EA Toner Technology & Image Quality in Electrophotography Printing

Dr. Reda Shawky Mohamed Abouzeid
Assistant Professor, Printing, Publishing and Packaging Department, Faculty of Applied Arts, Helwan University, Egypt

Abstract
The main factors that govern the quality of the electrophotography printed image are the small uniform particle sizes of toner transfer to the paper and fixed by heat and pressure with/without oil to give a stable multicolor image and the most problems that the large particle sizes of toner, which gives roughly details of image. The research utilized an experimental research method. The purpose of this study was to determine the significant differences that exist in the measurable print attributes (density, dot gain, print contrast, color gamut and ΔE) of conventional & EA **(**Emulsion Aggregation) toner on different printers. The experiment was conducted in digital workflow, CMYK color Test target (color chart IT8 7/3) was output by using three digital printers, which all printers are similar on the technology of building image but different on type of toner, 8000 AP printer use Conventional Toner and fusing with oil, 5000AP printer use EA toner with oil and DocuColor 250 printer use EA toner without oil, Only the attributes of density, dot gain, print contrast, color gamut and ΔE were used to compare the two toner technologies, as they were the all attributes that measured patches made up of solid and halftone dots, The findings of this study represent specific printing or testing conditions.
The findings of this research comparing EA toner (with and without oil) with Conventionally toner (with oil) lead to the conclusion that EA toner record high density, loss gain on high light dots and wider color gamut, On the contrary conventional toner record smaller ΔE, higher dot gain, with this findings, Despite EA toner go on better than conventional toner in recording a higher density and more saturation colors, except that the small uniform particle sizes led to loss of the fine details on high light areas which require large uniform particle sizes, or looking for achieving better deposition and fixing high light dots with the small uniform particle sizes of EA toner.

KEYWORDS:
Electrophotographic printing, Emulsion Aggregation Toner, Densitometry Colorimetry, Sharpness, Print Contrast.

1. Introduction

Toners are divided into liquid and powder toners, In the case of liquid toner, the coloring agents usually pigments, are contained in a base liquid. The transfer of the loaded particles on the imaging cylinder takes place via electric forces acting in a field. The concentration of toner particles is only about 5% and must be increased for printing, The viscosity is typically about 15 mPa · s.
Dry toners are usually produced in a melting-grinding process, where the toner particles obtain a more or less regular shape (fig. 1). The conventional toner manufacturing process, consists of starting with just the right plastic, melt mixing in pigment and special ingredients, and pulverizing the resulting block of composite plastic to a fine powder. Finally, the powder still has to be processed to remove oversized chunks and ultra fine particles. This multi-step process results in non-uniform angular particles with a wide size and shape distribution. As amazing as the resulting toners were, to step up to

the challenges that each new generation of xerography required, the manufacturing process still limited engineers in creating toner with all the capabilities they wanted. (Janice, 2003)
A more modern method is chemical direct synthesis (polymerization process), which ensures spherical particles with very even diameters. The layer thickness of dry toners on the paper is 6–15 μm per ink after fixing/fusing. (Helmut, 2001)
Electrophotographic printing requires the precise placement of many highly charged (roughly −30 to −60 μC/g), small-diameter (roughly 6 to 10 μm) toner particles in close proximity to one another, first on a photoreceptor, then transferred to paper and ultimately fixed to the paper through fusing. Specifically, a photoreceptive element is initially uniformly electrostatically charged, typically using a corona charger or an electrically biased roller in contact with the photoreceptor (D.s. Riami, 2010) Black powder we have been using to copiers and printers for the last sixty years doesn't seem to have changed very much. today's toners flow better, store better, fuse better, and develop more efficiently, resulting in cleaner, better looking prints. But under the surface, other technological advances in toner design have also enabled better, less expensive, and safer photoreceptor and fuser materials not to mention faster and cleaner operating machines. The newest advancement in toner technology is EA toner.

2. EA (Emulsion Aggregation)Toner

EA toner is chemical toner prepared by Emulsion Aggregation, or a chemical process
used to "grow" very small, uniform particle sizes from even smaller (sub-micron) size
toner components. The EA process can deliver the desired size and narrow particle size distribution required for excellent color image quality. This small size and the relative uniformity of all the particles in a particular "batch" of EA toner is more predictable than the conventional mechanical process of pulverizing extruded plastic for toner. It is also less energy intensive. Emulsion refers to the synthetic chemical process to form latex toner resin and aggregation means to bring the toner ingredient's particles together to form the desired particle size and spherical shape. (Janice, 2003)

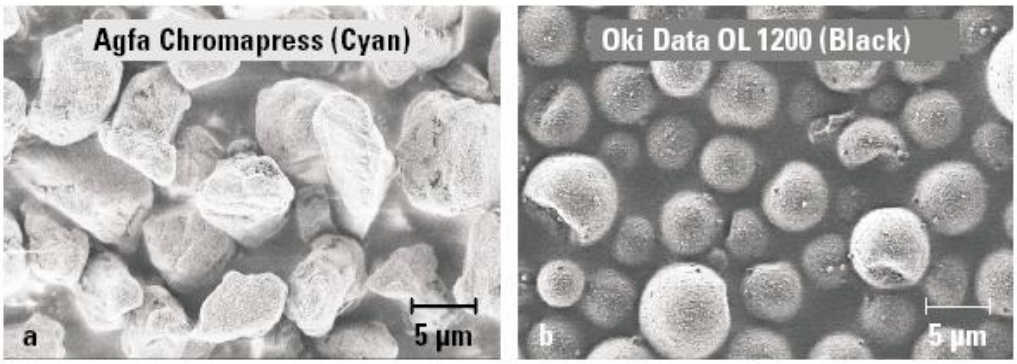

Fig. 1 Toner for electrophotography. Agfa Chromapress (Cyan)

a Manufacture in the melting-grinding process; toner particles have an irregular shape;
b Chemical manufacture (polymerization process); toners are spherical

2.1 The benefits of EA Toner:

- Smaller particle size.
- Lower temperature than other toners.
- Easy release from the fuser.

- Lower energy.
- Oil-less fusing.
- Don't Need toner collecting in the fuser component.
- Faster Warm-Up Time — Always ready.
- low melt point.

2.2 Densitometry and Colorimetry

A densitometer is a scientific instrument that is designed to determine, indirectly, the light absorbed by a surface. There are two types of densitometers: transmission and reflection densitometers. Transmission densitometers measure the amount of light that is transmitted through a transparent material such as a halftone film or color negative. Reflection densitometers measure the amount of light reflected from printed material or continuous tone photographs (Brehm, 1992). In the prepress and printing/press areas of the industry, densitometry allows us to find a balance for accurate tone reproduction. Hsieh (1997) stated that a densitometer can measure either incident light reflected from a substrate (reflection density) or light transmitted through a film (transmission density), or both. In prepress and printing/press areas,

In the spectral measuring process the total visible spectrum from 380 to 780 nm is measured. The light reflected from a printing ink is separated into its spectral components by means of a diffraction grate and measured by an array of sensors. Depending on the required accuracy, the identity of the incoming light is measured in steps of one, five or ten nanometers. The tristimulus values X, Y and Z are calculated from the measured reflections. Apart from the high absolute accuracy, one major advantage of spectral colour measuring is the fact that spectrophotometers can read out the tristimulus values for practically all standardised types of light and observers, if their values are stored in the computer. Furthermore, they can calculate colour densities for all filter standards. (Helmut, 2001).

2.3 Measurable print attributes

2.3.1 Density

Density is percentage of absorption of the ink film of the light falling upon. Logarithm represents mathematically the relationship between the amounts of light reflected from a point on the ink film to the amount of light falling on the same point (Helmut, 2001). (see equation 1)

$$D = Log\frac{L_W}{L_R}, \quad (1)$$

where L_W is the intensity of light reflected from the white region of the paper, and where L_R is the intensity of light reflected from the process ink region printed on the paper (Miroslav, 2003).

2.3.2 Dot Gain

Dot gain, also called tone value increase (TVI), is defined as the apparent halftone dot size increase from the halftone film/plate/digital dot to the printed sheet (Hsieh, 1997). It measures the difference in screen dote area between the digital file and final print (Helmut, 2001) It measures the difference between dote area of the digital file and final print. (see equation 2)

$$Z[\%] = F_D[\%] - F_F[\%] \quad (2)$$

Where Z is Dot gain/tone value increase Where (F_F) is the area coverage of the file, Where (F_D) is the tone value is transferred to/printed on the substrate via the printing form. (see equation 3)

$$F_D = \frac{1-10^{-D_R}}{1-10^{-D_V}}.100\% \quad (3)$$

where D_V is solid tone density, D_R is halftone density (Helmut, 2001).

2.3.3 Color Gamut

The ability of the printing system to produce a variety of color tones using the printing elements (inks, machines production speeds and operating system)

(Romano, 2000) Measuring CIEL*a*b* solid patches RGB-CMY**,** L***:** Brightness a***:** Green - Red – Axis, b*: Yellow - Blue- Axis.

2.3.4 Print Contrast (PC)

Print contrast is also known as shadow detail. PC indicates how well shadow detail is maintained or kept open in a halftone printed image. It is a ratio of the 75% screen dot density to solid density. It means the visual performance characteristic that illustrates the printing system's ability to hold image details in the upper tonal areas. PC is a good indication of print quality because shadow detail carries important information in many CMYK printed images. PC values correlate well to the subjective evaluations of print quality, such as low print contrast values versus high print contrast values (X-Rite, 2003). PC values require both high density and sharp printing to maintain shadow detail. The following equation is used by the densitometers to calculate the percentage print contrast values. (see equation 5)

$$\text{Percentage of PC} = \frac{D_s - D_t}{D_s} \cdot 100\% \qquad (5)$$

where: D_s = Density of solid

D_t = Density of tint, typically 75% (. H. Naik, 2005)

3. Methods

This research utilized an experimental research method. It was intended to determine the significant differences that exist in the measurable print attributes or characteristics of conventional and EA toner of multicolor (CMYK) electophotography printing. A detailed method of this experiment is summarized in the following paragraphs.

3.1 Programs, devices and materials used

3.1.1 Programs used

Different software programs were used in this study for building,

Test file and preparing for printing, these programs:

– Adobe acrobat 7.0 professional.

– Adobe Photoshop CS5.

– Free Flow DocuSP v5.1.

3.1.2 Devices used

The following are the main devices used in this work for printing

images and measuring standard colors:

– Computer IBM Pentium 4, Samsung 17-inch screen.

– HPLaser 300 Color M351a.

– DocuColor_ 8000 Digital Press (laser machine).

– DocuColor_ 5000 Digital Press (laser machine).

– DocuColor_ 250 printer-copier (laser machine).

– Measuring spectral reflectance device spectro eye.

(See Table 1 on page 7)

3.1.3 Materials used

– Xerox EA Color Toner (cyan–magenta–yellow–black).

– Xerox Conventional Color Toner (cyan–magenta–yellow–black).

– Coated Paper, 100 gsm^2.

3.2 prepress

Test file consists of four area firstly is IT8 7/3 color Chart for several print measures such as characteristic curve , dot gain, color gamut…. etc, Secondly is Heidelberg color bar (Consists of 26 color patches, solid CMYK for density measure, 25% - 50% - 75 % CMYK tents for Contrast measure, Over print RGB for Trapping Measure and one channel solid black and 3chanels CMY for color balance measure), thirdly some black and white text times new roman font, 7 pt for characters sharpness measure.

Photoshop CS 5 program was used to the layout of test file (Fig. 2), then the

image data were exported for processing as PDF digital format, 300 dpi and CMYK color gamut.

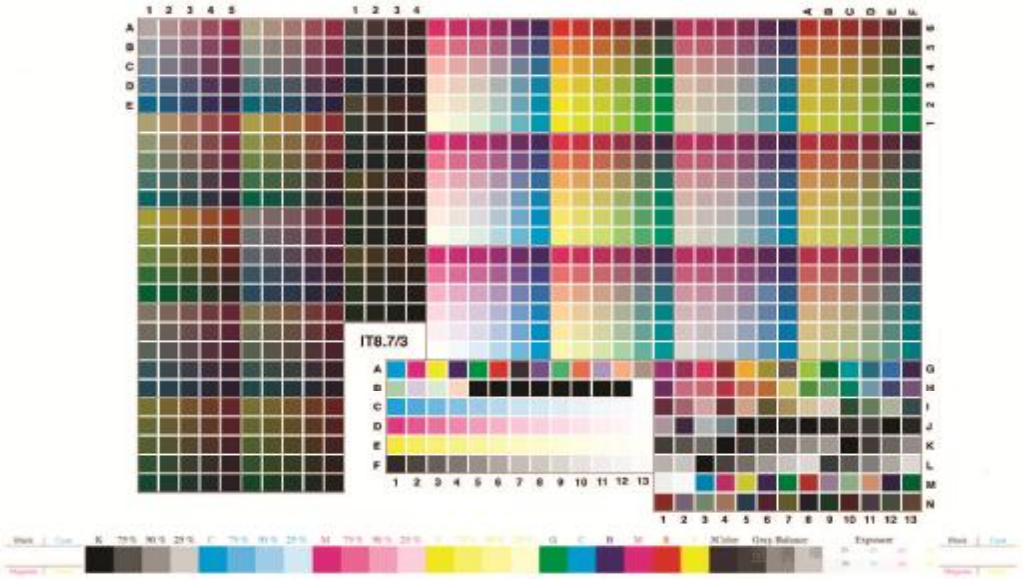

Figure 2 Test File Included Color Chart IT8 7/3.

3.3 Press

Experience printing has three different digital printing systems (Docucolor 8000AP, Docucolor 5000AP and Docucolor 250), with the stability of the type of paper (Coated paper 100 gm).Then measurements of color patches were done to determine the most toner design and printer to achieve the best range of color and detail of test file. Table 1 shows the comparison between the three digital printing system.

Table 1 Comparison between the four printing systems.

Specifications	8000 AP	5000 AP	DocuColor 250
Toner	Conventional Xerox toner cyan, magenta and yellow.	EA (Emulsion Aggregation) Xerox toner cyan, magenta and yellow.	EA (Emulsion Aggregation) Xerox toner cyan, magenta and yellow.
Fusing	With Oil	With Oil	Without Oil
Resolution	2400 * 2400	2400 * 2400	2400 * 2400
Print Speeds	-80 ppm (A4), 60 – 300 gsm. -4800 full process colour A4 4/0 sheets per hour. -2400 SRA3 4/0 sheets per hour. - Average Monthly Volume: 100,000 to 400,000.	-50 ppm color A4, 60 – 300 g/m ^{2}. -25 ppm color A3 60 – 300 g/m ^{2}. -25 ppm color SRA3, (12 in. x 18 in.) 60 – 300 g/m ^{2} . -Up to 3,000 full process color A4 (letter) 4/0 impressions per hour . -Up to 1,500 A3/SRA3 (tabloid) 4/0 impressions per hour. -Average monthly volume: 30,000 – 150,000	-As fast as 7.8 seconds color / 4.3 seconds black-and-white -Up to 50 ppm / 65 ppm -50 ppm Color -80 ppm Black-and-White. -Scan Speed with DADF (8.5 x 11 in. / A4). -Up to 200,000 pages per month

Paper Capacity	- Paper Trays up to 4,000.	- Paper Trays up to 4,000.	-2,000 sheet High-Capacity Feeder A4, SRA3)
Paper Format/Sizes	- Maximum Sheet Size 320 x 488. -Minimum Sheet Size 182 x 182 mm.	-Maximum sheet size: 12.6 in. x 19.2 in. (320 mm x 488 mm) -Minimum sheet size 7.2 in. x 7.2 in. (182 mm x 182 mm)	- Custom sizes up to 11 x 17 in. / A3 -Tray 3: 870 sheets; Size: 8.5 x 11 in. /A4 -Tray 4: 1,140 sheets; Size: 8.5 x 11 in. / A4
Paper Flexibility/ Weights	- Coated (gloss, matte, dull, silk); uncoated; specialty stocks; labels; synthetics; transparencies; -Xerox Premium -Digital Carbonless Paper. - Media weight: 16 lb. bond/60 g/m2 up to 110 lb. cover/300 g/m^2.	- Support on 60 to 300 gsm^2. - Coated and uncoated papers, bright papers, carbonless, DocuCard, labels, business cards, glossy brochures, window decals, durable/ synthetic, greeting cards, polyesters, and custom solutions.	- Plain paper -Plain paper Gloss -105 : 176 gsm^2 -105 – 176 gsm^2 Gloss . -177 – 300 gsm^2 -Transparency
Electrical	Base configuration: 200-240 VAC, 50/60 Hz, 30A (sole use). (Xerox 8000AP, 2009)	- Base Configuration: 200-240 VAC, 50 Hz, 30A (sole use). (Xerox 5000AP, 2009)	20 amp (115v), 10 amp (220 / 240v) (Xerox docucolor 250, 2006)

3.4 Measuring

We used a spectro eye device to measure all the measurable color patches were printed in the three printers, and select the high color value, which reflects the impact of type of toner in sharper image quality in electrophotography Printing, Such as dot area, dot gain, density, print contrast and color gamut.

4. Data Analysis and Findings

After the preparation of the test file and printing it by different digital printers, measurement of standard color bar of each printing type has been made to compare between them.

4.1 Color density

Color density of the measured printing image done by densitometry. Fig. 3 shows the density curves of the CMYK color to standard color bar. It can be compared with the printing tests and show that:

- Conventional toner (8000AP) recorded less density for process colors CMYK compared to standard value (ISO 12677-2) and black was higher recording.
- EA toner with oil (5000 AP) record less density for cmk than standard value but yellow was higher than ISO.
- EA toner without oil (DocuColor 250) recorded less density for process colors CMYK compared to ISO and K was closest to the ISO.

From the above it is clear that EA toner with oil in fusing (5000 AP) scored highest density of ink black and yellow, EA toner without oil (DocuColor 250) recorded the highest density of black and magenta, and conventional toner (8000 AP) recorded the lowest density values except black color.

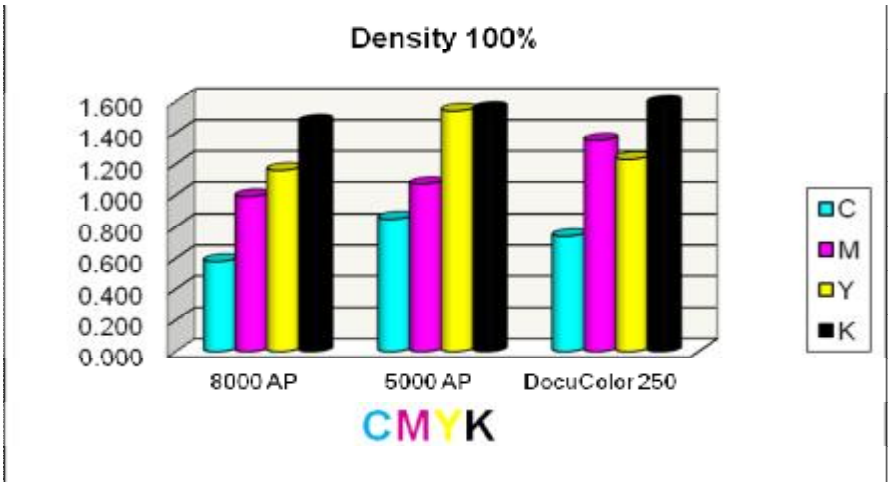

Figure 3 Density curves for Process color CMYK

.

4.2 Print contrast

PC of the measured printing image done by densitometry. Fig. 4 shows PC of the CMYK color to standard color bar. It can be compared with the printing tests and show that:

- All printers recorded higher than swop standards, where EA toner without oil (DocuColor 250) was higher recording of K,M,C colors, In case EA toner with oil (5000 AP) the yellow was the highest and magenta was the lower recording compared another printers.
- Conventional toner (8000 AP) recorded low contrast of K,Y,C colors, except magenta.
- Black was the higher contrast with EA toner with/without oil (5000 ap - DocuColor 250) and magenta was the lowest contrast, especially in EA toner with oil (5000 AP).
- Yellow was the higher contrast and cyan was the lowest with conventional toner (8000 AP).

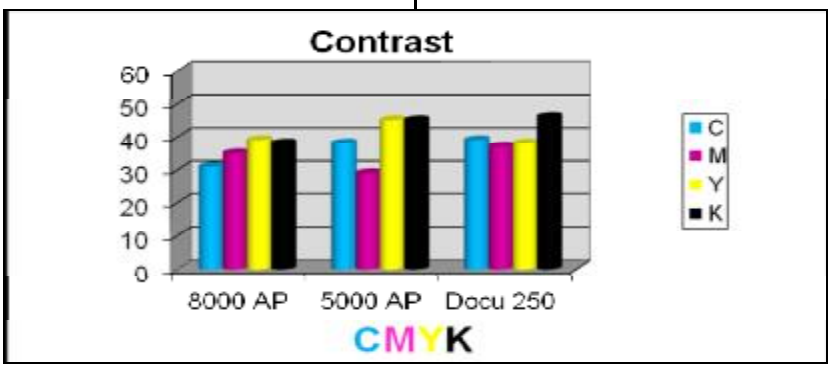

Figure 4 Contrast curves for Process color CMYK.

4.3 Dot gain

Dot gain of the measured printing image done by densitometry. Figs. (5,6,7,8) shows
dot gain of the CMYK color to standard color bar. It can be compared with the printing tests.
and Fig. 5 show that:

- Conventional toner (8000 AP) recorded higher dot gain of black color compared with EA toner with/without oil (5000 AP, 250) in several areas.
- There was less dot gain in high light area of black dot gain curve with EA toner especially with oil (5000 AP).

and Fig. 6 show that:

- Conventional toner (8000 AP) recorded higher dot gain of yellow color compared with EA toner with/without oil (5000 AP, 250) in middle tone areas.
- There was less dot gain in high light area of yellows dot gain curve with EA toner especially with oil (5000 AP).

and Fig. 7 show that:

- Conventional toner (8000 AP) recorded higher dot gain of magenta color compared with EA toner with/without oil (5000 AP, 250) in several areas.
- EA toner without oil (DocuColor 250) recorded the lowest values of dot gain curve in high light areas.

and Fig. 8 show that:

- Conventional toner (8000 AP) recorded higher dot gain of cyan color compared with EA toner with/without oil (5000 AP, 250) in several areas.
- In less than 10% high light area EA toner with/without oil (5000 AP, 250) recorded similar dot gain and higher than 10% dot gain of EA toner without oil (DocuColor 250) cleary increased.

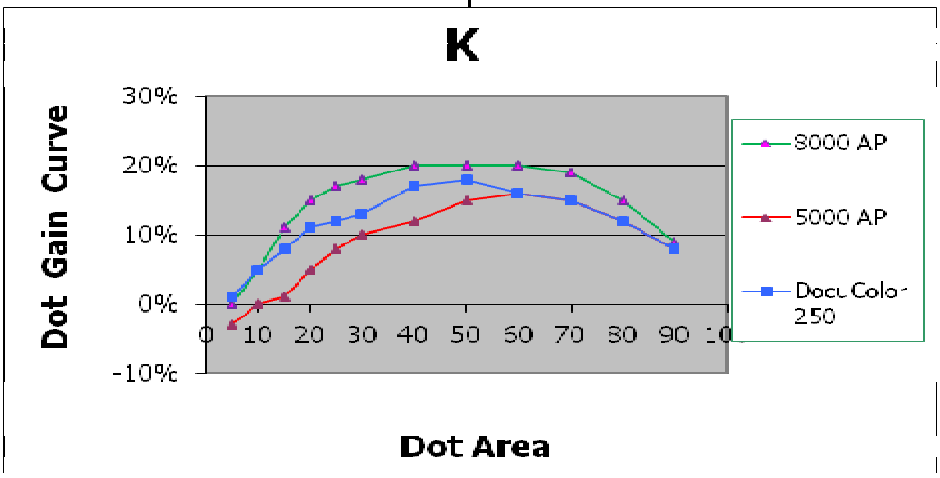

Figure 5 Dot Gain curves for Black.

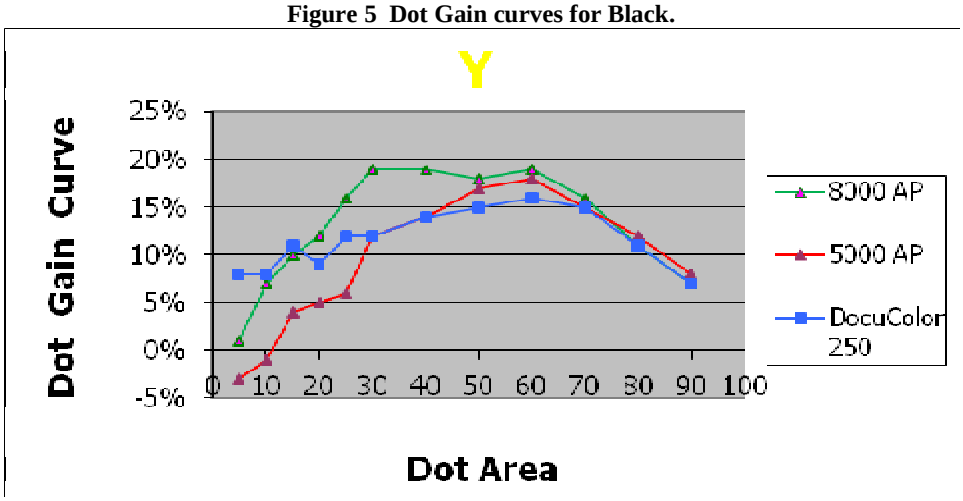

Figure 6 Dot Gain curves for Yellow

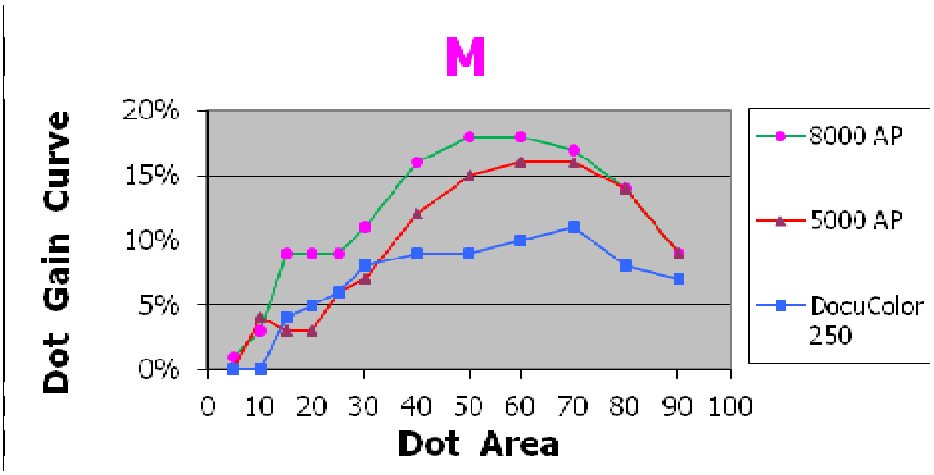

Figure 7 Dot Gain curves for Magenta.

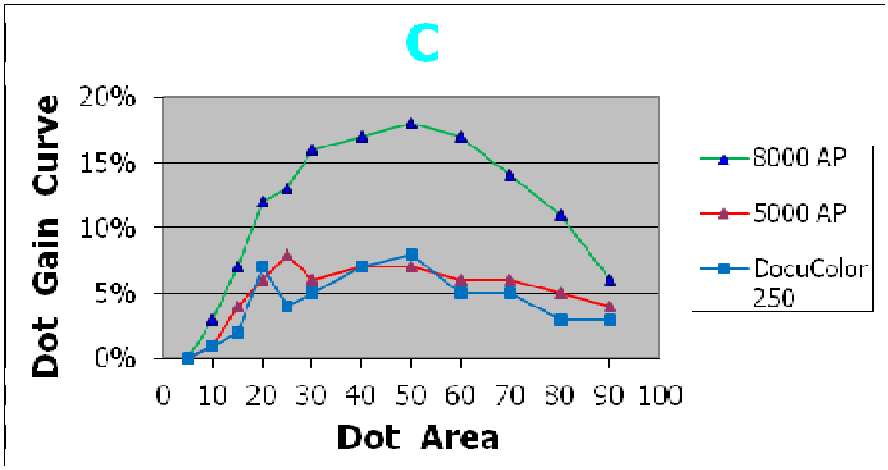

Figure 8 Dot Gain curves for Cyan.

4.4 Color Gamut

Color gamut of the measured printing image done by Colorimetry.
Comparison of color gamut curves of the color bar (CMYK – RGB) for test printing and (Fig. 9) shows that:

- Conventional toner (8000 AP) recorded low saturation color gamut except some color areas in green sector.
- EA toner with oil (5000 AP) record suitable color gamut compared with conventional toner, which more saturation in red-magenta sector, but green sector was low saturation than other.
- EA toner without oil (DocuColor 250) record the best color gamut except red-blue sector

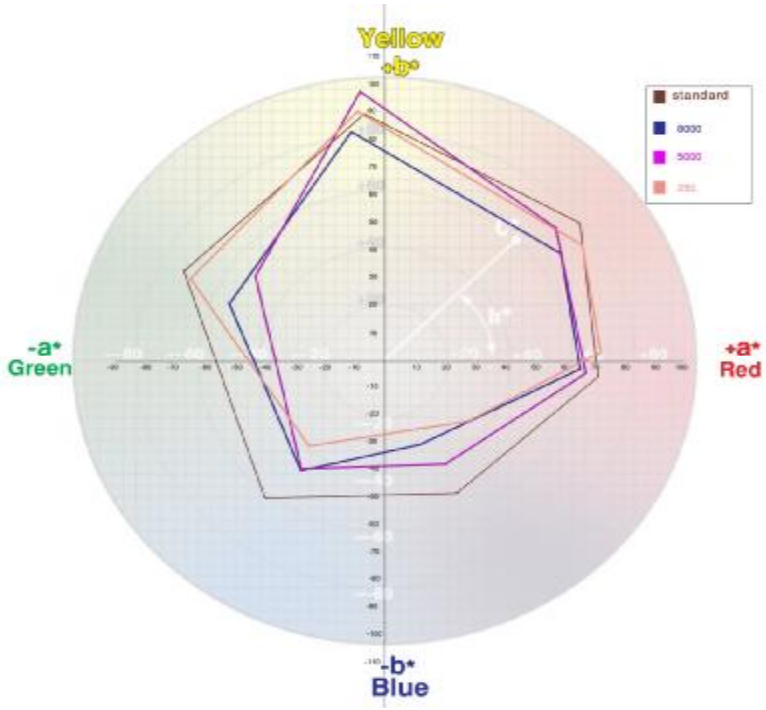

Figure 9 Color gamut curves of the printing systems.

5. Conclusions

The conclusions of this study are based upon an analysis of the data and major findings. The findings of this study represent specific printing or testing conditions. Type of Printer and toner , particle sizes of toner and fusing with/without oil that were used are important factors to consider when evaluating the results.

The findings of this research, comparing EA tonr (with/without oil) with conventional toner suggest that small uniform particle sizes of EA toner has been achieving higher density, recording greater details in the shadow areas (CMYK) of printed images and achieving wider color gamut, which means more saturation color compared with Conventional Toner, but on the contrary on dot gain curve there were less dot in high light areas, which means the inability to record high light dots less than 5% and using oil duing to more less of fine details, which suggests the need for further study to explore factors or variables that may have contributed to this result. May be need to large uniform particle sizes, or looking for achieving better deposition and fixing high light dots with the small uniform particle sizes of EA toner.

References

1. Brehm, P.V. (1992). Introduction to Densitometry: A User's guide to Print Production Measurement using Densitometry. Alexandria, VA: Graphic Communications Association.
2. Dharavath H. Naik, Dr. Ted M. Bensen and Mr. Bhaskar Gaddam 2005, Analysis of Print Attributes of Amplitude Modulated (AM) vs. Frequency Modulated (FM) Screening of Multicolor Offset Printing, Journal of Industrial Technology, Volume 21, Number 3 - July 2005 through September 2005
3. Habil, 2001. Helmut Kipphan Handbook of Print Media, Springer.
4. Hsieh, Y.C. (1997). Factors Affecting Dot Gain on Sheetfed Offset Presses. Journal of Visual Communications. University of Houston, Houston, TX: 39-52.
5. Miroslav, F. (2003). Separation model of colour regions in a halftone print. Journal of Computers & Graphics, 27 (3), 801–806.
6. O'Rourke Janice, XSBG, Chris AuClair, CMO, Jon Renault, CSBU, Dr. Hadi Mahabadi, XRCC, Dr. Grazyna Kmiecik-

Lawrynowicz, Chris Lyons, SDU (January 2003), Xerox Technology EA (Emulsion Aggregation) Toner, Xerox.
7. Rimai D. S., K. Brown, M. C. Zaretsky, K. Lofftus, M. Aslam, W. Y. Fowlkes and D. S. Weiss(2010), The role of adhesion in electrophotographic digital printing, J. Adhesion Science and Technology24 (2010) 583–617.
8. Romano, F., 2000. Technology Forecast, GATFWorld, vol. 12(1). GATF, USA.

Internet Sites

9. Xerox, 2011. <http://www.xerox.com/digital-printing/printers/digitalpress/ docucolor-5000ap/enus.html>.
10. Xerox 8000AP, 2008, <http://ccserver.copiercatalog.comlcatalogfiles/xerox/brochures/DocuColor-8000AP/Brochure.PDF.
11. Xerox 5000AP, 2009.<http://www.office.xerox.com/latest/DC5BR-01U.pdf.
12. Xerox 250, 2006. <http://office.xerox.com/latest/D0BR-01.PDF.