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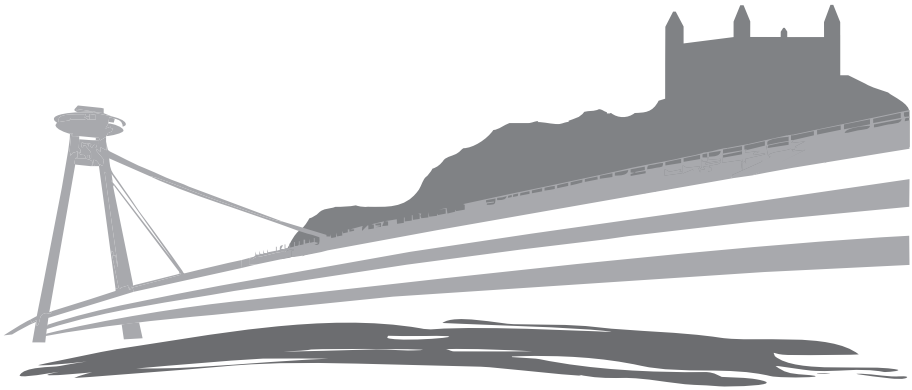

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High Label Production with NIP Technology

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Abstract: *Cardboard boxes and label printing is the most cost-effective graphics product globally. In the last 5 years, the production of labels has increased by 26.8%, which in the printed volume represents an increase of 0.31 trillion A4 labels. The reason for this trend is the new requirements of brands owner and designers to reduce marketing costs and placement as much information direct on products. Today the share of NIP printing technology on label production is still small, and flexo printing, offset printing and gravure are main players due to uniform quality and high production speed. However, with the development of new Electrophotographic (EP) and Inkjet machines, high-quality imaging become 1200 dpi and production speeds grew to 80 m/min. Over the past 2 years, the global growth of labels printed in electrophotography and Inkjet technology is respectively 6.5% and 150%. This is also reflected in the print volume where EP has an increase of 9.7 billion and Inkjet in 20.3 billion printed A4 label formats. This professional paper compares currently the two most productive NIP printing machines on the market (HP Indigo WS 6900 and Durst Tau 330 RSC) and their ability to print on polypropylene and label paper with a heat-sensitive dye layer. The results show that something better reproduction on polypropylene (PP) will be achieved by the UV Inkjet Durst Tau 330 RSC, while HP indigo will give better reproduction on the rougher label paper with a heat-sensitive dye layer.*

Keywords: *Label printing, liquid electrophotography toner, UV Inkjet, reproduction quality, FOGRA 39.*

1. Introduction

In the packaging and labeling industry, production and printed labels play a crucial role. The basic function of labels is to provide information on a packaged product. Depending on the performance, labels can be divided into two basic groups: nonadhesive and adhesive. Nonadhesive labels are simpler structures and can be realized on a variety of coated and noncoated printing substrates. Labels from category adhesive labels c are increasingly used because they can apply easily with self-adhesive or moistenable adhesive. Depending on the application request or possibility of removal, there are two main types of self-adhesive labels: pressure sensitive (permanent, removable adhesive) and heat-sensitive (instantaneous, delayed action adhesive). More affordable are moistenable adhesive labels. They are activated by pre-moisturizing, which can be applied partially or all over the surface. [1] Except for information function, labels must achieve good marketing function

of specified Brand, which entails the achievement of additional aesthetic value. A print substrate, printing inks and varnishes, and printing technologies play an important role. [2]

1.1. Trends in label production

In the last 10 years, trends in the production of printed products have significantly changed. Thus, we are witnessing a significant decline in the print run of traditional printed products (books, newspapers) and the increase in printed packaging. [3] Label printing is characterized by global growth, where money revenue and print volumes are steadily increasing. Thus, in 10 years period (of 2012 to 2022), there will be an increase in printed labels in billion dollars of 60.6%. In printed volume labels in A4 trillion, this means a 66.6% increase.

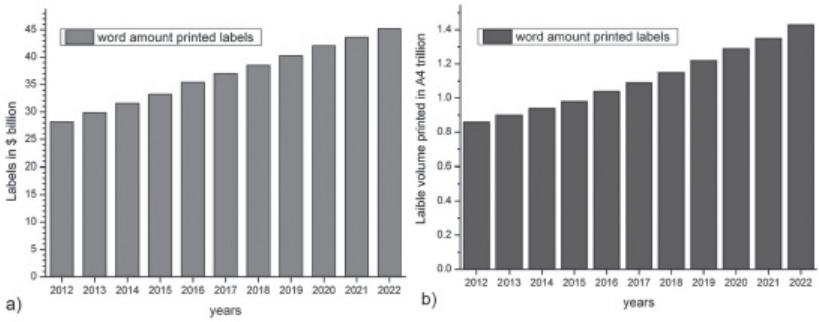

Fig. 1: Word amount printed labels: a) in billion dollars; b) in volume A4 trillion.

In the printing industry global trend is increasing, the share of digital printing technologies and the decline of classic printing technologies. In the production of labels, the majority of production is still printed with conventional printing technologies (offset, flexo, screen printing, gravure, letterset). However, due to the trend of decreasing print runs digital printing technology (Inkjet, EP), it is becoming increasingly used. Thus, from 2012 to 2022, financial revenue and print volume increase for all printing technologies 3 are expected. In profit growth in dollars stand out: Inkjet 41%, electrophotography 9.8%, letterset 8.9%, gravure 7.8%, sheet offset 7.2%, flexo 6.7% and screen printing 2.7%. Analysis of the overall print volume shows that in the last 10 years, the use of digital technologies has also an increasing amount in printed labels. The increase in print volume is: Inkjet 50%, electrophotography 9.3%, letterset 11%, gravure 10.8%, sheet offset from 8%, flexo 6.7% and screen printing 5.8%. Until 2018, EP printing machines were the dominant digital printing technology for labels. However, with the development of new Inkjet heads and UV Inkjet inks, Inkjet technology has taken dominance place in printing low print runs and personal printing.

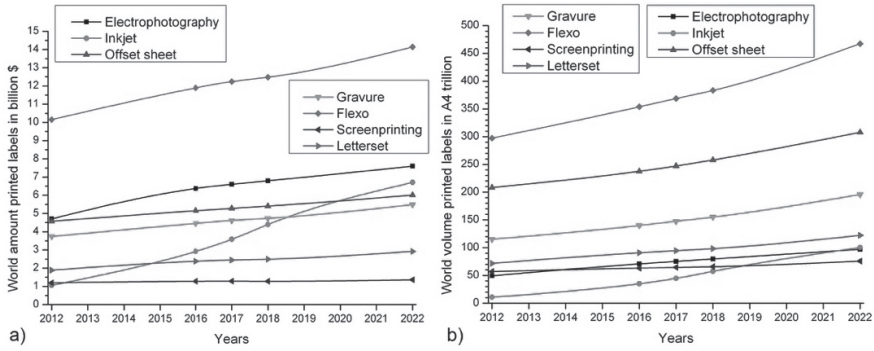

Fig. 2: Word amount printed labels with different printing technology:
a) in billion dollars; b) in volume A4 trillion.

Global trends are followed in a printing house in Czech Republic, Poland, and other eastern European countries. In the analyzed period of 2012 to 2022, there will be an increase in printed labels in million dollars of 13.1% in Poland, which corresponding to a 10.6% increase in printed volume labels in A4 trillion.

In Czech Republic, this growth is slightly lower (printed labels grow 8.9% million dollars or 7.7% in printed volume). In the same printing category other Eastern Europian countries (Baltic and Balkan countries, including Hungary, Slovakia, Slovenia, and Ukraine) have an increase in financial revenue and print volume. Such projection shows a 10.5% increase in printed labels in a million dollars or a 7.1% increasing in a printed volume. [4]

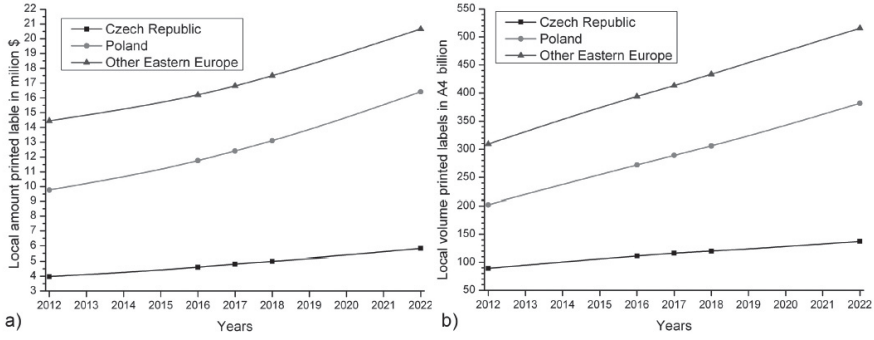

Fig. 3: Local amount printed labels with all printing technology:
a) in million dollars; b) in volume A4 billion.

2. Experimental part

Electrophotography and Inkjet printing techniques are increasingly being used for label production. Therefore, it is interesting to analyze the differences between these imprints and their comparative advantages. The two most productive digital printing machines were used for analysis: HP Indigo WS 6900 (EP with liquid toner) and the DURST Tau 330 RSC (Inkjet with UV curable ink). The technical characteristics of the machines used are shown in table 1 and table 2. [5,6]

Tab. 1: Technical characteristic printing press HP Indigo WS 6900.

Printing speed	30 m/min for 4/0 or 40 m/min in higher mode of productivity; 60 m/min in printing mode 1/0 or 2/0
Image resolution	812 dpi; 2438 x 2438 dpi (HDI = High Definition Imaging)
Line screens	175, 180, 196, 210 lpi
Max. Image format	320 x 980 mm
Substrate thickness	40 do 380 µm
Standard 4-colour printing	Cyan, magenta, yellow, and black
HP IndiChrome 6-colour printing	Cyan, magenta, yellow, black, orange, and violet
HP IndiChrome 7-colour printing	Cyan, magenta, yellow, black, orange, violet, and green
Inline Priming Unit (ILP**)	Application of coatings in thickness of 0,5 g/m2, 1 g/m2.

Tab. 2: Technical characteristic printing press DURST Tau 330 RSC.

Printing speed	High speed mode (CMYK OVG): 80m/min, CMYK OVG +W: 52
Image resolution	1,200 x 1,200 dpi; with droplets of size = 2 pl
Width of printing substrates	165 – 350 mm
Maximum width of the printed image	330 mm
Substrate thickness	20 – 500 µm
Standard UV colour printing	Cyan, magenta, yellow, and black
Additional UV inkjet inks	Orange, violet, green, white
Printing substrates	Coated and uncoated printing media, white and transparent film, PP, PE, PVC, PET, BOPP, aluminum foil
UV curing	Extra cooling roller, optional inert gas compra for reducing odors

Three tests were applied to determine the difference in the quality of the imprint: a tone color comparison of the prints regarding FOGRA 39, a resolution test (printing patch in size 1x1, 2x2, 3x3 4x4 pixel) and a microprint reproduction test (positive and negative text from 1 to 7 pt). For the color reproduction test, we use FOGRA media wedge CMYK 3.0 wedge (72 patch) and spectrophotometer x-rite eXact (set up option: M0, wb, compensation curve A and tolerance defined by ISO standard 12647-7). [7, 8]. The other two tests were performed by visual assessment microscope enlarged images (print surface dimension 21.8 mm x 16.3 mm) [9]. This experiment uses 2 printing substrates that are often used in the production of labels. There are adhesive paper with a heat-sensitive layer (the label is additionally used in thermographic printers) and Polypropylene. The technical characteristics of the printing substrates are given in table 3 and table 4.

Tab. 3: Technical characteristic printing substrate Termoeco_ScandTherm TCS.

Grammage	76 ± 5 g/m2 ISO 536
Thickness	82 ± 8 µm ISO 534
Adhesive	SSP 50AF
Thuckness of liner	54 ± 4 µm ISO 534

Tab. 4: Tech. characteristic printing substrate Arconvert_OPP TC WHITE GLOSS 60.

Grammage	45 g/m2 ISO 536
Thickness	60 µm ISO 534
Adhesive	PF2 = Acrylic adhesive in water emulsion
Thuckness of liner	56 µm ISO 534 (CB62)

3. Results and discussion

3.1. Color tone reproduction - comparison to FOGRA 39

Due to the printing substrates used reference value for the color tone reproduction test is FOGRA 39. In that case printing condition are: mode M0, backing wb, curve A (13%) and B (16%), color sequence KCMY, paper type 1/2 for illustration printing (woodfree white, glossy/matt coated), line screening 60-80 lpc, total ink limit 330%, ICC profiles ISO Coated v2 (ECI) or ISOcoated_v2_eci.icc. Color differences of FOGRA references and HP Indiga and Durst Tau 330 imprints on two printing substrates are shown in Figure 4.

On a printing substrate termoeco, the Dust Inkjet printing machine achieved average color change DEdurst = 3.89, while HP Indigo generates a larger color change DEHP6900 = 6.08. Thus, the durs will have a problem with the realization of

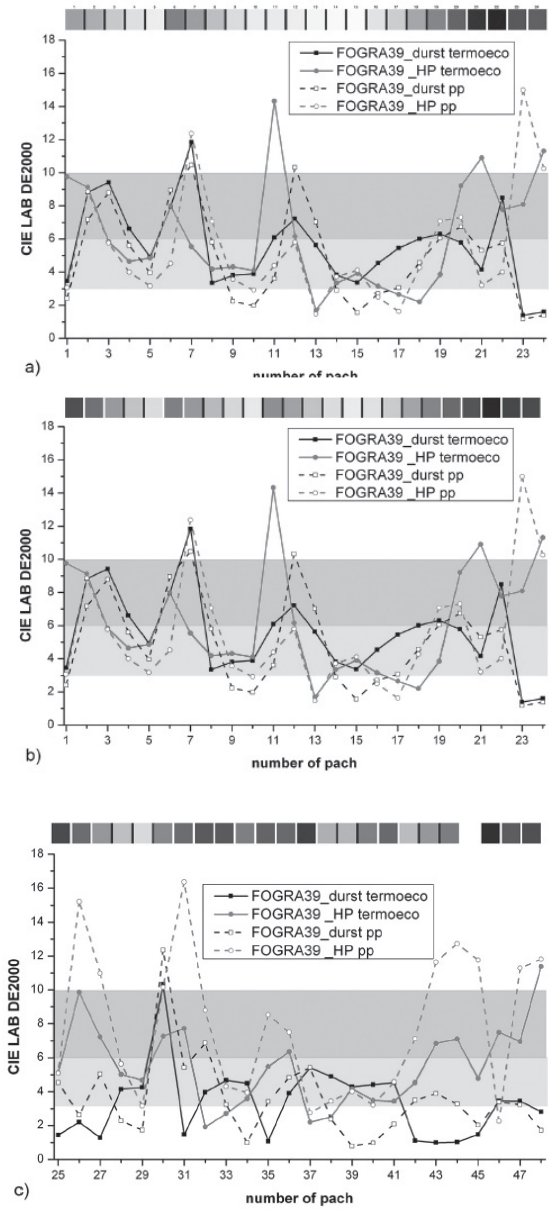

Fig. 4: Color differences between HP Indigo and Durst Tau imprints to Fogra 39 reference values: a) patch 1 to 24; b) patch 25 to 48; patch 49 to 72.

3 tone patches, while the HP Indigo has a problem with the realization of 10 color patch (color change are above FOGRA defined tolerance).Experimental prints on white polypropylene film produce more expressed color changes in relationship of Fogra 39 refernce. Durst machine again give better quality (average color deviation of the Media wedge is ΔEdurst = 3.95. Significant variation occurred in 5 color patch. When HP indigo machines printing on polypropylene substrate must be coated with primer unit. Because of that HP Indigo prints unfortunately have large color difference. Thus, the use of yellowish primer will require additional calibration process. The average color changes are ΔEHP6900 = 7.50 with larger deviations of 19 patch.

3.2. Resolution test

The resolution test shows the ability to generate the smallest print elements. Figure 5 shows an enlarged photo printed resolution wedge (8 x 5 mm) together with an ideal display screen.

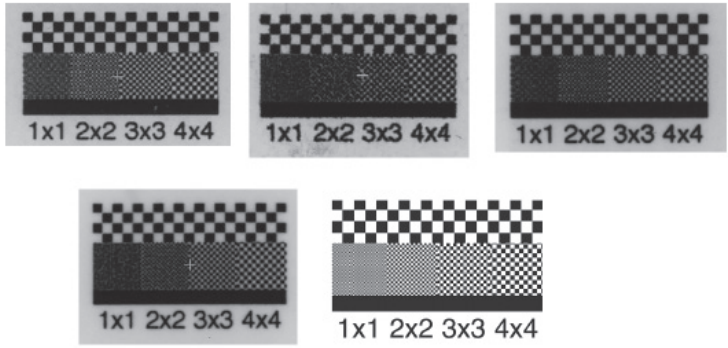

Fig. 5: Enlarged wedge images for resolution test: a) HP Indigo on Termoeco substrate; b) Durst on Thermoeco substrate; c) HP Indigo on PP substrate; d) Durst on PP substrate; e) the original display screen (monitor).

With less high-quality print media (greater absorbency and less whiteness), the resolution test has shown that the HP Indigo machine gives a better footprint. In this case, the textual part and the dot screen part are better noticed. When the printer uses higher quality and smoother printing substrates (PP), UV Inkjet inks are better to attach, forming a dot screen structure that is identical to the EP printing machine. The 1x1 pixel resolution is well printed and visible. The better print quality of the durst imprint on the PP can be attributed to the direct application ink to the printing surface. Higher quality HP indigo imprint on PP can be achieved with additional application fluid primer which reducing surface tension. Then the

Electroink will not uncontrollably dissipate and will give a greater sharpness to the imprint. This method reduces the whiteness of the printing substrate which affects the printing contrast achieved.

3.3. Text Reproduction Test (positive-negative)

An integral part of the label is declaration text which gives important product information. Due to the small size of the labels, the text size is very small. The quality of the reproduced positive text on two digital printing machines is shown in Figure 6.

Fig 6. Enlarged images of positive text: a) HP Indigo to Termoeco substrate; b) Durst to Thermoeco substrate; c) HP Indigo to PP substrate; d) Durst to PP substrate; e) the original display screen (monitor).

Both tested technologies gave satisfactory results. The text size of 2 pt stays visible without unwanted linkage text. The difference is only evident in paper with a dye thermal layer, where durst Inkjet machine achieves a font of slightly greater thickness. Modern label design for pharmaceutical and food industries demand text in negative. Figure 7 shows the segments of the reproduced negative text in EP and UV Inkjet printing technology.

Fig 7. Enlarged images of negative text: a) HP Indigo to Termoeco substrate; b) Durst to Thermoeco substrate; c) HP Indigo to PP substrate; d) Durst to PP substrate; e) the original display screen (monitor).

With negative text, HP Indigo imprint performs slightly better results. The more absorbent Thermoco substrate gives visual recognition negatives text in 3 pt. Unfortunately, this is not possible with liquid UV Inkjet ink (print is lower quality). But on PP substrate, UV Inkjet technology has proven better quality reproduction with the possibility of reproducing negative text on 2 pt. Because of the obligatory using HP Indigo Primer liquid, this effect is not possible to achieve.

4. Conclusion

Label as a graphic product printed in UV Inkjet and Electrophotography definitely has a positive perspective. The reason for that are trends in reducing print run and the possibility of printing greater content variations. Possibility modular design with a larger number of Inkjet heads will accomplish further increase the dimension machines and prints which results in higher production. Compared to conventional offset printing techniques (FOGRA 39 references), both systems tested (Inkjet and EP) produce labels with top quality, with minor differences.

The Durst tau 330 achieved slightly better results in the reproduction of secondary and tertiary tones on polypropylene foils. Therefore durst showed better color reproduction and more uniform color tone quality. Microtext tests and resolution tests are satisfactorily performed to ensure the printing of more complex images and text.

On the rougher and more absorbent substrate (Termoeco label paper), the HP Indigo WS 6900 machine gives better image reproduction. Although the deviation of the HP Indigo tones varies more than Durst, the tests of resolution and test of reproduction micro text are much better realized. Compared to the FOGRA 39 reference values, an additional calibration of the system is required in the print preparation process. That includes one adjustment TVI reproduction curves (curve compensation).

To get the right information about the stability of these technologies, the future plan is to perform a long-term reproduction test (larger print run). This test will show the real reproducibility of color label reproductions.

5. References

1. Kit L. Yam, Encyclopedia of packaging technology III. edition, John Wiley & Sons, Hoboken USA 2009, pp.633, ISBN 978-0-470-08704-6
2. Kipphan, H., Handbook of print media: technologies and production methods. Heidelberg: Springer, 2001, pp. 438–442, ISBN 3-540-67326-1
3. Majnarić I. Osnove digitalnog tiska, Sveučilište u Zagrebu Grafički fakultet, 2015, pp. 22-23, ISBN 978-953-7644-13-0
4. Smyth S., The Future of Global Printing to 2022, Smithers Pira, Surrey United Kindom, 2017.
5. https://durstus.com/wp-content/uploads/2017/05/durst-tau-330e-1.pdf
6. https://www8.hp.com/us/en/commercial-printers/indigo-presses/6900.html
7. ISO 12647-7:2007 Graphic technology: Process control for the production of halftone color separations, proof and production prints — Part 7: Proofing processes working directly from digital data5.

8. X-rite (2018). x-rite eXact Spectrophotometer, Available: https://www.xrite.com/categories/portable-spectrophotometers/exact.684_exact_advanced_sell_sheet/l7-684_exact_advanced_en.pdf
9. QEA, Personal IAS.Available:http: //www.qea.com/upload/files/products/ datasheet_personalias-newaddr.pdf
10. https://www.scandstick.se/CustomerData/Files/Folders/5-pdf-s-directthermal/60_scandtherm-tcs-ssp50af-hg0.pdf
11. http://en.arconvert.es/products/catalogues/films/opp-tc-white-gloss-60m-pf-1-cb62-912410l296-catalogue-code-ba31/details/?web=1
12. Majnarić, I., Bolanča, I., Bolanča, Z., & Milković, M. (2005). Conditions in digital printing of packaging on the print quality. In International Conference on Digital Production Printing and Industrial Applications, DPP2005 - Final Program and Proceedings, vol. 2005.
13. Majnaric, I., Modric, D., & Golubovic, K. (2008). Influence of laser power output on the quality of colour imaging. In Annals of DAAAM and Proceedings of the International DAAAM Symposium.
14. Majnarić, I., Hladnik, A., Muck, T., & Bolanca Mirkovic, I. (2015). The influence of ink concentration and layer thickness on yellow colour reproduction in liquid electrophotography toner. Tehnički vjesnik, 22(1), 145-150. https://doi.org/10.17559/TV-20140321230455