Integration of 2D codes in Paper and Board Packaging – Reproduction and Readability

Maja Stanic, Arie Hooimeijer, Sanne Tiekstra; Kenniscentrum Papier en Karton/Bumaga BV; Arnhem; The Netherlands

Abstract

KCPK is running an initiative called SSK, or Smart and Slim Supply Chains, dealing with bio-based packaging and innovations for making overall supply chains smarter and slimmer. SSK initiative covers the full trajectory from production, through distribution to the consumer. SSK focuses towards four different types of supply chains and several types of printed intelligence, with 2D codes included.

2D codes are a kind of 2D matrix symbology which, when compared to 1D or barcodes, have specific advantages that enable novel and extended opportunities of use. In 2D codes, data is encoded in both the height and width of the symbol, so large amount of information can be encoded in smaller footprint. 2D codes can be read in any direction. Some 2D codes provide readability of (up to 30%) obscured and/or damaged symbols, as well. Most known 2D codes are QR and Datamatrix, and other open and proprietary types exist. Other than for logistics and part marking, 2D codes are nowadays also more used in print to web, marketing and added-value applications. The aim of this paper is to investigate the application of 2D codes in bio-based packaging. Solid board is used as a specific example of such packaging. Direct printing of 2D codes, using digital printing techniques, is studied in terms of influence of material and process characteristics on achieved print quality reproduction and readability.

Introduction

SSK initiative

KCPK is currently running an initiative called SSK, or Smart and Slim Supply Chains, which is focused on more efficient and effective supply- chains. Smart part deals with application of active and intelligent packaging in the supply chain, e.g. communication of packaging by direct and indirect information. Slim part deals with the reduction of the quantity of packaging material and improving to include the wishes and needs of the producers/users. Furthermore, combinations of Smart and Slim solutions for development of sustainable packaging is also being researched. An example of such application is eco-design packaging which makes it possible to monitor the location and quality of the goods and to communicate it, e.g. via codes and indicators; in combination with decreasing the mass of the packaging material, thus contributing to both material and energy efficiency in the supply chain. Furthermore, the possibilities of achieving optimal supply chains by integration and communication with existing components are topic of research.

In the scope of the Smart part of the initiative number of active and intelligent printing technologies are being studied for the application in the packaging supply chain. The overall goal is to study the application of novel interactive, communicative technologies, in order to achieve more efficiency in the supply chain, i.e. lower costs, fewer mistakes, shorter supply-chains and less transport in combination with reduced out-of-stock and less waste.

SSK focus is on Food, Transport and Packaging. SSK therefore covers the full trajectory in the packaging; from production of the individual materials, to packed goods/packaging systems, to the point-of-sale and until the user/consumer. Specifically, four packaging chains are studied for application; Fresh food, Frozen, Dry food, Luxury (Cosmetics, Pharma) packaging.

Due to the applications of new technologies companies, producers and retailers, also consumers, can optimize the use of information from the chain. The solutions can be applied in order completion, product location, logistic optimum and quality improvement. Lot can be gained with the improved use of information, faster availability and easier sharing of information between links in the logistic chains. To apply this in the chain in an easy way there needs to be a focus on low investment costs and minimal variable costs of such systems. This can be reached by full integration of technologies in the existing parts of the logistic chains.

The three major goals of the SSK initiative are:

1. Reduction of energy and material losses in the whole supply chain: production, transport and consumption.
2. Low cost solutions: SSK aims at the possibilities of the application by intelligent communicative printing with the help of integrated techniques in existing production processes.
3. An inventory of the wishes and needs of the different links within the production and packaging chain in the field of active and intelligent packaging.

Focus within the three goals as mentioned above are on research of current possible technologies (desk study and literature review of the current, existing and solutions in development, with special emphasis on the solutions that are or will soon be commercialized), integration of interactive and communicative printing on packaging (possibilities to integrate the current technologies, possible needs for new technologies, what can be currently done by existing printing technologies and packaging producers).

2D Codes

2D codes are a kind of 2D matrix symbology which, when compared to 1D or barcodes, have specific advantages. In 2D codes, data is encoded in both the height and width of the symbol, so large amount of information and data can be encoded in smaller footprint. 2D codes can also be read in any direction. Some 2D

codes provide readability of (up to 30%) of obscured and/or damaged symbols, as well. Characteristics of 2D codes, in comparison with 1D bar codes provide further opportunities in areas such as product identification/retail, logistics, part marking, and also in areas such as connecting printed media with web, for added value, providing extra information, etc. While for product identification and logistics 2D codes are read mostly by employing scanners, for later applications, 2D codes are used in conjunction mostly with smart phones, which need to be equipped with both camera and code reading software.

Some of the characteristics of 2D codes that influence the code making, design and printing preferences are 2D code anatomy – with specific areas that are defined and need to be respected, quiet zone, ECL (error correction level), density (size/amount of information), amount and type of data/information that is coded, colors, "negative" codes, placement of logo/design element, if applicable, type of printing used, including material characteristics, application area and conditions in which codes will be used.

Most known 2D codes are QR (Quick Response) and Datamatrix codes, Figure 1. Also, other open and proprietary types exist as well and are being more or less used in various industries.

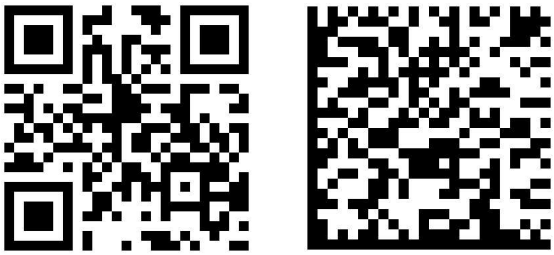

Figure 1. *Examples of QR and Datamatrix codes, left and right respectively*

QR code was developed in 1994 by Denso-Wave, which has patent rights, but is not executing it. The code was originally developed to be quickly decoded. QR code is standardized, among others as JIS and ISO standard. QR code is characterized by specific square shapes, and smaller squares (patterns) in corners. Although primarily was used for logistics and retail purposes, in recent years it is rapidly being used in various print to web, media, promotions, added value applications [1].

DataMatrix was developed and standardized by the company RVSI Acuity CiMatrix (Siemens). It is standardized as ISO, ANSI/AIM standard, and specified for use by GS1 for specific applications as well [2, 3]. Datamatrix code is characterized by L-shaped patterns. Some of areas of use are logistics, part marking, consumer products identification, and postal applications.

Solid board

Solid board is typical product of Dutch, also Western European, paper and board industry. Solid board is basic material, with core produced from recovered paper or by pressing several separate layers. Very often, basic material has cover (top) layer or layers, which can be of various types, such as regular paper, various plastics (PE, PET) and recently combinations with bio-plastics, preprinted paper, etc. Layers can be laminated to the base material inline, in the same machine. Examples of some of the various types of solid board are presented in Figure 2.

Figure 2. *Example of some of various types of solid board packaging materials*

In production of solid board waterproof adhesives are very often used, which makes it possible to used finished packaging in applications which require moisture resistance as well, such as for fresh and frozen food packaging, flower packaging, etc. Furthermore, due to the specific characteristics, namely its density. surface smoothness properties, good folding and cutting properties, and optimal thickness/mechanical properties relation, as well as recyclability properties, solid board is used in variety of different applications.

Mentioned characteristics of solid board make it as well suitable choice for research on applicability of 2D codes primarily for logistics and product identification uses, as variety surface characteristics and end-uses are possible.

Current Research in Application of 2D Codes in Packaging

In packaging, including paper and board packaging 2D codes are used in applications such as product identification/retail, logistics and also for added-value applications, to provide more information, promotion etc. Example of 2D code (QR code) is presented in Figure 3.

In basics, 2D codes are optical codes and as such are printed same as other graphic content. This can be done also with conventional or digital printing techniques, depending naturally on type of data than 2D codes must contain, static or dynamic (variable). In case of dynamic (variable) content and/or codes need to be personalized they have to be printed with digital printing methods, such as inkjet or electrophotography. As for the material requirements, majority of optical 2D can be printed with regular printing inks used. Attention needs to be paid to substrate/ink interaction, especially if small size 2D codes are being printed, as codes might be unsuitable for decoding if too much ink spreading occurs [4].

With regards to paper and board packaging as substrate for 2D codes applications, recent study done by PTS [5] on in-line printing by, among other laser and ink-jet printing showed that substrate is one of determining factors in terms of achieved print quality. Issues occurred were with water-based ink-jet inks, in

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terms of interaction with the board substrates. This needs to be taken in account both for drying and for later possible mechanical influences to packaging. In the case of UV ink-jet it was noted that board should not be varnished or printed in order to achieve adequate print quality, according to ISO/IEC 15415 standard.

It is important to note that criteria for print quality of 2D codes are not same as for other graphic content, so while they are not that much affected by some of factors in printing, their readability and therefore usability relies on adequate printing quality, again depending on the printing process characteristics and materials used and targeted application and conditions [6].

In relation to 2D codes print quality evaluation, ISO/IEC 15415 is one of the standards that defines methodologies for measuring, and as well grading of 2D codes (mark) characteristics. Furthermore, it identifies and helps with corrections for symbol degradation. In regards to material properties, it is stated that there are substrate properties that influence reflectance measurements, thus also readability, such as gloss, low opacity, presence of over-laminate, surface structure. Attributes of printed 2D codes that are inspected are symbol contrast, modulation, fixed pattern damage, axial non-uniformity, grid non-uniformity, unused error correction, print growth, etc. [7].

Figure 3. *Example of 2D code (QR code) applied on board material, sample from Interpack fair, May 2011*

In addition to mentioned printing technologies and material characteristics, parameters such as color/contrast influence the readability of the code. In most of applications, in order to ensure adequate contrast for reading and decoding, 2D codes are printed at black marks on light background. This is relevant as reader devices work on the contrast-based principle. Use of black or dark colors on white or light background is though not possible in some applications, i.e. when substrate color is not light enough or 2D codes are partially or fully printed in one or more colors. In study done on readability of Datamatrix codes printed by digital printing techniques (among others, ink-jet and laser printing) in different colors, it has been demonstrated that it depends on selected colors and colors combinations both for data and background, and as well as on selected raster tone value [8, 9].

In relation to previously mentioned studies and application of 2D codes in packaging, current research in the scope of SSK initiative is performed on specific selected issues in direct printing, using digital printing techniques, of 2D codes on paper and board packaging. Solid board has been selected as example material, due to various different possible combinations for surface/top layers, regarding material characteristics and also color. Material and printing properties influence on achieved print quality reproduction and consequently readability are being studied.

Conclusions

In the course of SSK initiative, application of 2D codes in bio-based packaging has been investigated. Due to its characteristics as substrate, with different material combinations being possible, solid board is used as example of packaging material. Direct printing of 2D codes, using digital printing techniques, is studied in terms of influence of material and process characteristics on achieved print quality reproduction and readability.

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Author Biography

Maja Stanic, born in 1981, is project manager at KCPK, The Netherlands, on working on topics of paper and board based packaging and printed intelligence. She has received PhD degree in Graphic Engineering, at the Faculty of Graphic Arts, University of Zagreb (2010). Her research interests are printed intelligence, especially various indicators and 2D codes, smart packaging applications, novel printing techniques, such as 3D ink-jet printing, developments in digital printing techniques, and print quality assessment.