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ANALYSIS OF THE FLEXO PRINTED MATTE VARNISHING STRUCTURE OF POLYESTER SUBSTRATE

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Abstract: *Flexographic printing is one of the fastest-growing sectors in the printing industry. Our related research project examined the potential of matte varnishing as a surface finishing process. Various surface finishing processes, such as various safety varnishes, protective varnishes, barrier varnishes, and the types of matt varnish we have chosen, are playing an increasingly important role in the development of today's packaging material trend. In the course of the research, we tested the changes in the surface structure of the varnishing layer in the case of varying amounts of lacquer application, and we measured the gloss values in the case of the use of clichés with different surface patterns.*

Key words: flexographic printing, varnishing, surface structure

1.INTRODUCTION

A number of factors have contributed to the importance of packaging and it is gaining strength nowadays. The most important of these is globalization and the resulting economic changes. Changes in the role of packaging are also affected by consumer and social changes, which are mainly due to demographic changes. Globally, the growing population is a challenge, which, in addition to the expanding supply of goods, is leading to an increase in the use of packaging. This process leads to a narrowing of packaging raw materials and, in parallel, an increase in their price, which often forces developers to innovate technologically (Dörnyei, 2019).
In the last few years, many product demands have transformed. The main requirement for the production of packaging materials has become a constant supply, constant quality, and simple workmanship, one of the basic pillars of which is varnishing (Kovács, 2021). Varnishes have always played a protective role, from which they developed into individual solutions. Today, most varnishes still play a significant role in mechanical protection, but processes have emerged that open up new opportunities for printers and also increase demand for their products. If the consumer sees a surface that seems interesting during a purchase, they will involuntarily step in to feel it. Just because the consumer grabs the products, he already evaluates them better they are more likely to buy them (Spence, Gallace, 2011).
One of the leading trends today is the solution of highlighting logos or other important elements on products by treating the surface around them with matt lacquer so that the brightly left area becomes dominant. It is no coincidence that this technique has become popular, as the optical experience it provides has a really significant effect, directing the gaze to the right place the result will be clear but dynamic and special. In our opinion, the use of matt lacquer still has many possibilities. We have built our present research to explore these and apply innovative application techniques.

2. MATERIALS AND METHODS

2.1 Stain resistance

The requirements for matte varnish are high heat resistance and fingerprint resistance so that no traces remain on the surface treated with matt lacquer after touch. We launched developments for the latter, during which we developed and tested a special matte varnish. To achieve the desired effects, a mineral filler was used as the matting agent, the proportion of which was increased to 15% and thus the desired opacity and opacity value were achieved. The success of the development is indicated by the positive feedback from our partners, which was followed by a successful introduction in several areas. Our tests were performed in a Hungarian flexo printing house.

2.2 Surface patterning

The visual effect of segmental varnishing is becoming an increasingly desirable feature in the graphic industry. The initial usage of varnishing was to protect products. Today, almost every product, from commercial to personalized items, includes some type of varnishing (Hudika, Majnarić & Cigula, 2020). In terms of design, the varnish is applied to the majority of products to increase their value by enhancing their visibility or personalizing the product for a customer. Varnishing could be, to some extent, conducted with most printing techniques, including screen printing, flexography, standard offset printing, drip-off offset systems, and inkjet digital printing (Kipphan, 2001).

An important aspect is the level of gloss achieved on the matt lacquered surface after the matte varnish. One of the main elements of our research is to examine the range in which we can modify the gloss value of matte varnish even within a given print. This technique can allow different patterns to be displayed by changing the structure of the matte finish. In order to map the possibilities of matte varnishing, we need to examine the factors that can be used to influence the quality and quality of the varnish application.

Surface patterning is a relatively new feature in flexo printing plate production. There are many structures and some possibilities to achieve a structured surface on the print. It is possible to execute lacquering in a post-press, but it´s more effective to do it in one step as part of the printing process. For this reason, we need to find the solution for the best settings of the printing process, what type of printing plate, which structure, and which anilox roller should be used.

A surface structure can be created in two ways: either it is inherently in the plate or it´s software-created and engraved on the plate. The software solutions are continuously improving and can be controlled very precisely in a standardized production process. Most ripping technologies offer their own structures for surface patterning. For the aims of this research, we took the available surface screens from Esko. We used nineteen different surface structures to find out, which one works the best way in our printing process. Between the screens, there have been some micro groovy (MG) screens, microcells (MC) and some others. On the figure 1 there is shown the compiled design of the test plate, which was used in our testing process.

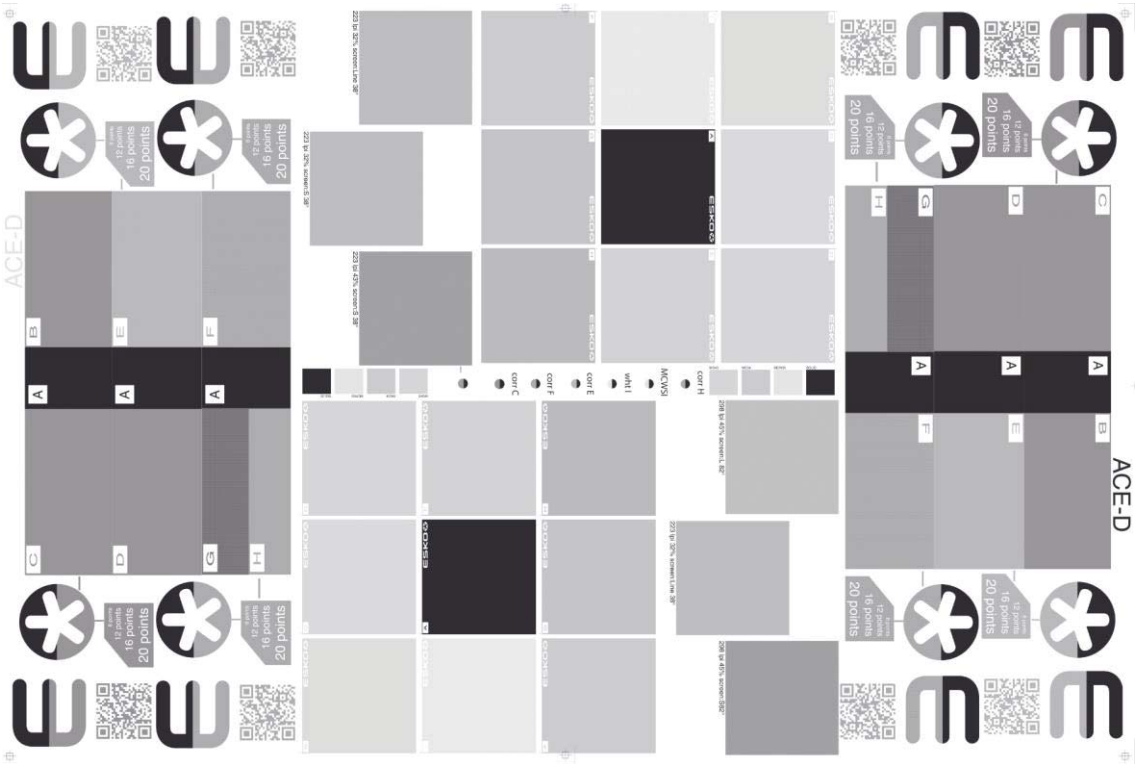

Figure 1: The applied test chart

On Figure 2 we are showing the magnified details of the surface patterning structures we used in the testing process for our research.

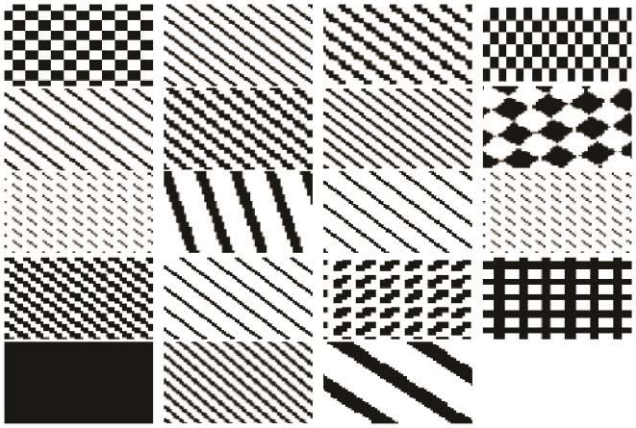

Figure 2: Applied surface patterns

2.3 Anilox rollers

The correct selection of an anilox roller is also a key factor to achieve the optimal ink coverage of a surface. It´s not the purpose to produce a print splashing in varnish (or ink), but to find the optimal balance between the plate and anilox for the specific ink or varnish. For the aims of our research, we used three types of anilox rollers with different ink volumes and screen line densities. Table 1 shows our anilox roller selection for the testing.

Table 1: Anilox rollers used in the testing process

	Screen line density (l/cm)	Ink volume (cm^3/m^2)
Anilox 1	360	5,5
Anilox 2	260	7
Anilox 3	200	10

2.4 Printing plates

The tests were performed using 3 different plate types. We took 2 plates from the Flint Group, digital variants of the nyloflex® ACE and nyloflex® ACT plates. The nyloflex® ACE Digital is a high durometer plate for the highest quality in printing of flexible packaging, labels, beverage packaging, and corrugated preprint. Its durometer is 78 Sh A. It should have a good ink transfer and provide smooth solids. The nyloflex® ACT Digital is a medium-hard plate, optimized for the printing of designs that combine halftones and solids in one plate. It has a hardness of 74 Sh A. Both plates are "standard" digital plates with no inherent flat-top dot system, but can be processed by hardware technologies to create flat-top dots. For our tests, the plates were processed on the DuPont™ Cyrel® DigiFlow technology, where flat top printing dots were created.

The third plate selected for the test was the MacDermid LUX ITP™ 60**.** This plate was the first to market with an inherently flat-top dot technology for flexographic photopolymer plates. It´s a hard durometer photopolymer plate with its 78 Sh A, where no additional platemaking steps or equipment are needed to take advantage of the flat-top dots provide.

After selecting the appropriate cliché and anilox rollers, the testing process began. Test printing was performed on a Soma Midi Flex 2 press on a 0.012 mm thick polyester substrate.

Measurements were performed with a Biuged BGD515/3 gloss meter. Furthermore, we visually examined plate surfaces and structural changes of matte varnished surfaces using a high-resolution microscope and Peret Flex Pro instruments.

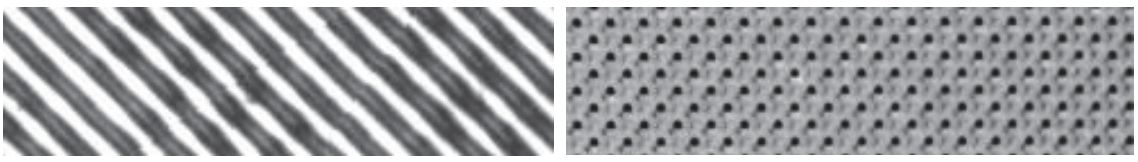

Figure 3: Magnified surface structure on the plate

3. RESULTS

We were the first to perform visual examinations using a high-resolution microscope and Peret Flex Pro. It is clear from the samples to what extent the structure of the location of the matting grains within a given varnished surface can be changed. In the second test cycle, the gloss values were measured in 19 different parts of the test chart.

Table 2: Measurement results for the 360 l/cm / 5.5 cm^3/m^2 anilox roller

Anilox 360L/cm /5.5 cm^3/m^2			
Sample	ITP-60	ACT-D	ACE-D
S1	32,7	40,7	36,5
S2	21,5	24,6	29,7
S3	32,7	27,3	32,8
S4	32,7	34,3	43,3
S5	28,1	33,2	46,3
S6	33,7	32,1	37,3
S7	33,5	35,4	38,2
S8	35,6	30,2	36,3
S9	57,6	54,3	71,8
S10	62,4	66,8	62,5
S11	33,8	35,9	38,6
S12	23,1	23,7	29,4
S13	32,3	29,2	38,3
S14	35,6	33,3	34,7
S15	39,2	35,5	49,3
S16	28,6	27,9	27,6
S17	34,3	41,8	49,8
S18	45,8	41,9	60,7
S19	63,8	46,5	68,1

Table 3: Measurement results for the 260 l/cm / 7 cm^3/m^2 anilox roller

Anilox 260L/cm /7 cm^3/m^2			
Sample	ITP-60	ACT-D	ACE-D
S1	35,3	29,6	33,5
S2	26,7	25,6	22,1
S3	32,9	29,4	33,8
S4	35,7	37,8	42,1
S5	39,8	35,1	42,4
S6	32,0	32,1	35,1
S7	36,2	45,2	32,7
S8	36,1	36,2	39,5
S9	69,3	69,5	71,1
S10	55,4	64,9	54,1
S11	26,1	37,8	33,4
S12	31,1	22,1	25,3
S13	27,7	28,3	30,1
S14	32,2	32,8	33,7
S15	32,5	36,6	56,2
S16	19,8	26,6	29,0
S17	41,2	44,5	59,8
S18	49,8	48,8	59,9
S19	43,8	49,3	66,0

Table 4: Measurement results for the 200 l/cm / 10 cm^3/m^2 anilox roller

Anilox 200L/cm /10 cm^3/m^2			
Sample	ITP-60	ACT-D	ACE-D
S1	16,3	12,8	15,1
S2	8,6	8,4	8,4
S3	8,9	8,6	9,8
S4	9,6	8,2	10,6
S5	10,5	7,3	9,2
S6	9,7	7,5	8,6
S7	13,7	12,4	18,7
S8	9,0	8,1	8,1
S9	47,4	19,8	63,1
S10	44,8	37,1	48,5
S11	16,1	17,1	19,8
S12	7,8	9,1	9,2
S13	7,7	8,2	9,4
S14	8,3	7,6	9,8
S15	10,6	9,5	10,5
S16	9,3	7,6	9,0
S17	13,1	10,4	14,0
S18	18,1	11,5	15,7
S19	18,2	10,6	17,3

4. DISCUSSION AND CONCLUSIONS

By selecting the appropriate anilox roller, the available gloss range can be defined well as it follows:

Table 6: Gloss range

Gloss range	Screen ruling (L/cm)	Ink volume (cm^3/m^2)
8-50	200	10
20-70	260	7
25-70	360	5.5

In all cases, the lowest gloss values were obtained with the Flint nyloflex® ACT plates, from which it can be concluded that the opacity of the lacquered surface can be increased by using softer printing plates.
By evaluating the results, we determined the range over which the gloss of the varnished surface can be changed using different cliché surface structures. Within a printed test sheet, the maximum brightness difference from a minimum of 8.4 to a maximum of 63.1 can be achieved using Anilox 3 (200 L / cm screen line density, 10 cm^3 / m^2 ink volume) and Flint ACE-D cliché.
Most matte surfaces were obtained by the surface patterns with the geometry shown in Figure 4.

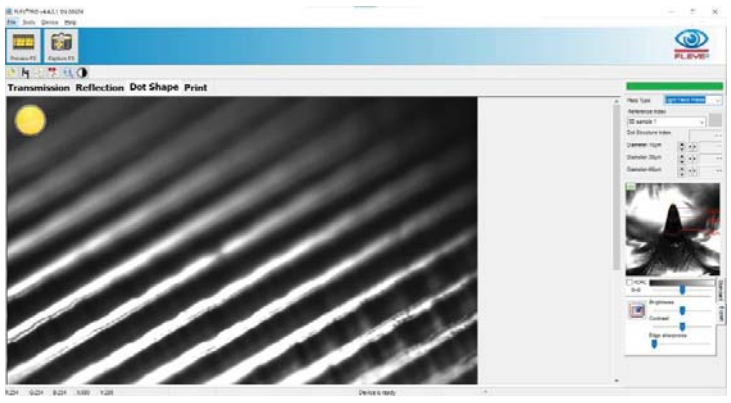

Figure 4: A surface pattern that formed the most matte surface

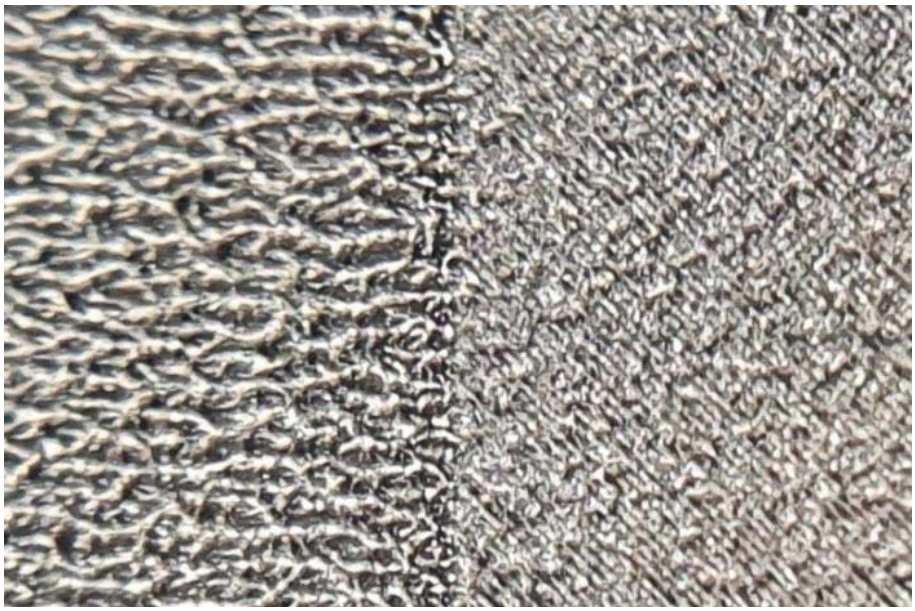

Figure 5: printed without a pattern (left) and with pattern (right)

It can be seen in Figure 3 that we were able to change the structural surface of the lacquered parts with the microcellular patterns, without printing on the left side, with a line pattern on the right side.
The above test results, as a segment of the potential of flexo printing technology, can have a significant economic impact in terms of efficiency and economy, thus contributing to the protection of our environment. In addition to minimizing the amount of varnish used, production can be optimized with the most suitable surface pattern and the most efficient varnish type to use. With the help of the test results, we got a more accurate picture of the brightness values of the type of varnish developed by us when using clichés with different surface patterns, thus allowing covering the widest possible range of applications.
Despite the crisis of the past two years the packaging industry and the the flexographic printing haven´t lost their dynamics ensuring the realization of many research and development projects. Between our future research plans is included further research, where we want to detect the appropriate screen ruling to achieve the minimal gloss values for our matte lacquering research project.

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