UNIVERSITY of SOPRON | FACULTY OF WOOD ENGINEERING AND CREATIVE INDUSTRIES

APPLICATION TECHNOLOGY INVESTIGATIONS IN THE PRE-PRESS PROCESSES OF FLEXOGRAPHICALLY PRINTED FLEXIBLE PACKAGING

Maňúrová Klaudia

Thesis Booklet

Supervisors: Joóbné Dr. Preklet Edina and Dr. habil. Horváth Csaba

University of Sopron

Jozsef Cziraki Doctoral School of Wood Sciences

Faculty of Wood Engineering and Creative Industries

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1. Introduction, motivations

The market for printed packaging materials has developed and continues to develop continuously and strongly in the first decades of the 21st century, driven by changes in customer preferences, the advantageous solutions arising from the possibilities of new printing technologies, the new world of communication and related tools.

The initial goal of the research that underpins the doctoral dissertation was to examine the entire flexographic printing process. The prepress is a very important element of this technological chain, but the real result, the print, is produced by other companies. Thus, only complete and joint investigations can yield useful research results. Thus, the first step of the research was to gain comprehensive information and knowledge about the world to which it applies.

I based the theses of my doctoral dissertation on the results of a questionnaire survey. In this research step, I mapped the flexographic printing presses in Hungary that deal with the production of flexible packaging materials and label printing. The two aforementioned segments of flexo printing are technologically similar to each other, so the research focused on these two segments. Flexo printing of corrugated cardboard requires completely different conditions and parameters, so the dissertation only deals with this segment tangentially. The topics intended for research were selected based on the summary of the responses received from the printing houses, as we were looking for answers to questions that come from a real environment and seek solutions to real problems.

In our doctoral dissertation, we are therefore trying to achieve the goal of providing potent answers to the multiple questions posed by the profession.

2. The research goals

The aim of the research work is to examine the possibilities of the processes used in today's flexo printing in terms of optimization, standardization and efficiency. The aim is to carry out application technology studies that can make the printing industry's prepress processes of flexible packaging materials more efficient.

Hungary has a significant flexo printing potential in the Central European region. There are many printing companies in the country, from international multinationals to small, regionally operating family businesses.

Manufacturers operate in all segments of the packaging industry in Hungary. Flexo printing technology is mainly used to produce flexible consumer and industrial packaging, labels and corrugated cardboard - these three categories account for more than 60% of all packaging materials (Horváth, Koltai 2019).

The indirect objectives of the doctoral thesis include an overview of Hungarian flexographic printing presses and printing supplier companies and a survey of their attitude towards the planned research topic. The survey was carried out using a printing industry questionnaire. In order to implement the further research tasks, test printing plates were made using current platemaking and flexographic printing plate manufacturing technologies. The printing plates were tested under real printing conditions. The results obtained were evaluated according to the criteria of the tasks set. In search of answers to the questions posed by industrial practice, the behavior of microcellular structures applicable to the surface of flexographic printing plates was examined. The question arose as to how the ink transfer of printing plates can be improved, considering the density and ink spread on the types of raw materials used by the industry.

A further aim of the research is to potentially increase the efficiency of flexographic printing, especially by reducing the number of printing plates while maintaining or increasing the print quality. The subject of the study is also the applicability, advantages, disadvantages and current perception of extended color gamut flexo printing in the Hungarian flexo printing industry.

3. Summary of the results achieved during the research

It is important to note that the application technology research of the doctoral dissertation is limited to companies producing certain types of packaging materials. Narrow-, medium- and wide-web flexo printing faces many challenges and high quality requirements, especially when printing labels, plastic or paper-based packaging materials, aluminum and other materials up to approximately 120 microns thickness. The most practical information is available in the mentioned area, so we based our research on this segment. We did not include the segment producing corrugated cardboard and other packaging materials in our studies. We collected data on flexo printing companies operating in Hungary back in 2020. We managed to map 60 companies that have flexo printing presses and print labels, produce flat foil, aluminum, various duplex or triplex materials, etc. from a variety of materials. The survey was conducted in May 2022 using questionnaires. The questions in the evaluated questionnaires determined the research topics, based on which the studies and theses described below were created.

3.1. Surface patterning and microcells on flexographic printing plates

The operation of surface structures cannot be predicted and cannot be based on assumptions. In flexo printing, phenomena can often occur that should work according to the paper form, but in reality, this is not always the case. I used printing tests to examine the operation of surface structures and the verifiability of the question that surface microcellular structures work on all substrates and improve ink transfer.

It was given the opportunity to conduct the tests in 4 Hungarian flexo printing houses. All four printing houses work with UV technology on narrow-web printing machines. Their main profile is labels and shrink sleeves. For the sake of comparability, it is important to select test subjects that work very similarly to each other. A total of thirty print samples were produced for fifteen types of substrates in the four printing houses. Four different printing plates were produced for the tests, customized for each printing house based on the appropriate size. The size limit was determined by the width of the printing presses and the width of the available printed material. A "printing cliché" and a white underprint were prepared for each printing press for printing transparent materials. The tests were carried out with both cyan and black ink. This is necessary because the results of the cyan print sample can be used to draw relevant conclusions about the printing characteristics of the magenta and yellow colors. However, we requested a separate sample for the black color, because in our experience, black ink often shows different characteristics than the other colors. The test was carried out on the fifteen materials listed below.

1. PAP Silver (Press 1)
2. PAP WH (Press 1)
3. PP Clear (Press 1)
4. PP Silver (Press 1)
5. PE WH (Press 2)
6. PAP– Raflacoat (Press 2)
7. PP WH (Press 2)
8. PE WH (Press 3)
9. PAP WH (Press 3)
10. PE TR (Press 3)
11. LIM WH (Press 4)
12. PET TR (Press 4)
13. PP WH (Press 4)
14. PAP WH (Press 4)
15. PAP KR (Press 4)

The measurements were made with the X-Rite eXact handheld photospectrometer. The device is capable of measuring density on prints. Density is a concept used in many scientific and industrial fields. Its basic meaning is “thickness”. In optics, it means the degree of coverage of a surface and is measured at 100% tones.

Examining the results of the research, the following conclusions can be made:

- The use of surface structure does not increase density on all types of substrates.
- Based on our practical tests, we can conclude that surface roughening does not work on paper. We assume that the relationship is to be found in the fact that the smoother the surface of a substrate, the better the microcells work.
- We can conclude that, apart from paper, the use of surface microcell structures brought improvement on all other tested substrates.
- We can also note that while the surface roughening did not work on the plain paper, it did on the silver-surfaced paper.
- In most cases, the MCWSI, a one-pixel microcell, performed best.

We summarize the obtained values and results using the graph shown in Figure 1.

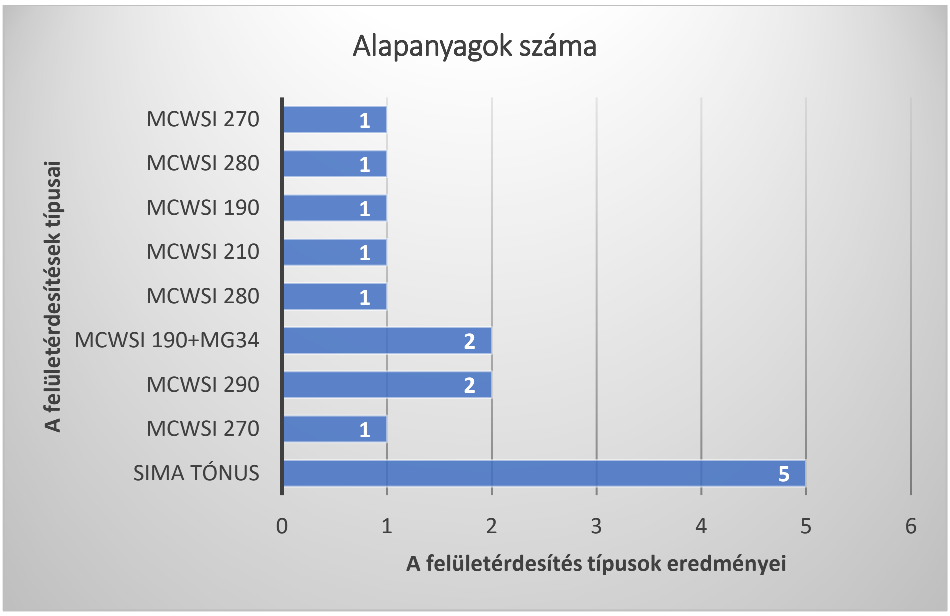

Figure 1: Summary of the results of the surface structures

On the 5 paper-based samples, the smooth tone is the correct setting. In all other cases, except for two, the MCWSI structure is the most suitable, with different laser powers. Of the two exceptions, one is a clearly proven MG34 and structure, and in the other case the result was not clear.

Thesis 1: Microcellular structures applied to printing plates used in flexography improve the quality (density) of ink transfer on synthetic single-layer and self-adhesive printing media (polypropylene - in the case of tested PP WH, a maximum increase in density of 0.22, PP TR 0.14-0.22 increase, polyethylene - in the case of tested PE WH, a maximum increase in density of 0.4, PE TR 0.3 increase, polyester - in the case of tested PET TR, a density increase of 0.18-0.27 can be observed). The same effect cannot be demonstrated on paper or on printing media with a structured surface.

3.2. Characteristics of flexo printing on brown kraft paper

The aim of the research work was to investigate the effect of different surface structures and cliché base materials on the quality of solvent flexographic printing on brown kraft paper. The topic of printing brown kraft paper is constantly current. Based on the printing industry survey, it can be stated that the rise of brown kraft paper to the forefront is still in progress. For this reason, it was brought to the forefront to examine the printability of the base material and find the most optimal way to do so. Kraft paper is considered a problematic base material due to its color and surface inhomogeneity. The tests of printing brown kraft paper were performed on the Varga Flexo OK-288 printing press of Krajcár Kft. The printing press uses 1.14 mm thick printing plates. The following companies' base materials were available to us for testing: DuPont, XSYS (formerly Flint Group) and MacDermid. The following base materials were tested:

1. DuPont™ Cyrel® DPR
2. DuPont™ Cyrel® DPN
3. DuPont™ Cyrel® DPI
4. Flint Group nyloflex® ACE D
5. Flint Group nyloflex® ACT D
6. Flint Group nyloflex® FTF
7. MacDermid Lux® ITPTM 60
8. DuPont™ Cyrel® EASY ESM

Examining the results of the research, we can make the following statements.

- The use of surface structure does not bring a clear increase in density on brown kraft paper either.
- It can be said in the case of solvent flexo printing that microcellular structures on the inhomogeneous surface of paper - compared to plastic-based films - only brought positive results in one exceptional case.
- Based on our practical tests, we can state that the softest cliché base materials worked best on brown kraft paper.
- It can also be stated that the best result in terms of practice was achieved by the DuPont™ Cyrel® EASY ESM plate. Its density without any treatment was 0.92, which is important for industrial use because it involves less resource expenditure. Its use is most practical for printing on brown kraft paper.
- However, it is important to mention the results of the nyloflex® ACT D sheet, which, thanks to its surface structure, achieved a density result of 0.96 comparable to the DuPont™ Cyrel® EASY ESM sheet.

Figure 2 summarizes the best results achieved by each material.

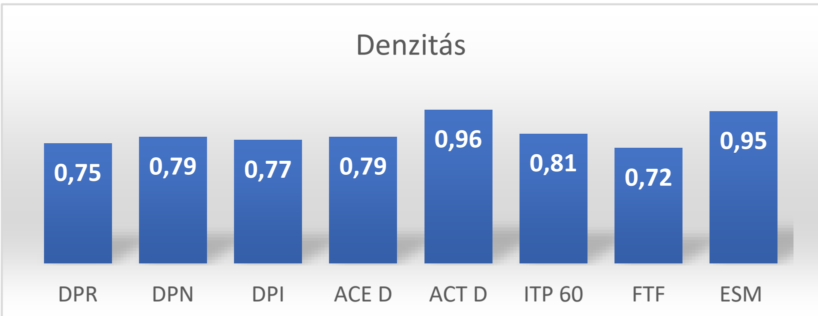

Figure 2: Summary of results of tests on brown kraft paper

As a limitation of the research, I would like to mention that brown kraft paper is a specific material, the results achieved here cannot necessarily be applied to other paper-based materials. Looking to the future, it would be worthwhile to perform similar tests on different paper-based substrates, even while changing certain printing parameters and analyzing their effects (printing speed, ink viscosity), and then comparing the results.

Thesis 2: When printing on brown kraft paper, the density of the printing ink decreases significantly - by up to 0.5 - compared to synthetic single-layer and self-adhesive printing substrates (polypropylene, polyethylene, polyester), solely due to the nature of the material. The density can be increased by 0.25 for brown kraft paper by using a soft, flat-top printing plate, without applying a surface structure. Reducing the hardness of the printing plate and using microcellular surface roughening together provides a comparable improvement in color reproduction, but is not recommended for industrial use due to the higher resource consumption.

3.3. Critical elements of flexo printing

Relying on both the literature and practical experience, we can state that every modern printing technology has its limits and critical elements, which are difficult for certain printing technologies to implement or reproduce. This is not different in the case of flexo printing. The critical elements in flexo include the following: tone values, highlights, positive and negative thin lines, positive and negative thin texts. We have already dealt with the optimization of tone values and opacity in the previous sections. We can see that a reliable solution can be provided by the combination of microcellular structures and a cliché base material of the appropriate composition. Printing the appropriate highlights – we are mainly thinking of shadows and bleeds here – is also a matter of the appropriate printing calibration. In this part of my research, I am interested in whether there is a setting or grid structure that can help prepress to print these critical elements without damaging other graphic elements.

A digitally modulated grid structure for flexo printing has only been available for 3-4 years. The technology is known as Bellissima and is actually a set of digitally modulated grids (DMS) that have been specifically developed and optimized for flexography. These grid structures are illuminated with a resolution of 4000 dpi, thus ensuring extremely high quality reproduction (exceeding the quality corresponding to 300 lpi) and are also free from moiré. The use of printing plates made with Bellissima alleviates typical flexo printing problems such as dot bridging, dot rivering, barring, bounce, slur, etc., resulting in a much more stable printing process.

The basis of the study was a comparative printing test. A set of printing plates were printed with a structure working with a classic AM screen with a resolution of 136 lpi, and a digitally modulated screen. The test mainly included photographs, positive and negative elements and texts. The relevant part of the test is shown in Figure 3.

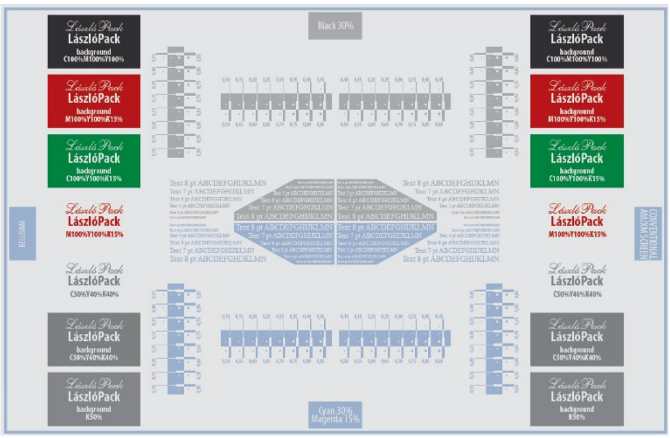

Figure 3: Detail of the visual design, showing the examined elements

Examining the results of the research, we can make the following statements:

- By using the appropriate grid structure, preparation can greatly improve the reproducibility of critical-sized lines and texts.

- The smaller the grid points and higher the grid density a given grid structure can operate with, the better the readability and displayability can be achieved for positive and negative lines and texts.

Thesis 3: The use of stochastic rosettes in flexographic printing significantly improves the readability of small-sized graphic elements. In the case of positive-based lowercase letters, the 3pt font size is unreadable with a classic grid, but is readable with a stochastic rosette. In the case of positive-based lowercase letters, the 4 and 5pt letters begin to become discernible with a classic grid, but can only be considered readable from a size of 6pt. In the case of negative lowercase letters, even 3pt font size is clearly readable with a stochastic rosette, while in the case of a classic AM grid, it only becomes readable at 6pt font size. The test was conducted by one test subject. The fonts used were Times New Roman and Myriad Pro.

3.4. Color space reproduction in flexo printing

The goal of all printing technologies is to reproduce the widest possible color space spectrum, which, however, will always be only a certain part of the spectrum that can be perceived by the human eye. During my research, I sought to answer the question of what the color space reproduction of digital printing is like, how the color space reproduction of digital and flexo printing relates to each other, and what effect does prepress (printing plate manufacturing technology) have on the color space reproduction of flexo printing.

The research was carried out by Sipospack Kft. in Sóskút. The ideal conditions were given, which in this case was an HP Indigo 20000 digital printing press. The web width of the machine is 762 mm, the printing speed is 101 ft/min (30.78 m/min) in 4-color mode, 82 ft/min (25 m/min) in 5-color mode and 137 ft/min (41 m/min) in EPM mode. (Hewlett Packard, 2013). The test pattern included several photo elements, test elements used in flexographic printing tests and a measurement pattern consisting of 1472 test fields, from which it was also possible to measure the ICC profile.

The test material was 20µ thick transparent polypropylene. The GMG software system and the i1iO automatic measuring arm were used for the measurement.

Additional color profiles were needed to carry out the research. During my doctoral studies, I continuously and purposefully collected the material for this research. I selected samples from color space tests carried out over the past 2-2.5 years to represent multiple printing houses, solvent and UV technologies, and multiple printing plate manufacturing processes, and of course, all from several different printing companies.

10 color profiles made with flexo printing were included in the study:

Nr.	Substrate	Plate type	Plate-making technology	Ink
1.	PP TR	MacDermid Lux® ITPTM 60	Bellissima DMS	UV
2.	PP TR	MacDermid Lux® ITPTM 60	Bellissima DMS	UV
3.	PP TR	Kodak Flexcel FNXH	Kodak NX A	UV
4.	PP TR	DuPont™ Cyrel® ESXR	Digital Flat Pixel A	UV
5.	PP TR	DuPont™ Cyrel® DPN	Classic Digital	solvent
6.	PP TR	MacDermid Lux® ITPTM 60	Bellissima DMS	solvent
7.	PP TR	Kodak Flexcel FNXH	Kodak NX A	solvent
8.	PP TR	DuPont™ Cyrel® ESXR	Digital Flat Pixel A	solvent
9.	PP TR	MacDermid Lux® ITPTM 60	Bellissima DMS	solvent
10.	PP TR	Kodak Flexcel FNXH	Kodak NX A	solvent

ICC profiles from the listed samples were also created using the aforementioned GMG software and i1iO measuring device. This resulted in 11 ICC profiles, which were compared using the software called Gamutvision. The software is able to visually compare and display two ICC profiles, and can also numerically express the range of the color space, which is given by the "gamut volumes" information. The following results were obtained:

Sz.	Substrate	Plate	Ink	Press	GV	% to Lab	% to D
1.	PP TR	Digitális	digitális	NY 1	460722	54,84 %	100%
2.	PP TR	Bellissima	UV	NY 2	348449	41,47 %	75,63 %
3.	PP TR	Bellissima	UV	NY 3	407321	48,48 %	88,40 %
4.	PP TR	Kodak	UV	NY 3	388433	46,23 %	84,30 %
5.	PP TR	Digital Flat	UV	NY 3	340696	40,55 %	73,94 %
6.	PP TR	Classic Digital	oldószer	NY 4	341701	40,67 %	74,16 %
7.	PP TR	Bellissima	oldószer	NY 5	397610	47,33 %	86,30 %
8.	PP TR	Kodak	oldószer	NY 6	297472	35,41 %	64,56 %
9.	PP TR	Digital Flat	oldószer	NY 6	398108	47,39 %	86,40 %
10.	PP TR	Bellissima	oldószer	NY 6	386358	45,99 %	83,85 %
11.	PP TR	Kodak	oldószer	NY 7	419919	49,98 %	91,14 %

Based on these results, the following conclusions can be made:

- Digital and flexo printing technologies can cover approximately half of the Lab color spectrum. Among them, digital printing technology outperformed the best performing flexo sample by 4.86%.
- The technology and type of printing plate affect the color space reproduction of flexo printing. Evidence of this can be seen in samples 3-4-5 and 8-9-10. These samples were made at the same printing houses, printed on the same printing machine, with the same anilox, ink settings, substrate and machine operators. Despite this, it can be seen that there are large differences between the gamut ranges in both cases. For printing house number 2, which was a UV ink printing house, the gamut range fluctuation interval is 340696 – 407321, which shows a value of 66625. In the case of printing house number 6, this value is even higher: the interval is 297472-398108, of which the relevant value is 100636, which is already relevant, since compared to the higher value, the color space performance of the other printing plate is only 74.72%.
- The grid structure applied to the printing plate also affects the color space reproduction of flexo printing.
- We can observe the influence of flexo printing caused by several factors. This is evidenced by samples 2 and 3. Two different printing houses produced the samples, but the type and manufacturer of the printing machine, the printing plate, and the printed material were the same. Two different companies supply the ink to the two printing houses. This difference caused a difference of 58872 gamut ranges. The first printing house could only provide 85.54% performance in this area compared to the second.

In terms of future research, I would consider it an interesting question to investigate the methods that can increase the range of the reproducible color spectrum in the field of flexo printing.

Thesis 4: The largest reproducible color space can be achieved with electrophotographic digital printing technology based on the color space comparison of solvent flexo printing, UV flexo printing, UV EGP flexo printing and digital printing, on one of the most commonly used print media: 12 micron thick transparent polyester base material in reverse. With flexographic printing technology, the best result - 91.14% (considering the color space of digital printing as 100%) was achieved with solvent ink systems and "semi-digital", flat-top printing plates.

3.5. Application of Extended Gamut Printing (EGP) in practice

Today, the most common printing method in flexo printing is printing with basic CMYK colors and additional Pantone® colors. In flexo printing, Pantone® colors are most often used in 3 cases: if a logo or other element with a similar purpose has a fixed color (brand, logo, etc.), if flexo technology has difficulty in solving an element by printing several colors on top of each other (thin positive or negative texts and lines), if a selected color cannot be reproduced correctly from the CMYK basic colors.

The essence of Extended Gamut Printing (EGP) would be that by using 3 constant spot colors, it should cover most Pantone® colors based on currently accepted theoretical assumptions. Since most flexo printing machines are 8-color, this printing method calculates with 4 basic colors + 3 spot colors and 1 white underprint. These colors are orange, green and purple.

The following are the advantages of EGP printing.

- Only a small number of colors need to be kept in stock.
- The printing press does not need to be washed after each print.
- Set-up and changeover times are shortened.

One might ask why everyone does not use this method. The answer lies in the fact that the process using EGP technology:

- the printing press must have extremely precise registration (e.g. imagine small texts with brown tones),
- special color separation is required,
- strictly standardized printing conditions are required.

In the relevant part of my research, I again dealt with color reproduction. I sought to answer the question of to what extent EGP printing can actually reproduce Pantone® colors if a printing house with an appropriate technical background switches to EGP printing.

Thesis 5: Impact studies of the application of extended color space flexo printing (EGP) prove that it is possible to produce the majority of Pantone® spot colors with multicolor printing (replacing spot color printing), especially in the case of red, brown and green hues. For colors located around the –b axis of the CIELAB color space, or on the border of the +a and +b axes, the EGP printing technology is also unable to keep the color difference below the expected value of ΔE=2, compared to spot color printing.

4. Major publications related to research work

During the research for my doctoral dissertation, the following articles were published:

1. Maňúrová Klaudia, Horváth Csaba, Preklet Edina: **Színtérreprodukció a csomagolóanyag-nyomtatásban – A flexográfiai és a digitális nyomtatás komparatív vizsgálata.** In: Csiha, Csilla (szerk.) Wood 4 Sustainability : Processing, Construction, Products and Design 2024. Sopron, Magyarország: Soproni Egyetem Kiadó (2024) 281 p. pp. 67-78., 12 p. ISBN: 9789633345412
2. Csaba, Horvath; Klaudia, Manurova; Edina, Preklet; Ferenc, Varza: **Investigation of relationships between the flexographic printing plate patterning and the anilox surface and volume in case of solid white ink printing on transparent materials.** In: Cathy, Ridgway (szerk.) Advances in Printing and Media Technology, Vol. XLVII. Greenville (SC), Amerikai Egyesült Államok: International Association of Research Organizations for the Information, Media and Graphic Arts Industries (IARIGAI) (2022) pp. 12-18., 7 p.
3. Klaudia, MAŇÚROVÁ; Edina, PREKLET; Csaba, HORVÁTH; Viktor, VETÉSI: **STANDARDIZATION POSSIBILITIES OF PREPRESS WORKS AND FLEXOPRINTING BY A UNIVERSAL TESTCHART.** In: Csanák, Edit (szerk.) 8TH INTERNATIONAL JOINT CONFERENCE ON ENVIRONMENTAL AND LIGHT INDUSTRY TECHNOLOGIES. Budapest, Magyarország: Óbudai Egyetem (2021) pp. 48-56., 9 p.
4. Horváth, Csaba; Várza, Ferenc; Manúrová, Klaudia: **Analysis of the Matte Varnishing Structure of Flexible-walled Packaging Materials In the Case of Flexographic Printing Technology.** In: s., n. Proceedings of the Technical Association of the Graphic Arts, TAGA. Oklahoma City (OK), Amerikai Egyesült Államok : Technical Association of the Graphic Arts (TAGA) (2022) pp. 1-10. , 10 p. - referred by SCOPUS
5. Horváth, Csaba ; Várza, Ferenc ; Manúrová, Klaudia: **Analysis of the flexo printed matte varnishing structure of polyester substrate.** In: Kašiković, Nemanja; Novaković, Dragoljub; Pavlović, Živko; Dedijer, Sandra (szerk.) The Eleventh International Symposium GRID 2022: Proceedings; Novi Sad, Szerbia: University of Novi Sad, Faculty of technical sciences, Department of graphic engineering and design (2022) 892 p. pp. 343-348. , 6 p.– referred by SCOPUS
6. Horváth, Csaba; Klaudia, Palova: **Relationships Between the Surface Texture of Flexographic Printing Plates and Printability of Kraft Paper.** In: Proceedings of the 71th TAGA (Technical Association of the Graphic Arts) Annual International Technical Conference, March 17-20, 2019, Minneapolis, MN, United States (2019) pp. 176-188., 13 p.– referred by SCOPUS
7. Maňúrová, Klaudia Joóbné, Preklet Edina; Horváth, Csaba; Várza, Ferenc: **A FLEXÓ NYOMTATÁS ÉS NYOMDAI ELŐKÉSZÍTÉS STANDARDIZÁLÁSI ÉS OPTIMALIZÁLÁSI LEHETŐSÉGEINEK VIZSGÁLATA A MAGYARORSZÁGI NYOMDÁKBAN.** In: Koncz, István; Szova, Ilona (szerk.) TIZENKILENC ÉVE AZ EURÓPAI MAGYARORSZÁG TUDOMÁNYOS MEGÚJULÁSA ÉS A FIATAL KUTATÓK SZOLGÁLATÁBAN: A PEME XXIII. PhD – Konferenciájának előadásai (Budapest, 2022. április 28.) Budapest, Magyarország : Professzorok az Európai Magyarországért Egyesület (2022) 163 p. pp. 114-125., 12 p.
8. Klaudia, Maňúrová;Csaba, Horváth; Viktor, Vetési: **Investigation of Relationships between Light and Weather Resistance.** In: Ridgway, C. (szerk.) Advanced in Printing and Media Technology VOL: XLVI (Published by IARIGAI – International Association of Research Organizations for the Information, Media and Graphic Arts Industries) Darmstadt, Németország: International Association of Research Organizations for the Information, Media and Graphic Arts Industries (IARIGAI) (2019) pp. 135-143. , 9 p.
9. Horváth, Csaba; Koltai, László; Maňúrová, Klaudia: **Prospects for the future of commercial printing.** In: Dedijer, Sandra (szerk.) Proceedings – The Tenth International Symposium GRID 2020. Novi Sad, Szerbia: University of Novi Sad, Faculty of Technical Sciences (2020) 736 p. pp. 413-420. , 8 p. – referred by SCOPUS
10. Manurova, Klaudia; Horváth, Csaba: **A koronavírus-válság hatásai a magyar nyomdaiparra.** In: Czeglédy, Tamás; Resperger, Richárd (szerk.) VÁLSÁG ÉS KILÁBALÁS: INNOVATÍV MEGOLDÁSOK Nemzetközi Tudományos

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11. Manurova, Klaudia; Horvath, Csaba: **HOW TO BUILD SUSTAINABLE, GREEN PRINTING PLANTS?** In: 20th SGEM International Multidisciplinary Scientific GeoConference Proceedings 2020, pp. 201-210., 10 p. – referred by SCOPUS
12. Manurova, Klaudia: **Új lehetőségek a flexó nyomóforma készítésben a Belissima digitálisan modulált rácsának köszönhetően.** MAGYAR GRAFIKA 65 : 1 pp. 23-27. , 5 p. (2021)
13. Klaudia, Maňúrová; Csaba, Horváth: **Megatrendy v oblasti potlačených obalových materiálov v Európe.** In: Michal, Čeppan; Milan, Mikula; Vladimír, Dvonka; Viera, Jančovičová; Lukáš, Gál; Pavol, Gemeiner; Katarína, Vizárová; Štefan, Šutý; Radko, Tiňo (szerk.) Proceedings of reviewed joint conferences "Wood, Pulp and Paper 2020 and Polygrafia Academica 2020. Pozsony, Szlovákia: Vydala Slovenská chemická knižnica FCHPT STU (2020) pp. 78-84., 7 p.
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