



PRINTING QUALITY ENHANCEMENT ACCORDING TO ISO 12647-2 (APPLYING IN ONE OF EGYPTIAN PRINTING-HOUSES)

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ABSTRACT

This paper is concerned about finding a solution for the printing quality's inconsistency, when repeating the same job order for several times, in most of the Egyptian printing houses.

It was found that most of these inconsistencies may be occurred due to the methodology of quality inspection, where most printers depended only on visual inspection to control the printing quality, which can be considered as an insufficient method for controlling the quality of the printing production, in spite of using good quality production machines and raw materials imported from overseas.

On the other hand, they do not use any devices or systems to control and enhance print quality.

In this paper, an investigation of the factors affecting printing quality on sheet-fed offset lithography presses was studied using an offline quality control system, according to ISO 12647-2 specifications, without any changes in the materials or machines used, aiming to enhance the final print quality.

The important results of this paper;

- 1- Most of Egyptian printing houses are using visual inspection as their main tool of quality control, which can be considered as not sufficient to reach an optimum quality level.
- 2- All of them believe that printing quality can be started from the printing process.
- 3- By using an offline quality control system, there are many advantages, which can be listed in the following:
 - a. The OK sheet can be achieved after just few numbers of printed sheets.
 - b. The possibility to control using more quality control items.
 - c. The possibility of using the ISO 12647-2 as a quality control reference.
 - d. The print quality must be started from prepress process.

As a conclusion of this paper, the printing quality can be enhanced according to the ISO 12647-2 by activating the quality control systems' and devices' roles.

Keywords: *printing quality- L*a*b*- density- dot gain- linear curve- grey balance- trapping- contrast- tonal value increased- ISO12647-2.*

RESEARCH PROBLEM

The research problem can be summarized in one question:

Can we enhance the printed media quality in the Egyptian printing companies by applying the quality control systems and tools, according to the ISO 12647-2, without any more requirements of materials, equipments or processes?

RESEARCH AIMS

The main aim of this paper is to enhance the litho-offset sheet fed printing in the Egyptian companies by using quality control systems and devices.

RESEARCH LIMIT

Research limit included one of the Egyptian offset printing-houses.



RESEARCH METHODOLOGY

This paper was carried out by practical and analytical methods to enhance the quality of printed sheets, produced by sheet fed litho-offset printing in one of the Egyptian printing companies according to the ISO 12647-2 and using offline quality control system.

The achievement of the objective of this paper, was carried out through three main items.

1. LITERATURE REVIEW

This part will be discuss the definition of quality control parameters according to ISO 12647-2 :2103

1.1. QUALITY PARAMETERS ACCORDING TO ISO 12647 : 2103

ISO 12647 consists of the following parts:

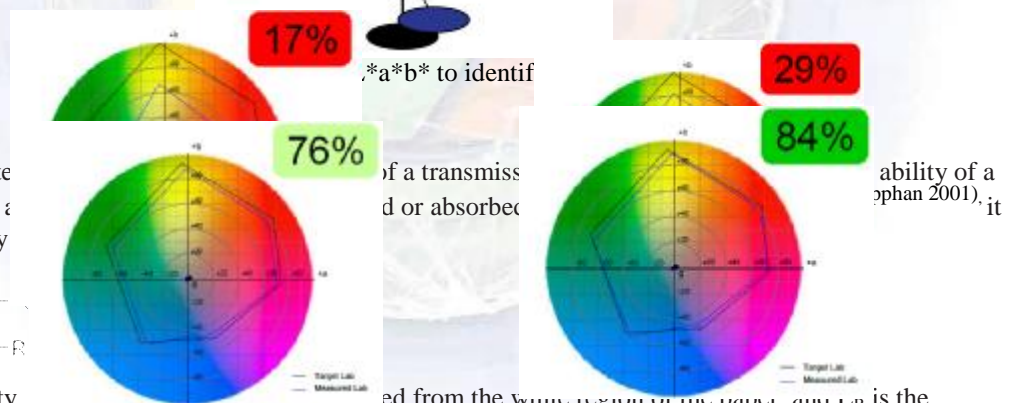
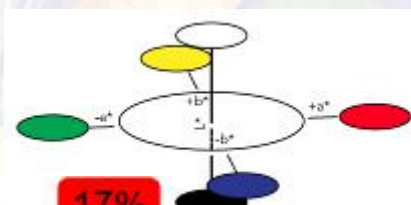
The general title Graphic technology — Process control for the production of half-tone color separations, proof and production prints: — Part 1: Parameters and measurement methods — Part 2: Offset lithographic processes — Part 3: Cold-set offset lithography on newsprint — Part 4: Publication gravure printing — Part 5: Screen printing — Part 6: Flexographic printing — Part 7: Proofing processes working directly from digital data — Part 8: Validation print processes working directly from digital data

In this paper, our results will be compared with the ISO 12647-2:2013 (ISO – 12647-2 (E), 2013), which include the following quality control items:

1.1.1. CIE L*a*b*

CIE L*a*b* is the most widely used system. The well-balanced structure of the L*a*b* color space is based on the theory that a color cannot be both green and red at the same time, nor blue and yellow at the same time. As a result, single values can be used to describe the red/green and the yellow/blue attributes.

When a color is expressed in CIE L*a*b*, L* defines lightness; a* denotes the red/green value; and b* the yellow/blue value (X-Rite (2004)), as shown in figure (1).



1.1.2. Density

Refers to a compute reflective surface to a can calculate density

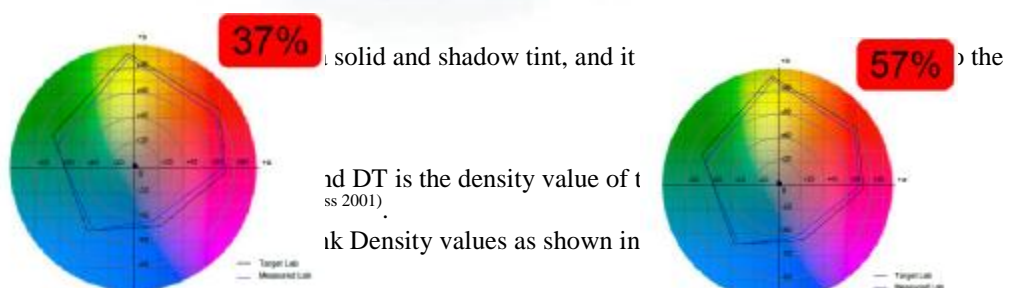
$$D = \log \frac{L_0}{L_R}$$

Where D is Density, L_0 is the intensity of light reflected from the white region of the paper, and L_R is the intensity of light reflected from the process ink region printed on the paper (Miroslav, F. 2003).

1.1.3. Contrast

Contrast can be c following equation Print Contrast = $\frac{D_s}{D_t}$ solid and shadow tint, and it

Where D_s is the preferred to use the Print contrast is us



and D_t is the density value of t ss 2001).

ink Density values as shown in

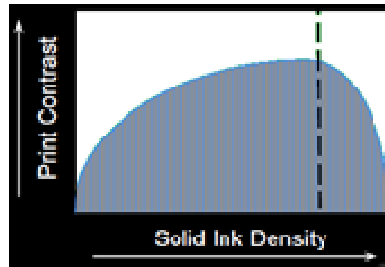


Figure (2) : The relationship between optimal print contrast and solid ink density (Norm Uress 2001).

According to ISO 12647-2 :2013, the optimal print contrast of sheet-fed litho-offset printing is as shown in table (1)

Table (1) : optimal Value percent of Print contrast

Ink Color	Black	Cyan	Magenta	Yellow
Print Contrast (%)	40	36	36	30

1.1.4. Dot area / Dot Gain (Tonal Value Increase “TVI”)

Dot gain, also called tone value increase (TVI), is defined as the apparent halftone dot size increase from the halftone film/printing plate dot to the printed sheet. It measures the difference in screen dote area between the printing plate and printed sheet.

Dot gain can calculate according to the next equation

$$Z\% = F_d \% - F_p \%$$

Where Z % is dot gain value, F_d % tonal value (dot percentage on the printed sheet) and F_p % tonal value (dot percentage on the printing plate).

According to ISO 12647-2 :2013, the optimal Dot gain of sheet-fed litho-offset printing is shown in figure (3)

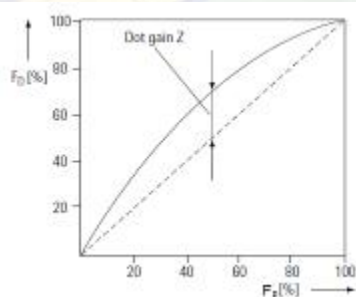


Figure (3): Print Characteristic Curve and Dot Gain (Helmut Kepphan 2001)

1.1.5. Trapping

The term “trapping” is used to describe the ink acceptance behavior when printing one ink film on top of another ink film.

To measure the trapping attribute, according to the following equation as shown in figure (4).

$$\% \text{ Ink Trap} = \frac{D3 - D1}{D2} \times 100$$

Figure (4) Density-based ink trapping formula (Robert Chung and Fred Hsu 2008).

Where: $D3$ = Density of two color overprint, minus paper density, $D1$ = Density of first ink down, minus paper density, and $D2$ = Density of second ink down, minus paper density (Robert Chung and Fred Hsu 2008).

Standard trapping value percent according to ISO 12647-2 should be equal or more than values, which illustrated in the table (2).



Table (2): Value percent of trapping according to ISO 12647-2

Ink Color	Trapping (%)
Red (Magenta + Yellow)	85
Green (Cyan + Yellow)	90
Blue (Cyan + Magenta)	90

1.1.6. Gray Balance

Gray Balance can be considered as one of the important parameters to control of litho-offset printing quality. Standard process offset printing states that the correct dot gain for each different printing ink is one of the most important preconditions for balancing printing. It has also been determined that the difference between the colors is not to be too great (key word: spread), or a deviation, for instance in the gray balance, may occur.

Usually the dot gain of each single process color is measured to verify this stipulation. Even before a measurement is made, a color shift (e.g. a red cast) in the chromatic gray patch when compared to the true gray patch can be detected by simply inspecting it with the naked eye ^{(ECI/bvdm Gray Control Strip(s) 2005)}.

It can carried gray balance between cyan +Magenta + yellow and black by the dot percent as shown in table (3).

Table (3): Dot area percentage to create gray of both (CMY) and Black ^{(ECI/bvdm Gray Control Strip(s) 2005)}

Ink Colors		(30%) CMY		(50%) CMY		(70%) CMY
Cyan	(30%)	27	(50%) Black**	45	(70%) Black***	65
Magenta	Black*	20		36		57
Yellow		18		33		50

*High Light gray balance, **Mid tone gray balance, *** Shadow gray balance

1.2. Printing Quality Control Systems

Printing quality control can be classified as four main systems;

1.2.1. Hand Held Systems

There are many devices, which can be used as hand held systems, such as densitometer, spectrodensitometer, plate reader and spectrophotometer, which can used to measure manually all parameters of printing quality ^{(X-Rite (2004))}.

1.2.2 Offline Systems

It can be considered as software, which is supported by ISO 12647, and connected to a spectrodensitometers to achieve the quality parameters and offer the suitable solution in solving the deviation and also adequate linear curve according tonal value increase for each color ^(Press SIGN 5 2010).

1.2.3 Online Systems

There are two main types of these systems; one related to only one printing machine and an other ^(Heidelberg 2/2006), which can be, connected with five various printing machines.

There are three sequences steps to achieve quality control;

Firstly, operators should pull printed sheet from the delivery pile and put it on the inspection table.

Secondly, system measures all parameters of printing quality by scan head and according to reference of job orders- and ISO- specifications.

Thirdly, operators should be adjust machine conditions according to output report.

1.2.4 Inline Systems

By using this system, quality parameters can be checked and controlled according to the reference of job orders specifications ^{(KBA (Koenig & Bauer AG) 4/2012)} and printing press conditions can be adjusted automatically without any personal decisions.

2- EXPERIMENTAL WORK

This section of the paper includes the programs, devices, tools, machines, raw materials, and process conditions used to achieve the experimental work.



2.1.Devices, tools and programs

2.1.1 X-rite spectrodensitometer

In this paper a Spectrodensitometer is used under trade name X-Rite Eye One, as shown in figure (5).



Figure (5): X-Rite Spectro Eye One

It can be plugged in into any full powered USB port on the computer that is running pressSIGN Client.

When you launch pressSIGN, or if pressSIGN is running and you then plug in the Eye-One the calibrate window automatically opens.

2.1.2. PRESSSIGN 5 SOFTWARE

pressSIGN makes it easy to print to any international printing standards. It can measure the control strip in one sweep or measure individual patches. By using this program, we can;

1. allow to test during the run and to make any density adjustments knowing any color shift during ink drying will be compensated for,
2. read the density and suggests the correct density adjustment, making it easy to get to the right settings quickly,
3. set the correct tonal curve,
4. read one sheet or multiple sheets and within seconds,
5. adjustment curve to export to RIP or PDF, and
6. Import this data directly into the most popular RIPs.

Figure (6) shows the interface of PressSIGN during running.

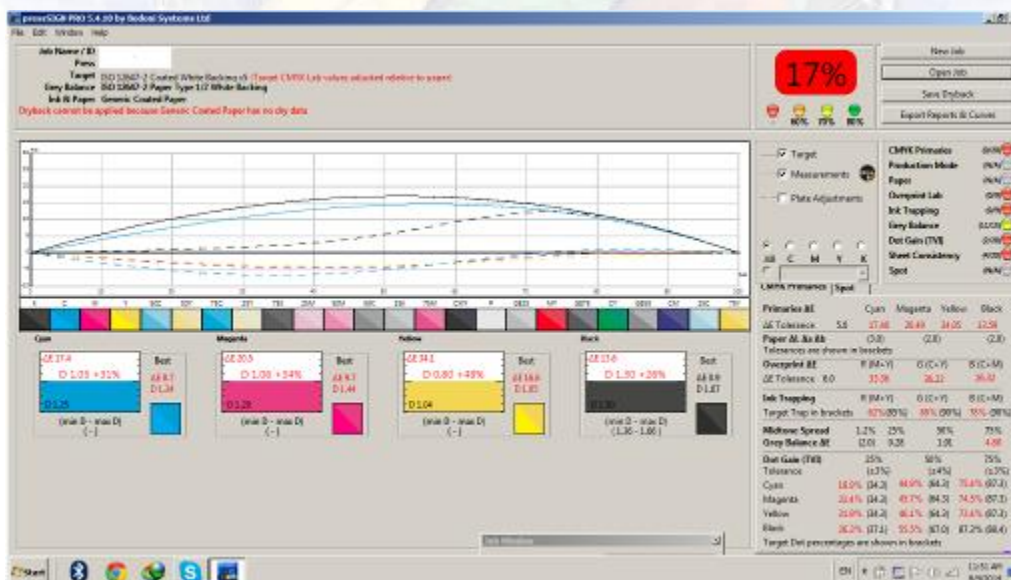


Figure (6): Interface of PressSIGN

2.1.3. MEASURING RULER

Measuring ruler can be described as white semi-rigid plastic, 120 cm. to suitable for various dimensions of printed sheets, which use the images below to align the ruler and the strip. The text labels should be just aligned with one of the edges of the ruler as shown in figure (7). Make sure the ruler is parallel to the strip, and centre the strip in the ruler, as shown in figure (8).

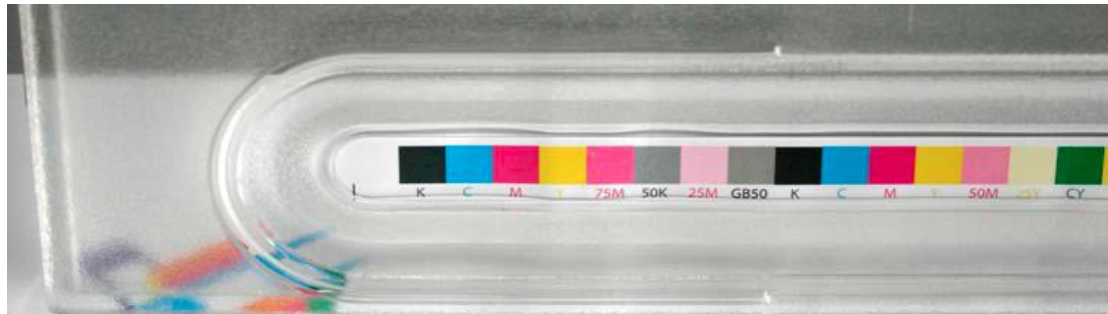


Figure (7): Close up of strip showing ruler alignment



Figure (8): Using the long pressSIGN ruler to measure a full press sheet

2.1.4. COLOR CONTROL STRIP

PressSIGN library has many color control strips, which are adequate for various printing conditions, these strips are calibrated according to various printing standards, which can be set to the adequate printing job, as length, width, number of colors, number of ink keys and their width, color sequences, and type of machine. They can be imported as pdf. or eps files, figure (9) shows the color control strip, which was used in this paper.



Figure (9): color control strip

2.2. MACHINES AND MATERIALS

2.2.1. PRINTING MACHINE

Heidelberg CD 102, Model 2010, sheet-fed litho-offset, four units, maximum printing plate size is 79x103 cm., and maximum printing area is 72x102 cm..

2.2.2. PRINTING INK

Cold-set Sheet-fed litho-offset printing inks, under trade name SunLite[®], produced by SunChemical.

2.2.3 DAMPENING SOLUTION

It has used domestic dampening solution production, under trade name Al-Wafa chemical company.

2.2.4. SUBSTRATE

Coated paper is used as the research paper, with glossy surface, 150gm/sqm.

2.3. PROCESS CONDITIONS

2.3.1. Experimental work was carried out in two phases

Phase one: by using the current company's linear curve

Phase two: by using the linear curve which created according to results of phase one.

All experimental work was achieved by fixed the following factors;

Ambient temperature : 25 °C ± 2°C

Color sequences : Black – Cyan – Magenta – Yellow



Technical specifications of dampening solution;
 pH = 4.5 – 5.5
 Conductivity = 1400 μ s/cm
 Temperature degree = 12°C
 Ratio of Iso propyl alcohol (IPA) = 10%
 Speed balance = 30% inking system – 50% dampening system
 Impression value = 0.2 mm.
 Printing speed : 6000 copy/hour
 Number of printed sheets/experimental step : 150 sheets

2.3.2. Experimental planning

Experimental works were carried out into two separate phases;

Phase one, it has achieved by four experimental works, which have enhanced the printing quality level by 17%, as a satisfied result (OK Sheet), according to case study after that, and by using offline quality control system to increase the level to 29%, 37% and finally 57% as the best quality according to the printing conditions, after that the linear consumption curve was imported from the best result (57%) to export it to the RIP, to carry out the second phase of the experimental works.

Phase two, it was carried out through two experimental stages, which have increased the printing quality level to 76% and 84%.

All of them were carried out with the same process conditions.

3. RESULTS

In this section, the analysis of results for both phases of experimental works will be illustrated.

3.1. L*a*b* value

L*a*b* values are one of the important Parameters, table (4) shows the difference between target and measured lab for phase one.

Table (4): L*a*b* values – Phase one

Phase One	
Experiment 1(17%)	Experiment 2 (29%)
It can be obvious that big gap between measure and target L*a*b*.	Change by fine adjustment of ink densities for all color inks according to result one, it can be obtain a minimize gap between measure and target L*a*b*
Experiment 3 (37%)	Experiment 4 (57%)
According to result of exp.2, and change by fine adjustment of ink densities. it can be obtain more minimizing of gap between measure and target L*a*b*	To reach the best result, according to results of exp.3, and change by fine adjustment of ink densities. it can be obtain more minimizing of gap between measure and target L*a*b*



To enhance the quality of printed sheet, it should be import the linear curve according the last result (57%) and export it into RIP, as shown in table (5).

Table (5): Dot Percentage Values should load into RIP to obtain a consumption curve to decrease dot gain according to ISO 12746-2.

Dot Percentage	Target Black	Target Cyan	Target Magenta	Target Yellow
0%	0%	0%	0%	0%
2%	1.5%	1.5%	1.5%	1.5%
5%	3.8%	3.5%	3.8%	3.5%
10%	7.5%	7.7%	7.7%	7%
20%	14.7%	14.5%	14.7%	14.2%
25%	18.3%	18.2%	18.7%	18%
30%	22%	22%	22.8%	22%
40%	29.5%	30.5%	32%	30.5%
50%	37.5%	40.8%	42.5%	40.3%
60%	46%	50%	53.2%	50.5%
70%	55.2%	60%	63.8%	60%
75%	59.8%	65.2%	68.8%	64.5%
80%	64.5%	70.8%	74%	69%
90%	75.5%	82.8%	86.5%	79%
95%	82.9%	91%	93.5%	86.3
100%	0%	0%	0%	0%

According to table (5). It can be obvious that:

1. Phase one: The values of the linear curves for all ink colors were at the same level.
2. According to table (5): values of linear curves for all ink colors were not at the same value, due to variable mechanical state of each unit, the nature of blanket conditions, and ink types.

Table (6) shows the difference between target and measured lab for phase two, after used resulted linear curve of best outcome of phase one.

Table (6): L*a*b* values - phase two

Experiment 5 (76%)	Experiment 6 (84%)
Within the first 100 printed sheets to obtain an approved sheet. It can obvious the different value between measured and target L*a*b*	By adjustment ink densities to enhance the optimum results

3.2. DENSITY

Density is one of the ruling factors to decide an appropriate linear curve which can achieve an optimum result, table (7) shows the different values between target and measured density for phase one.



Table (7): Density values - phase one

Phase 1																															
<p>Experiment 1 (17%)</p> <table border="1"> <caption>Data for Experiment 1</caption> <thead> <tr> <th>Ink color</th> <th>Measured Density</th> <th>Target Density</th> </tr> </thead> <tbody> <tr> <td>Cyan</td> <td>1.05</td> <td>1.25</td> </tr> <tr> <td>Magenta</td> <td>1.05</td> <td>1.3</td> </tr> <tr> <td>Yellow</td> <td>0.8</td> <td>1.05</td> </tr> <tr> <td>Black</td> <td>1.3</td> <td>1.5</td> </tr> </tbody> </table>	Ink color	Measured Density	Target Density	Cyan	1.05	1.25	Magenta	1.05	1.3	Yellow	0.8	1.05	Black	1.3	1.5	<p>Experiment 2 (29%)</p> <table border="1"> <caption>Data for Experiment 2</caption> <thead> <tr> <th>Ink color</th> <th>Measured Density</th> <th>Target Density</th> </tr> </thead> <tbody> <tr> <td>Cyan</td> <td>1.45</td> <td>1.25</td> </tr> <tr> <td>Magenta</td> <td>1.35</td> <td>1.3</td> </tr> <tr> <td>Yellow</td> <td>0.95</td> <td>1.05</td> </tr> <tr> <td>Black</td> <td>1.15</td> <td>1.5</td> </tr> </tbody> </table>	Ink color	Measured Density	Target Density	Cyan	1.45	1.25	Magenta	1.35	1.3	Yellow	0.95	1.05	Black	1.15	1.5
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<p>Experiment 3 (37%)</p> <table border="1"> <caption>Data for Experiment 3</caption> <thead> <tr> <th>Ink color</th> <th>Measured Density</th> <th>Target Density</th> </tr> </thead> <tbody> <tr> <td>Cyan</td> <td>1.4</td> <td>1.35</td> </tr> <tr> <td>Magenta</td> <td>1.35</td> <td>1.3</td> </tr> <tr> <td>Yellow</td> <td>0.95</td> <td>1.0</td> </tr> <tr> <td>Black</td> <td>1.55</td> <td>1.6</td> </tr> </tbody> </table>	Ink color	Measured Density	Target Density	Cyan	1.4	1.35	Magenta	1.35	1.3	Yellow	0.95	1.0	Black	1.55	1.6	<p>Experiment 4 (57%)</p> <table border="1"> <caption>Data for Experiment 4</caption> <thead> <tr> <th>Ink color</th> <th>Measured Density</th> <th>Target Density</th> </tr> </thead> <tbody> <tr> <td>Cyan</td> <td>1.35</td> <td>1.35</td> </tr> <tr> <td>Magenta</td> <td>1.3</td> <td>1.3</td> </tr> <tr> <td>Yellow</td> <td>0.95</td> <td>0.95</td> </tr> <tr> <td>Black</td> <td>1.55</td> <td>1.6</td> </tr> </tbody> </table>	Ink color	Measured Density	Target Density	Cyan	1.35	1.35	Magenta	1.3	1.3	Yellow	0.95	0.95	Black	1.55	1.6
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Yellow	0.95	0.95																													
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As a result of table (7), the main aim of density result was to achieve an optimum measured densities (57%), which corresponded with target densities according to ISO 12647-2, to can acquire linear curve.

Table (8) shows the difference between target and measured densities for phase two, after using the resulted linear curve of best outcome from phase one.

Table (8): Density values - phase two

Phase (2)																															
<p>Experiment 5 (76%)</p> <table border="1"> <caption>Data for Experiment 5</caption> <thead> <tr> <th>Ink color</th> <th>Measured Density</th> <th>Target Density</th> </tr> </thead> <tbody> <tr> <td>Cyan</td> <td>1.2</td> <td>1.35</td> </tr> <tr> <td>Magenta</td> <td>1.1</td> <td>1.35</td> </tr> <tr> <td>Yellow</td> <td>0.85</td> <td>1.0</td> </tr> <tr> <td>Black</td> <td>1.45</td> <td>1.65</td> </tr> </tbody> </table>	Ink color	Measured Density	Target Density	Cyan	1.2	1.35	Magenta	1.1	1.35	Yellow	0.85	1.0	Black	1.45	1.65	<p>Experiment 6 (84%)</p> <table border="1"> <caption>Data for Experiment 6</caption> <thead> <tr> <th>Ink color</th> <th>Measured Density</th> <th>Target Density</th> </tr> </thead> <tbody> <tr> <td>Cyan</td> <td>1.3</td> <td>1.35</td> </tr> <tr> <td>Magenta</td> <td>1.25</td> <td>1.35</td> </tr> <tr> <td>Yellow</td> <td>0.9</td> <td>1.0</td> </tr> <tr> <td>Black</td> <td>1.55</td> <td>1.65</td> </tr> </tbody> </table>	Ink color	Measured Density	Target Density	Cyan	1.3	1.35	Magenta	1.25	1.35	Yellow	0.9	1.0	Black	1.55	1.65
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As a result of table (8), it was obvious that the results of exp. 5 has a little difference between measured and target density values, by enhancing quality level as shown in exp. 6, it can be minimize the difference between measured and target densities, according to ISO 12647-2.

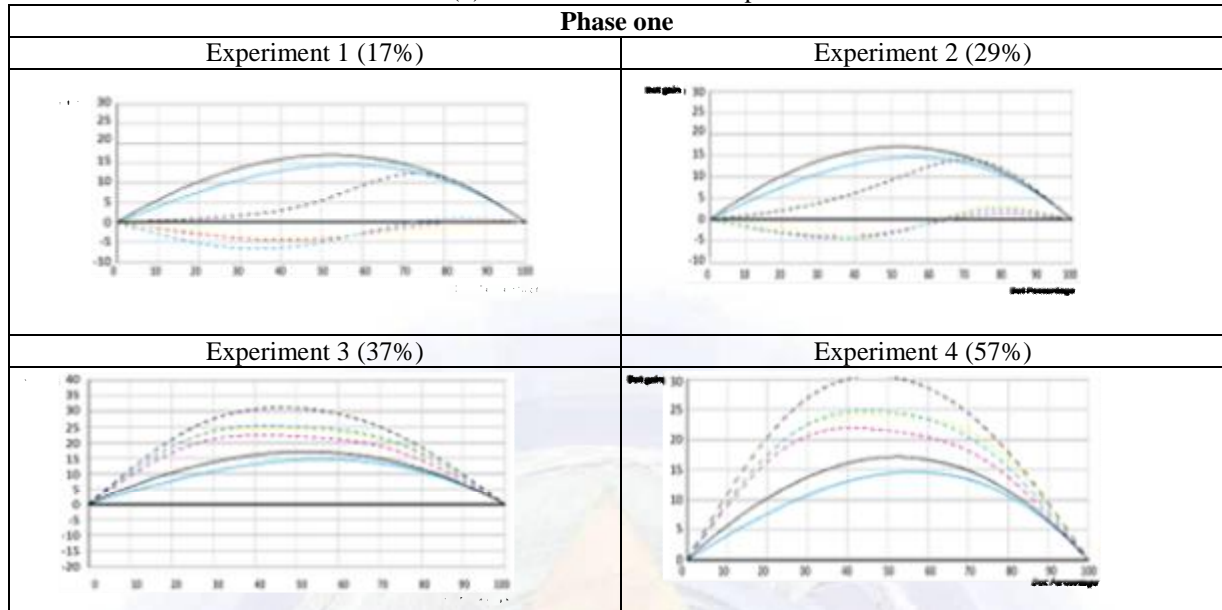
3.3. Dot gain and tonal value increase

Also, dot gain and tonal value increase can be considered as a ruling factor to decide an appropriate linear curve which can achieve an optimum result, according to previous results which could be illustrated in table (7).

Table (9) shows the difference values between target and measured dot gain for phase one.



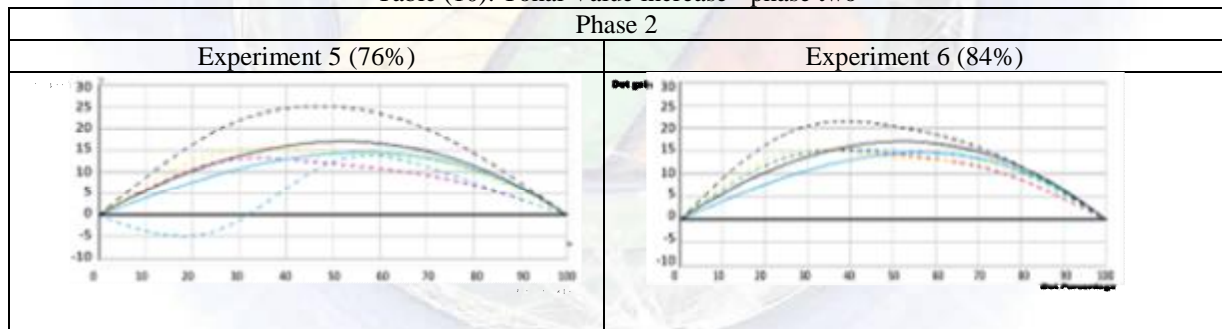
Table (9): Tonal Value increase - phase one



As a result of table (9), in spite of the result of exp. 4 which has more dot gain values, it can be considered as an optimum result, because it obtains the aim of the density according to ISO12647-2.

Table (10) shows the difference between target and measured tonal value increase for phase two, after used resulted linear curve of best outcome according to $L^*a^*b^*$ and density from phase one.

Table (10): Tonal Value increase - phase two



As a result of moderate linear curve according to phase one, it can obtain the good result of dot gain, in spite of not changing the impression value or under layer of blanket.

3.4. GRAY BALANCE

Gray Balance can be considered as one of the important parameters to control of litho-offset printing quality, table (11) shows the results value of $L^*a^*b^*$ gray balance for phase one.



Table (11): L*a*b* Gray Balance - phase one

phase 1	
Experiment 1 (17%)	Experiment 2 (29%)
Experiment 3 (37%)	Experiment 4 (57%)

As an analysis of the results of table (11), according to ISO 12647-2, it can be obvious that the measured L*a*b* gray balance values were different from the target values.

After modulating the linear curve, the new results can be illustrated as shown in table (12).

Table (12): L*a*b* Gray Balance - phase two

Phase 2	
Experiment 5 (76%)	Experiment 6 (84%)

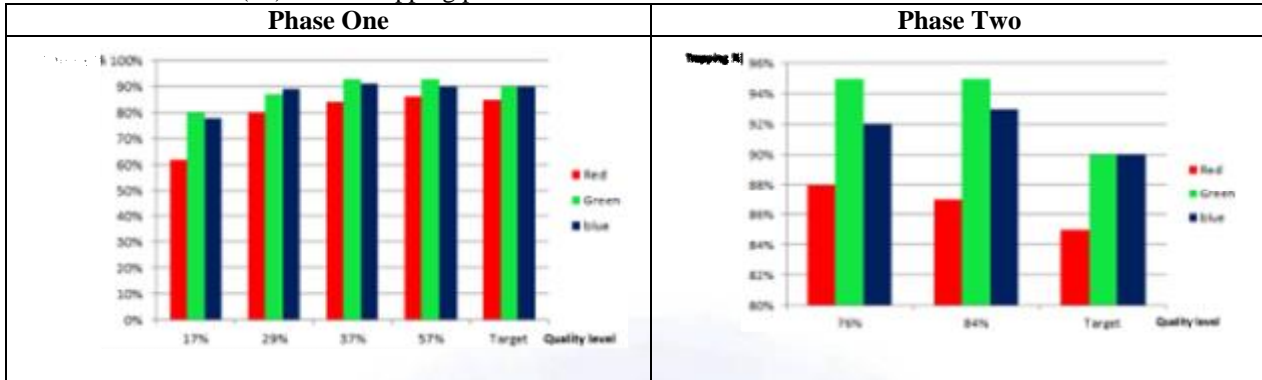
As a results of table (12), it could be obtained a minimize of gap between measured and target value according to apply the resulted linear curve, also fine adjustment of ink density.

3.5. TRAPPING

In table (13), the trapping percentage between all experimental works as phase one and two can be compared between.



Table (13) Color Trapping produced before and after linearization – Phase one and two



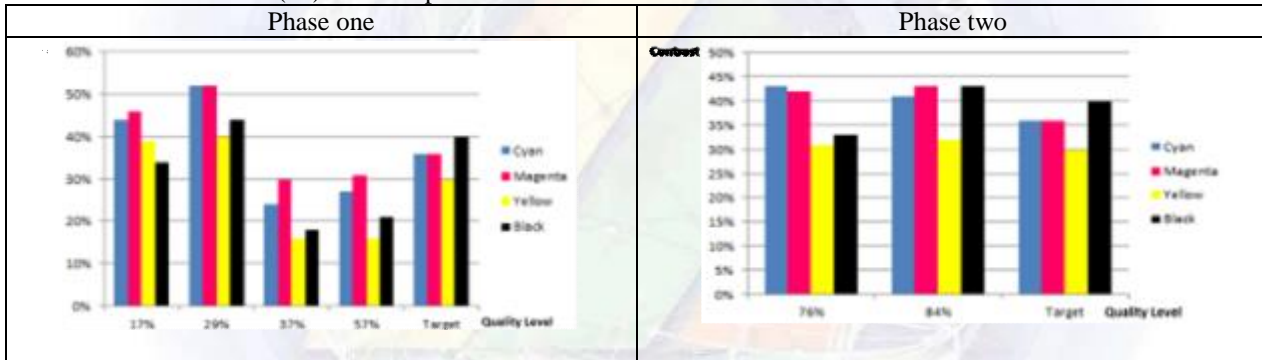
According to ISO 12647-2, the target trapping value percentage can be considered as the least value can be achieved.

In table (13), it can be obvious that some results of trapping value percentages for phase one were lower than target. On the other hand, after applying the linear curve, the phase two results were higher than the target.

3.6. CONTRAST

Table (14) shows the measured percentage values of contrast and comparing them with the ISO 12647-2 target values for both experimental works (Phase one and two).

Table (14) Contrast produced before and after linearization – Phase one and two



Table(14) can be analyzed as following;

1. Phase one; all values of contrast were unstable than the target value
2. Phase two; Cyan and Magenta contrast is higher than the target value, while yellow and black were corresponded with the target value.

4. CONCLUSIONS

As a comparative study between the results, the following can be concluded;

4.1.The difference between approved sheet according to visual inspection and the best result depending on offline quality control system and changing the linear curve, achieved through this paper is equal to;

$$84\% - 17\% = 67\%$$

4.2.The difference between approved sheet according to visual inspection and the best result depending on offline quality control system without any changes of linear curve, achieved through this paper is equal to;

$$57\% - 17\% = 40\%$$

4.3.The difference between the best result depending on offline quality control system without any changes of linear curve and after linear curve result achieved through this paper is equal to;

$$84\% - 57\% = 27\%$$



5. RECOMENDATION

- 5.1. We cannot depend on visual inspection only to enhance the printing quality.
- 5.2. Actually, in our Egyptian presses, the Printing Quality can be enhanced according to the ISO 12647-2.
- 5.3. The role of quality control system should be activated in order to achieve continuous enhancement of the printing quality according to the ISO 12647-2.
- 5.4. The quality control should be started from the prepress stage to adjust the linear curve according to the actual process conditions, materials and state of printing machine.

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