VARIOUS SURFACE PROPERTIES AND CHARACTERISTICS OF NON-ISO PAPERS AND THEIR IMPACT ON COLOUR GAMUT IN DRY TONER BASED DIGITAL PRINTING PRESS

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Abstract

Digital printing presses are getting the attention of the printing industry for its numerous benefits over the conventional printing techniques. Under the digital printing process, dry toner-based electrophotography technology is considered as a mature form of printing while comparing with the inkjet technologies. These presses are known for improved colour gamut reproducibility characteristics also, and most the prospective print consumers demand for high colour gamut for enhanced colour reproduction. Paper plays an important role, while discussing the colour gamut print quality factor and moreover the surface characteristics of paper is the utmost concern in this context. In this research work, the surface properties of various kinds of non-ISO papers have been studied and is related with the colour gamut while printing in a multi colour electrophotography digital printing press.

Keywords; Electrophotography, Gloss coated paper, Uncoated paper, Matt coated paper, tonner, Colour gamut, Digital press.

Introduction

With the use of ink, paper, and a printing press, when text and images are reproduced, it is simply termed as printing. Since for the inception, it has successfully transformed from art and craft to large scale industrial applications to take care of wide range of requirements and needs of the print consumers (WordNet, 2021). In a simpler term, printing is related to the reproduction of an original in multiple copies and the number can be varied from one to any number. Reproduction is aimed at preparing the subsequent copies as closer as to the original, so that variation in terms of visual appearance and other attributes should be as low as possible. (Bhattacharya, 2017).

As per the historical record, printing was first created in China and it then extended to Europe and it received the real momentum after the invention of movable types by Johannes Gutenberg in 15th century and subsequent introduction of printing press into it. (History, 2018). After the introduction of letterpress of printing, other various methods and ways of putting ink onto paper came into picture and this different printing methods came into picture to take care of varying needs of this sector.

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Traditional printing techniques are specifically categorized into five sub-heads for catering to the specific applications in the printing marketplace. (Stafford, 2020).

Printing is evolving and along with the five traditional printing techniques, digital printing technique in the recent years is also available in the marketplace. Digital printing is well accepted as because of uniform printing quality from the first print copy to the last copy, low press set-up time, low level of material wastage, print on demand, personalization, environmental friendliness, and elimination of pre-press set-up time (Venkateswaran & Pugazh, 2017). Chester Carlson in 1938, invented the electrophotographic printing technique and this printing technique is also popularly known as xerography, which is derived from the Greek words for dry and writing. This is one of the fastest growing forms of printing technology in the recent times (Venkateswaran & Pugazh, 2017).

Paper is on the first choice of the printing industry as the printing substrate. Paper and pulp industry is one of the dynamic industries and are also diversified. A wide range of raw materials are used by this industry for manufacturing of different kinds of paper to meet the requirements of printing consumers. raw materials derived from cellulose fibers, generally wood, recycled paper, and agricultural residues are generally used by the paper industry to prepare papers for printing purpose (Gullichsen, 2000). Digital printing is also known as the non-impact printing and electrophotography is the most widely used forms of printing under this category. Many companies are involved in manufacturing of electrophotography printing machines and they are offering a bundle of benefits for printing applications (Hp, 2016).

Colour is one of the most important stimuli in all the aspects of life, and is equally important to printing industry also. Webster defines color as the sensation resulting from stimulating the eye's retina with light waves of certain wavelengths. And moreover, these sensations have been assigned the names of; blue, red, green, purple (McKinley, 2018).

Colour gamut is the range of colours that a particular device can able to produce; computer monitor, desktop printer, digital press, offset press, display unit, etc. There are some printing quality factor attributes which defines the colour gamut of a particular printing device; saturation, hue, brightness, lightness of the different printing inks, and moreover the surface characteristics of the printing substrate. The particular printing engine in use also equally important for the colour gamut (Printing Concepts, 2012).

There are a number of variables which controls the reproduction of printing colour accuracy and dot gain is one the most important issue, which cause tonal variations and needs special care and attention. By proper measurement, recording and analysis of these printing attributes, it is certainly possible to reproduce consistent colour throughout the printing production process (Haji, et al., 2018). Colour gamut is a function of the printing substrate, printing ink, and the printing machine in use for the reproduction purpose and the suitable combination of these three elements, higher level of colour gamut van be achieved (Upton, 2019).

Review of literature

Authors, Baral & Chopra, 2017, mentioned that, in the recent years, digital printing has certainly changed the face of the traditional printing techniques and making the impossible to possible. It essentially offers a bundle of benefits which the conventional printing systems may not be able to think upon. Without the use of master/plate, this technique is able to effect printing and the time for print production is certainly low in comparison to the traditional printing. The images to be printed are captured digitally and guides the printing inks to be deposited onto the substrate with consistent print quality throughout the whole printing cycle.

Authors Viluksela, et al., 2010, mentioned that, digital printing is highly effective in short run job quantities and also essentially helps to reduce the press makeready considerably. As this printing technique does not use a printing plate or master for printing, comparing to the conventional printing techniques, it uses very less time for press set-up. In the short run printing jobs, it is competing with the sheet fed offset printing, as the press set-up cost in offset presses is quite high and time consuming also. Electrophotography is certainly taking care of the above issues more systematically and with cost effectiveness.

Authors, Chen, et al., 2004, indicated that, colour gamut of a printed product is related to the volume of solid colour which is defined colourimetrically being produced by a set of particular printing substrate and printing ink colours. There are many factors which affects and controls the colour gamut; printing process, surface properties of the printing substrates, ink formulation, laydown the printing colours, etc. generally, with four process colour inks; yellow, magenta, cyan, and black a relatively small colour gamut can be reproduced in a particular printing process

Fogra, 2018, explained that, in the recent times, the basic needs, requirements and demand of print consumers are changing constantly. Main focus is on; shorter delivery time, low print run jobs, high proportion of variable contents, on demand, flexibility and environmentally sustainable print output. All these requirements are highly addressed by the electrophotography printing technique with cost benefits. These presses are designed to take care of these points and the trade-off between the print quality and cost effectiveness is certainly high.

IPI, 2014, mentioned that, printing substrates generally used in electrophotographic presses are either coated or uncoated papers. Coated papers are used for the high-quality print production applications in comparison to the uncoated papers. Papers with high surface properties are certainly preferred for high-end printing applications, and especially it results into higher print colour gamut. In dry toner based electrophotographic presses, high level of colour gamut can be achieved with proper selection of paper substrates.

Research objectives

Dry toner based digital electrophotography presses are quite popular today in the marketplace and specifically short run printing jobs with personalization and print on demand are the few points which drives its penetration into printing industry. Reproduction of consistent colours with higher range of colour gamut always occupies a larger place in the printing quality arena and most of the dry toner presses are trying hard to achieve these points for their growth and development model. Paper always plays an important role while targeting a colour gamut that can be achieved. The main objective of this research is to; list down various surface properties eight types of non-ISO papers with uncoated, gloss coated and matt coated surfaces and their possible impact on the colour gamut while printing on a dry toner based electrophotographic press.

Research methodology

Eight types of papers non-ISO papers were selected which are used for various printing applications in digital printing presses; 75 gsm uncoated, 80 gsm uncoated, 90 gsm uncoated, 90 gsm matt coated, 105 gsm art gloss coated, 115 gsm art gloss coated, 130 gsm art matt coated, and 170 gsm art matt coated. Paper surface properties; Basis Weight (Grammage), Thickness, ISO Brightness, Side 1 / Side 2, CIE Whiteness, Side 1 / Side 2, Yellowness, Side 1 / Side 2, Opacity, L* a* b*, Tensile Index, MD/CD, Test Factor, MD/CD, Brust Factor, and Roughness (Bendtsen) Side 1 / Side 2 were tested for the above eight selected papers. One multi colour dry toner based digital printing press was selected and with the help of a developed test chart (containing all the elements for the digital printing) the above papers were printed.
The printed sheets were measured with GMI (Graphic Measures International) for the colour gamut of the eight types of non-ISO selected and printed paper. GMI essentially monitors and reports each aspect of the printing job and in this case, it is colour gamut. CMYK primaries, Overprint LAB, Gray balance, and Dot gain (TVI) are the four components, considered for the measurement and display of colour gamut of the printed sheets. The collected data is then presented in suitable formats for discussion and conclusion.

Data collection & Analysis

Table 1, CMYK primaries of non-ISO papers

CMYK Primaries				
	Cyan	**Magenta**	**Yellow**	**Black**
P1	0.63	0.77	0.50	0.90
P2	0.60	0.74	0.47	0.87
P3	0.58	0.72	0.45	0.85
P4	0.54	0.68	0.41	0.81
P5	0.41	0.55	0.28	0.68
P6	0.39	0.53	0.26	0.66
P7	0.52	0.66	0.39	0.79
P8	0.50	0.64	0.37	0.77

Table 1, represents the cyan, magenta, yellow, and black primary colour ink toners average Lab values for the eight selected papers. ΔE **(Delta E, it's a measurement of how much a displayed color can differ from its input color. A lower Delta E means better color accuracy) tolerance of the four primaries is 3.5 and the values shows in the table is a good sign and falls within the tolerance limit.**

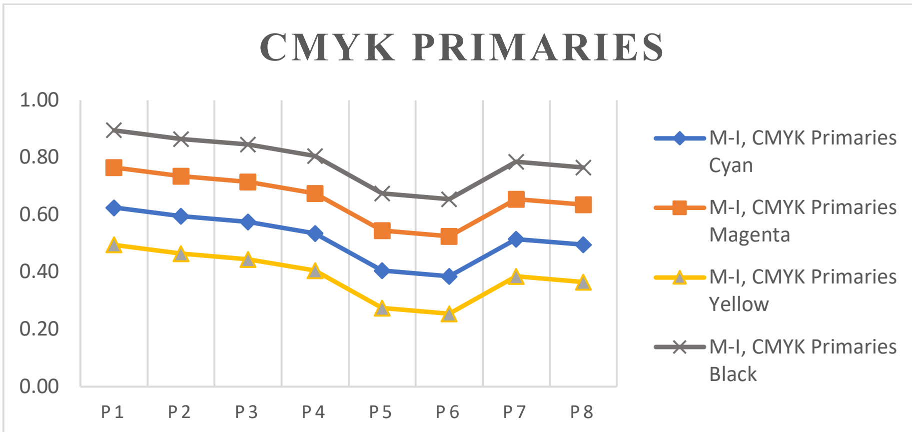

Figure 1, CMYK primaries of non-ISO papers

Figure1, represents the cyan, magenta, yellow, and black primary colour ink toners average Lab values for the eight selected papers. All the four primary colours are highly closer to the tolerance limit and much away from the 3.5 value.

Table 2, Overprint LAB of non-ISO papers

Overprint LAB			
	M+Y	**C+Y**	**C+M**
P1	0.66	0.54	0.77
P2	0.63	0.51	0.74
P3	0.61	0.49	0.72
P4	0.57	0.45	0.68
P5	0.44	0.32	0.55
P6	0.42	0.30	0.53
P7	0.55	0.43	0.66
P8	0.53	0.41	0.64

Table 2, represents the cyan plus magenta, cyan plus yellow, and cyan plus magenta overprint Lab values for the eight selected papers. ΔE **(Delta E, it's a measurement of how much a displayed color can differ from its input color. A lower Delta E means better color accuracy) tolerance of the three overprint is 3.5 and the values shows in the table is a good sign and falls within the tolerance limit.**

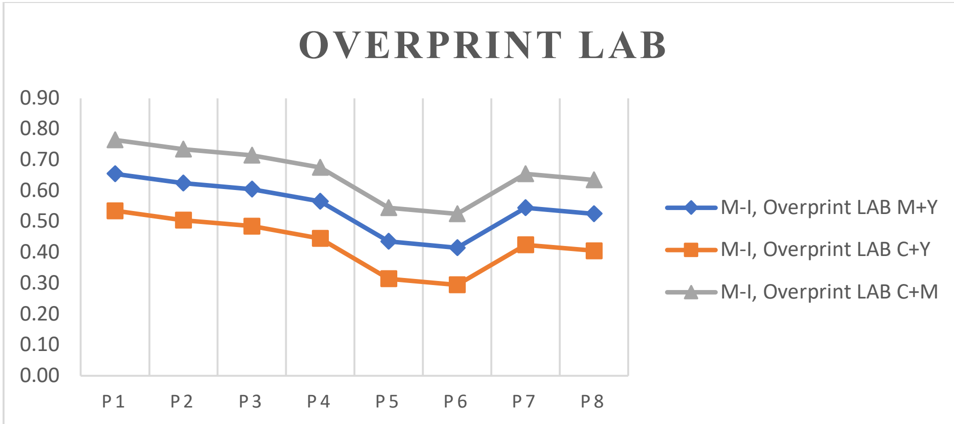

Figure 2, Overprint LAB of non-ISO papers

Figure 2, represents the cyan plus magenta, cyan plus yellow, and cyan plus magenta overprint Lab values for the eight selected papers. The values are very close to the tolerance limit, i.e., 3.5., which is certainly a good sign.

Table 3, Gray balance of non-ISO papers

Gray Balance			
	HGB	**MGB**	**SGB**
P1	0.48	0.40	0.57
P2	0.45	0.37	0.54
P3	0.43	0.35	0.52
P4	0.42	0.34	0.51
P5	0.37	0.29	0.46
P6	0.35	0.27	0.44
P7	0.40	0.32	0.49
P8	0.38	0.30	0.47

Table 3, represents the HGB (highlight grey balance), MGB (middletone grey balance,), and SGB (shadow grey balance) average values for the eight selected papers. ΔE **(Delta E, it's a measurement of how much a displayed color can differ from its input color. A lower Delta E means better color accuracy) tolerance of the four primaries is 2.0 and the values shows in the table is a good sign and falls within the tolerance limit.**

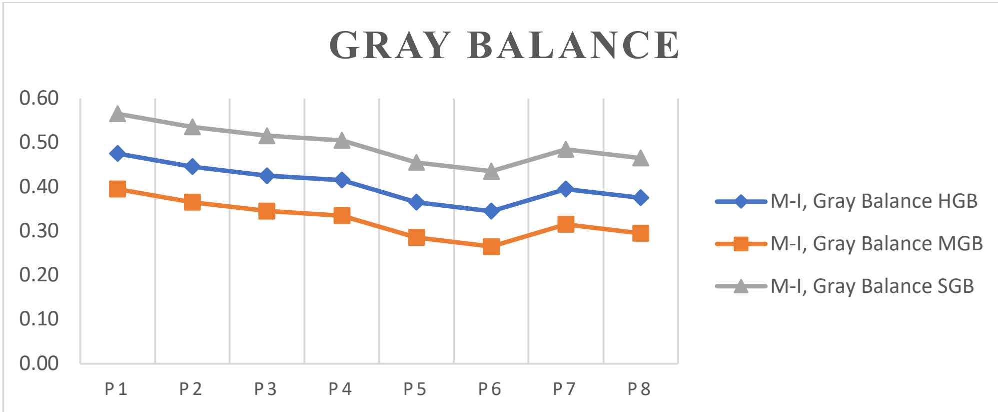

Figure 3, Gray balance of non-ISO papers

Figure 3, represents the HGB (highlight grey balance), MGB (middle-tone grey balance,), and SGB (shadow grey balance) average values for the eight selected papers. All the values are well within the **tolerance of the four primaries is 2.0 and the values shows in the graph is a good sign.**

Table 4, Dot gain (TVI) of non-ISO papers

Dot Gain (TVI)				
	Cyan	**Magenta**	**Yellow**	**Black**
P1	51.30	51.53	51.05	51.67
P2	51.27	51.50	51.02	51.64
P3	51.25	51.48	51.00	51.62
P4	51.06	51.29	50.81	51.43
P5	50.79	51.02	50.54	51.16
P6	50.77	51.00	50.52	51.14
P7	51.04	51.27	50.79	51.41
P8	51.02	51.25	50.77	51.39

Table 4, represents the **Dot gain (TVI) at 50% of four primary colours (CMYK)** average values for the eight selected papers. The tolerance limit is plus, minus 4%, **and the values shown in the table is a good sign and falls within the tolerance limit.**

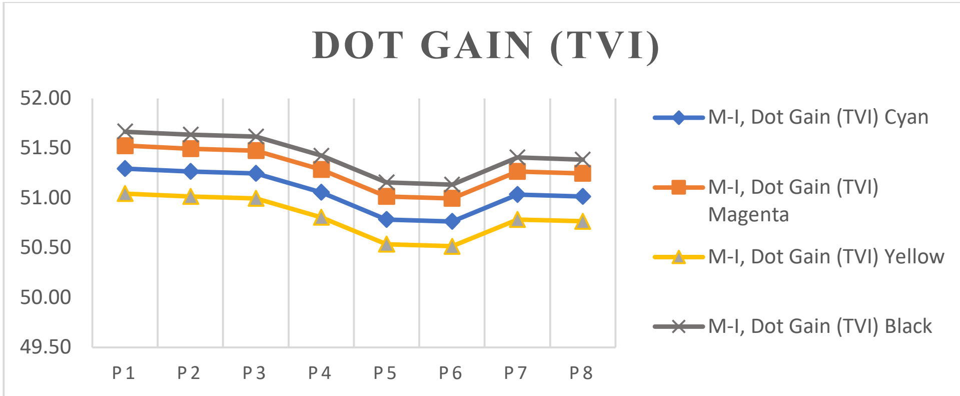

Figure 4, Dot gain (TVI) of non-ISO papers

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Table 5, Gamut volume of non-ISO papers

Gamut Volume	
Paper types	**Gamut Volume in Percentage**
P1	82.78%
P2	83.05%
P3	83.23%
P4	83.98%
P5	84.91%
P6	86.28%
P7	84.21%
P8	84.55%

Table 5, represents the **Gamut Volume** average values for the eight selected papers. The unit of measurement is in percentage and the values near to 100 percent is excellent, and the table indicates it is more than 80 percent and hence little bit away from the best possible colour gamut values.

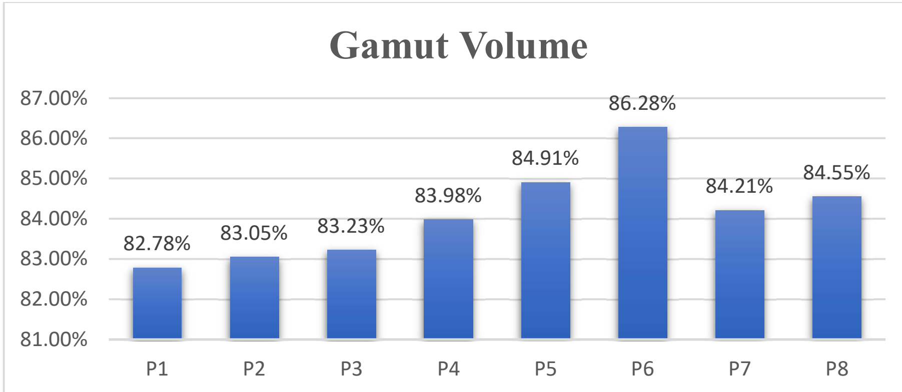

Figure 5, Gamut volume of non-ISO papers

Figure 5, represents the **Gamut Volume** average values for the eight selected papers. The unit of measurement is in percentage and the values near to 100 percent is excellent, and the graph indicates it is more than 80 percent and is a good sign.

Results & Discussion

The surface characteristics of printing paper while printing in a multi colour dry toner-based electrophotography is highly important for achieving the desired colour gamut value. Colour gamut of digitally printed output is of utmost importance for reproducing the acceptable range of colours to meet the demands and requirements of the print consumers. Uncoated papers always come with a rough and uneven surface as compared to the coated papers. Due to the rough surface, uncoated paper makes the printed ink layer to be absorbed into the base paper, which results into lowering the printed colour saturation and vibrancy. As per the various tables and graphs, it is very much clear that, uncoated papers lead to limited colour gamut and in this press, it is lower than the coated papers.

In case of matte coated papers, the surface is smooth and having a lower level of gloss in comparison to the gloss coated papers. This type of paper offers a better printing ink control and low level of ink absorption into the paper surface. Improved colour accuracy coupled with sharper dot details results into improved colour accuracy. From the various tables and graphs relating to the research work indicates a wider colour gamut than the uncoated papers taken into consideration.

Gloss coated papers exhibit highest level of surface smoothness in comparison to the uncoated and matte coated papers and the surface is also highly reflective. This surface characteristics results into minimum ink absorption and hence the printed ink layers sit perfectly onto the paper surface leading to improved and enhanced level of printed colour vibrancy and saturation. Gloss coated papers have shown widest colour gamut among the three types of paper surfaces taken into research.

Conclusion

Dry toned based electrophotographic presses are quite popular in the printing industry for taking care of short run jobs, improved colour gamut, consistency in colour reproduction, low level of material wastage, print-on-demand, shorter press set-up time, environmentally sustainable print products, and cost effectiveness. Form the above research work, it is highly established that the colour gamut of this type of printing presses are highly dependent upon the surface characteristic properties of the printing substates that are chosen for printing purpose. Besides the various paper surface properties, the working properties of toners, press calibration, and colour management workflows also have bigger role to play for controlling and achieving the improved colour gamut value. The choice of the paper, tonner, and the digital press and moreover the paper and tonner interaction and the workflow management should be taken into account for achieving better colour gamut related printing quality factors.

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