POLİTEKNİK DERGİSİ

JOURNAL of POLYTECHNIC

ISSN: 1302-0900 (PRINT), ISSN: 2147-9429 (ONLINE)

URL: http://dergipark.org.tr/politeknik

Investigation of the effect of different screening structures on print quality in digital printing system

Dijital baskı sisteminde farklı tramlama yöntemlerinin baskı kalitesine etkisinin incelenmesi

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Bu makaleye şu şekilde atıfta bulunabilirsiniz(To cite to this article): Özomay Z., Şahin C. and Keskin B., "Investigation of the effect of different screening structures on print quality in digital printing system", ***Politeknik Dergisi***, 24(3):1213-1217, (2021).

Erişim linki (To link to this article): http://dergipark.org.tr/politeknik/archive

DOI: 10.2339/politeknik.884893

Investigation of the Effect of Different Screening Structures on Print Quality in Digital Printing System

Highlights

- *Digital printing is strengthening its place in the printing industry every passing day.*
- *In this study, the effect of different dot structures on printing quality was investigated.*
- *High-quality 100 g/m² papers of the same whiteness and thickness were used in the study.*
- *The change in the dot structures affects the printing quality.*
- *It is recommended to choose Quality or Smoothing dot structure for minimum color difference.*

Graphical Abstract

The selection of the dot structure used in digital printing in the RIP unit was changed before printing, and the basic measurements such as color values, dot gain, and the difference and color consistency between colors were evaluated.

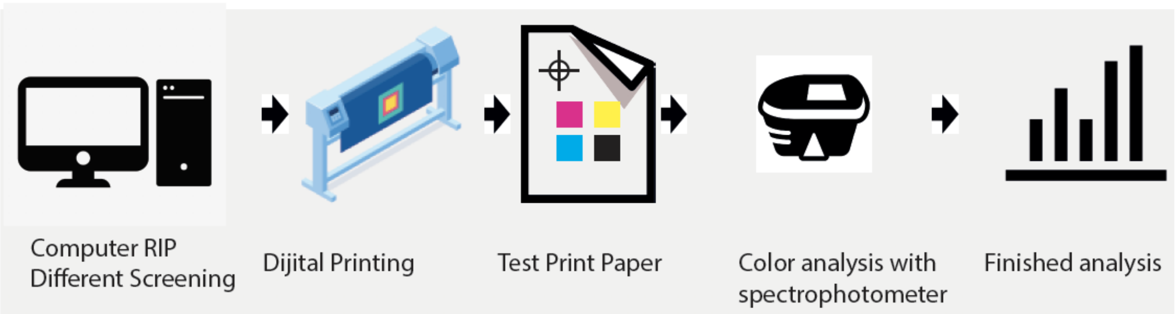

Figure. Quality in digital printing system sheme

Aim

In this study, it is aimed to reveal the effect of different dot structures on digital printing quality.

Design & Methodology

Basic measurements such as color values, point gain, difference between colors and color consistency were evaluated by changing the point structure selection used in digital printing in order to get the effect of the dot structure.

Originality

This study has been produced from the research conducted in Marmara University digital printing laboratory in the department of Printing Technologies.

Findings

The change in dot structures in the digital printing technique creates differences in dot gain, ground tone density, and color.

Conclusion

It has been determined that it would be appropriate to use the Smoothing screen structure in digital printing processes in order to have the point gain value at optimum levels. When the Delta E values obtained are examined, it is recommended to choose the Quality or Smoothing dot structure in order to minimize the color difference.

Declaration of Ethical Standards

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

Investigation of the Effect of Different Screening Methods on Print Quality in Digital Printing System

Araştırma Makalesi / Research Article

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(Geliş/Received : 22.02.2021 ; Kabul/Accepted : 03.03.2021 ; Erken Görünüm/Early View : 12.03.2021)

ABSTRACT

Digital printing is the process of printing the designs and photos prepared in computer environment with advanced printing technologies on different materials in a high quality and fast way. The digital printing system, which is increasing its effectiveness today, has taken great steps with technology since the first years of its existence and has started to have a voice in the sector for the last ten years. The digital printing, which is an alternative to the offset printing system in making design a product, exhibits significant improvements in terms of production efficiency, cost and quality. Offset has become competitive with flexo printing with the developing color efficiency in digital printing machines. High quality and different applications can be made with digital printing machines. In order to achieve this (screening) process, it is necessary to know the boundaries of the color universe that can be seen or produced by the devices and machines used in the system. In this study, the difference between colors and color consistency and basic measurements such as color values, dot gain were evaluated by changing the selection of screen methods used in digital printing. The differences caused by the screening structure variable have been shown with graphics and tables, then suggestions have been made. It has been determined that the change in the screening structures in digital printing creates differences in dot swelling, density and color.

Keywords: Digital printing, color, dot gain, printing quality.

Dijital Baskı Sisteminde Farklı Tramlama Yöntemlerinin Baskı Kalitesine Etkisinin İncelenmesi

ÖZ

Dijital baskı, ileri baskı teknolojileri ile bilgisayar ortamında hazırlanan tasarım ve fotoğrafların farklı malzemeler üzerine kaliteli ve hızlı bir şekilde basılması işlemidir. Günümüzde etkinliğini artıran dijital baskı sistemi, kurulduğu ilk yıllardan itibaren teknoloji ile büyük adımlar atmış ve son on yıldır sektörde söz sahibi olmaya başlamıştır. Tasarımı ürün haline getirmede ofset baskı sistemine alternatif olan dijital baskı, üretim verimliliği, maliyet ve kalite açısından önemli gelişmeler sergiliyor. Ofset, dijital baskı makinelerinde gelişen renk verimliliği ile flekso baskı ile rekabete girmiştir. Dijital baskı makineleri ile kaliteli ve farklı uygulamalar yapılabilmektedir. Bu (perdeleme) işleminin gerçekleştirilebilmesi için sistemde kullanılan cihaz ve makinelerin görülebildiği veya üretebildiği renk evreninin sınırlarının bilinmesi gerekmektedir. Bu çalışmada, dijital baskıda kullanılan ekran yöntemlerinin seçimi değiştirilerek renkler ile renk tutarlılığı arasındaki fark ve renk değerleri, nokta kazancı gibi temel ölçümler değerlendirilmiştir. Tarama yapısı değişkeninin neden olduğu farklılıklar grafik ve tablolarla gösterilmiş ve önerilerde bulunulmuştur. Dijital baskıda eleme yapılarındaki değişimin nokta şişmesi, yoğunluk ve renkte farklılıklar yarattığı tespit edilmiştir.

Anahtar Kelimeler: Dijital baskı, renk, nokta kazancı, baskı kalitesi.

1. INTRODUCTION

A dynamic method widely used in copiers, faxes, and digital printers is electrophotography (xerography). It is an imaging technology that produces a digital file as a printed output using a photoreceptor, light source, electrostatic principles, and toner [1]. A series of mirrors were widely used in analog copiers till this method was used for digital printing to illuminate the page from which a lamp was copied, projecting the page directly onto the surface of the drum [2]. Digital copiers have been replaced by a sensor that transforms direct light and analog images into digital information and transfers laser light images to the drum (Figure 1). Many digital printers are currently based on the same system as digital photocopiers [3]. The basic method of electrophotography remains largely unchanged, despite many advances in technology over the years [4].

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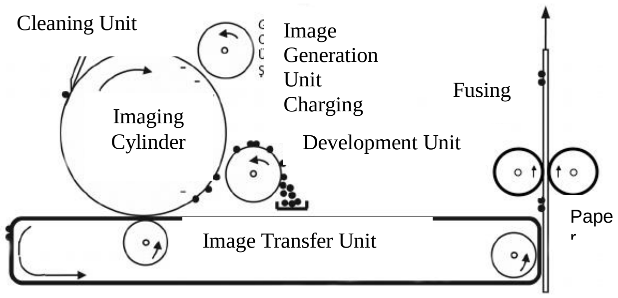


Figure 1. Digital Printing Scheme

A very fine, dry powder structure used in electrophotographic or xerographic printing is a toner [5]. It primarily involves pigment, resin and process acceleration additives. When combined or shaken by a triboelectric impact, the toner particles become electrically charged [6]. The composition of the toner contributes not only to its imaging properties but also to maintaining and controlling charging properties. This electrical charge is the state that allows the toner to be fully transferred throughout the process [7].

There are two main types of toner production, powdered and chemically (Figure 3). Conventional toner has been used extensively in previous digital printers and is manufactured until the desired consistency and size is obtained by subsequent phases of compound mixing and grinding. In size and shape, the resulting toner particles are irregular and usually average 6.2 to 10.2 microns in size. Powdered toner gives good results up to 600 dpi resolution; however, it requires a consistent size and shape along with a smaller particle size to obtain better clarity and detail at higher resolutions [8-9]. Furthermore, screening shapes are formed in the form of round, cross, ellipse, line and square and create changes in color and tone values.

A halftone cell is a foreordained number of dots which is used to affect a grey level [10]. The dots are arranged in a specific way within the halftone cell in order to construe the desired halftone dot shape (for example, circle, square, triangle, etc.), or the dots are randomly administered. By altering the size of the halftone stain, different grey level densities are produced within each halftone cell.

The quality of a printer's images depends on the correct arrangement of the dots inside each half-tone cell of the half-tone pattern. Customized halftone patterns are used by many printing devices for this purpose. The accuracy of the printer's images is enhanced by a customized halftone pattern, as it does not create a linearly distributed density range without using the halftone pattern of the printer. Given the hardware capabilities and limitations of the printer for reproducing image density, the half-tone pattern is typically manually generated by a successful half-tone application. An artist opens each end of each halftone cell to show the printer features on a computer terminal to visually produce halftone shapes that are minimal work for the specific printer. This is a laborious and time-consuming process. Also, based on the subjective nature of making each half-tone cell, it is open to human error.

2. MATERIAL and METHOD

In this study, the high-grade paper pulp of 100g/m^2 which has the same thickness and whiteness was used as a substrate material. Measurements were made in accordance with ISO 8791-4 and TAPPI T 555 standards in order to determine the surface properties. ISO 2470 whiteness, ISO 2493 stiffness, ISO 536 grammage, ISO 534 thickness measurement values were averaged.

Printing phase was carried out on Konica Minolta Bizhub Pro C6000L digital printing machine. The test prints were created in the printing machine RIP (Raster Image Processor) section with stochastic, smoothing, and quality screening options with 1200dpi resolution and transferred to the substrate.

Printability cyan, magenta, yellow, black colors have been achieved in a digital printing machine in accordance with the standards under optimum printing room conditions. In the printing room, papers were conditioned at 23 ± 1 °C and 50%± 3% relative humidity for 24 hours before the test prints were printed. Densitometric measurements were carried out with a Konica Minolta Spectrophotometer (measurement conditions: D50 light, 2º observer, 0/45 or 45/0 geometry, black background) that can measure reflection.

Dot area and dot gain consists of the ratio between the amount of light reflected or transmitted from a given halftone and the amount of light collected from or through a ground of the same color [11-12]. The calculation formula, called the Yule-Nielsen equation, is as follows:

$$\%estimated\ pysical\ dot\ area = \frac{1-10^{-(\mathrm{Dt}-Dp/\mathrm{n})}}{1-10^{-(\mathrm{Ds}-Dp/\mathrm{n})}} x100 \quad (1)$$

D(s) is density of the solid;

D(t) is density of the tint;

D(p) is density of the paper/substrate;

“n” is an empirically determined factor,

The color difference measurement is;

CIE Lab Delta E was calculated using the following equations to measure the degree of color accuracy and show the difference in reproduced colors;

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_1 - a_2)^2} + (b_1 - b_2)^2 = \sqrt{\Delta L^2} + \Delta a^2 + \Delta b^2 \quad (2)$$

$\Delta L = L_{sample\ (1)} - L_{standard}$

$\Delta a = a_{sample} - a_{standard}$

$\Delta b = b_{sample} - b_{standard}$

Figure 2 shows CIE Lab Color Space. The lightness value, CIE L* defines black at 0 and white at 100. The a* axis is relative to the green–red opponent colors [13-14], with negative values toward green and positive values toward red. The b* axis represents the blue–yellow opponents, with negative numbers toward blue and positive toward yellow [12].

After measured L*a*b*, the color differences (ΔE*) of the samples were calculated according to CIE ΔE ISO 13655 standards with an average of five measurements [15-16].

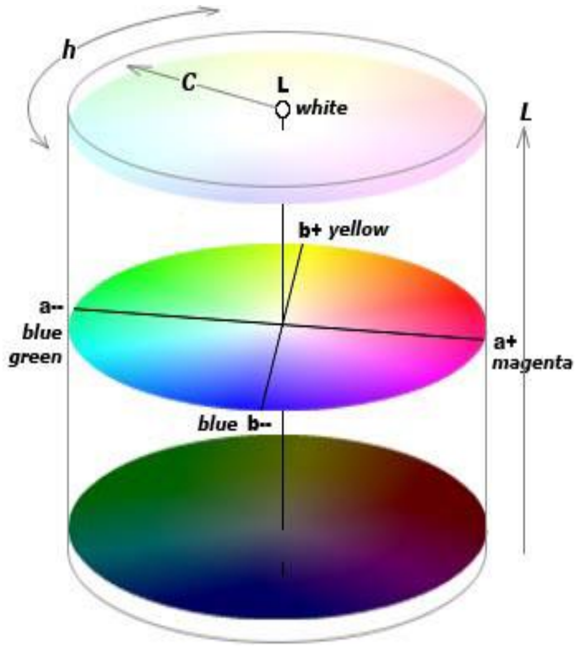


Figure 2. Color Space Three-Dimensional Sphere [17]

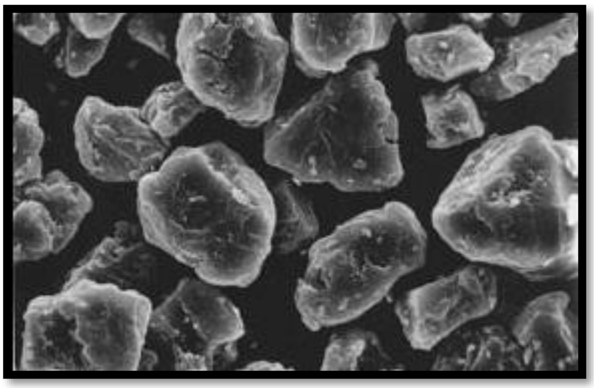
3. RESULTS and DISCUSSION

According to ISO Standards, about the high-grade paper pulp, the results obtained by taking the average values of ISO 2470 whiteness, ISO 2470-2 brightness, ISO 536 grammage, ISO 534 thickness measurement are shown in Table 1.

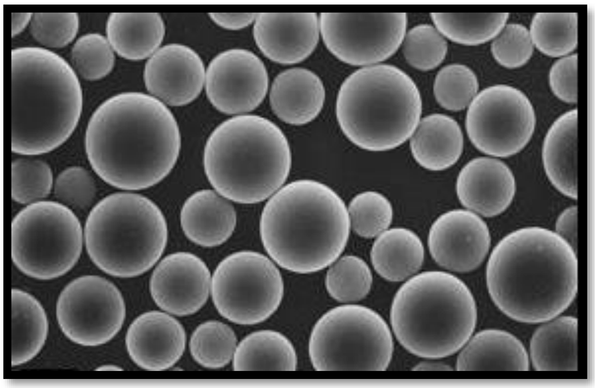
Table1. Technical specifications of under print material

	Unit	Value	Measurement Standard
Basis Weight	(g/m²)	100,0	(ISO 536)
Bulk	(cm³/g)	1.05	(ISO 534)
Brightness D65	(%)	114,0	(ISO 2470-2)
CIE Whiteness	(%)	170,0	(ISO 2470
Opacity	(%)	95.0	ISO (2471)
Roughness Bendtsen	(ml/min)	50.0	(ISO 8791-2)

The toner used in digital printing is a polymerized toner that has an effect on increasing the print quality and its SEM image is shown in Figure 3.



[a]



[b]

Figure 3. [a] Conventional Toner and [b] Polymerized Toner Scanning electron microscope (SEM) image

Figure 4 shows the dot gain was measured by printing with 1200dpi resolution Stochastic screening method on the high-grade paper pulp of 100g/m² used in the study. The dot gain values in this application increase approximately at the same rates and above the standard values for each color. It is seen that the dot gain of 40% dots, which is important in terms of controlling the printing standards [18], is 70% in printing, while the dots of 80% reach 95%.

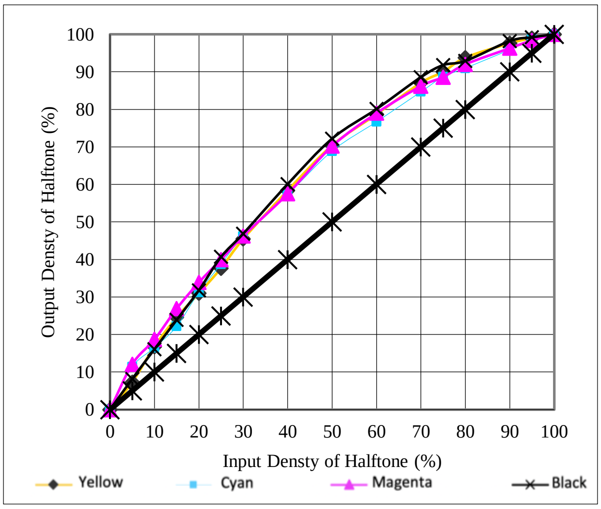


Figure 4.1200 dpi Stochas dot gain (%)

Figure 5 shows the Smoothing screening method applied on the high-grade paper pulp of 100 g/m^2 used in the study at 1200dpi resolution. The dot gain values in this application show that they are approximately the same proportions and standard values for each color. The dot gain of 40% dots, which is important for the control of printing standards, is 55% in printing, and it is seen with post-printing measurements that 80% dots reach 90%.

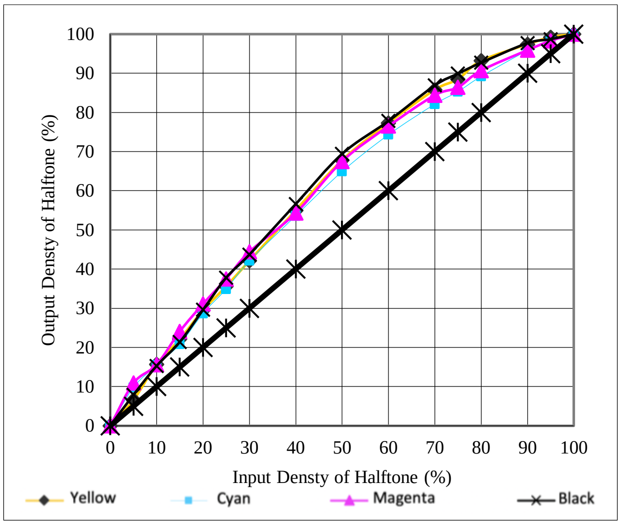


Figure 5. 1200 dpi Smoothing dot gain (%)

In Figure 6, Quality screening method with 1200dpi resolution was applied on the high-grade paper pulp of 100 g/m^2 used in the study. The dot gain values in this application increase approximately at the same rates and above the standard values for each color. The dot gain of 40% dots, which is important for the control of printing standards, is 60% in printing, while it is seen with post-printing measurements that 80% dots reach 95%.

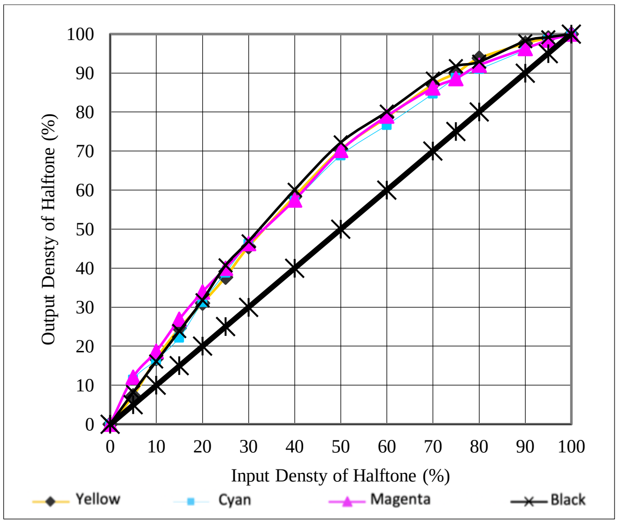


Figure 6. 1200 dpi Quality dot gain (%)

Apart from the dot gain measurements, the values determined by CIE lab measurements performed with the spectrophotometer are shown in Table 2. As a result of the measurement, it is seen that the L* value of the samples printed with Stochastic screening method is lower than other screening methods in all C, M, Y, K colors. When the results were compared, it was determined that there were differences in a* and b* values in all screening methods.

Table 2. Stochas, Quality, Smoothing screening L, a, b Values

		L	a	b
Stochas	C	56,92	-37,94	-45,17
	M	50,46	74,41	1,25
	Y	92,34	-5	93,51
	K	13,54	-0,66	2,64
Quality	C	57,23	-36,76	-47,44
	M	51,28	75,13	-0,9
	Y	92,92	-5,48	94,49
	K	16,74	-0,48	2,87
Smoothing	C	58,62	-36,21	-46,92
	M	52,14	74,4	-2,28
	Y	93,96	-6,16	92,38
	K	17,87	-0,54	3,4

According to the delta E values shown in Figure 7; Quality and Smoothing screening methods is the best match to get minimum color difference. In the cases where the same dot structure cannot be selected during adjustments made before printing, it is recommended to choose between Quality or Smoothing dot structure in order to get color difference at minimum.

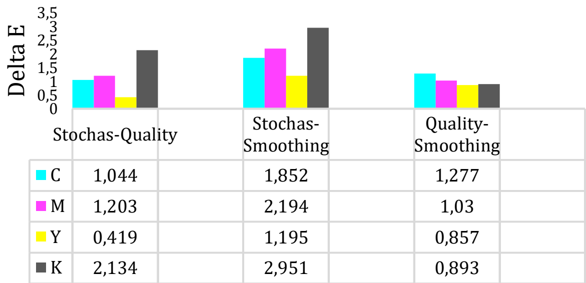


Figure 7. Comparative Delta E values of screenings

4. CONCLUSION

The change in the screening structures in digital printing creates certain differences in the dot swelling, density and color in the printing. In the study, it was determined that the minimum Delta E value in Cyan and Yellow colors are between Stochas and Quality. In Magenta and

Black colors, it shows that the least color difference is obtained in the comparison of Quality and Smoothing screening structure. Delta E was found to be higher than other comparisons between Stochas and Smoothing screening structure in all colors. The dot gain values give the most suitable result in the prints created with smoothing screening. Based on the findings, it is highly recommended to choose Quality or Smoothing dot structure in order to achieve optimum print quality.

DECLARATION OF ETHICAL STANDARDS

The author(s) of this article declare that the materials and methods used in this study do not require ethical committee permission and/or legal-special permission.

AUTHORS' CONTRIBUTIONS

Zafer ÖZOMAY: Performed the experiments and analyse the results. Wrote the manuscript.

Cengiz ŞAHİN: Wrote the manuscript.

Bekir KESKİN: Performed the experiments and analyse the results.

CONFLICT OF INTEREST

There is no conflict of interest in this study.

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