# Determining the most appropriate printing techniques for digital printing to achieve printing quality of Teslin polymers

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## Abstract:

Polymeric Teslin material faces many print quality challenges when it is printed with any of the digital printing techniques to determine the most appropriate techniques for printing on plastic Teslin material to obtain the required print quality by measuring both (Colour, density, dot gain and trapping), and to achieve this goal it has this paper deals with the theoretical, practical and analytical study of digital printing techniques used in experiments to print on Teslin material, which is the inkjet technology using the Com Colour GD 9630 Riso printer, and the dry electro photographic technology using the limited production library printers which is the HP Colour LaserJet Enterprise M553 Printer, and Mass Production Printers, which is a Ricoh C7200 SL. Liquid electro-photography technology was used using the HP Indigo 7800 printer, and the study found that the most appropriate technology for digital printing on the two stems is dry electrographic technology, whether with limited or mass production, and that inkjet technology is not suitable for printing on it.

**Keywords:**

Printing quality, L*a*b*, density, dot gain.

**Introduction:** Print quality on the Polymers are encountered when printing on these materials, and one of the most popular polymer materials available in Egypt is Teslin plastic material.

The digital printing method has become widely used by many government and private agencies, which allow printing variable and static data in printed documents. This printing method has many printing techniques that were dealt with in the research, and accordingly the research dealt with experimental and analytical study of the extent of suitability in terms of print quality with these techniques on the raw material Teslin plastic.

**Problem**: Is it possible to determine the most appropriate digital printing techniques on Teslin plastic to obtain the required print quality by measuring Colour, density, dot gain and trapping?

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**Objectives**: Access to the most appropriate digital printing techniques for printing on Teslin plastic material to obtain the required print quality (Colour measurement, density, point gain and trapping).

**Methodology**: The research used the descriptive method to describe the used material and digital printing techniques in the experiments studied by the research. It also used the experimental and analytical method to reach the results, discuss them and draw the final results.

## Materials and Methods:

**The polymer material used in experiments**, Teslin plastic material sheets were used.
Manufactured by the Japanese company Teslin® PPG, it is a single-layer polyolefin film with a synthetic polymer base and silica that is unique and uncoated. In 1984, Ron Goade produced the first plastic card based on the Teslin material, and it was done by covering the Teslin layer after it was printed, and it is widely used to produce waterproof maps, and in the manufacture of cards and plastic gifts and other uses that can be used in documents as certificates. Graduation, birth certificates, and more.
This type of material is manufactured in several different thicknesses and versions, and the two grades are referred to as a letter and a number such as "SP 1000". The letters are the type of Teslin paper and are determined depending on the printing method and end use, and the numbers represent the thickness where 1000 is (0.01 inch), 600 is (0.006 inch), 700 is (0.007 inch), etc.

**The used inks according to each printing technique**: Several printing techniques were used in the experiments carried out on the Teslin material, and each technique had its own inks.
**(1) - Oil-based liquid inks for the inkjet technology:** Riso Com Colour GD 9630 printer. These printers use inkjet technology, which is based on piezoelectric crystals technology, which uses Pigment-Coloured inks that are anhydrous, oil-based inks and is treated to help prevent staining of the printed paper on the back side, and it is also resistant to dissolving with light and water. It is a newly developed magenta ink which is greatly improved to give print quality to Colour image by expanding the Colour range. A special grey ink has also been used with the black ink to reduce light reflection on the paper which results in a more intense and saturated black.

**(2) - Dry Toner Inks for Dry Electro Photographic Technology/** Desktop production**:** HP Colour LaserJet Enterprise M553 Desktop Laser Printer
It is a technique that uses electrostatic force to precipitate dry toner particles to transfer pigment or toner particles to an image, the used dry inks are made of spherical resin particles, and are transferred through the technology of electrostatic charging and the toner fixing / fusing procedure on the plate (Drum) through heating and cleaning. These inks work under temperatures ranging from o15 to o30 m and a relative humidity ranging between 30 to 70%. - The manufacture of inks used with electro photographic printers has evolved from mechanical mixing (which gives particles a diameter ranging from 7- 12 micrometres (7-12) m) and thus shows some jaggedness at the edges), to the technology of chemical composition in the late 1990's (which gives spherical particles a shape that is about 6.5 mμ in diameter, resulting in increased sharpness, resolution, and Colour reproductions quality.

**(3) - Dry Toner Inks for Dry Electro Photographic Technology/** Mass production**:** Ricoh C7200 SL Mass Production Laser Printer

The inks used in quantitative production printers are not much different from those used with desktop laser printers, as they use the same dry toner electrophotography (DEP) technology. In these printers the image is stabilized by strip fusing without an oil-less belt fusing method.

**(4) - Liquid toner inks for Liquid electro photographic:** HP Indigo 7800

They are inks based on liquid toner through the presence of (liquid / solvent) to transfer pigment particles or toner to the image and this type of inks is called Electro Ink, and is characterized by the following:

1) The size of toner particles is very fine (1: 2 micron).

2) The Electro Ink used in these printers is bright when using medium glossy papers.

**The design file:** PDF file was designed on Adobe Illustrator CS5 that contains the design elements required to carry out experiments and to perform the required measurements. It contains linear elements (vector lines) and (Raster image) images.

**Printing techniques used in the experiments**

**(1) - Ink Jet Drop-On-Demand (DOD) technology:**

That uses piezoelectric crystallization technology and that is implemented on the Riso Com Colour GD 9630 printer. This technique is based on a piezoelectric crystal using a crystal of titanium, zirconium and lead (which replaced the thermal resistors in thermal jetting technology), as these crystals are affected by the passage of electric current through it and crossing it. About the digital print information for each print point in the electronic file to be printed, and changing the voltage of the crystal leads to changing its size by expansion, which puts pressure on the liquid ink to eject it from the nozzle.

**(2)- Dry toner electrophotography (DEP) technology** - By implementation on:

- HP Colour LaserJet Enterprise M553 desktop Colour laser printer.
- Also, on Ricoh C7200 SL mass production printer.

**(3) - Liquid toner electrophotography (LEP) technology**: on the HP Indigo 7800 printer.

Indigo machines technology is based on combining the two methods of litho-offset printing through the use of a rubber medium and electro photographic digital printing through exposure mechanism (electrostatic image), so it is called digital offset printing, where the image is printed in three stages:

1. The image is first formed on the light conductive cylinder (PIP) Photo Image Plate.
2. Then it is transferred to a special hot rubber medium covered with a rubber substance whose temperature reaches approximately 100 ° C in order to help to volatilize the solvent carrying the toner and to melt the toner (resin) on which it is deposited so that a sticky layer of the image thickness of up to (m 1µ) is called, Offset Thermal Technique.
3. Transferring the image onto the printed material, and the image sticks to the material well, as it is cooler. The Colour image is completely formed on the rubber media cylinder and then moves to the material in one step (which is the one on which the experiments were carried out), and in which the printed material does not need a long time to dry.

**The devices used in the measurement operations**:

Spectrophotometer (SpectroEye X. rite)

## Tests and results:

Experiments were carried out under normal printing conditions in terms of white light, humidity and temperature in normal rooms.

**Measuring density**

| C | M | Y | K | Face/ back | Printing teq./ printer |
|---|---|---|---|---|---|
| 0.78 | 1.22 | 1 | 1.38 | face | **HP indigo 7800** |
| 0.78 | 1.1 | 0.96 | 1.31 | back | |
| 1.05 | 1.01 | 1.26 | 1.28 | face | **Ricoh C7200 SL** |
| 0.93 | 0.9 | 1.04 | 1.28 | back | |
| 1.31 | 1.23 | 1.24 | 1.51 | face | **HP Laser jet M553** |
| 1.2 | 1.17 | 1.14 | 1.34 | back | |
| 0.48 | 0.58 | 0.54 | 1.08 | face | **Riso ComColour GD 9630** |
| 0.5 | 0.55 | 0.53 | 1 | back | |

**Measuring dot gain**

| C | M | Y | K | Face/ back | Printing teq./ printer |
|---|---|---|---|---|---|
| 18 | 15 | 20 | 13 | face | **HP indigo 7800** |
| 17 | 12 | 17 | 11 | back | |
| 9 | 9 | 14 | 19 | face | **Ricoh C7200 SL** |
| 5 | 8 | 10 | 14 | back | |
| -3 | -9 | -4 | -9 | face | **HP Laser jet M553** |
| 3 | -4 | 1 | -2 | back | |
| 29 | -3 | 6 | -10 | face | **Riso ComColour GD 9630** |
| 30 | -2 | 7 | -10 | back | |

**Colour Measurement (L, a, b)**

| **C** | | | **M** | | | **Y** | | | **K** | | | **Face/ back** | **Printing teq./ printer** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **L*** | **a*** | **b*** | **L*** | **a*** | **b*** | **L*** | **a*** | **b*** | **L*** | **a*** | **b*** | | |
| 63 | -21 | -38 | 54 | 68 | -6 | 92 | -5 | 80 | 26 | 0.3 | 0.8 | face | **HP indigo 7800** |
| 63 | -21 | -38.5 | 52 | 71 | -5.6 | 92 | -5 | 83 | 23 | 0.2 | 0.8 | back | |
| 62 | -46 | -41 | 55 | 77 | -2 | 97 | -6 | 130 | 20 | -0.8 | 3 | face | **Ricoh C7200 SL** |
| 64 | -42 | -37 | 58 | 71 | 0.3 | 99 | -6 | 97 | 23 | -1 | 3 | back | |
| 58 | -34 | -46 | 54 | 67 | 7 | 100 | -8 | 88 | 27 | -0.7 | 3 | face | **HP Laser jet M553** |
| 58 | -37 | -48 | 53 | 69 | 7 | 100 | -8 | 90 | 21 | 0.09 | 3.5 | back | |
| 77 | -20 | -22 | 72 | 45 | 4 | 100 | -9 | 63 | 35 | -0.03 | 3 | face | **Riso ComColour GD 9630** |
| 74 | -17 | -30 | 70 | 43 | -3 | 96 | -8 | 52 | 36 | 0.5 | -1.3 | back | |

**Measuring trapping**

| **Red** (Magenta + Yellow) | **Green** (Cyan + Yellow) | **Blue** (Cyan + Magenta) | **Face/ back** | **Printing teq./ printer** |
|---|---|---|---|---|
| 68 | 78 | 69 | face | **HP indigo 7800** |
| 67 | 78 | 66 | back | |
| 62 | 92 | 80 | face | **Ricoh C7200 SL** |
| 57 | 83 | 71 | back | |
| 29 | 93 | 39 | face | **HP Laser jet M553** |
| 43 | 100 | 41 | back | |
| 62 | 80 | 52 | face | **Riso ComColour GD 9630** |
| 65 | 86 | 52 | back | |

## Discussion:

The results of the measurements were analysed for samples carried out on the polymeric material and using digital printing techniques the results were compared to the reference values of ISO 12647-2 on the coated paper as there are no reference values for ISO on the polymer or for digital printing techniques, and the matte coated paper material is closer to the polymer material in absorption. The ink penetrated into the material.

**Measuring the density** of Teslin materials using several digital printing techniques
The following table shows the reference values for measuring density of ISO 12647-2, used in the analysis of the results:

| Substrate for printing | Solid ink density | | | |
|---|---|---|---|---|
| | K | C | M | Y |
| Gloss coated paper | 1.85 | 1.50 | 1.40 | 1.30 |
| Matt coated paper | 1.85 | 1.50 | 1.40 | 1.30 |
| Uncoated paper | 1.50 | 1.30 | 1.40 | 1.10 |

**Conclusion:**

| **C** | | **M** | | **Y** | | **K** | |
|---|---|---|---|---|---|---|---|
| **HP Colour LaserJet Enterprise M553** | **ISO 12647-2** | **HP Indigo 7800** | **ISO 12647-2** | **Ricoh C7200 SL** | **ISO 12647-2** | **HP Colour LaserJet Enterprise M553** | **ISO 12647-2** |
| **1.31** | **1.5** | **1.22** | **1.4** | **1.26** | **1.3** | **1.51** | **1.85** |

**Measuring the dot gain** of Teslin materials using several digital printing techniques
The following table shows ISO 12647-2 dot gain values used in the analysis of the results:

**Conclusion:**

| C | | M | | Y | | K | |
|---|---|---|---|---|---|---|---|
| **HP Colour LaserJet M553** | **ISO 12647-2** | **Ricoh C7200 SL** | **ISO 12647-2** | **HP Colour LaserJet M553** | **ISO 12647-2** | **HP Indigo 7800** | **ISO 12647-2** |
| **3** | **9** | **8** | **9** | **1** | **9** | **11** | **10** |

| Halftone value | Gloss coated paper | Matt coated paper | Uncoated paper |
|---|---|---|---|
| 50% Cyan | 8-10-12 | 09-12-15 | 12-16-20 |
| 50% Magenta | 8-10-12 | 09-12-15 | 16-20-24 |
| 50% Yellow | 8-10-12 | 09-12-15 | 12-16-20 |
| 50% Black | 10-12-14 | 10-13-16 | 12-17-22 |

**Measuring the Lab Colour values** of Teslin polymers using several digital printing techniques The following table shows Measurement of the ISO reference Lab Colour values of ISO 12647-2 used in analysing the results

| Colour (L,a,b) for Matt coated paper | | | |
|---|---|---|---|
| Ink Colour | $L^{*b,c}$ | $a^{*b,c}$ | $b^{*b,c}$ |
| C | 55 | -37 | -50 |
| M | 48 | 74 | -3 |
| Y | 91 | -5 | 93 |
| K | 16 | 0 | 0 |

The following table shows the deviation ΔE*ab in the Lab Colour values for ISO reference of ISO 12647-2:

| Parameter | Colour | | | |
|---|---|---|---|---|
| | Black | Cyan[a] | Magenta[a] | Yellow[a] |
| Deviation tolerance | 5 | 5 | 5 | 5 |
| Variation tolerance[a] | 4 | 4 | 4 | 5 |
| [a] The contribution of the hue difference shall not exceed 2,5. | | | | |

## Cyan:

$\Delta L^* = L^*_{act} - L^*_{ref} = 58-55=3$

$\Delta a^* = a^*_{act} - a^*_{ref} = -37-(-37) =0$

$\Delta b^* = b^*_{act} - b^*_{ref} = -48-(-50) =2$

$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} = \sqrt{(3)^2 + (0)^2 + (2)^2} = 3.6$

## Magenta:

$\Delta L^* = L^*_{act} - L^*_{ref} = 52-48 =4$

$\Delta a^* = a^*_{act} - a^*_{ref} = 71-(74) =3$

$\Delta b^* = b^*_{act} - b^*_{ref} = -5.6-(-3) =-2.6$

$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} = \sqrt{(4)^2 + (3)^2 + (2.6)^2} = 5.6$

## Yellow:

$\Delta L^* = L^*_{act} - L^*_{ref} = 99-91= 8$

$\Delta a^* = a^*_{act} - a^*_{ref} = -6-(-5) = 1$

$\Delta b^* = b^*_{act} - b^*_{ref} = 97-(93) = 4$

$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} = \sqrt{(8)^2 + (1)^2 + (4)^2} = 9$

**Black:**

$\Delta L^* = L^*_{act} - L^*_{ref} = 20\text{-}16 = 4$

$\Delta a^* = a^*_{act} - a^*_{ref} = 0.8\text{-}(0) = 0.8$

$\Delta b^* = b^*_{act} - b^*_{ref} = 3\text{-}(0) = 3$

$\Delta E^*_{ab} = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}} = \sqrt{(4)^2 + (0.8)^2 + (3)^2} = 5.1$

**Conclusion:**

| | **C** | | | | **M** | | | | **Y** | | | | **K** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **$\Delta E^*_{ab}$** | | | | **$\Delta E^*_{ab}$** | | | | **$\Delta E^*_{ab}$** | | | | **$\Delta E^*_{ab}$** |
| | HP Colour LaserJet | | | | HP Indigo | | | | Ricoh C7200SL | | | | Ricoh C7200SL | | | |
| | **$\Delta L^*$** | **$\Delta a^*$** | **$\Delta b^*$** | **ISO 12647-2** | **$\Delta L^*$** | **$\Delta a^*$** | **$\Delta b^*$** | **ISO 12647-2** | **$\Delta L^*$** | **$\Delta a^*$** | **$\Delta b^*$** | **ISO 12647-2** | **$\Delta L^*$** | **$\Delta a^*$** | **$\Delta b^*$** | **ISO 12647-2** |
| | **3** | **0** | **2** | | **4** | **3** | **-2.6** | | **8** | **1** | **4** | | **4** | **0.8** | **3** | |
| **$\Delta E^*_{ab}$** | **3.6** | | | **5** | **5.6** | | | **5** | **9** | | | **5** | **5.1** | | | **5** |

**Measuring the trapping** of Teslin polymers using several digital printing techniques:
The following table shows the standard values of the trapping measure of ISO 12647-2 used in analysing the results:

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

**Conclusion:**

| **Red ink** | | **Green ink** | | **Blue ink** | |
|---|---|---|---|---|---|
| **printer** | **ISO Ref.** | **printer** | **ISO Ref.** | **printer** | **ISO Ref.** |
| HP Indigo 7800 | ISO 12647-2 | HP Colour LaserJet M553 | ISO 12647-2 | Ricoh C7200 SL | ISO 12647-2 |
| **68** | **85** | **100** | **90** | **80** | **90** |

## Result extraction:

The study reached the following results:

1) The most appropriate density values for samples executed on the two substrates using several techniques for digital printing of cyan inks, and yellow and black were recorded on dry electro photographic technology while on magenta ink only it was using liquid electro photographic technology.

2) The most appropriate values of the dot gain of the samples were carried out on the two substrate materials using several digital printing techniques for cyan, magenta and yellow inks were recorded on dry electro photographic technique while on black ink only it was using liquid electro photographic technique.

3) The most appropriate values of the deviation ΔE * ab for the Lab Colour values of the samples carried out on the two substrate materials using several techniques for digital printing of cyan inks, and the yellow and black were recorded on dry electro photographic technology while on the magenta ink only it was using the liquid electro photographic technique.
4) The most appropriate value of trapping for two tuberous ore samples using several techniques for digital printing of green and blue inks was recorded on dry electro photographic technology, while on red ink only it was using liquid electro photographic technology.
5) The inkjet technique is not suitable for printing on the Teslin materials.

## Recommendations:

Based on the previous results, the study recommends the following:
1) Not to print by using inkjet technology on the Teslin materials.
2) The most suitable technology for digital printing on the Teslin materials is the dry electro photographic technique.

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