Post-Printing of Colored QR Code on Corrugated board Packages in the Egyptian Printing Industry

Mahmoud F. El Feky
Lecturer, Printing, Publishing and Packaging Department, Faculty of Applied Arts - Helwan University, Egypt
Khaled Talaat Youssef
A. Prof., Printing, Publishing and Packaging Department, Faculty of Applied Arts - Helwan University, Egypt

Abstract:
The term flexo "post"-printing is used for printing on combined corrugated boards, as opposed to "pre-" printing of the liner board before assembling the corrugated board, (Martin H., 2007), The low printing pressure and flexible printing plates make flexo the primary printing method for corrugated boards. This study aims to investigate the effect of using this flexo post-printing method to print halftone Colored QR codes and QR codes colored with the main printing process colors (CMYK) which are the most famous colors used on corrugated boards packages in the Egyptian market, on the readability of these printed QR codes by Smartphone cameras that uses any suitable reader software. As a result of an experimental study, it has been proven that the very dark colored QR codes are very good to print on corrugated board because they can be read correctly from the first time because they make a very high contrast difference between them and the brown background (80% and more). Similarly halftone process colored QR codes can be printed on corrugated boards by regular flexo post- printing machines, and can be decoded correctly and very quickly by Smartphone cameras, provided that keeping the printing parameter like color registration in its high accuracy level for getting a high quality printed QR codes very close to the printed solid ones, and they should make at least 60% contrast difference between them and the brown corrugated board. On the other hand, colored QR codes that make a very low contrast difference with the background, and halftone process colored QR codes which make a slightly contrast difference with the brown background, ranging between 52% to 57% are not preferable to print, So finally, If you're going to colorize your QR code and print it on corrugated board package, make sure there is at least 60% contrast difference between the squares and the background, and keep color registration in its high accuracy level for getting a high quality printed QR codes very close to the printed solid ones.

Keywords:
- ***Post-Printing,***
- ***QR Code,***
- ***Quick Response Code,***
- ***Corrugated board,***
- ***Flexographic printing,***
- ***Packaging, Packages***

Paper received 21th September 2014, Accepted 15th December 2014 Published 1st of January 2015

Introduction
Flexography, flexo for short, or aniline printing as it was then called, is a letterpress printing technology, Letterpress printing, or relief printing, is the oldest printing method where ink is transferred from a printing plate to paper through raised printing elements, like with rubber stamps. Letterpress printing was originally done with rigid printing plates and relatively high pressure. Flexo printing, in contrast to letterpress printing, the printing plates are flexible (Martin H., 2007).

The main advantages of the flexographic printing process are that it is able to print onto almost any surface type, including corrugated board and flexible films, and that the process is relatively inexpensive. The main disadvantages are that the resolution possible is lower than that for other high volume processes, the printing pressures required to print solids and halftones are different and image distortion occurs on uneven substrates, such as corrugated board (Frank N. S., et al 1991).
The term flexo "post"-printing is used for printing

on combined corrugated boards, as opposed to "pre-" printing of the liner board before assembling the corrugated board, (Martin H., 2007). Corrugated boards have been extensively used to contain and to protect merchandise from damages during transportation, with low demands on print quality. However, a better print quality can gain more market shares, and hence the print quality has increased over time. The flexo print quality today is superior to the one before, moving the corrugated box from just being a container of merchandise, to being a part of the display in the stores. Unfortunately, the prints on corrugated boards are still often accompanied by the visible stripes in the printed images. This is the most common and persistent print non-uniformity problem for the flexo post-printing industries (Cusdin, G. B. , 2000). A characteristic feature of flexo printing is the low printing pressure; so called kiss printing. The low printing pressure and flexible printing plates make flexo the primary printing method for corrugated boards (Martin H., 2010).

Originality/ value:

As the movement of using QR codes in advertising field, is still in its infancy, this paper serves to be one of the first comprehensive papers to fully delineate (a) the designers who are preparing digital files in pre-press stage, (b) the plate maker , (c) the printer, (d) the product manufacture (the client) who want to sell and advertise his product to the user, and finally (e) the user himself. Also, printing colored QR codes in halftone process colors will be cost effective, which we can print colored QR code embedded in the whole design without the need of preparing an extra film and an extra plate special for spot or special QR code.

Literature Review:

What is QR code?

QR code stands for Quick response code, developed by a Japanese automatic data capture equipment company called Denso-Wave in 1994 (Ching-yin L., et al 2010). It was originally developed and used for warehouse logistic but quickly adopted for the other use (Jakub N., 2013). With the advent of smart and web capable mobile devices, we witness a steady growth of interesting commercial applications using QR codes (Ching-yin L., et al 2010).

QR codes can be created in a very simple way, for instance by using free software tools. Therefore, they appear in many places, such as posters or flyers, and they can store simple text, contact information, or URLs. To access the information, it is sufficient to capture the code with a camera, which is decoded via a proper application (Wojciech M., et al 2014). With smart phones, we can visit the Website linked by the URL quickly, we can send the SMS message directly or we can save the contact information onto the address book easily (Ching- yin L., et al 2010). So QR codes have in recent years become common in consumer advertising and packaging. As a result, the QR code has become a focus of advertising strategy as in theory it provides the potential for quick and effortless access to the brand's website.

Printing QR code on Corrugated board:

Corrugated boards are most commonly printed with the flexographic printing method. When the printing is performed after the liner and medium boards are combined, the process is called flexo post-printing, (see Fig. 1) (Martin H., et al 2007).

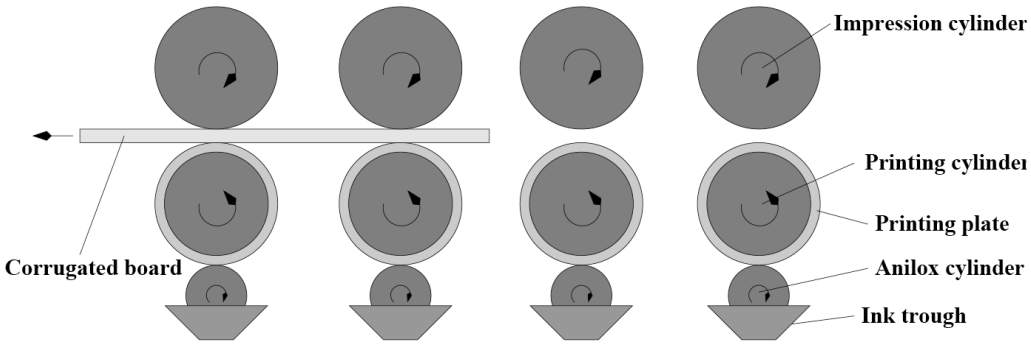

Figure 1: Shows A flexo printing press with four printing stations.

The individual square blocks of QR code are easier to print than the traditional bar code because they are about 1/25 inches square (3 time the width of the narrowest of the bar code elements) and the white spaces between code elements are the same width. Also, because the elements are evenly spaced, they are far more readable than conventional bar codes. As with bar codes, the printable resolution of the printing of the process determines the printed size of the code. When

printing a QR code using regular flexo post-print the typical line screen is between 50 and 85lpi (Ralph Y., 2011). (Judd W., 2011), claims that if you want to print QR code you should follow the following tips:

- Print on white or soft pastel color background
- Don't print on a dark color
- Do not reverse or invert in print. The black must be black or a dark contrast color for scanners to appropriately pick it up. The scanners use the three dark corner marks as reference points

QR Codes are most commonly displayed as a black code on a white background, and with good reason, as this color combination provides the greatest contrast. Contrast is an important factor in scan reliability (Jason S., 2012), which the contrast refers to the difference between the highest and the lowest reflectance values in the profile, in simple terms the difference between the dark and light areas as seen by the scanner (GS1, 2011), so a black code on a white background is the safest display option in terms of color. However, it is also possible to display QR codes in a variety of colors, provided there is sufficient contrast between the foreground (code) and the background. Generally, the darker the color of the code, and the lighter the background, the more reliably the code will scan. (Jason S., 2012). But in case of the need of printing colored QR code in halftone structure, to be embedded with a process colored design without the need of preparing an extra film or an extra plate special for spot or special QR code on corrugated board by regular flexo post-printing, this may causes a big problem.

The research hypothesis is that printing colored QR codes as halftone process colors instead of spot or special colors by regular flexo post-printing machines on corrugated board and then decode them correctly and very quickly, is very easy, especially by choosing the appropriate colors which make a high contrast difference between the squares of the code and the background, and by using the appropriate line screen that used in flexo post-printing technique (50 lpi which is very common in printing the corrugated board in the Egyptian market) with taking into account keeping the printing parameter like color registration in its high accuracy level for getting a high quality printed QR codes very close to the ones that printed in a spot color structure.

Objectives

This study aims to investigate the effect of using this flexo post-printing method to print halftone Colored QR codes and QR codes colored with the main printing process colors (CMYK) which are the most famous colors used on corrugated boards packages in the Egyptian market, on the readability of these printed QR codes by Smartphone cameras that uses any suitable reader software.

Methodology

In order to achieve the research objectives, an experimental study is conducted as following:

Materials and procedures:

1- A test form of 21 colored QR codes patches were generated by Adobe InDesign CC **software**, encoded by some information about the authors, in a size of (5.2029 cm X 5.2029 cm), and the colors were selected for coloring the 21 patches as following:
   - All patches were selected as the most famous colors used to print corrugated boards in the Egyptian market, and 20 of them (from patch no. 1 to no. 21 except no. 4) make a high contrast difference with the white background on the monitor.
   - The patches from 1 to 4 were colored with the main printing process colors CMYK.
   - The patches from 5 to 21, were prepared to be printed as halftone process colors not as spot or special colors.
   - The patch no. 8 was colored with a tint of the patch no. 1. (see Fig. 2)

2- The 21 colored QR codes were printed by a regular flexo post-printing technique, **with** rough anilox rules of (250 line/inch), and an analogue flexographic plate with a thickness of 2.84 mm and a rough screen rulings of 50 line/inch, which are very **suitable** for this flexo post-printing technique. The printing speed was 240 sheet/min, with printing sequence of YMCK with water based Ink, and 2 rubbers for the yellow and magenta printing units, and 2 plastic doctor blade for the cyan and black printing units.

3- It was taking into consideration, keeping the printing parameters specially color registration in its high accuracy level for getting a high quality printing values for the QR codes from 5 to 21, which prepared to be printed as halftone process to be very close to the ones that printed in a spot color structure.

Figure 2: 21 patches of colored QR codes on digital file in pre-press stage

Figure 3: 21 printed patches of colored QR codes after printing on brownish corrugated board

4- The samples were printed on a brown American Kraft double wall corrugated board substrate (K127) and structure of combination of two media (125), and three facings (K127), with a thickness of 0.7 cm (B=3mm and C=4mm), (see Fig. 3).

5- Three different smart phones (with Android, Windows, and iPhone operating Systems) with three different decoding software (QR Code Reader, QR Droid Scanner, and QR Quick Scanner) were used to read all printed patches, to assure the scan reliability, (Jason S., 2012) says "It's always a good idea to test your codes for scan reliability on a range of QR code readers, and on multiple device types".

6- The contrast of all printed patches was measured by (TECHKON-"Scan-Densitometer RS 400 device").

7- A table was structured to outline the key results of QR code reading, (see table 1).

8- Two tables were structured to outline the QR code reading results, one for the patches from

1-4, and the other for the rest patches . (see table 2 and 3).

9- A table was structured to outline the contrast values of the printed QR codes on the brown corrugated board, (see table 4).

Results:

There are three different results, and the following table (Table 1) outlines the Key results for the research experimental procedures:

Table 1: outlines Table Key results

QR codes read from the first time	QR codes Slightly difficult to read	QR codes Unreadable definitively
P	**P H**	**Î**

- **First**: for the patches which colored with the main printing process colors CMYK (see Table 2):
  - **1-** The patches No. 1 and 2, were colored with the main printing process colors (Black and Cyan), were read correctly and very quickly and from all angles from the first time.
  - **2-** The patch No. 3, was colored with the main printing process color (Magenta), was read correctly but hardly from all angles.
  - **3-** The patch No. 4, was colored with the main printing process color (Yellow), was not read definitively from all angles.
- **Second:** for the patches which were prepared to be printed as halftone process colors not as spot or special colors (see Table 3):
  - 1- The patches No. 5, 6, 9, 11, 13, 14, 15, 16 ,17, 18, 19 and 20, were read correctly and very quickly and from all angles from the first time.
  - 2- The patches No. 7, 8, 10, 12 and 21 ,were read correctly but hardly from all angles.

Table 2: the reading results of patches from 1 to 4 colored with main printing process colors CMYK

Patches no.	1	2	3	4
Readable QR codes	**P**	**P**	**PH**	**Î**

Table 3: the reading results of patches from 5 to 21, which prepared to be printed as halftone process colors not as spot or special colors

Patches no.	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Readable QR codes	**P**	**P**	**PH**	**PH**	**P**	**PH**	**P**	**PH**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**P**	**PH**

Table 4: the contrast values of the printed QR codes

Printed QR Code patch No.	Contrast difference with the brown corrugated board
1	0.80 %
2	0.87 %
3	0.56 %
4	**0.38 %**
5	0.74 %
6	0.74 %
7	0.56 %
8	0.52 %
9	0.64 %
10	0.55 %
11	0.60 %
12	0.57 %
13	0.64 %
14	0.73 %
15	0.64 %
16	0.76 %
17	0.70 %
18	0.76 %
19	0.69 %
20	0.62 %
21	0.55 %

Discussion:

- **First**: for the patches which colored with the main printing process colors CMYK:
  - **1-** The patches No. 1 and 2, were read correctly from the first time because they were printed in a solid structure not in halftone, and they make a very high contrast difference between them and the brown background in the same time, it ranges between 80% to 87% (see table 4).
  - **2-** The patch No. 3, was read correctly but hardly from all angles, however it was printed as spot color (C=0, **M=100**, Y=0 and K=0), because it makes a slightly contrast difference with the brown background (56%).
  - **3-** The patch No. 4, was colored with the main printing process color (Yellow), was not read definitively from all angles, however it was printed as spot color (C=0, M=0, **Y=100** and K=0), because it makes a very low contrast difference with the brown background (38%).
- **Second:** for the patches which were prepared

to be printed as halftone process colors not as spot or special colors:

1- The patches No. 5, 6, 9, 11, 13, 14, 15, 16 ,17, 18, 19 and 20, were read correctly and very quickly and from all angles from the first time, however they were printed in halftone structure, for two reasons: **first,** because of keeping the printing parameters specially color registration in its high accuracy level for getting a high quality printing for the QR codes to be very close to the ones that printed in a spot color structure, **Second**, because they make a high contrast difference between them and the brown background, it ranges between 60% to 76% (see table 4).

2- The patches No. 7, 8, 10, 12 and 21 ,were read correctly but hardly from all angles because they make a slightly contrast difference with the brown background, , it ranges between 52% to 57% (see table 4).

Conclusion

As a result of the investigation, the following conclusions have been drawn:

- Very dark colored QR codes are very good to print on corrugated board which they can be read correctly from the first time because they make a very high contrast difference between them and the brown background (80% and more).
- Colored QR codes that make a very low contrast difference with the background should not be printed, also halftone process colored QR codes which make a slightly contrast difference with the brown background, ranging between 52% to 57% are not preferable to print.
- Halftone process colored QR codes can be printed on corrugated boards by regular flexo post-printing machines, and can be decoded correctly and very quickly by Smartphone cameras that uses any suitable reader software, provided that keeping the printing parameter like color registration in its high accuracy level for getting a high quality printed QR codes very close to the printed solid ones, and they should make at least 60% contrast difference between them and the brown corrugated board.
- So finally, to colorize QR code and to print it on corrugated board package, it has to be there at least 60% contrast difference between the squares and the background, with keeping the printing color registration in its high accuracy level for getting a high quality printed QR codes very close to the printed solid ones.

References

1. Ching-yin L. and Simon S., (2010), QR Codes in Education, Journal of Educational Technology Development and Exchange- Law, C. & So, S. - Volume 3, No. 1, pp85,86
2. Cusdin, G. B. , (2000), Why does ”washboard” show up in my print? Flexo، Vol. 25, No. 1, p28
3. Frank N. S., Charles W. and George J. P., (1991), Flexography Principles and Practices, 4th Edition, Foundation of Flexographic Technical Association
4. GS1, (2011), An introduction and technical overview of the most advanced GS1 Application Identifiers compliant symbology, Retrieved from http://www.gs1.org/ Accessed on 18 January 2015, p34
5. Jakub N.,(2013), QR-code based non-repudiation transaction verification system, Retrieved from http://www.slu.cz/opf/cz/informace/acta-academica-karviniensia/casopisy-aak/aak-rocnik-2013/docs-4-2013/Nantl.pdf, Accessed on 4 January 2015, p148
6. Jason S., (2012), Best Practices for Integrating QR Codes into Marketing Materials, Retrieved from. http://qfuse.com/documents/QR-Code-Best-Practices-Qfuse.pdf, Accessed on 19 January 2015
7. Judd W.,(2011), QR Code Best Practices for Print, Retrieved from http://www.themobilists.com/, Accessed on 18 January 2015
8. Martin H., (2010), Nip mechanics, hydrodynamics and print quality in flexo post-printing, Thesis for PhD, Unpublished, Mitt universitetet –MID Sweden university
9. Martin H. and Tetsu U., (2008), Print uniformity of corrugated board in flexo printing: Effect of corrugated board and halftone dot deformations, Packaging Technology and Science Journal, Willy InterScience
10. Martin H., (2007), Striping on flexo post-printed corrugated board, FSCN - Fibre Science and Communication Network, Department of Natural Sciences, Mid Sweden University, SE-851 70 Sundsvall, Sweden, p1
11. Ralph Y., (2011), Maintaining Quick Response (QR) Code integrity when printing on corrugated, Retrieved from http://askralph-aiccbox.org/2011/03/17/maintaining-quick-response-qr-code-integrity-when-printing-on-corrugated/, Accessed on 18 January 2015

12. Wojciech M. and Luca C., (2014), Steganography in Modern Smartphones and Mitigation Techniques, Retrieved from http://arxiv.org/pdf/1410.6796.pdf, Accessed on 3 January 2015 p4