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Evaluation Of Gray Balance Reproduced By Liquid Toner Electrophotography And Dry Toner Electrophotography Technology On Gloss Coated Paper

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Abstract:

Variable Data Printing is best suited to be reproduced using a digital printing process. Among all the available digital printing processes in the current time, Electrophotography process is the most common process used by the printers for printing the Variable Data Printing Jobs. The invention of this process dates back to the mid-20th century, when an American Physicist invented this process and filed an application for patenting this process of digital printing. This technology is now commonly used in the modern office printers. This process has evolved throughout the time in terms of technology, speed, quality, reliability and cost efficiency. Recent developments in the field of printing and allied industry have enabled this technology to reproduce excellent results in multi-colour jobs. When the question comes to the point of "quality" in a multi-colour job, there are few parameters that can be checked for ensuring the acceptable print quality. Gray Balance is one such parameter that can be very handy for checking print quality during print production and that too with just visual tools. For accuracy purpose, standard tools for colorimetry measurement may also be used for evaluation of print quality. In this study, a systematic approach is implemented to determine the print quality based upon reproduction of Gray Balance on Gloss Coated Paper using two different presses based upon Liquid Toner Technology and Dry Toner Technology.

Keywords: Electrophotography, Gray balance, Liquid Toner, Dry Toner, Gloss Coated Paper

Introduction

Printing of Variable Data in good quality multi-colour reproduction has always been a target for technologist which continuously compels them to do research and developments in the field of digital printing technology. Instead of relying on the conventional printing processes for reproduction of quality jobs, focus is now driven for improving the existing digital printing technology and developing new technologies which can reproduce similar or higher quality print jobs as compared to the conventional offset lithography or gravure process. In this run for the quest, a very recent development of Liquid Toner Electrophotography technology is driving the attention of printing technologist towards its quality and efficiency. It does differ slightly in terms of state of vehicles used for toner, with that of Dry Toner Electrophotography Technology.

Electrophotography process may be classified into two categories based upon the type of toner used:

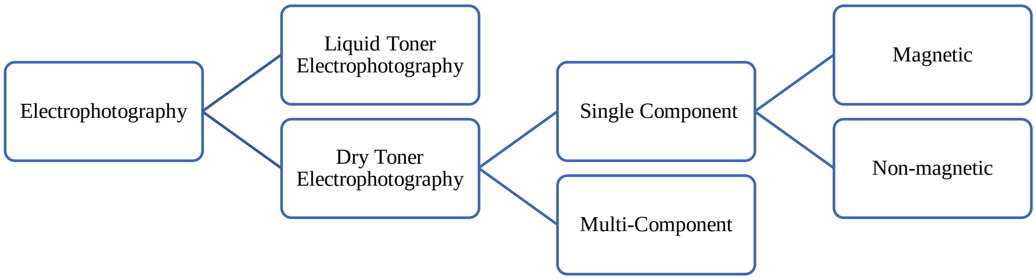

Figure 1: Classification of Electrophotography Process based upon Toner Used.

In Liquid Toner Electrophotography Technology, toner is carried by liquid state vehicle, which is essentially evaporated during or before fusion of the toner to the substrate. The toner particle size in this case ranges between 1 µm to 3 µm. [H. Kipphan, Handbook of Print Media: technologies and production methods. Springer. pp. 695.] With this smaller size of particle, it is possible to print thinner layer of ink film on the substrate which makes it comparable to offset technology; where the ink film thickness ranges between 0.5 µm – 2 µm. [H. Kipphan, Handbook of Print Media: technologies and production methods. Springer. pp. 58.]

Whereas, in Dry Toner Electrophotography Technology, toner may be of single component or multi-component type. Two component Toner System is most commonly used; in which the carrier particle (usually 80 µm in size), hold the toner particles on its surface. Size of toner particles vary from 5 µm to 20 µm. In high grade toner systems, the size of toner particles ranges between 6 µm to 8 µm. [H. Kipphan, Handbook of Print Media: technologies and production methods. Springer. pp. 693.]. For printing multi-colour jobs, two component toner system is widely used as single component toner system is not capable of printing high quality multi-colour printing jobs.

In order to check the print quality, several print quality parameters may be referred for the purpose of comparison and selection of right technology for print production of a job. One such parameter is Gray Balance. Gray Balance is measured via Gray Balance patches/Strips which may be incorporated in a designed and trimmed off during the print finishing processes. Gray Balance Patches are usually designed in 70 %, 50 % and 30 % tonal values. A patch of 70 %, 50 % and 30 % tonal value of Chromatic Gray (consisting of Cyan, Magenta and Yellow colours) is placed adjacent to 70 %, 50 % and 30 % tonal value of True Gray (consisting of Black colour). After printing, the patch is examined for colour variation. Lesser colour variation represent higher Gray Balance and vice-versa.

Research Problem:

When a Variable Data Printing Job is reproduced, the challenge comes for identification of “Standard Sample”. Usually, it is advised to print a job which is closely matching with the Standard Sample, with slight deviations towards Light and Dark Print, in order to sort the job as “Good” and “Not Good”. For Identification of Standard Sample, several print quality parameters may be considered for reference. Some of these parameters require measurements using Spectrophotometer/Densitometer, whereas some are identifiable with naked eyes. Therefore, it is necessary to identify at least one such parameter which may be used for evaluation of printed job for identification of colour accuracy.

Research Objective:

The objective of this research is to evaluate Gray Balance reproductions in prints obtained by Liquid Toner Electrophotography and Dry Toner Electrophotography Technology on Gloss Coated Paper.

Research Methodology:

This study was conducted in three stages:

Stage 1: In the primary stage of this study, selection of printing machine, selection of substrate, selection of print quality parameters, selection of print quality measurement tool and designing of Master Chart was done.

Stage 2: Secondary stage consisted of Printing of Master Chart using selected printing machines on the selected substrate, data collection and analysis related to print quality parameter of the printed sheets.

Stage 3: In the tertiary and final stage of the study, illustration of the results and conclusion are discussed.

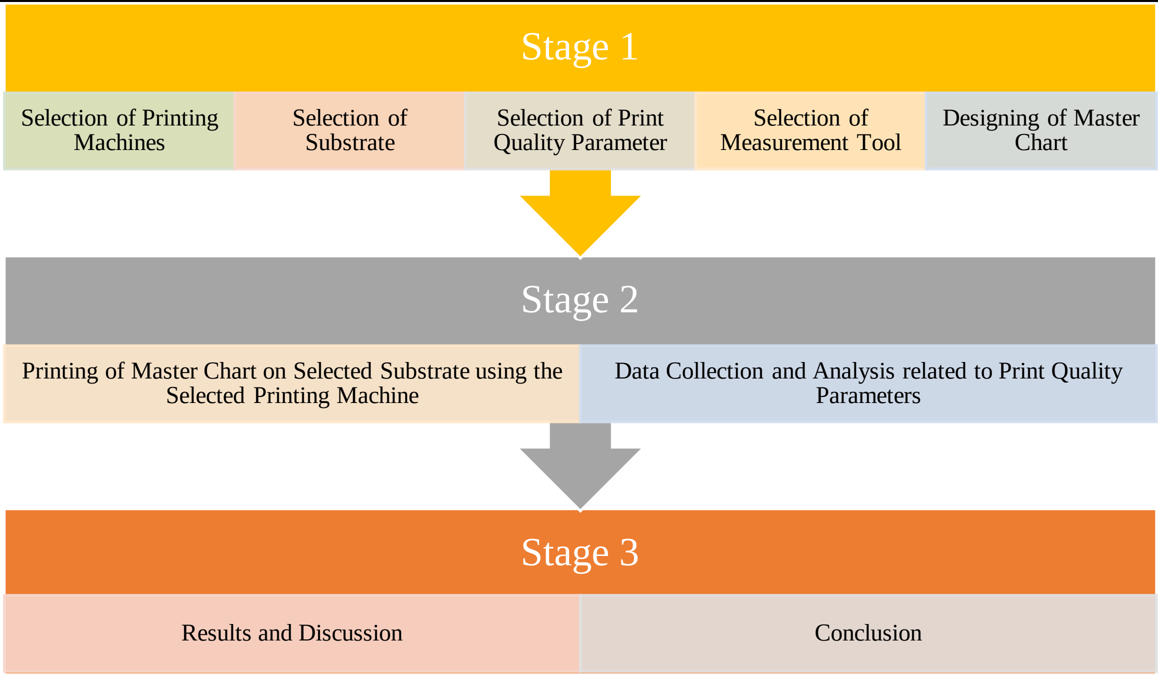

Figure 2: Three Stages of the Study

Stage 1

1.1 *Selection of Printing Machines:* Two Printing Machines were selected for this study. HP Indigo 5600 was selected for printing Master Chart using Liquid Toner Electrophotography Technology and Xerox Versant 2100 was selected for printing Master Chart using Dry Toner Electrophotography Technology.

1.2 *Selection of Substrate:* Gloss Coated Paper of 200 GSM grammage was selected for this study as this substrate is compatible with both the machines. Sheets size of 13” X 19” was compatible with both the machines and the Master Chart did not require “Resizing” for this Substrate Size.

1.3 *Selection of Print Quality Parameter:* Gray Balance was selected for measurement of multi-colour print production. It was decided to measure it on FOGRA39 Gray Control Strip at patched of 70 %, 50 % and 30 % tonal values.

1.4 *Selection of Measurement Tools:* X-rite eXact™ Spectrophotometer with scanning condition of M0 (No Filter) was selected for measurement of L*a*b* values of the FOGRA39 Gray Control Strip. It was decided to measure Gray Balance by calculating Colour Difference (ΔE*) of the respective 70 %, 50 % and 30 % tonal values patches of Chromatic Gray and True Gray using CIE76 formula.

1.5 Designing of Master Chart: A Master Chart containing several Print Quality related parameters was designed. The size of Master Chart was 12” X 18”. The Master Chart was saved in PDF/X-3:2002 format.

Stage 2

2.1 Printing of Master Chart: 50 Sheets of Master Chart were printed on each of the two printing machines selected for this study (HP Indigo 5600 - for Liquid Toner Electrophotography Technology and Xerox Versant 2100 - for Dry Toner Electrophotography Technology).

2.2 Data Collection and Analysis: Data collection was performed using X-rite eXact™ Spectrophotometer with scanning condition of M0 (No Filter) for measurement of L*a*b* values of the FOGRA39 Gray Control Strip. Gray Balance was measured by calculating Colour Difference (ΔE*) of the respective 70 %, 50 % and 30 % tonal values patches of Chromatic Gray and True Gray using CIE76 formula:

Equation 1: CIE 76 Formula for Calculating the Colour Difference (ΔE)*

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

Data such obtained was analyzed using the Graphical Tools of the Microsoft® Excel® Software.

Stage 3

3.1 *Results and Discussions:* Based upon the data analysis, a technical approach for discussing the results was followed.

3.2 *Conclusion:* The outcomes of this study was systematically concluded to provide error free results and leaving a further scope for research.

Data Collection & Analysis:

Data Collected from measuring the FOGRA39 Gray Control Strip of 50 sheets each printed by Liquid Toner Electrophotography and Dry Toner Electrophotography is derived into the values of ΔE* (Colour Difference) using the Formula mentioned in Point No. 2.2 of the Research Methodology and is as represented in the Table 1.

Table 1: ΔE Values of FOGRA39 Gray Control Strip on Gloss Coated Paper printed by Liquid Toner and Dry Toner Electrophotography Technology*

Liquid Toner Electrophotography Process			Dry Toner Electrophotography Process		
ΔE* 70	ΔE* 50	ΔE* 30	ΔE* 70	ΔE* 50	ΔE* 30
1.262	1.124	1.06	3.666	1.915	1.384
0.399	0.632	0.795	3.566	1.888	1.374
0.759	0.871	0.933	5.278	2.297	1.516
1.362	1.167	1.08	3.867	1.966	1.402
0.809	0.899	0.948	6.266	2.503	1.582
0.985	0.993	0.996	6.473	2.544	1.595
0.732	0.855	0.925	5.058	2.249	1.5
1.242	1.114	1.056	5.733	2.394	1.547
0.899	0.948	0.974	6.701	2.589	1.609
1.198	1.094	1.046	7.201	2.684	1.638
1.016	1.008	1.004	5.322	2.307	1.519
1.014	1.007	1.004	6.094	2.469	1.571
0.958	0.979	0.989	5.668	2.381	1.543
0.875	0.935	0.967	5.756	2.399	1.549
1.226	1.107	1.052	5.281	2.298	1.516
0.606	0.778	0.882	5.825	2.413	1.554
0.953	0.976	0.988	4.492	2.119	1.456
0.866	0.93	0.965	3.387	1.841	1.357
0.91	0.954	0.977	5.063	2.25	1.5
0.959	0.979	0.99	6.21	2.492	1.579
0.931	0.965	0.982	7.156	2.675	1.636
1.077	1.038	1.019	5.583	2.363	1.537
0.785	0.886	0.941	5.903	2.43	1.559
1.443	1.201	1.096	5.943	2.438	1.561
1.262	1.123	1.06	5.196	2.279	1.51
1.151	1.073	1.036	5.45	2.335	1.528
1.305	1.142	1.069	6.231	2.496	1.58
1.504	1.226	1.107	4.657	2.158	1.469
0.933	0.966	0.983	4.895	2.212	1.487
1.131	1.063	1.031	5.895	2.428	1.558
0.891	0.944	0.972	6.146	2.479	1.575
0.991	0.996	0.998	5.179	2.276	1.509
0.935	0.967	0.983	4.887	2.211	1.487
1.062	1.031	1.015	4.619	2.149	1.466

0.92	0.959	0.979	4.878	2.209	1.486
0.405	0.637	0.798	4.269	2.066	1.437
1.007	1.004	1.002	5.461	2.337	1.529
0.591	0.769	0.877	4.617	2.149	1.466
1.403	1.185	1.088	5.145	2.268	1.506
1.127	1.061	1.03	4.295	2.072	1.44
1.064	1.031	1.016	5.584	2.363	1.537
0.834	0.913	0.956	4.2	2.049	1.432
0.697	0.835	0.914	5.517	2.349	1.533
0.98	0.99	0.995	6.667	2.582	1.607
0.742	0.862	0.928	6.811	2.61	1.615
0.98	0.99	0.995	4.561	2.136	1.461
0.956	0.978	0.989	5.845	2.418	1.555
0.829	0.91	0.954	4.462	2.112	1.453
0.608	0.78	0.883	4.664	2.16	1.47
0.827	0.909	0.954	3.86	1.965	1.402

Analysis of the data represented in the Table 1 is represented in the Table 2 in a format where Min. represents minimum value observed, Max. represents maximum value observed, Avg. represents average value and S.D. represents standard deviation of the values in the data collected from 50 sheets.

Table 2: Data Analysis of the Gray Balance Values of Liquid Toner Electrophotography and Dry Toner Electrophotography

	Liquid Toner Electrophotography			**Dry Toner Electrophotography**		
	ΔE* 70	**ΔE* 50**	**ΔE* 30**	**ΔE* 70**	**ΔE* 50**	**ΔE* 30**
Min.	0.399	0.632	0.795	3.387	1.841	1.357
Max.	1.504	1.226	1.107	7.201	2.684	1.638
Avg.	0.968	0.976	0.986	5.31	2.295	1.514
S.D.	0.243	0.128	0.066	0.927	0.204	0.068

Results and Discussion:

Results of this study suggests that the average values of Colour Difference (ΔE*) of FOGRA39 Gray Control Strip printed on Gloss Coated Paper are similar along all the tonal values (70 %, 50 % and 30 %) and minimum (Below 1) in the sheets printed by Liquid Toner Electrophotography Technology.

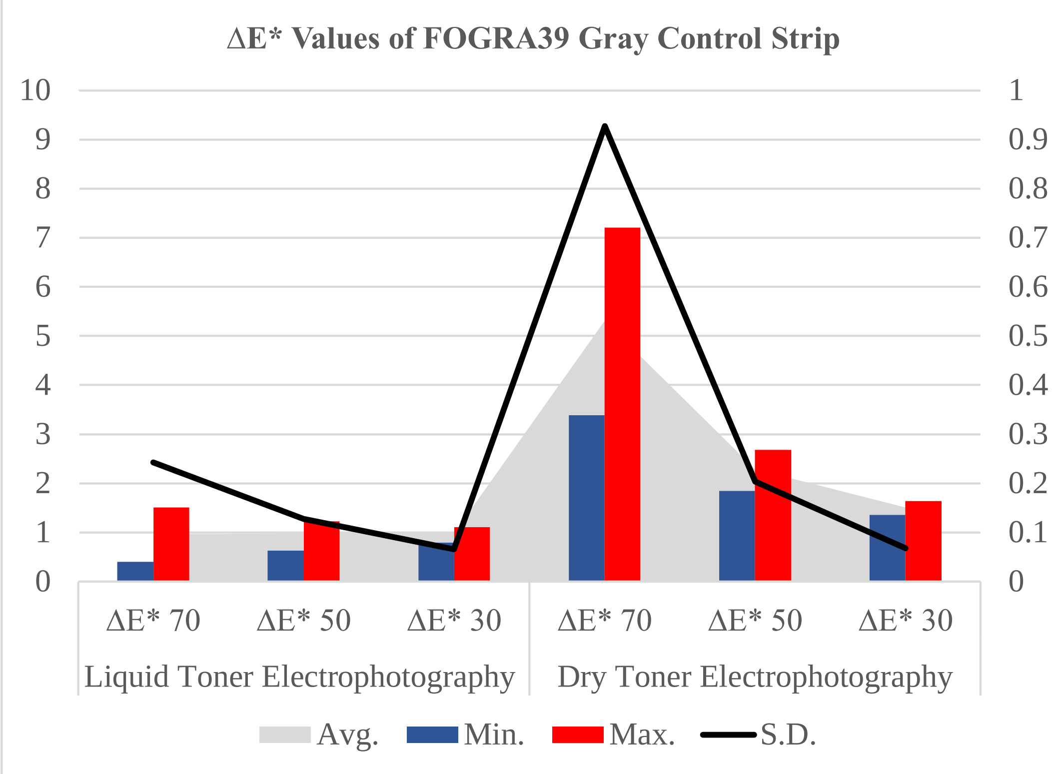

Figure 3: ΔE Values of FOGRA39 Gra Control Strip on Gloss Coated Paper printed by Liquid Toner Electrophotography and Dry Toner Electrophotography Technology*

Whereas the average values of Colour Difference (ΔE*) of FOGRA39 Gray Control Strip on Gloss Coated Paper varies along all the tonal values (70 %, 50 %, 30 %) and also Above 1 on sheets printed by Dry Toner Electrophotography Technology.

In Figure 3, x-axis is divided in to two parts. One part consists of ΔE* Values of all the tonal values (70 %, 50 %, 30 %) printed by Liquid Toner Electrophotography Technology and another part consists of those printed by Dry Toner Electrophotography Technology. Primary axis along y-axis represents values of ΔE* and secondary axis along y-axis represents values of standard deviation of ΔE*. Shaded graph area represents average values of ΔE*.

Figure 3 clearly illustrates that consistency is obtained better on Gloss Coated Paper printed by Liquid Toner Electrophotography Technology. However, standard deviation increases with increasing tonal values in samples printed through both the cases. This may be due to the density of halftone dots in the respective patches (highlight area contains less halftone dots than middle tone and shadow area). Average values of Colour Difference is lower and similar (0.9) in samples printed by Liquid Toner Electrophotography Technology. Average values of Colour Difference is Highest (5.3) at 70 % Tonal Value of samples printed by Dry Toner Electrophotography Technology, which is easily distinguishable with naked eye; at 50 % tonal value, colour difference value is 2.2 (below 3).

Conclusion:

From the results, it is evidently visible that Gray Balance is best achieved on samples printed using Liquid Toner Electrophotography Technology. Samples printed with Dry Toner Electrophotography Technology exhibited high colour difference in the 70 % and 50 % tonal values of the FOGRA39 Gray Control Strip. Hence, it can be concluded that Liquid Toner Electrophotography Technology produces better Gray Balance on Gloss Coated Paper.

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