Exploring Various Possibilities for Enhancing the CMYK Primariesof Different Digital Printing Presses with Reference to non-ISO Cellulosic Printing Substrates

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Abstract

There are four primary colours; Cyan (C), Magenta (M), Yellow (Y), and Black (K), denoted as CMYK colour model used in the printing industry for the printing applications and mixing of subtractive colours to create a wide array of colours, for the reproduction purpose. Each of these primary printing colours are related to the maximum amount of printing ink in a particular inking unit or channel. With varying applications of these four primary colours, a wide range of possible colours can be produced in the final print output. Enhancing the CMYK of the printed colours is one of the important characteristics to maintain the colour gamut of printing process and in recent times the print consumers are demanding for an increased colour gamut.

Digital printing; dry toner based, liquid toner based, and inkjet printing techniques are getting wider acceptance in the printing industry for their quick turnaround time, print-on-demand, low level of material wastage, consistent colour quality along with personalization characteristics. Along with the regular ISO specified papers, there are other papers also which are being used by the digital printing for printing a wide range of jobs as per the demands of the print consumers. In this research work, various possibilities are being explored for enhancing the colour gamut of non-ISO papers when they are printed in different digital printing engines.

Keywords: Primary colours, CMYK colour model, ISO papers, Digital printing, coated paper, uncoated paper, Colour gamut.

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Introduction

As per the historical record, the very earliest forms of printing were developed in China, Japan and Korea. It was in the form of hand printing and from AD 594onwards, books were prepared in China by rubbing paper against inked surface of the woodblocks. As it was not possible to repeat the above step for printing both the sides of the thin and porous sheets, the sheets were stitched on the sides to print smoothly and easily. Skilled manpower along with high craftsmen were the prerequisites for effecting such printing (NCERT, 2016).Until the fifteenth century, woodblock printing was the dominant forms of printing and the introduction of movable metal types changed the complete face of the woodblock printing. This has certainly enabled the mass production of books for the mass people. Due to this, mass communication and

education was possible and the common people find accessibility towards knowledge and information in the form of books (Wikipedia, 2021).

New millennium has witnessed the exponential growth of digital printing presses. The future of any technology lies its ability to take care of for the wider acceptability and application point of view. Digital printing presses, especially the electrophotography presses and inkjet presses need to work upon the physical and printability parameters of the particular printing engine, so that it will able to sustain in a long-term basis. Digital printing technology essentially use the non-impact principles without the use of a plate or master for effecting printing. These presses are equipped with latest technology to perform printing cycle with least time and possible reduction of use of various resources during the print production cycle (Sobotka, 2001).

Digital printing technique does not utilize any printing master for effecting printing, rather each print can be made altogether different from one another, as because each time a new printed image is formed. As there is no pressure or mechanical contact is required for printing, it is also commonly known as non-impact printing Viluksela, et al., 2010). Both the electrophotography and inkjet methods are quite popular in the print marketplace and are suitable for producing a wide range of printing output. Inkjet printing uses the technology of deposition of droplets onto the printing substrates in a pre-defined pattern, and the final printing quality is dependent upon the ink and paper interaction, and ink droplet formation (Lundberg, 2011).

Inkjet printing presses functions on the principles of spraying a very fine stream of quick-drying ink on the paper substrate. There are some inkjet presses, which works well on the inkjet coated paper, and these papers have a specific paper coating. Care must be observed to print on the shiny side of the paper to achieve high print values. There are two main categories of inkjet presses available in the marketplace for taking care of wide requirements of printing applications; drop-on-demand and continuous inkjet heads. The choice and selection of the particular technology should be based upon the print quality and the nature of the printing job in hand(Baral& Chopra, 2017).

Colour is one of the most important stimuli and it is equally applicable to all aspects of life and industrial manufacturing units. Colour is basically the sensation being produced in our mind when see any object. It essentially affects our mood and feelings also. There are a wide range of colours which can be reproduced in any printing process. As the digital presses are manufactured with a motive to reproduce consistent colour reproduction throughout the complete print production process, colour certainly a bigger role in such type of presses (McKinley, 2018).

Colour gamut is related to the range of colours that can be achieved in any particular printing device. In any printing process, it is highly important to know before actual printing operation, the range of colours that can be achieved with the particular imaging system, so that it can be reproduced easily, smoothly, and without much problem. Printing colours are basically defined by three attributes; hue, colourfulness (chroma, purity, saturation, etc), and lightness. For achieving a particular range of colours for fulfilling the particular requirements of the printing job, proper selection of printing substrate, ink and press should be taken into consideration (Perales, et al., 2014).

Digital printing presses are equipped with the functionsto result shorter press makeready time and hence the response time is very quick. This helps to have more press time for production and thereby undercutting raw material requirements for the press set-up. As the presses are capable of reproducing consistent colour during the printing cycle, rejection of the printing jobs is highly minimized. The savings from these points can certainly helps the press organization to generate and surplus funds for possible expansion and procurement of new devices and equipment to support the production facilities (Trochoutsos& Anastasios, 2018).

Inkjet presses are designed to print on both the coated and uncoated paper sticks, but to achieve better results it is always demanded to use coated paper stocks. Uncoated papers due to its rough and irregular surfaces, are prone to absorb the ink, which results into blurred images and hence loss of colour intensity. But in case of coated papers, with a suitable smooth and regular surface, the ink remains on the surface of the paper rather getting penetrated into the base paper, which finally results into brighter, more saturated and greater image details. Care must be observed to select the right paper for the right job, so that the desired result can be achieved easily and smoothly (IPI, 2004).

An ideal paper substrate for the application in a typical inkjet press should have the following properties; sufficient hold out of the printing ink onto the paper surface for achieving high optical print density, low or minimum bleeding of ink on the paper surface, low show through and strike through and high fastness of the printed colours. For the electrophotographic presses the fusing of the tonner and paper and tonner interaction is highly important to achieve the desired colour gamut (Svanholm, 2007).

Review of literature

As per, Viluksela, et al., 2010, in comparison to the inkjet printing technique, electrophotography printing technique is a relatively matured printing system. In the recent times, inkjet printing system has undergone a strong development; in comparison to the toner inkjet inks are cheaper in cost, print engines/heads are simpler to work upon, fewer press part, lesser power requirement to operate the press, larger web width for printing, high quality printing output, high possibilities of formulation of wide range of inkjet inks to suit a wide range of printing applications and substrates.

As per, Efi, 2005, digital printing technologies continues to change the face of the traditional printing process and certainly here to stay for a longer time and catering to the varying needs and requirements of the modern print consumers. These technologies are aimed at to achieve shorter makeready time, consistent colour reproduction with higher accuracy, producing with print on demand attributes, possible reduction of wastages, low level of inventory management, with personalization and higher press productivity (Efi, 2005).

As per the authors, Hussain, et al., 2013, inkjet printing has travelled a long way to reach to the present level of sophistication and accuracy in colour reproduction capability along with cost effectiveness. Today it is one of the major forms of printing for the electronic industry and the industrial inkjet presses are manufactured with high level of press automation and higher speed of operation. These presses are designed to handle a wide range of printing jobs with higher throughput time and minimum cost of production. In the coming times, inkjet printing is going to certainly occupy a larger printing market share.

As per, PFL, 2019, besides the electrophotographic presses; both the dry toner and liquid toner presses, inkjet presses are also considered as the most economical method of print production with higher printing quality and speed of press operations. Particularly, the industrial inkjet presses are designed to print a wide range of printing substrates and variable web widths. Now it is compatible with a wide range of printing substrates.

As per, PrintCity, 2010, there is a strong relationship between the colour gamut and solid ink density, a high solid ink value will result into a larger colour gamut and vice-versa. Proper ink and printing substrate interaction is also crucial towards achieving a larger colour gamut. Surface of the paper essentially decided the colour gamut that can be achieved with the particular ink and press combination. Uncoated papers with rough and irregular surfaces are able to produce low level of colour gamut in comparison to the coated paper with smooth and regular surface properties.

Research objective

Digital printing technologies are becoming popular in the printing marketplace as because of numerous advantages that it offers over the conventional printing techniques; cost-effective for short run printing jobs, shorter press set-up time, lower level of material wastage, print-on-demand, environmentally friendly and low lead time. Consistent colour reproduction is also a major offering of these type of printing presses. Dry toner based digital presses, liquid toner based digital presses, and inkjet printing engines are the various technologies available under the digital printing.

CMYK primaries are the main components of achieving colour gamut of any printing process. The Lab values of these primary colours should be withing the tolerance limit, so that the increased colour gamut of the final print product can be resulted. Paper plays an important role while discussing the Lab values of the four primary colours. The main objective of this research is to exploring various possibilities to enhance the primary printing colours for the digital printing engines in relation with various non-ISO papers used for printing applications.

Research methodology

Three types of papers; 75 gsm uncoated paper, 90 gsm matte coated paper and 105 gsm art gloss coated papers were selected for the printing purpose on four digital printing engines; two dry toner based digital presses (M-I & M-II), one liquid toner digital printing machine (M-III), and one piezoelectric inkjet machine (M-IV). 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 three types of selected papers.

A test master was developed as per the specific standard for printing of the selected papers with the four digital printing engines. Lab values of the four process colours were then measured and data was presented in suitable tables, followed by data analysis, result & discussion, and conclusion.

Data collection & Analysis

Table 1, CMYK Primaries of un-coated paper

CMYK Primaries				
	Cyan	**Magenta**	**Yellow**	**Black**
M-I	0.63	0.77	0.50	0.90
M-II	0.83	0.95	0.69	1.08
M-III	1.98	2.09	1.85	2.25
M-IV	0.33	0.45	0.22	0.57

Table 1, represents the average Lab values of four primary colours, CMYK, on uncoated paper, for the four types of digital presses covering the dry toner based, liquid toner based and inkjet printing machines. It is clearly indicated that, M-IV, the piezoelectric inkjet press produces better result, followed by two dry toners based electrophotographic presses and the least value is with the M-III, the liquid tonner based digital press. Uncoated papers are not suitable for the liquid toner based digital printing machines.

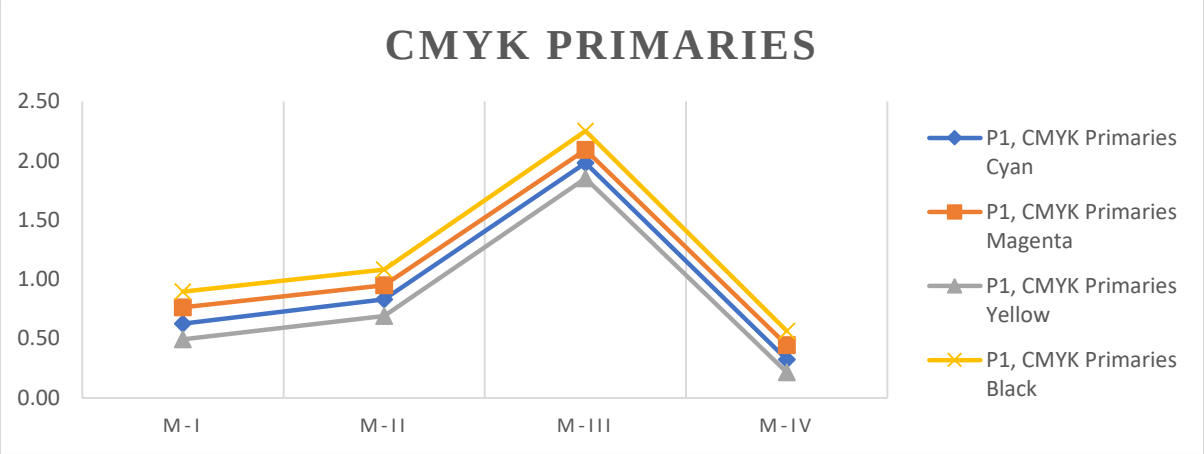

Figure 1, CMYK Primaries of un-coated paper

Figure 1, represents the average Lab values of four primary colours, CMYK, on uncoated paper, for the four types of digital presses covering the dry toner based, liquid toner based and inkjet printing machines. It is clearly indicated that, M-IV, the piezoelectric inkjet press produces better result, followed by two dry toners based electrophotographic presses and the least value is with the M-III, the liquid tonner based digital press. The trend shows closer values are with black primary, followed by cyan, magenta, and yellow.

Table 2, represents the average Lab values of four primary colours, CMYK, on matt coated paper, for the four types of digital presses covering the dry toner based, liquid toner based and inkjet printing machines. It is clearly indicated that, M-IV, the piezoelectric inkjet press produces better result, followed by two dry toners based electrophotographic presses and the least value is with the M-III, the liquid tonner based digital press.

Table 2, CMYK Primaries of matt coated paper

CMYK Primaries				
	Cyan	**Magenta**	**Yellow**	**Black**
M-I	0.54	0.68	0.41	0.81
M-II	0.76	0.88	0.62	1.01
M-III	1.92	2.03	1.79	2.19
M-IV	0.26	0.38	0.15	0.50

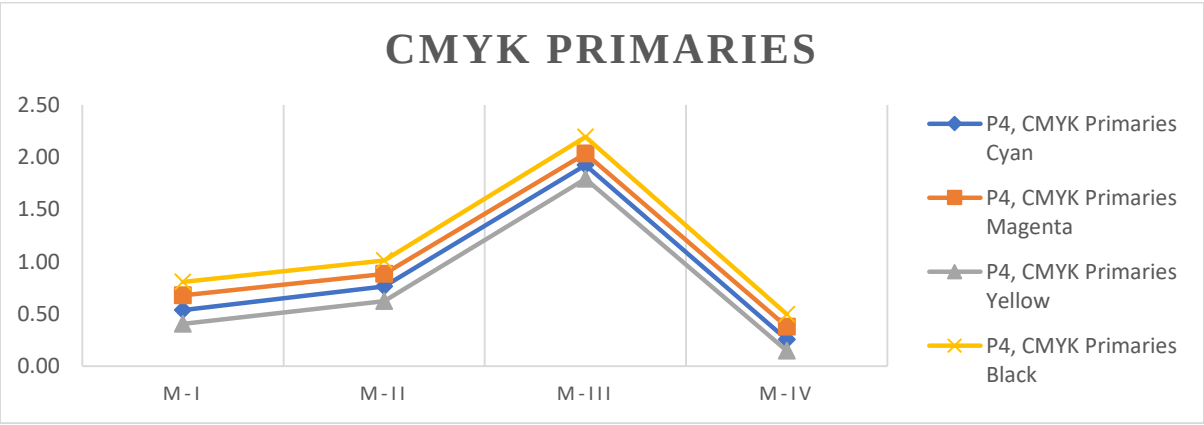

Figure 2, CMYK Primaries of matt coated paper

Figure2, represents the average Lab values of four primary colours, CMYK, on matte coated paper, for the four types of digital presses covering the dry toner based, liquid toner based and inkjet printing machines. It is clearly indicated that, M-IV, the piezoelectric inkjet press produces better result, followed by two dry toners based electrophotographic presses and the least value is with the M-III, the liquid tonner based digital press. The trend shows closer values are with black primary, followed by cyan, magenta, and yellow.

Table 3, CMYK Primaries of gloss coated paper

CMYK Primaries				
	Cyan	**Magenta**	**Yellow**	**Black**
M-I	0.41	0.55	0.28	0.68
M-II	0.65	0.77	0.51	0.90
M-III	1.82	1.93	1.69	2.09
M-IV	0.15	0.27	0.04	0.39

Table 3, represents the average Lab values of four primary colours, CMYK, on gloss coated paper, for the four types of digital presses covering the dry toner based, liquid toner based and inkjet printing machines. It is clearly indicated that, M-IV, the piezoelectric inkjet press produces better result, followed by two dry toners based electrophotographic presses and the least value is with the M-III, the liquid tonner based digital press.

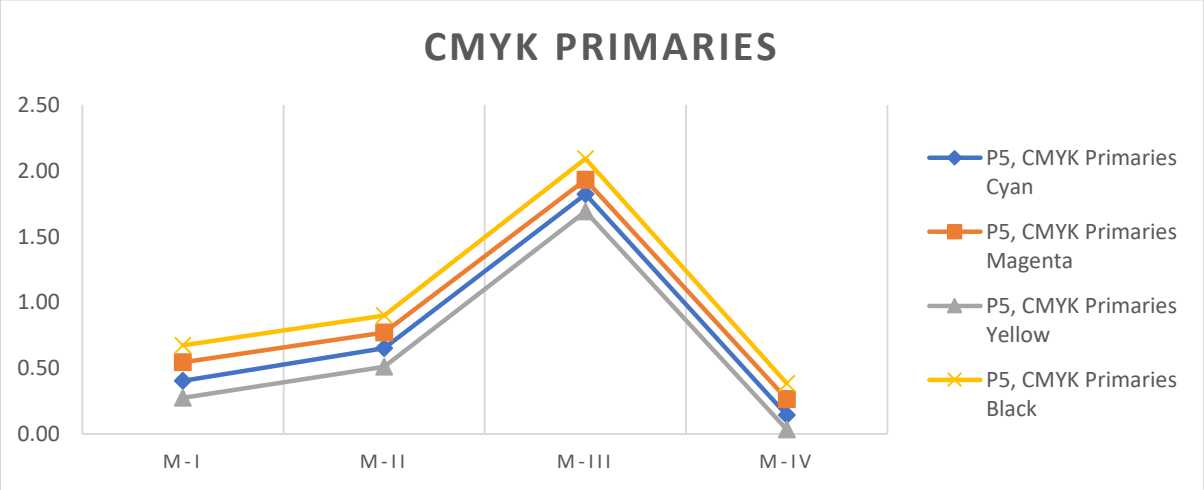

Figure 3, CMYK Primaries of gloss coated paper

Figure3, represents the average Lab values of four primary colours, CMYK, on gloss coated paper, for the four types of digital presses covering the dry toner based, liquid toner based and inkjet printing machines. It is clearly indicated that, M-IV, the piezoelectric inkjet press produces better result, followed by two dry toners based electrophotographic presses and the least value is with the M-III, the liquid tonner based digital press. The trend shows closer values are with black primary, followed by cyan, magenta, and yellow.

Results & Discussion

Digital printing systems have certainly made a drastic change in the printing industry and giving a tough time to the traditional printing methods to survive and grow in the printing market place. As it offers bundles of potential benefits that suits well to the print consumers, there is always a mounting pressure on the digital printing machine manufacturers to equip the machine to produce increase colour gamut. Lab values of the four primary colours plays an important role as far as the colour gamut is concerned.

By optimizing the ink feed and deposition layer onto the substrates, switching to high density inks and the proper selection of printing substrates will result into enhanced Lab values of the primary colours. In the four machines that were taken into printing, it clearly shows that optimum Lab value is obtained with all the three types of commonly used papers; uncoated, matte coated, and gloss coated paper in inkjet presses, followed by dry toner based digital presses, and the least result with liquid toner based digital printing press. In addition to the four primaries, additional printing colours like; orange, green and violet colour can be printed so as to enhance the colour gamut value.

Conclusion

There is a continuous pressure from the print consumer side to increase the colour gamut of the printed products and the digital printing machine manufacturers are working hard on this subject for offering substantial benefits to the whole printing industry. All the four primary colours always play a very crucial role in terms of optimizing the Lab values which will result into higher colour gamut. Paper surface is a highly crucial concern along with the printing inks characteristics for attaining an increased colour gamut of the printing output. Proper selection of the paper for the liquid electrophotography digital press is very important, because the research indicates a special coated papers are best suited for such types of presses to offer effective result. Inkjet presses are superior than the other two categories in terms of primary colour optimization.

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