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ANALYSIS OF THE QUALITY OF UNPRINTED VARNISHED FOLDING BOXBOARD AND THAT ONE, PRINTED BY DIGITAL ELECTROPHOTOGRAPHIC TECHNOLOGY WITH THE USE OF DRY TONER

ANALIZA JAKOŚCI LAKIEROWANYCH TEKTUR PUDEŁKOWYCH NIEZADRUKOWANYCH ORAZ ZADRUKOWANYCH TECHNIKĄ CYFROWĄ ELEKTROFOTOGRAFICZNĄ Z TONEREM SUCHYM

ABSTRACT: In the present paper, the visual and touch-sensitive analysis of box cardboards with the refining layer in a form of varnish has been carried out. The experiment was conducted in cooperation with Konica Minolta company. Three different substrata without printing and the coated printed cardboard, using three different electrophotographic machines have been covered with varnish. Then, the visual effects and the obtained layer have been compared according to the thickness of the employed layer.
On the grounds of the conducted tests, it has been determined what the possibilities of varnish coating were, and what type of box cardboards was the best one in the process of varnish refining.
Key words: digital printing of packaging, refining of packaging, ink-jet UV varnishing, ecological printing

STRESZCZENIE: W ramach niniejszego artykułu, dokonano oceny wizualnej oraz dotykowej tektur pudełkowych z warstwą uszlachetnienia w postaci lakieru. Badanie zostało przeprowadzone we współpracy z firmą Konica Minolta. Zalakierowane zostały trzy różne podłoża bez zadruku oraz tektura powlekana zadrukowana przy wykorzystaniu trzech różnych maszyn elektrofotograficznych. Następnie porównano efekty wizualne i uzyskaną warstwę lakieru w zależności od grubości warstwy, jaka została nałożona.
Na podstawie przeprowadzonych badań określono, jakie są możliwości lakierowania, a także który rodzaj tektur pudełkowych najlepiej się sprawdza w procesie uszlachetniania lakierem.
Słowa kluczowe: drukowanie cyfrowe opakowań, uszlachetnianie opakowań, lakierowanie ink-jet UV, drukowanie ekologiczne

1. INTRODUCTION

In the period of decreasing volume of printed materials and the possibility of obtaining digital prints of a very good quality, the producers of packaging decide, more and more frequently, to utilize digital electrophotographic or spray devices in the implementation of their orders. They apply also successfully refining, e.g. in a form of varnishing, what increases the colour depth of prints and, by this, affects positively the aesthetic impressions of the customers. At present, it is difficult to distinguish which packaging has been printed by classical technology (e.g. offset) and which was made with the application of digital technology. It has a great meaning for printing house, possessing – more and more often – digital machines which solve the problem of "disintegrated" orders (i.e. the increased

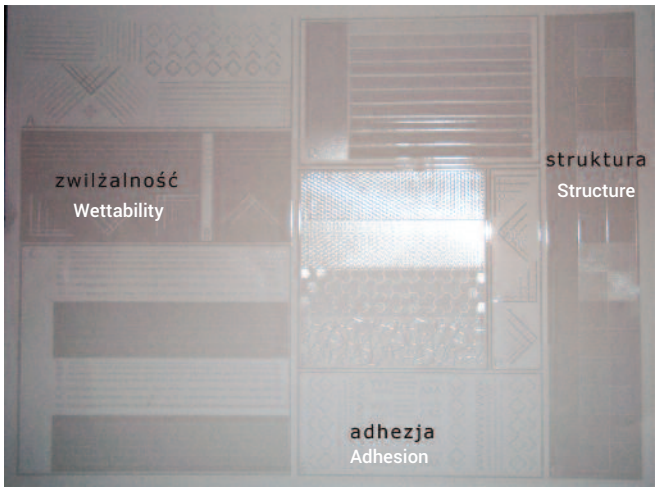

FIG.1. TEMPLATE OF APPLYING A LAYER OF VARNISH

SOURCE: THE SAMPLE PERFORMED IN PAINTING FACILITY OF KONICA MINOLTA COMPANY

number of orders but usually of a small volume). Moreover, digital printing is more ecological than the offset because it generates much less waste. Today, the ecology is also the important problem for all packaging producers [1].

PARAMETERS OF VARNISHING PROCESS

When performing the test printing with the applied layer of varnish, the template released by Konica Minolta company was used; it is employed for checking of the quality of the product with the applied varnish layer. When analysing the quality of the varnished box cardboard, the attention was paid to adhesion, that is, capacity to surface linking of varnish and substratum particles and, also, to absorption, that is, how the substratum absorbs the laid varnish. The wettability, i.e. capacity of varnish to cover the prints completely was also examined. To be possible, the surface tension of varnish must be lower than the surface tension of substratum and paint.

Figure 1 shows a fragment of template from which the properties of the samples were read out.

Parameters of machines used for performance of the samples

To apply a layer of varnish, the machine by Konica Minolta MGI JETVARNISH 3D One, was employed. It is used for a selective application of varnish on paper or cardboard. It is an ink-jet UV varnishing technology and the thickness of the applied layer was equal to 21 micrometers.

In Table 1, the parameters of machine have been presented.

AccurioPress c1200 machine is a digital device by Konica Minolta company. It has been used for printing of apla (uniform colour plane) with components of CMYK colour.

Table 2 shows the parameters of the machine.

Xerox 770 Digital Color Press machine is a digital colour device by Xerox company. It was employed in printing of apla with the components of CMYK colour.

In table 3, the parameters of the mentioned machine have been presented.

TABLE.1. SPECIFICATION OF VANISHING MACHINE

Printing technology	Technology of ink printing MGI; Technology Drop-on-Demand (DoD); Piezoelectric printing heads of Konica Minolta company One run printing; Flexible and scalable architecture of print;
Coat thickness	Coat thickness is dependent on surface of substratum and paint; On laminated coats and those based on water solutions: 21µm – 116 µm For effects of convex texture 3D at finish making the touching impressions; On toner and paper or coated cardboard: 30 µm – 116 µm For effects of convex texture 3D at finish making the touching impressions;
Production yield	in mode 2D/flat: up to 2077 sheets A3 per hour (21 µm); in mode 3D/raised up: up to 1260 sheets A3 per hour (51 µm); up to 547 sheets A3 per hour (116 microns);

Fitting	SmartScanner in combination with the solution of Artificial Intelligence (AIS) ensures completely automated system of fitting between the sheets at a real time
Formats	min. 210 x 297 mm; max. 364 x 760 mm; max. width of print 353 mm;
Substratum thickness	min.: 135 g/m² and not less than 150 µm or 6 mm before printing and lamination max.: 450 g/m² and not less than 450 µm or 18 mm before printing and lamination engine-driven regulation of the height of printing heads;
Substrata*	Printing on the majority of laminated matt and glossy surfaces, with the coat, based on water solution or without it; on cardboard, plastics, PVC and other coated materials;
Varnish on toner	Spot coating 3D directly on the most of digital prints without the need of laminating and coating;
UV coats and volume	Varnish is supplied from the container of 10-litre volume;
Automatic high-volume feeder	Feeder supporting piles of sheets of the height up to 30 cm; 2500 sheets with grammage of 135 g/m²;
Exit tray	Feeder supporting the pile of sheets up to 15 cm or ca. 1250 paper sheets with grammage of 135 g/m² and all formats of paper from A4 to 36.4 x 75 cm
Paper path	Paper path flat in 100%; Vacuum paper feeding system; Pneumatic feeding system; Automatic detection of double sheets; In-line LED dryer; Immediate drying and preservation during operation with the application of integrated LED lamps
Maintenance and remote technical support	Daily maintenance takes less than 10 minutes; Procedures are mostly automated; automatic cleaning system; From cold start-up to production during less than 15 minutes; Remote troubleshooting and support via internet camera (quick internet link is required)
Control panel	Integrated and user-friendly touch LED screen
Balance	± 1200 kg
Electric parameters	V: 220-240V 50-60Hz; A: 20; plug: 2 plugs CEE 17 IP44 32A (32A 250V, 1P+N+PE); RCD 30 mA; Switch-off 32A curve C
Working temperature	18 to 30°C; Relative environment humidity: 30-55% (without condensation);
Respect for the environment	Eliminates wastage of resources (electric energy, paper and varnish); Without films (offset) and screens (screen printing); Extreme reduction of the quantity of operating materials and utilization of bulk packaging; coating without volatile solvents
Options	Automatic converter of PDF files; Lighting AIS SmartScanner for metallised substrata

SOURCE: HTTPS://WWW.KONICAMINOLTA.PL/PL-PL/URZADZENIA/USZLACHETNIANIE/MGI-JETVARNISH-3D-ONE [2]

PACKAGING REVIEW 2/2024

TAB.2. TECHNICAL DATA OF DIGITAL MACHINE OF KONICA MINOLTA

Printing resolution	2400x3600 dpi x 8 bits
Format of sheet	Up to 1300 mm in two-side mode 900 mm
Speed of printing A4	120 pages/minute
Speed of printing A3	69 pages/minute

SOURCE: HTTPS://WWW.KONICAMINOLTA.PL/PL-PL/URZADZENIA/DRUK-PRODUKCYJNY/ACCURIOPRESS-C12000 [3]

TAB.3. TECHNICAL PARAMETERS OF DIGITAL MACHINE BY XEROX COMPANY

Printing resolution	2400 x 2400 dpi x 8 bits
Maximum format of sheet	330 x 480 mm
Minimum format of sheet	140 x 182 mm
Speed of printing	55-75 pages/minute

SOURCE: HTTPS://COPERONSALE.COM/WP-CONTENT/UPLOADS/BROCHURES/XEROX-770-DIGITAL-COLOR-PRESS-BROCHURE.PDF [4]

TAB.4. TECHNICAL DATA OF DIGITAL MACHINE BY CANON COMPANY

Printing resolution	2400 x 2400 dpi
Maximum format of sheet	330 x 1300 mm
Minimum format of sheet	182 x 182 mm
Speed of printing A4	90 pages/minute

SOURCE: HTTPS://PROXER.PL/OFERTA-DRUK/CANOC-IMAGEPRESS-C9010VP/ [5]

FIG.2. LAYER OF VARNISH ON NON-COATED BOX CARDBOARD

SOURCE: OWN PHOTO

FIG.3. WETTABILITY

SOURCE: OWN PHOTO

ImagePress C9010VP machine is a digital equipment of Canon company. It was used for printing of apla with the components of CMYK colour.

In table 4, the parameters of the mentioned device have been given.

VARNISHING OF NON-PRINTED SUBSTRATA

Initially, varnishing was performed on 3 different unprinted substrata; in the discussed study, the following box cardboards were employed: coated, non-coated and laminated soft touch materials. It was examined how varnish soaked in different substrata and visual assessment of the produced prints was carried out.

The non-coated cardboard has no additional coat which makes that the product is more stable and had no effect of gloss. Figures 2 – 4 represent the sample with a layer of varnish on uncoated box cardboard.

We may observe that the payer of varnish on the non-coated cardboard is least perceptible. When touching the surface, we feel the smallest difference between the substratum with varnish layer and that one without it. As far as visibility of the structure with different shapes is concerned, it is well visible for each element, even the smallest one. Depending on the type of the structure, varnish is less or more sensible in touch (palpable), however it is still in minimal degree.

In Fig 3, we may see a fragment where the wettability is read out. At value below 5 pixels, the lines become thinner and less distinct and at value of 1 pixel, they are invisible. It is evidence

FIG.4. PERCENTAGE COVERAGE WITH VARNISH

SOURCE: THE SAMPLE PERFORMED IN VARNISHING MACHINE BY KONICA MINOLTA

FIG.6. VARNISH LAYER ON UNCOATED PAPER

SOURCE: OWN PHOTO

that the application of layers with such small resolution is not possible on uncoated cardboard.

Figure 4 represents percentage coverage with a layer of varnish. It is commenced at 10% from the top and is ended at 100% in the bottom of the photo. In the case of 10% coverage, varnish is impalpable and practically invisible. Together with the increase in the percentage coverage, its tangibility by touch is increased. In the case of other substrata, the mentioned palpability is smaller, even at 100%. As far as the visibility is concerned when we look at the print, we do not perceive the layer of varnish until it is placed under the light; then we may see the presence of the discussed layer. It becomes well visible at coverage higher than 70%.

Figure 5 shows a fragment of layer with the text at the top: the text is covered with varnish; at the bottom, the surface around has been also coated with varnish. In the case of varnishing only the letters, even the smallest letters (size equal to 4 points) can be seen exactly and clearly. The image is readable and transparent. As far as surface is concerned, where the area around the letters was also coated with varnish, the visibility is good only for the letters of the size of 8 points and more. Below the mentioned size, the test becomes blurred, is less distinct and visible; in the case of 4 points, it is unreadable.

The coated paper is a type of paper with the additional coating which increases its aesthetic values, gives a smooth finish and reduces absorbance of printing ink. Figures 18-21 illustrate the sample with the layer of varnish applied on the mentioned paper.

In the case of coated box cardboard, varnish is visible on each layer and well palpable. We may feel the difference between the layer where varnish was applied and the site where it is absent. As far as the structure is concerned, it is exactly visible

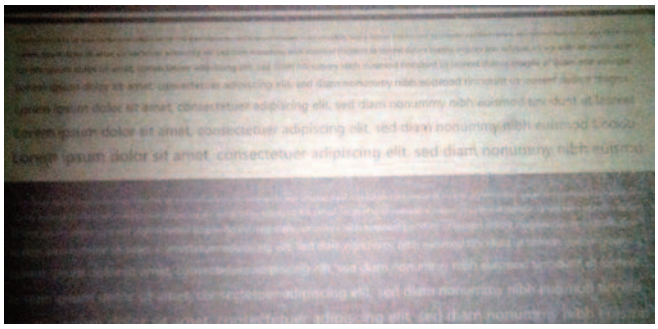

FIG.5. FRAGMENT WITH THE VARNISHED TEXT

SOURCE: OWN PHOTO

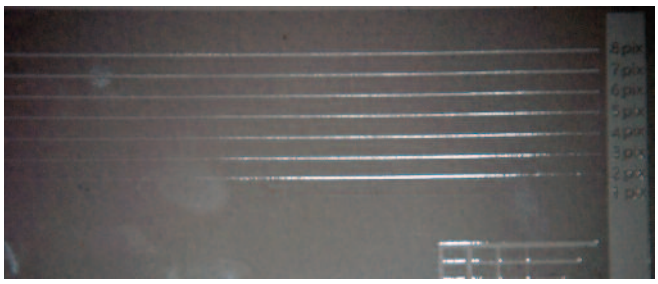

FIG.7. VISIBILITY OF POINTS DEPENDING ON THE RESOLUTION

SOURCE: OWN PHOTO

FIG.8. PERCENTAGE COVERAGE WITH VARNISH

SOURCE: OWN PHOTO

for all elements: the smooth ones and those with different, even the smallest designs. When touching them, we may distinctly feel the completely varnished, smooth surface and that one where the texture has a design (pattern). The irregular, rugged elements may be palpable.

FIG.10. VARNISH LAYER ON LAMINATED SOFT TOUCH CARDBOARD

SOURCE: OWN PHOTO

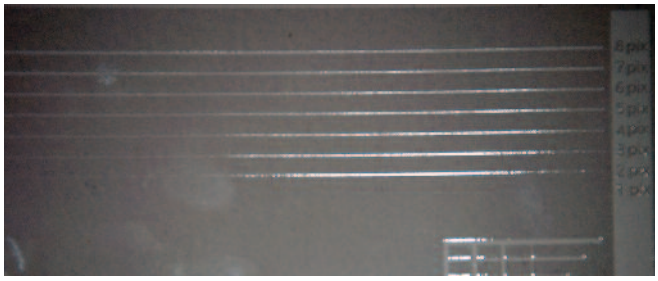

FIG.11. WETTABILITY

SOURCE: OWN PHOTO

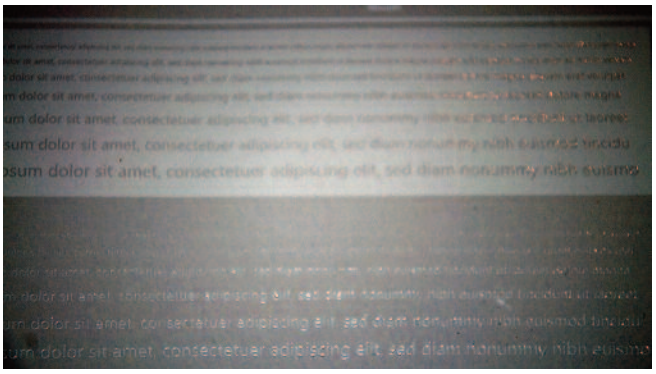

FIG.9. FRAGMENT WITH THE VARNISHED TEXT

SOURCE: OWN PHOTO

In a part of the segment, we may perceive the surface where the wettability is read out. The lines are visible up to the details with resolution of 2 pixels. The line of 1 pixel size stops to be visible. In the case of coated paper, the application of the layer with such small resolution is also not possible.

Together with the increase of the percentage coverage, the detection of varnish in touch of the surface is increased. On the areas with 10-30% coverage, varnish is invisible and the lighted elements have the non-uniform gloss. In the case of 40% coverage, we may see delicate scratches. Above 40% coverage, after each repeated application, the surface becomes smoother and at 100%, we may see the transparent tile.

In the case of the coated cardboard with the surface with varnish layer, all inscriptions are exactly and clearly visible only in letters, even those of the 4-point size. In the situation when the area around the inscriptions was also varnished, the visibility is weak. We can read the text of the size equal to 10 points but each smaller one is possible to read only when using a magnifying glass. For the letter of the size below 6 points, the read out, even with the magnification, is not possible. The inscriptions are unclear, as if the surface was spilled out.

The laminated sort touch cardboard was the last employed substratum. It is a substratum with the layer of laminated film soft touch (it is a matt foil) which makes that the cardboard becomes soft and delicate in touch. Figures 10-13 illustrate the substratum with the varnish layer.

In the case of coated cardboard, we do not feel greater difference in touch. The layer of varnish is well visible. The

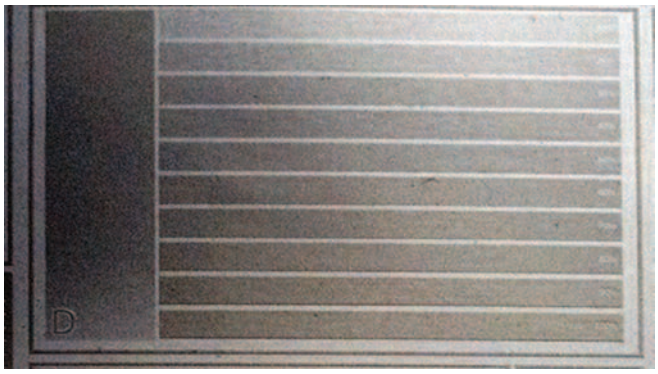

FIG.12. PERCENTAGE COVERAGE WITH VARNISH

SOURCE: OWN PHOTO

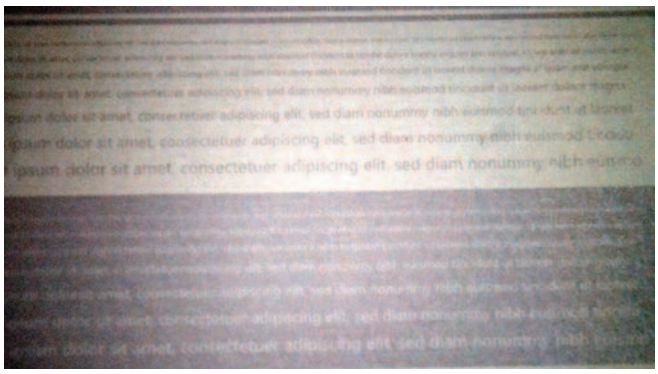

FIG.13. FRAGMENT WITH THE VARNISHED TEXT

SOURCE: OWN PHOTO

structure of the elements with irregular surface is also distinctly sensible in touch. However, in the places where the patterns with very small lines were employed, we have to look carefully at them in order to perceive the exact appearance of the surface. In the case of the mentioned substratum, the wettability is the best. We may see exactly all lines. Also, the line of 1 pixel resolution is visible.

In the case of box cardboard of soft touch type, the sensibility of varnish is increasing together with the increase of the percentage coverage of the surface. However, as early as at 10-% coverage, the layer is smooth and transparent.

The letters in size of 5-10 points are visible in the fragment where varnish was applied only on them. The text of 4-point size blends and it is not possible to read it out.

In the case of text where the layer of varnish was applied also around it, we may read the text at the size of letters equal to 8-10 points. We need, however, look at it carefully as the light is reflected from the layer and the text is spilled out.

SUMMING UP

The photos do not reflect precisely what may be seen in a direct contact with the samples. They were employed in order

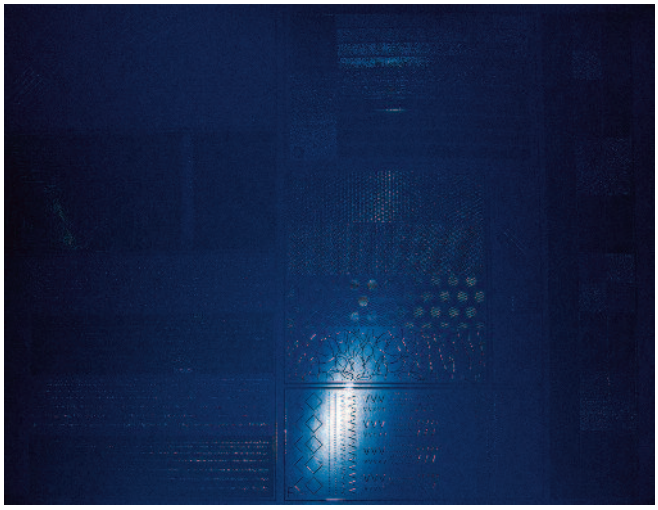

FIG.14. PHOTO OF THE SAMPLE WITH APLA IN CYAN COLOUR AND LAYER OF VARNISH

SOURCE: OWN PHOTO

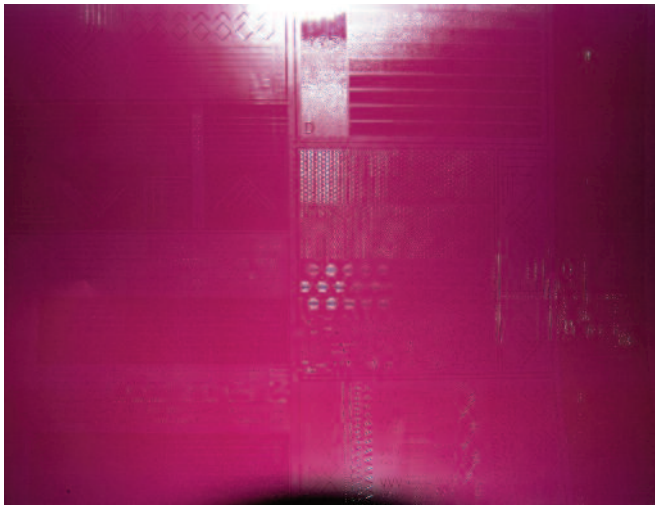

FIG.15. PHOTO OF THE SAMPLE WITH APLA IN MAGENTA COLOUR AND LAYER OF VARNISH

SOURCE: OWN PHOTO

to illustrate how the fields for reading out of different parameters of the samples look like.

In respect of adhesion, all box cardboards have a good ability to enter into combination with paper. The most optimal choice includes the choice of coated cardboard. We obtain then a good and clear structure but we may also successfully varnish the text without risk that it will become illegible. Good surface coverage is already visible at 40%.

SUBSTRATA WITH THE PRINTED CMYK LAYER AND VARNISH APPLIED SELECTIVELY

The test consisted in applying the layer of varnish on prints coming from digital machines by Konica Minolta, Canon and Xerox. On each machine, the printing of the complete apla was performed and the percentage composition was as follows:

C 25% M 25% Y 25% K 100%

C 0% M 0% Y 100% K 0%

C 0% M 100% Y 0% K 0%

C 100% M 0% Y 0% K 0%

Then, the layer of varnish was applied on earlier printed surface. Fig.14-17 represent the photos of the samples from 3 different machines.

In the present paper, the photographs of the samples with the best presentation of the effect obtained after varnishing on the surface of colour-printed substratum, have been demonstrated. The mentioned photographs do not however reflect the real appearance of the samples. They were printed with the layer of varnish of 21 μm thick (it is the optimum layer of varnish applied on the substratum of this type). After the analysis of the research material, it may be stated that after applying of the varnish layer on coated cardboard which is printed, the visibility of the image is the worst. Varnish spreads out the most.

In touch, each sample is identical. The structure of different applied layers is also the same for each colour and from each machine. As far as the visibility of details is concerned, they are best visible in aplas with cyan and black colour. It is most difficult to perceive the details on the samples printed with yellow colour.

We may see the differences in percentage coverage depending on the printing machine. The prints coming from equipment of Canon and Xerox have a smooth surface already at 70% whereas for prints deriving from Konica Minolta machine, the smooth surface is visible as late as in the vicinity of 90% coverage of the surface. It should be mentioned that Canon and Xerox machines are used in manufacturing conditions whereas Konica Minolta equipment is a basic machine, being used only sporadically.

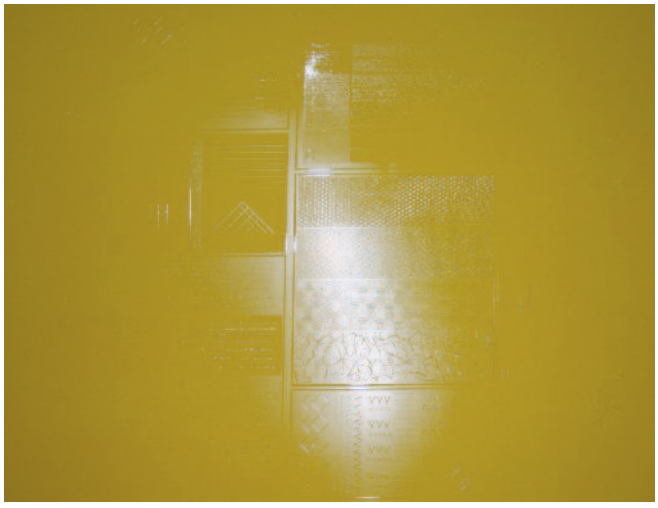

FIG.16. PHOTO OF THE SAMPLE WITH APLA IN MAGENTA COLOUR AND LAYER OF VARNISH

SOURCE: OWN PHOTO

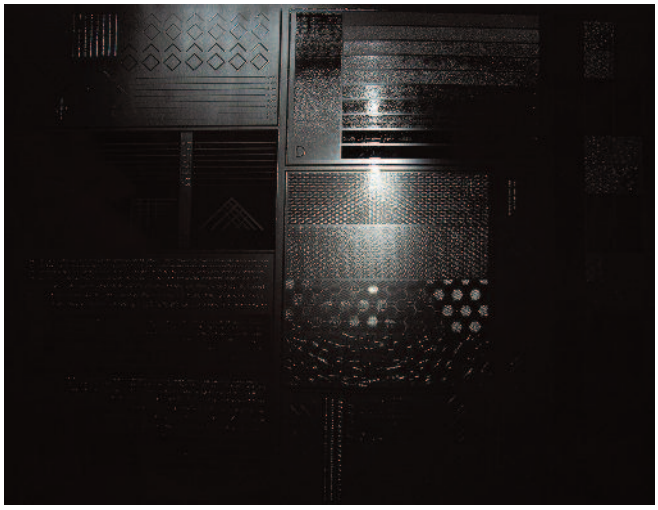

FIG.17. PHOTO OF THE SAMPLE WITH APLA IN MAGENTA COLOUR AND LAYER OF VARNISH

SOURCE: OWN PHOTO

As compared to unprinted coated paper, the difference in wettability is visible; on the paper without print, the spot with the resolution of 1 pixel was not visible and on the samples covered with the ink, it was distinct and readable.

It should be added that the photos made for work purposes were performed with the use of the same camera, at the same settings, from the same perspective and at the same light. In spite of this fact, the way of reflecting the light depending on the colour and type of the employed machine was different. It could be caused by the fact that each machine has toners with somewhat different composition so they could reflect the light in a different way.

FINAL CONCLUSIONS

Machine, with the use of which varnishing was carried out, contains piezoelectric heads with DoD system (drop on demand), which sprinkles the surface what facilitates spot application of varnish. The employed solution enables application of thicker layer of varnish what allows obtaining convex and 3D effect. In effect, we may obtain more interesting sensible and visual impressions.

In the present research tests, the layer of varnish of 21 μm was applied. It is the thickness employed in order to obtain 3D effect; the thicker layer should be even applied. The smallest details would be then visible and different structures would be sensible. In the case of non-coated cardboard, to obtain the result similar as on the coated substratum, we should increase the thickness of the varnish layer so as remain its greater part of the substratum surface and not allow its soaking into the mentioned substratum. It does not however guarantee the success as the non-coated cardboards are not intended for prints with the refining layer due to the differences in surface tension between substratum and varnish. In the case of soft touch cardboard where the touch effects were well sensible, but the visibility was the worst one, it should be necessary to use thinner layer of varnish; then, the visibility would be smaller but the chance that the visibility might be improved could take place and the effect of spreading out would not exist.

Printing of coated substratum with colour made that the spots with 1 pixel resolution which were not visible on the coated unprinted paper became visible. On the mentioned prints, varnish was most spreading out and the visibility was limited. We should, however, pay attention that they were the samples where a specified colour was applied in 100% on one of them. During the implementation of the discussed order of the customers, it rather will not occur that it will be necessary to use one componential colour on the total surface and cover it with varnish. Mixing of the colour and post application could improve visibility. We should however remember about the correct choice of the thickness of varnish and analyse how great the varnished surface should be as to give the best result. When varnishing the fragments such as letters or unprinted surface, the texture of which we intend to change (owing to varnish), we may obtain interesting effects which will affect the visual impressions of the consumer [6, 7].

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