancolour were recorded 18.70%whileyellow, magenta and black colours were found 14.33%, 3.78%and 95% respectively.

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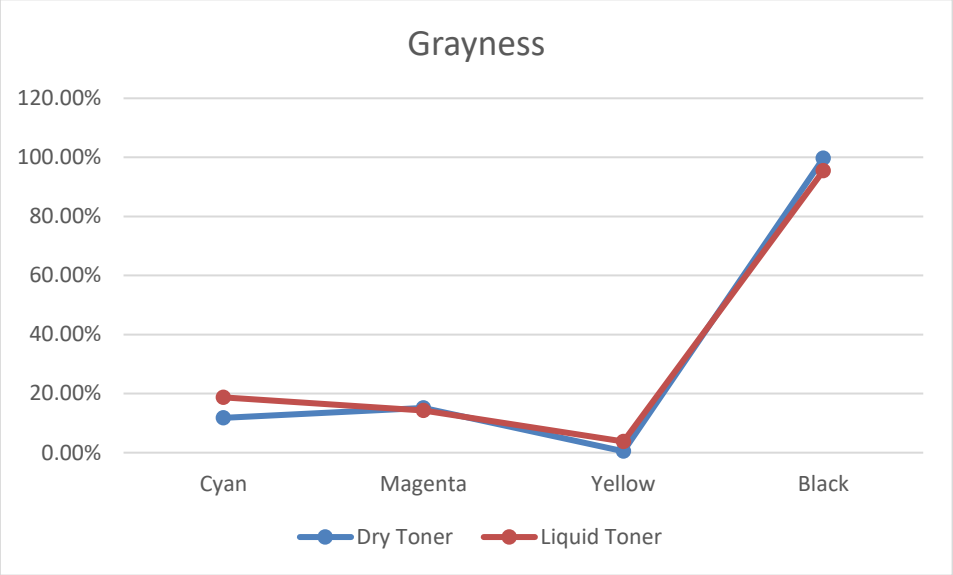


Graph3: Grayness

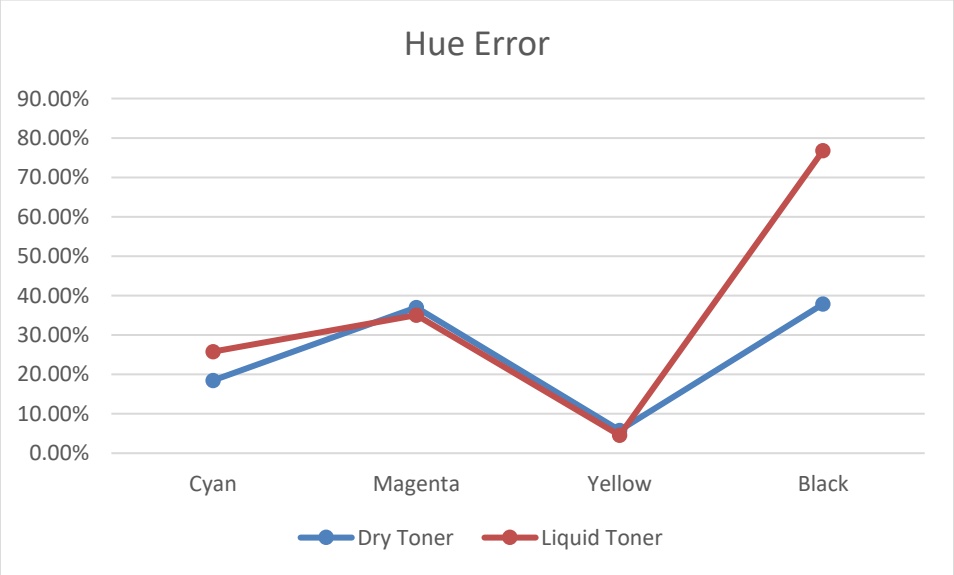
Hue error: The hue error is the major parameter for the print quality. The hue error defined as measure of the larger contamination portion of an ink. The hue error of all four colour cyan, magenta, yellow and black for the digital print are discussed below in table number 4 and Graph number 4.

Table no.: 4: Hue error

Hue Error	Cyan	Magenta	Yellow	Black
Dry Toner	18.45%	37.03%	5.81%	37.85%
Liquid Toner	26%	35.08%	4.55%	76.78%

The hue error of dry toner digital of cyancolour were found 18.45%whileyellow, magenta and black colours were recorded 15.13%, 0% and 99.65% respectively.

The hue error of liquid toner digital of cyancolour were recorded 18.70%whileyellow, magenta and black colours were found 14.33%,3.78% and95% respectively.



Graph4: Hue Error

Findings

In the Printing and Packaging IndustriesDigital Printing is emerging segment and liquid toner and dry toner two different types of digital inks are available in the market. The print qualities of both

inks are excellent in digital print but in some parameters the liquid toner is better than to dry toner and vice-versa, because dry toner gives excellence quality of printing of line arts and texts and Liquid toner gives excellence quality of images and photographs. The average Solid-Ink densities of dry toner digital of yellow colour were found 1.39 while cyan, magenta and black colours were recorded 1.37, 1.44 and 1.67 respectively. The average Solid-Ink densities of liquid toner digital of yellow colour were recorded 1.47 while cyan, magenta and black colours were found 1.17,0.78 and 1.55respectively. The delta E of dry toner digital of cyan colour were found 15.40 while yellow, magenta and black colours were recorded 8.66, 10.73and 3.28 respectively. The delta E of liquid toner digital of cyan colour were recorded 26.50 while yellow, magenta and black colours were found 11.18, 14.36 and 7.02 respectively. The grayness of dry toner digital of cyan colour were found 11.78 while yellow, magenta and black colours were recorded 15.13%,0% and 99.65% respectively. The grayness of liquid toner digital of cyan colour were recorded 18.70% while yellow, magenta and black colours were found 14.33%, 3.78% and 95% respectively. The hue error of dry toner digital of cyan colour were found 18.45% while yellow, magenta and black colours were recorded 15.13%,0% and 99.65% respectively. The hue error of liquid toner digital of cyan colour were recorded 18.70% while yellow, magenta and black colours were found 14.33%, 3.78%and 95% respectively.

Conclusion

Thus, both the dry toner-based digital printing and liquid toner-based digital printing techniques have their unique strengths and weaknesses. The dry toner-based printing technology results for printing text and line art and other side output of liquid toner-based printing performs in printing images and photographs. In addition, when it comes to print quality, both the techniques produce excellent results on vinyl substrates, making them suitable for a wide range of printing applications. In this way, the comparative analysis evaluated the print quality of dry toner-based digital printing and liquid toner-based digital printing techniques on vinyl substrate. The study has produced excellent results with some notable differences. For the future concern, further studies could be conducted to evaluate the performance of these techniques on other substrates to determine which one performs better for specific applications.

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