pdp CONVENTION

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Međunarodni studentski kongres iz oblasti grafičkih tehnologija/ International student congress of graphic technologies

pdp CONVENTION

Zbornik radova/ Proceedings

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International students congress of graphic technologies “PDP Convention 3”

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Uvodna reč

„Kada vetar počne da duva, ili razapni jedra ili pravi sklonište“, kaže stara narodna poslovica.

I ove godine PDP convention razape svoja jedra ...

PDP convention okrenut grafičkim tehnologijama,

PDP convention okrenut kreativnoj misli,

PDP convention okrenut budućnosti,

PDP convention okrenut tebi .

Kongres kao ni prethodnih godina, ni ove godine se nije oslanjao na univerzalni moto, na univerzalnu temu, nego dopušta svakom predavaču, izlagaču, slušaocu, posmatraču, da posegne za onim bitnim i ključnim momentima i odvoji samo njemu znan trenutak i sačuva ga. Isprepleten edukativnim predavanjima svetski poznatih umetnika i grafičkih radnika, konstruktivnim i nadasve konkurentnim konkursima, graciozno izvedenom izložbom studentskih radova, propraćen tehničkim dostignućima iz polja štamparstva mnogih domaćih i stranih kompanija, PDP convention pruža veliki broj mogućnosti, i postoji kako bi misao i znanje svog vremena preneo putem posrednika (stručnih predavača i studentskih radova) zainteresovanom mladom čoveku.

U tekućoj godini, u kojoj su velike manifestacije imale problema u obezbedjivanju postojanja na Univerzitetu u Novom Sadu, grupa studenata treću godinu za redom je uspela, pored velike finansijske krize, da svojim kolegama na Fakultetu tehničkih nauka upriliči manifestaciju dostojnu svetskih standarda.

Tokom tri godine PDP convention je uspeo da od malog studentskog projekta izraste u prepoznatljiv brend koji se i van granica naše zemlje ceni i uvažava. Ovaj brend cene ne samo slobodni umetnici, nego i akademske institucije, koje iz godine u godinu šalju svoje studente, kako bi i oni bili deo inovativnog umetničkog i tehnološkog talasa, kakav je PDP convention.

Veliku zahvalnost dugujemo svim kompanijama koje su nas ove godine podržale, i koje su našle za shodno da deo svojih sredstava ulože u nas. Pored institucija iz privrednog sektora, sa velikim zadovoljstvom napominjem da su nas bezrezervno potpomogli, kako Fakultet tehničkih nauka, na čelu sa prof. Dr Ilijom Ćosićem, dekanom fakulteta, tako i departman za Grafičko inženjerstvo i dizajn-Fakulteta tehničkih nauka, na čelu sa prof. Dr Dragoljubom Novakovićem.

Kompletan organizacioni tim PDP convention, koga čine mladi i perspektivni ljudi, iza sebe ima veliki broj napisanih projekata, odslušanih seminara, dizajnerskih i multimedijalnih poduhvata koji i u trenucima neadekvatne finansijske situacije bez velikih poteškoća svoje ideje najkreativnije moguće rešavaju.

Na kraju mogu sa ponosom reći da iza projekta PDP convention stoje studenti, koji provedeno vreme u realizaciji istog posvećuju ne samo sebi i svojoj afirmaciji, već i boljem sutra u grafičkoj struci.

Iza velikih dela stoje veliki ljudi!

Boris Petrović - *Generalni menadžer PDP convention*

Introduction

„When the wind starts to blow either set your sails or take a shelter” ...

This year too PDP convention is sailing...

PDP convention is dedicated to graphic technologies. PDP convention is dedicated to creative thought. PDP convention is dedicated to future. PDP convention is dedicated to you.

This year as well, the convention doesn’t lean solely on one subject but rather it allows lecturers, exhibitors and observers to follow their own direction in the given themes. PDP convention is a place of possibilities where wordly acknowledged professionals and experts give lectures, where students have the opportunity to exhibit their work and where visitors have the opportunity to see the meeting point of printing, design and photography.

During the last three years PDP convention managed to grow in every sense and managed to become a famous brand known internationally. PDP convention, as innovative artistic and technological wave, is respected by both free artists and academic institutions.

Of course, we owe our gratitude to all companies that supported us and invested in PDP convention.

KBA modling - Serbia, MCA d.o.o. - Slovenia, Grafoprodukt - Serbia, Merus - Serbia, MASEL group - Serbia and EXIT festival.

Aside from these companies we wish to thank the Faculty of technical sciences, the faculty’s dean, Mr. Ilija Cosic and the department of Graphic engineering and design, lead by Mr. Dragoljub Novakovic.

PDP convention team is comprised of young people who managed to creatively rise above the current economic situation thanks to their accumulated knowledge and skills.

Finally and with pride I can say that PDP convention was carved, nurtured and carried out by students.

Great people stand behind great projects!

Boris Petrović - *PDP convention general manager*

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DIFFERENCES IN COLOUR APPEARANCE BETWEEN THE PRINT AND MONITOR PROOF

Student: Ana Agić; Doc.dr.sc. Lidija Mandić
Faculty of Graphic Arts, Zagreb

Summary
Displaying colours is different on various devices and on different media. The goal of this scientific was to determine distinction between colour appearence on a printed sample, and the colour displayed on the screen. Testing a target with 20 different uniform samples (patches) , which were printed, and then scanned. Further on, visual equalisation of patches on screen with the ones that were previously printed was performed. After equalising colours, testing samples were printed again. By means of a spectralphotometric measurments colour labelled patches on both prints, and their computed colorimetric differences were made. Difference in colour display on printed samples and on screen were not the same for all colours. Highest differential values were for yellow colour, light brown colour and for navy green colour .One can conclude that during colour reproduction it is necessary to pay more attenttion onto that colour reproductions.
Key words: spectrophotometric measurement, colour reproduction, colour appearance.

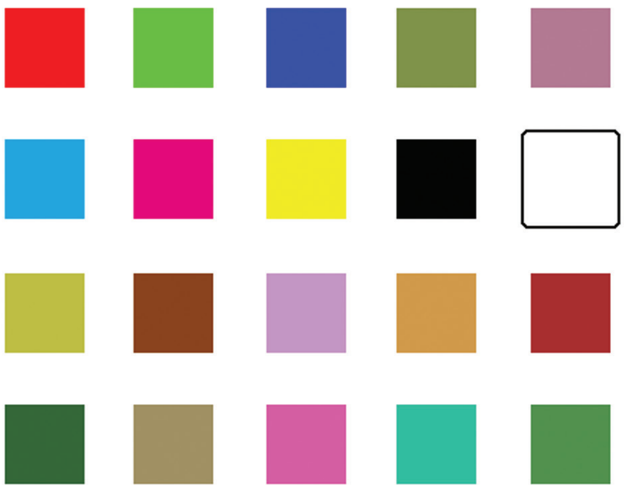
1. INTRODUCTION

Every day people in graphic industry, and more often, people who are not specialized enough, encounter with some image processing method and it's reproduction, which is why it is important to prepare and set sample, picture or template on a proper and specific way for further reproduction. That is important considering the fact that there are missalignments and variances in colour reproduction on screen itself, which may not be callibrated, or possibilities of displaying sample after screening or printing, because final product must not deviate or differ from the original sample.

2. ANALYSIS AND ELABORATION OF TESTING SAMPLE

In graphic industry for printing processes and needs a model of suptractive synthesis and screening system is used. Suptractive synthesis is based on fact that colours mixed give final product, wich is impression of black colour, and opposite of that system there is aditive synthesis RGB, used on screens.

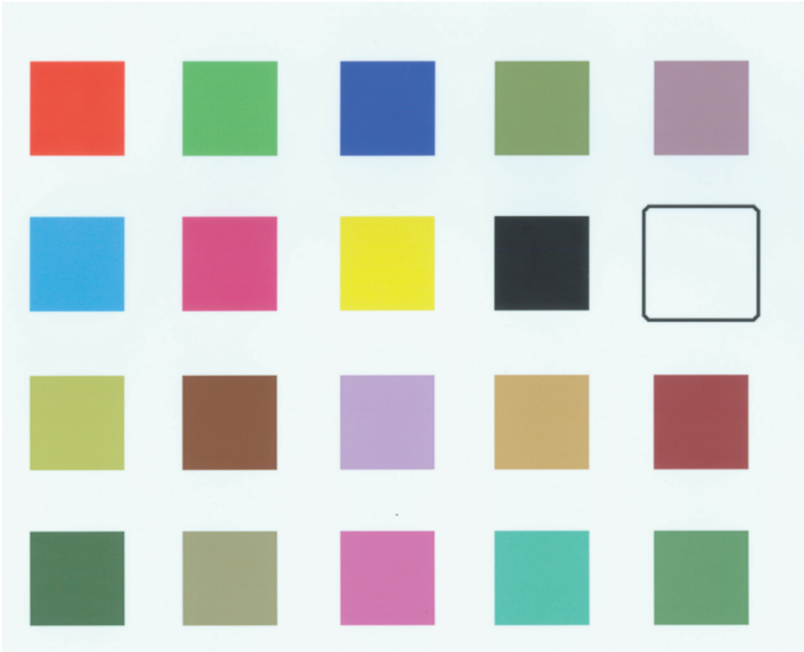
For beginning of measurments the difference in colour reproduction on testing sample, an original was made, on iMAC os X 10.4 monitor (which was previously genericly calibratet), in Photoshop CS3. Original contains of 20 various colours (patches) among which are also basic colours of aditive synthesis (red, green, blue) and suptractive synthesis (cyan, magenta, yellow), as most important colors in printing technologies. Beside them, some other interesting colors for reproduction were prepared, such as brown, pink, greenish etc.



Picture 1. The arrangement of colours in prepared original

After preparing the testing sample, we printed it on Epson Stylus pro 3800 printer with appropriate ICC profile.

Reproduction was scanned on Micro- tek scan maker 8700 scanner, also with appropriate input profile.



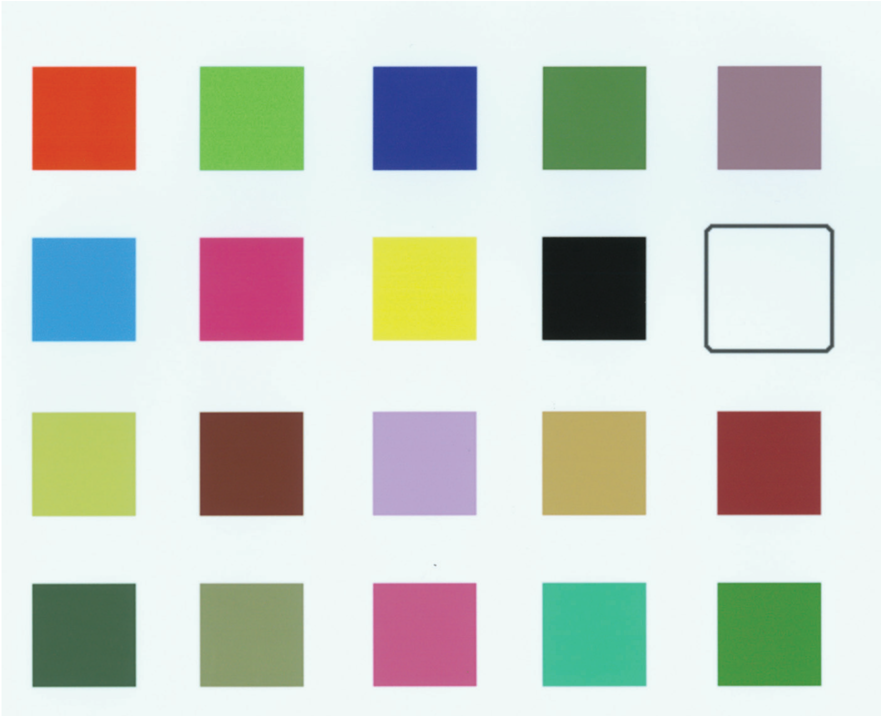
Picture 2. Scanned testing sample

Scanned testing sample (print) we used in visual analysis. To a group of students we gave task to equalize colours on screen (original testing sample) with colours on printed sample.

After they have equalised colour appearance, we printed testing sample again on Epson stylus pro 3800 printer, on same paper, and using the same profile.

Testing samples were measured by using calibrated spectofotometer. Spectofotometer *GretagMacbeth i1* and measuring software was *Colorshop x.*

Measuring sistem was D50, 2°, profile S RGB- EFI, colour temperature 5000 K.



picture 3. Analysed testing sample

3. MEASURING METHODS AND RESULTS

Colorimetrical differences are prescibed in CIE $L^*a^*b^*$ colour specifications. Colorimetrical difference is capacious (spacial) distance between 2 colours, which represent coulors in given coulor space. Values have been measured on two samples:

1. printed original testing sample .
2. tone equalised reproduction.

Following measurments were made:

sample

	A	B	C	D	E
1	14.28	4.62	12.87	12.62	12.94
2	9.67	15.52	23.48	11.06	4.7
3	12.44	0.9	13.90	18.02	14.40
4	14.29	9.06	15.16	4.10	8.90

Table 1. Colour value variations of printed original and scanned (tone-equalised) reproduction

From measured values of colour difference ΔE, obvious is that on our 20 compared colour samples are few large variations in achived values. Only patches which had shown difference in appearance less than 1 is dark brown B3 colour patch (value 0.9), after this one followes green patch B1 (ΔE 4.6), and white field E2 (ΔE 4.7).

Other coloured patches had shown variances greater than ΔE 6, which is considered to be acceptance limit. Greatest difference had showm following fields: yellow patch C2 (ΔE 23.48) and light brown patch D3 (ΔE 18.02).

Regardless of both, scanner and printer profiles, again it's noticable colour deviation described above.

Picture 4. Measuring device (spectrophotometer)

4. CONCLUSION

After measuring testing sample colours on printed original and on scanned and printed reproduction one can conclude that corelations between reproduced samples are greater at specific colours and at some colours less great which tells us abuot fact that we need, when reproducing samples concider model and system of reproduction, also and devices used during process because of missalignment of colours. At some colour patches the correction was sucsessful e.g for dark brown colour. At white colour patch colour changed due to scanning process and profile appliance. Greater changes occured with yellow patch (ΔE 23.48), light brown (ΔE 18.02), and magenta (ΔE 15.52) patch where difference in colour reproduction of testing samples were unacceptable, and all colour changes confirm the aim of this study, that alteration between colours did occure.

LITERATURE AND USED DEVICES

1. Fraser, B.: *Color management*, Peachipt Press; 51-79.
2. Häuser, F.: *Die Entstehung des Farbeindrucks bei der autotypischen Farbmischung*, Polygraph Verlag- Frankfurt am Main, 33-34.
3. Scanner - MICRO TEK SCAN MAKER 8700
4. Printer - EPSON STYLUS PRO 3800
5. Spektrofotometer - GRETAGMACBETH i1
6. Measuring software - X-rite COLORSHOP X
7. Hardware - MAC PLATFORM

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THE INFLUENCE OF PRINTING RESOLUTION ON SPECIFIC TONE VALUES PRINTED WITH UV CURING INKJET

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Summary

*The Roland printing UV machine recently acquired by the Faculty of Graphic Arts in Zagreb is the example of continuing development of the digital printing technology. The printing machine uses inks that dry by UV light. Research is needed to fully understand the process and advantages and limitations of an UV drying machine. This paper covers different aspects of the process. Samples printed on three different printing resolutions were analyzed in order to observe their differences. This was done by analyzing their gamut, measuring their L*a*b* values and comparing them to ISO offset, examining them with image analysis apparatus and by comparing their reflectance rate. The results that, when increasing the printing resolution, the droplet size of the ink decreases and that the number of droplets increase.*
Keywords: UV InkJet, printing resolution, reproduction gamut

1. INTRODUCTION

To print the samples needed for this study, a Roland printing UV machine with piezo InkJet technology was used. To better understand the later explained results of the tone values, an understanding of the chemistry and technology process is needed.

There are many parameters which affect the printing quality, such as nozzle size, printing head movement, ink viscosity, porosity of printing substrate. All this parameters directly or indirectly affect the speed of printing. By changing those parameters the size of the ink droplet varies, resulting in a change in the printing quality.

The goal of this paper is to further investigate the influence of the parameters on the screen value size in relation to print resolution with UV curing inks. Furthermore, those changes also affect the printing speed.

2. UV INKS

In terms of UV curing inks, photo initiators are chemicals that become excited by UV wavelengths (10 to 400 nm), forming free radicals, which then react with the vehicle of the ink to begin the polymerization process.

The characteristic of UV inks is their ability to shift almost simultaneously from fluid to solid state by means of a chemical reaction, initiated by ultra violet light, and conducted by photo initiators. The formulation of these inks is similar to that of other inks, which mostly consist of pigment, vehicle, solvent and additives. While the pigments remain similar to those used in conventional inks, the other parts of the formulation chemically differ significantly. The solvents in UV curing inks have a low viscosity. The vehicle is composed of oligomers, while the additives consist of a large amount of photo initiators, which react to the photons of UV radiation. In conclusion, the UV inks consist of 15-20% pigment, 20-35% prepolymers, 10-25% monomers and oligomers, 5-10% photo initiators, and of 1-5% other additives.

If irradiated with UV wavelengths, the chemically active sites on the vehicle molecules (such as alkenic double bonds) will undergo polymerization. This polymerization is, nonetheless, rather ineffective without the photo initiators, which provide the radicals to start the polymerization process in the first place.

Benzophenone is one of the cheapest, most widely used photo initiators. [1] In order to yield radicals easily, it requires a proton donor, such as amine, creating a synergism between the two products, i.e. being much more efficient than being either one alone. This synergism is a common feature of photo initiation in UV inks. Some of the photo initiators include benzyl, benzophenone derivates and, thioxanthones such as isopropyl thioxanthone. [1]

There are many advantages of printing with UV curable formulations, such as no solvent emissions, achieving of extremely high gloss prints, elimination of spray powder, and elimination of the heating IR and hot air drying ovens.

3. RESEARCH

For the production of samples, the Roland VersaUV LEC Series 300 UV Printer/Cutter with piezo Inkjet technology was used. Monaco PROFILER colour patches were printed on fine art paper of 300 g/m^2 on three different printing resolutions – 360 dpi, 720 dpi and 1440 dpi.

The printer retained factory colour settings (no colour management was made).

Once the patches were printed, they were measured by means of a spectrophotometer X-Rite DTP41 with a Standard Observer 2º angle using D50 illumination. Specifically, this was done with cyan, yellow, magenta and black colours with the help of Monaco GamutWorks, a program used to visualize the gamut of specific spectres – 20%, 50% and 80% lightness for the three different printing resolutions.

Gamut is a certain complete subset of colours. The most common usage refers to the subset of colours which can be accurately represented in a given circumstance, such as within a given colour space or by a certain output device. [2]

Spectrophotometric measurements in printing, as well as the colour space, used in graphic technologies in colour definition, as well as tolerance between two colours are defined by CIE L*a*b* colour space. [3] The value L* represents lightness, a* is the red-green axis, and b* blue-yellow axis. These values do not have a specific measure unit.

With the results of the spectrophometric measurements the CIE L*a*b* values were obtained. These results were then compared to ISO 12647-2:2004 L*a*b* values using the ΔE value, a numerical value for the difference between two colours in a colour classification system. [4] Specifically, the ΔE_{2000} formula was used rather than the ΔE_{94}, as it describes better the differences in the blue area. [5]

The diameters of the smallest printing elements of 5% screen value were analyzed with the equipment for image analysis (QEA Personal IAS) for cyan, magenta and yellow. The black colour was not analyzed, as the Roland UV machine printed it combining cyan, magenta and yellow, rather than using the black ink.

4. RESULTS AND DISCUSSION

The printed patches were measured with spectrophotometer X-Rite DTP41. Once the patches were digitalized, they were analyzed with Monaco GamutWorks, which created a 3D gamut preview for each resolution of printing. This 3D model can be seen on figure 1, which contains all of the three mentioned printing qualities. The left gamut is from the position of –b (blue), and the right from position +b (yellow). The 360 dpi resolution is shown black, 720 dpi is yellow, and the 1440 dpi resolution is red.

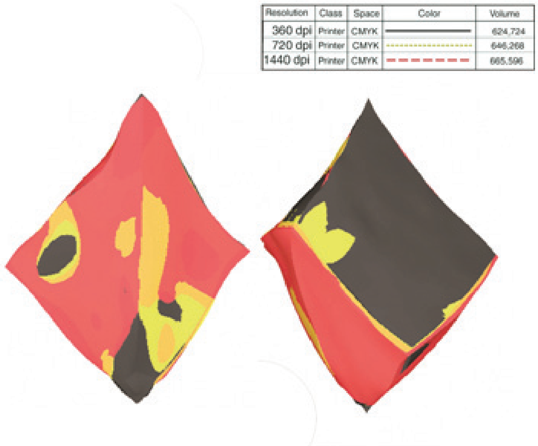

Figure 1. Gamut preview from –b and +b viewpoints

The results showed that a certain increase in the gamut volume occurred as the printing resolution increased. Specifically, the gamut volumes were approximately: V_{360dpi}=624, V_{720dpi}=646, $V_{1440dpi}$=665. This indicates a volume increase of 22 when shifting from the lowest to the medium, and an increase of 19 when changing from the medium to the highest printing resolution. These results indicate that, when it comes to gamut volume, the difference between volumes at the lowest and medium resolution isn't that much bigger than the difference between volumes at the medium and highest printing resolution.

Figure 2 shows the cross sections of the gamut showed in figure 1. Those cross sections were made at 20%, 50% and 80% lightness respectively and consist of gamuts of the three used printing qualities. At the 20% lightness cross section it can be seen that the highest quality of reproduction results in a much larger gamut volume, while in the 80% lightness cross section the gamut for the three printing qualities is basically the same.

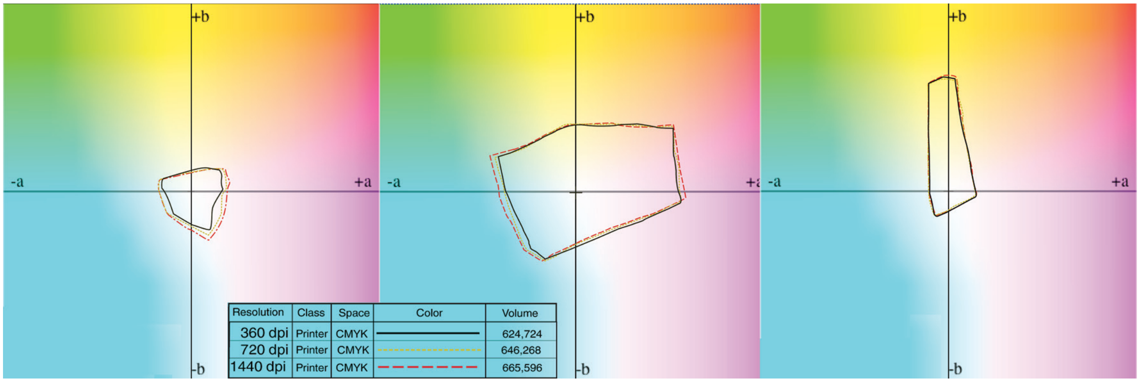

Figure 2. Gamut cross sections at 20%, 50% and 80% lightness

Once the gamut profiles were made, the data was transformed to a 3D graph in which the values in the CIE L* a* b* colour space were shown (figure 3). This was done for 100% screen value for the cyan, magenta and yellow colours for the three printing resolutions (points 1, 2 and 3 on the graph) and compared to standard offset samples previously acquired (point 4). The black colour was not taken into consideration because the microscopic images showed that the black colour was created by using the combination of the CMY colours.

In the case of cyan and magenta colour the L* (lightness) values were the highest at the lowest printing resolution, while in the case of yellow the lowest resolution had the highest L* value, except from the standard offset. This is the result of the cyan and magenta traces in the yellow print. As a result of this contamination, the 720 dpi print had a middle lightness value.

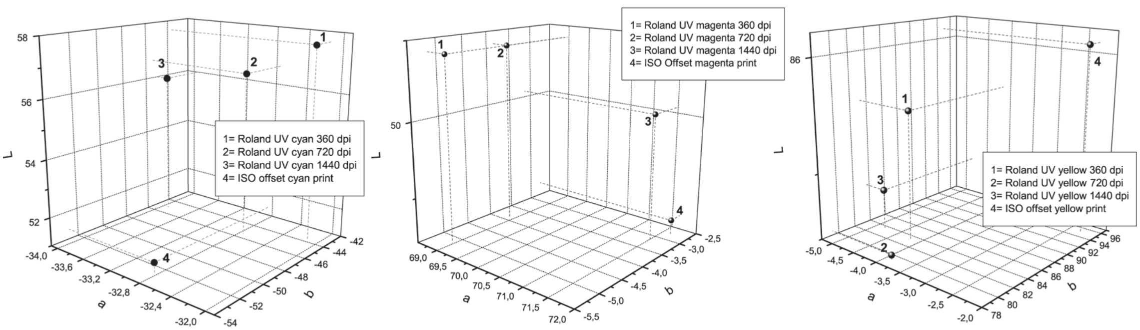

*Figure 3. 3D L*a*b* graph for 100% screen value for CMY colours*

The ΔE value was measured for the three colours and resolutions and then compared to ISO 12647-2:2004 values. In case of cyan the values were ΔE_{360dpi}=6.6201, ΔE_{720dpi}=5.5581, $\Delta E_{1440dpi}$=5.1699. These results show that the difference between the two higher resolutions is much smaller than the difference between 360 and 720 dpi. In case of magenta the results were ΔE_{360dpi}=2.5551, ΔE_{720dpi}=2.3880, $\Delta E_{1440dpi}$=1.4964. These results again show than in case of magenta, the 1440 dpi resolution shows a much better printing quality than the other two. With yellow the values were ΔE_{360dpi}=2.6692, ΔE_{720dpi}=3.5607, $\Delta E_{1440dpi}$=2.8910.

When it comes to standard offset values, in magenta and cyan the highest printing resolution meant the closest L*a*b* values as would be expected, although this was not the case with yellow where the lowest resolution had the closest values to the offset standard. This, however, can be easily explained by taking a look at the enlarged images that were taken with the equipment for image analysis (QEA Personal IAS) and are shown in figure 4.

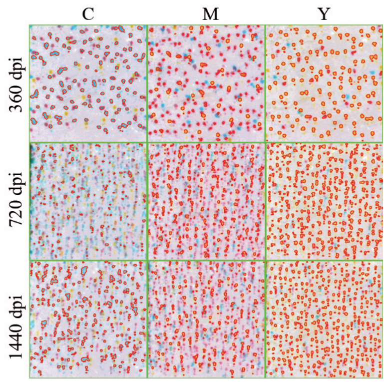

Figure 4. Enlarged images of CMY colours at 5% screen value in three printing qualities

Figure 4 shows the enlarged details of the CMY colours at 5% screen value in all three printing qualities – first 360 dpi, second 720 dpi and last 1440 dpi. It can be seen that each colour is contaminated by the other two. This is most visible in case of yellow, where such contamination results in a greater deviation from the expected measurements. This is the reason why the standard in the yellow L*a*b* graph in figure 3 was the closest to the L*a*b* values of the lowest printing resolution. In the case of the highest printing resolution the number of dots per inch is the highest, and the contaminating dots are as well, so it is only logical to observe that the lowest (and less contaminated) printing resolution had the closest L*a*b* values to offset standard.

One can also observe that the dot number is – as expected – higher as the resolution increases, and the same case is with the uniformity of dot shape. The visual difference between 360 and 720 dpi is more apparent then between 720 and 1440 dpi. The deformation of the screen elements is more pronounced at 360 dpi. The reason could be the gradual polymerization of the vehicle in ink, which could possibly result in the increase of the ink viscosity. [6]

While trying to find an explanation to this phenomenon, it was decided to observe not only the screen element surface, but also ink film thickness. Possible method could be microscopic examination of its cross section, but as the sample preparation is very time-consuming and destructive for the print, it was decided to obtain the results in an indirect way, through observing the reflectance of a single screen element.

To research this phenomenon more carefully, a reflectance chart of a single 5% screen element in cyan, magenta and yellow at all three printing resolutions was made, which is shown in figure 5.

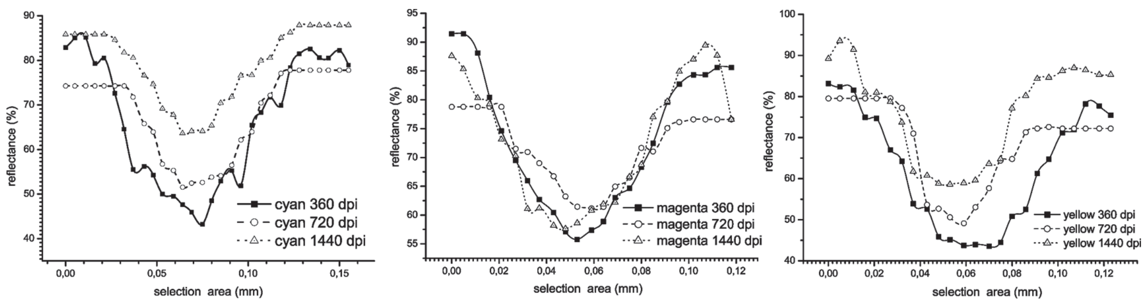

Figure 5. The reflectance in CMY colours at three printing qualities

The reflectance chart was made using the equipment for image analysis (QEA Personal IAS). This was done selecting a single dot from the 5% screen value image for cyan, magenta and yellow. The dot was then enlarged and its reflectance was analyzed and charts shown in figure 5 were made. The first chart is the reflectance percentage of all three printing resolutions in cyan, the second in magenta, and the third in yellow. One can observe that the results are always a parabola. This can be expected, as the dot is formed in a shape of a more or less perfect circle, so the closer to the centre, the thicker the ink film will be and the lesser will the dot's reflectance rate be. Moreover, as the printing resolution increases, the dot will more and more assume the shape of a perfect circle, as a result of the slower printing head movement. This will now result in increase of reflectance rate (the prints become lighter), which is reverse proportional to the ink film thickness, which results in a more perfect parabolic shape of the function.

5. CONCLUSIONS

For the purpose of this research a single type of paper substrate (fine art paper), a single ink type (UV ink) and a single printing technology (piezo InkJet with UV curing ink) was used. The goal was to investigate the influence of the screen value size in relation to different print resolutions (360 dpi, 720 dpi and 1440 dpi). To do so, certain aspects of colorimetry, dot shape and reflectance were studied.

When it came to gamut, a certain volume increase was observed when increasing the printing resolution. This can be explained by observing the printing head movement. At lower printing resolutions, the printing head moves at a faster rate, so the printer makes up for the velocity with bigger droplet size. This was confirmed by both observing and measuring the droplets by the image analysis apparatus and by analyzing its reflectance rate. With bigger droplets, the printer can't make the fine tone adjustments needed to cover the complete gamut. However, as the printing resolution increased from 360 to 1440 dpi and the droplet diameter decreased from 76 μm to 50 μm, the gamut volume increased by a total of approximately 41.

The ΔE values were also examined at different printing resolutions. In case of cyan, the 720 dpi resolution showed very satisfactory results, as $\Delta E_{720dpi\text{-}1440dpi}=0.39$, a change which isn't noticeable by a human eye. [3] In case of magenta $\Delta E_{720dpi\text{-}1440dpi}<1$, which is once again not noticeable by a human eye, so the 720 dpi resolution shows an adequate result. With yellow, due to the colour contamination with cyan and magenta the ΔE was most satisfying at 360 dpi, although $\Delta E_{360dpi\text{-}720dpi}<1$, therefore again barely noticeable. From this entire one can conclude that the 720 dpi resolution was more than satisfactory, although a printer calibration in order to adjust the printing parameters would be recommended.

The dot shape was observed by means of image analysis equipment. The greatest observed difference was visually detected when shifting from 360 to 720 dpi, rather than from 720 to 1440 dpi. Moreover, at 720 dpi the shape of the droplets was more alike to that of a circle. The explanation to this exceeds the paper's magnitude, but it is probably caused by the faster movement of the printing head at lower resolution. As the printing head moves at a higher rate, the inertia force causes the droplets to splash in a more irregular way, following the printing head movement.

The reflectance analysis calculated a decrease in the droplet diameter, $r_{360dpi-1440dpi}$=26 µm. In addition, the reflectance graph showed a higher reflectance rate when increasing the printing resolution, which means a thinner ink layer. From these two one can conclude that with the printing resolution increase, the droplet size is decreased, leading to larger gamut volumes and more accurate L*a*b* values.

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CHARACTERISTICS OF DI (DIRECT IMAGING) PRINTING FORMS

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Summary

We are facing the fast growth of desktop publishing and digitalizing data in graphic industry market that is very dynamic. As a result of these changes and market demands for yielding high quality products that will satisfy a consumer, with decreasing the production time (market law), Direct Imaging (DI) technology is introduced. Quick, on-demand, top quality — those are the features which define the push toward on-press imaging. In this research paper, main features of DI printing forms will be introduced, altogether with pros and cons regarding to these features. Information utilized in this research paper is based on Presstek's thermal ablative DI Waterless printing plates. Presstek is known as the main supplier of printing plates for DI technology.
Key words: Direct imaging, waterless offset, slightly recessed printing areas

1. INTRODUCTION

Direct imaging (DI) is a new technology in graphic industry that is used to image plates directly on the press. The most important feature of DI is laser imaging of printing plates, that are already mounted on the plate cylinder. With a direct imaging press a digital file is sent directly to the press. All four plates (that means four separations) are simultaneously imaged on press. Data about the color separations are sent from computer directly to imaging heads (laser heads). Namely, through interface, RIP (raster image processor) is connected with imaging heads, data are decompressed with the data flow of 64 million pixels per second for every single imaging head [2].

DI printing forms are available in two types [1]:

-non-imagable DI plates and,

-reimagable DI plates

Depending on the materials used for making printing plates, there are such that enable the deletion of printing image after printing, and to create different image on the same surface for the next printing order. Respectively, it can be used for a variety of work orders. The non-imagable plates, however, do not offer this possibility. Non-imagable plates can be used only for a specific job, after which they are no longer usable, but it is possible to recycle them.

Direct Imaging machines (regarding to the plates that will be discussed here) are based on the dry (waterless) offset. Presstek's DI plates provide 90% of the printing industry market that use DI printing process [2]. Because of these facts, this research work will be based on data that are based on Presstek's thermal ablative DI plates - PearlDry Plus and ProFire Digital Media. As stated earlier, DI printing machines mostly operate on the principle of dry offset, so the Presstek's DI plates are adapted for dry offset. These are such plates that do not require chemical processing, and are represented in the form of rolls with polyester base or as a single flat panel with aluminum base.

2. ANALYSIS OF CHARACTERISTICS OF THE DI PRINTING FORMS

Waterless printing is a technique that eliminates the dampening system which is normally a key factor in conventional offset printing technique. In the waterless offset, printing process and making printing forms (that included the use of chemicals for processing plates in conventional offset), are replaced with a simple mechanical process [3]. Now it slowly comes to the first essential feature of the DI printing form - silicone layer.

On the one DI printing form (figure 1.) silicone layer represents non-printing elements. Silicone is hydrophobic because of its chemical structure. Silicone layer is the one that helped the elimination of dampening system. Below this layer is so-called intermediate layer (in the case of Presstek's plates - titanium layer), which absorbs electromagnetic radiation and its role is in forming the outline of the printing area. Finally, below the middle layer is polyester or aluminum base that accepts ink and has an important role in maintaining the dimensional stability of the printing form itself [3]. What all this suggests to us? The other essential feature of DI printing form: slightly recessed printing elements.

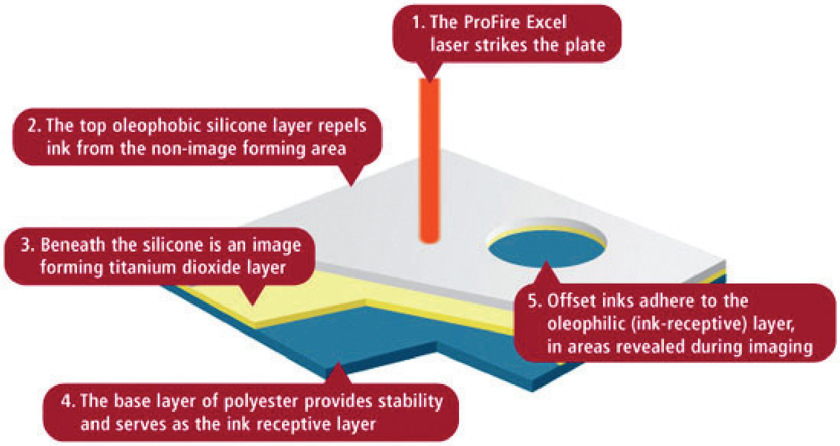

Figure 1. DI printing form

Slightly recessed printing elements are provided thanks to the layout and features of materials from which the DI plate consists of, and thanks to a special procedure that treats the printing plates - ablation. Imaging of DI printing forms is done with the help of lasers, that use heat to operate on printing plate. Given that the characteristics of the laser are coherent, monochromatic, extremely strong electromagnetic radiation, and for the imaging (ablation) of plates heat is required, the infrared range (IR - from 830 to 1064 nm) of electromagnetic radiation is a basis for the development of lasers for plate imaging, because the IR lasers have, above all, thermal effect [9]. Therefore, IR laser diodes are frequently used for the imaging of the DI plates, and the imaging system is a set of laser diodes (modules). IR laser diodes are located above the plate cylinder in the printing machine, and usually make a horizontal movement parallel to the axis of the cylinder. DI imaging system for the waterless offset printing system is located in the place where dampening system is located in conventional offset[1][2].

3. DISCUSSION

What has been achieved with slightly recessed printing elements? A much higher resolution of printing is enabled (at PearlDry Plus plates - up to 300 lines per inch) [3]. It should also emphasize that improving the resolution is achieved thanks to the plate ablation, with which the size of engraved point 16 microns is [2].

Figure 2. waterless image vs. conventional offset image (comparison based on differences in resolution)

Figure 2 shows how much sharper and richer the picture that is made by waterless offset looks (resolution 300 l / inch) than the picture made in conventional offset (resolution 175 l / inch) [8]. It is also an obvious advantage of waterless offset over conventional offset in color saturation and contrast for the resolution of 300 l / inch.

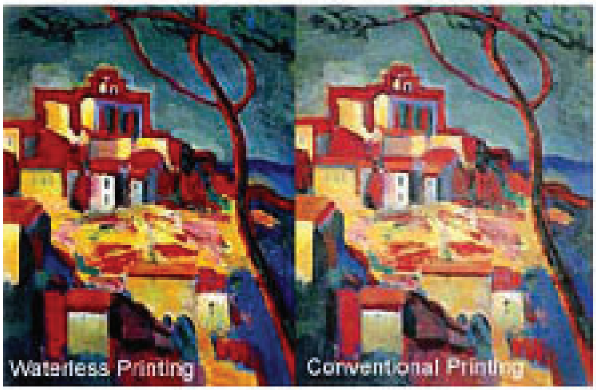

Figure 3. waterless image vs. conventional offset image (comparison based on possibility to reproduce tiny details)

Why so? Because with the resolution of 300 l / inch, more details can be reproduced.(figure 3).

DI printing forms enabled as a result of the elimination of dampening system, less dot gain (Figure 4). Thus, a raster point becomes much sharper giving high-quality prints on the substrate. A smaller dot gain is the merit of the design of waterless offset printing forms with slightly recessed printing elements (Figure 5). The walls of slightly recessed printing elements provide a kind of support for ink during their transfer from the plate cylinder to the blanket cylinder.

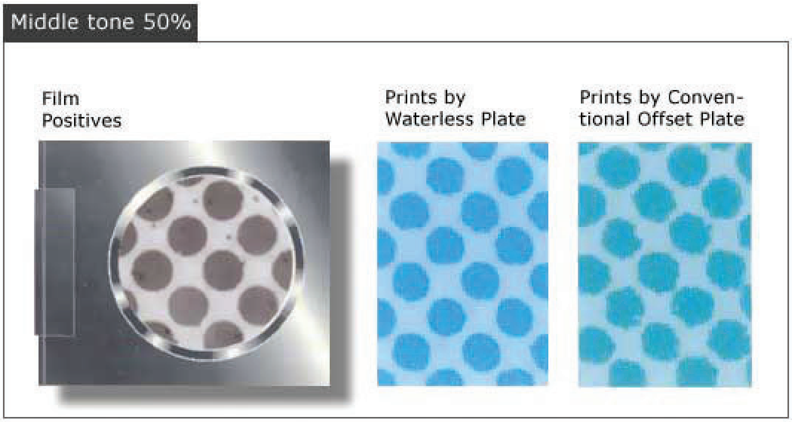

Figure 4. comparison of dot gain in waterless and conventional offset

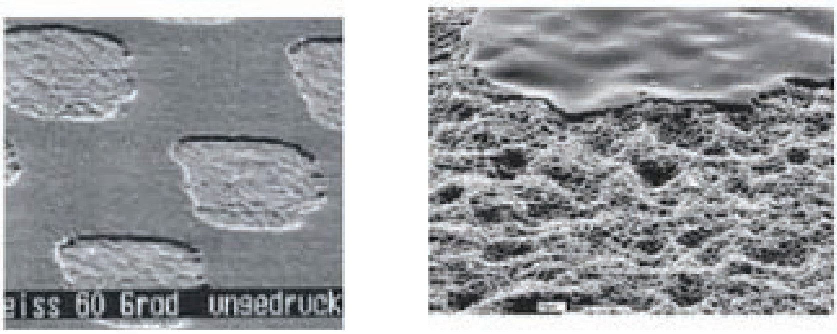

Figure 5. slightly recessed printing elements in waterless offset (left) and printing element in conventional offset (right)

Dot gain in waterless offset is reduced by up to 50% compared to conventional offset [7], which results in much more detail and greater image clarity, especially in the shadows and middle tones of images.

In waterless offset, the color range (gamut) is much larger than in conventional offset (Figure 6) due to more ink (quantity) possible to apply by a printing element, and therefore has a higher density [6]. When it comes to color density, it can be up to 20% higher than the density of ink in the conventional offset [6]. Greater color space contributes to the high resolution printing, with which it is possible to apply thicker film of ink on the printing elements, and thanks to a combination of higher density and sharper raster points, provides better contrast than conventional offset.

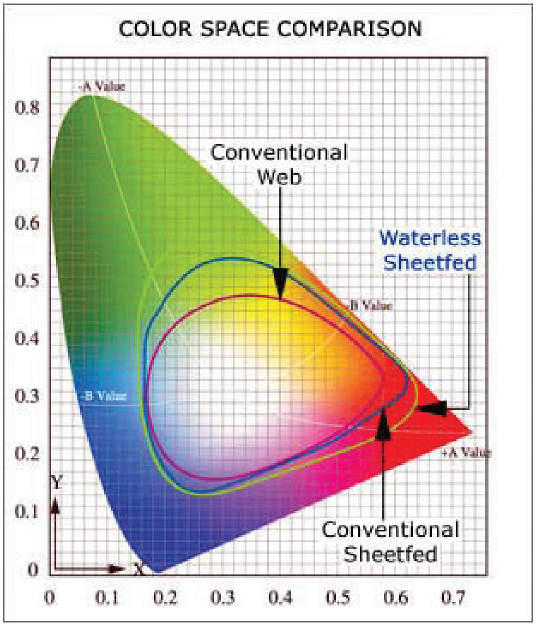

Figure 6. color space comparison

Printing without the use of water and other compounds for wetting contributes to higher quality of printing on uncoated and recycled papers [5]. This is made possible through the reduction of the stretching and bending of paper under the influence of moisture and better transfer of ink to the substrate. These qualities eliminate the need for multiple crossings of inking system. The registry is also improved because the stretch of paper is eliminated. Non-absorbing substrates such as metal, plastic and synthetic paper, are traditionally a problem in the conventional offset. Due to the nature of these materials, water is hard to absorb, and can easily exceed the printable area causing a high degree of emulsification with ink . Waterless offset provides a high level of control in the press on these substrates [5].

One of the important features of the DI forms is that its structure and texture allow the reduction of production steps[1][2][3][4]. This will be illustrated and explained in the graphic (Figure 7). Figure shows that the DI printing forms reduced the number of operations required in production, and therefore it may take less time to get a high quality image on substrate. DI forms eliminated the use of films in production and, consequently, in the process of making printing forms it is not necessary to perform editing films on the plates, lighting, developing, gumming and drying. These stages are replaced with the ablation, after which the plate is inked and register is adjusted, and finally, printing is on turn. This is a convenient way considering ecological point of view, since the elimination of the off-press processes in the development of the printing form eliminated the use of chemicals.

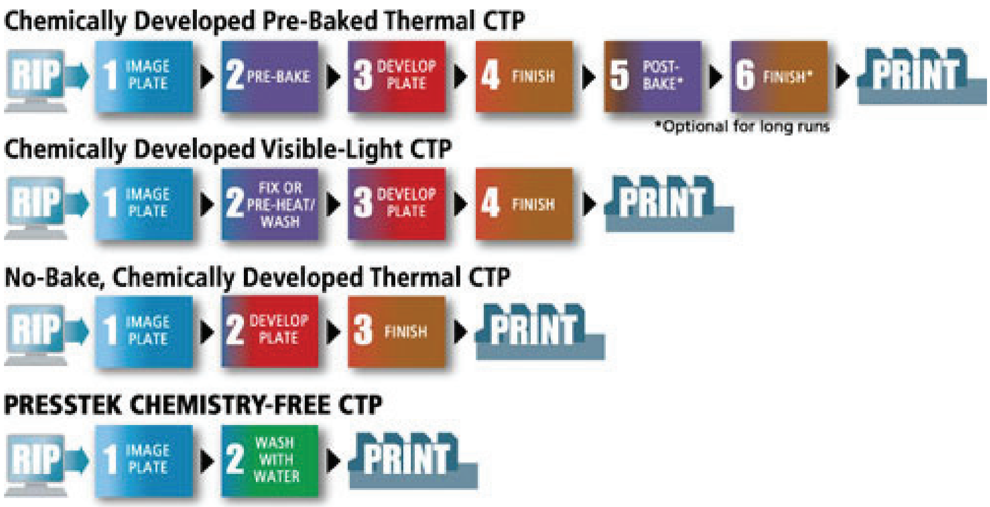

Figure 7. printing form production steps

One of the most important feature of DI printing form is its run-length. Studies reveal that DI printing forms show very large increase in the quality of production in run-lengths under 5000 impressions [4][5]. Research shows that the largest increase in run lengths lies between 500 and 999 impressions. In general, it can be said that the DI printing forms are best suited for run lengths between 250 and 10,000 impressions [4]. All this tells that DI printing forms, if compared with other printing techniques can not cope with large run lengths, which is a consequence of the structure and characteristics of materials which constitute a DI form.

Market studies indicate that the number of jobs with run length of 20 000 impressions and bellow are increasing, while the frequency of longer run length jobs are decreasing (figure 8). DI presses fit well in environments that are experiencing this trend. These environments which include commercial print shops, digital print and quick print/franchise shops utilize DI presses to handle increases in run lengths. Research also predict that the DI will have the largest increase in run length in the future. 94% of all studies predict an increase, and even believe that the DI will be able to compete with traditional offset printing in terms of run lengths [4].

Research also reveals that, considering print volume growth trends, DI printing are increasing, while conventional offset volumes are declining [4]. Why? Because of the changes in print market toward shorter run lengths and faster turnaround times.

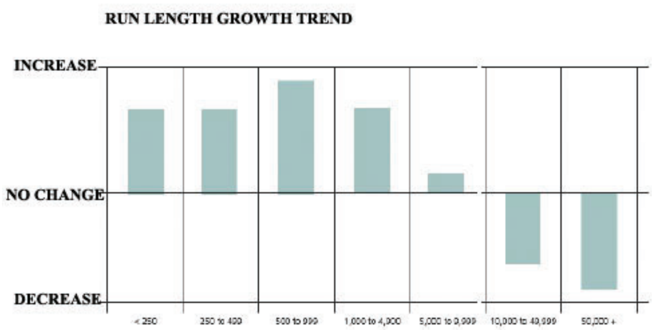

Figure 8. run length growth trend

The next important factor, that could adversely affect the viscosity of the ink is temperature [1]. Due to the elimination of water from the printing process, the effect of cooling the surface of the plate is lost. Lack of water can cause an increase in temperature on the plate cylinder because of friction. This is the primary growth of temperature. The secondary rise of temperature is on ink rollers due to friction between the ink (due to its high viscosity) that passes between the rollers. Because of this, a device for precise temperature control inside the printing unit is needed. Currently, a solution to this problem is the installation of the device containing vibrating rollers with cooling effect. Refrigerant (water) with the help of pumps is injected into the vibrating rollers which make cooling and temperature control in the printing unit.

4. CONCLUSION

The above facts in this paper suggest the following conclusions:

DI technology, with the digitalization of data and in-line plate imaging, eliminated production steps and variables normally associated with off-press platemaking.

DI printing forms provide more consistent color, contributing to greater range of colors, higher color saturation, allow presentation of more details of an image and contribute to a very low dot gain. Eliminating of the dampening system eliminated the problem of color/water balance. A very accurate registry, is provided, which reduced the time an operator needed to set the correct registry. The range of services on offer extended, as a result of various substrates for printing available.

In terms of run length that DI printing forms can endure, DI printing forms are most appropriate for run lengths between 500 to 20 000 impressions. Market research has shown that jobs with print volumes up to 20 000 are in the largest increase, while the demand for print volumes greater than 20 000 are in decrease.

And, perhaps the most important, in addition to high quality and profitability, DI technology is acceptable to the environmental point of view. Environmental benefits, which are a consequence of the structure of DI printing and dry offset forms are evident:
- Reduce the emissions of volatile organic compounds
- Avoids the unnecessary consumption of large amounts of water
- High speed of production means reducing the amount of waste, that affects both the environment and the reduction of the amount of ink and paper in production Possession of DI printing machine allows the step into the world of new possibilities and benefits related to printing. DI technology enables the production of new products, penetration into new markets, as well as the benefits of competition. Speed, high quality and ease of use makes this technology very attractive, and very profitable. It can be said that DI technology set the standard for digital offset printing, combining high quality and variety of offset printing techniques with automation and high-speed of digital printing.

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METHOD FOR CONTROLLING THE IDENTITY OF REPRODUCTION PRINT

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Summary

A quality control of print should be observed in two aspects. First - conformity of a print to the original, second - stability of circulation. The first aspect has a large subjective component, especially if the colour coverage of the process of reproduction is insufficient for exact reproduction of the original. The second aspect is usually objectively controlled by a system of test-objects, however, due to an indirect way, it always leaves a place for disputes. Recently, in connection with the development of information technology, systems of estimation of image quality and printing process, based on computer processing of the scanned print, began to appear. The offered method refers just to this direction and is relevant both in scientific and practical terms.

Keywords: Identity of reproduction print

1. INTRODUCTION

The main scientific objective of the research is to develop an objective device-independent technique for assessing the quality of the printing image and establishing its conformity to the original.

To solve the main task of the research it is necessary to solve the following problems [5]:

1. To perform analysis of the technological and technical characteristics of controlled object (print).

2. To define the parameter which will determine a way of controlling the identity of prints.

3. To perform analysis of the existing ways of segmentation of digital images. To develop an algorithm for segmentation of the analyzed image in areas with equal brightness-chromatic characteristics.

4. To develop algorithm of quantitative analysis of properties of the isolated segments of the image. To run the calculation of the segmented sections area with equal brightness-chromatic characteristics.

5. To develop zones of maximum permissible deviations from the absolute value for the investigated parameter (segmented sections area value).

6. When the listed problems are solved, it is necessary to define the form of comparison of investigated parameters to prepare the conclusion about the conformity of quality of the analyzed image to the reference sample.

2. RESEARCH

In the research the assumption is that for the estimation of conformity of the reproduction quality of the printing image it is possible to use digital three-dimensional model of the analyzed image.

The solution of these problems is based on the possibility of representing the two-dimensional image in the three-dimensional basis. Thus, the spatial coordinates of the image are directed on lengthways axis *x* and *y,* and luminance coordinates (optical density) - in the direction *z*. The image in a such form looks like a certain “landform” in which the magnitude of «peaks and dints» is set by the magnitude of brightness (luminance), and character of their formation in the space – by the magnitude *y* [1].

Dissecting the “landform” parallel to *OXY* plane with some interval ΔL (D), we receive a series of the cross-sections which square will characterize the certain half-tone characteristic of the image.

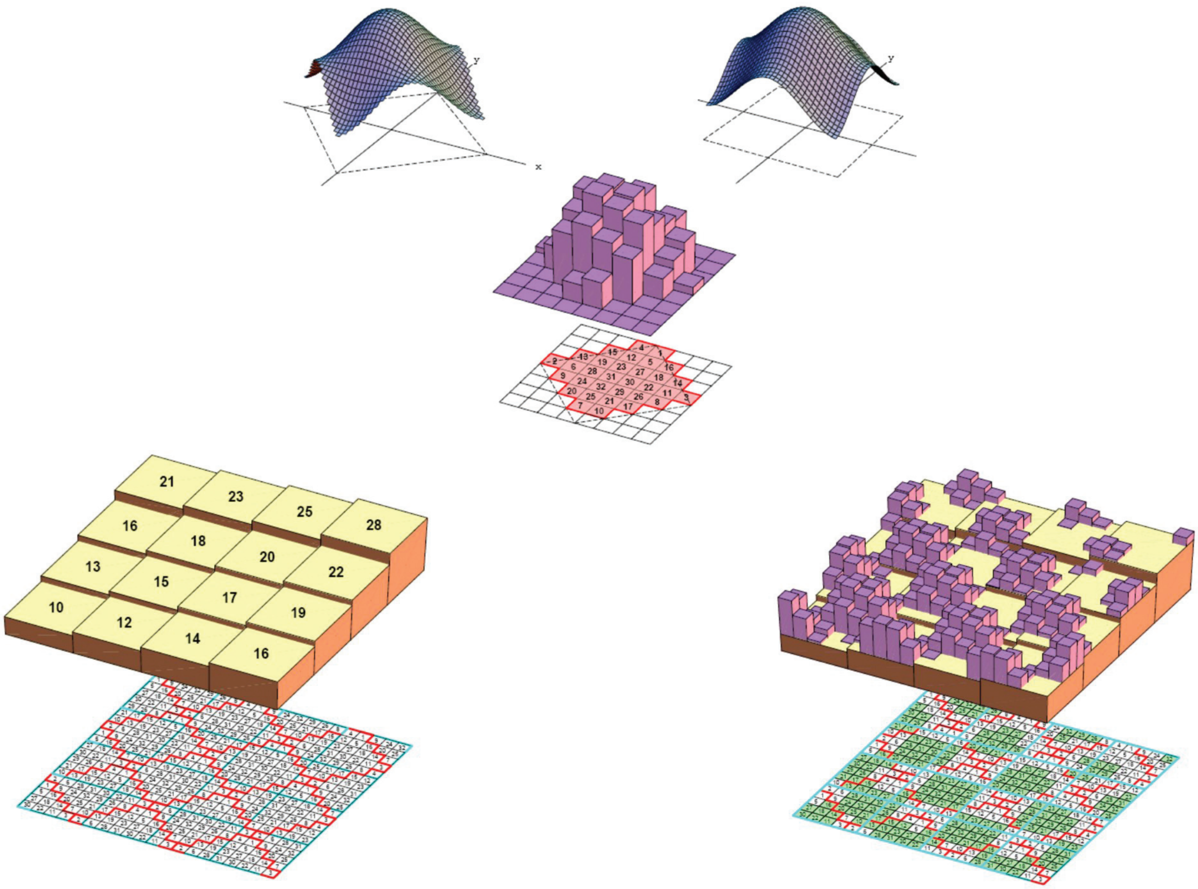


Figure. 1. Model of distribution of the half-tone characteristic of the image on its area

Computing the area occupied with sections having equal half-tone characteristics on the image, we build the diagram on which we put in succession the meanings of all computed areas for the analyzed image. Next we perform a comparison of the gained meanings for the investigated image with the corresponding parameters for the reference image; on the basis of the results of this comparison we make a conclusion about the identity of the analyzed printing image to the original.

The definition of a parameter on which basis the analysis of quality of printing images will be made.

In a basis of the development of an objective method for controlling the identity and the quality of analyzed print, the characteristic parameter should be assumed, which could be determined by disposable technical means and would allow to define operatively half-tone and chromatic parameters of a print [2].

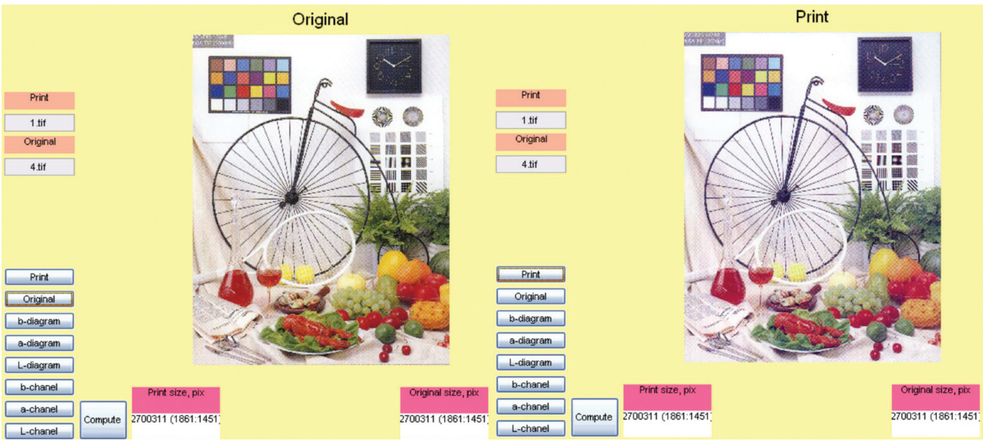
Thus, the objective parameter defining the identity of print, within working thickness of inking layers, is the value of the luminous flux reflected from the controlled areas of the printing image illuminated by a stable light source and, specifically, the value of the segmented areas with equal half-tone and chromatic parameters. The control of the image by means of such values is more consistent with the visual perception process, than the control of quantitative analysis of brightness or colour coordinates on separate image elements. The observer is more likely aimed to find the most important, distinctive characteristics of such type as contours or textural areas and to form of them the combinations subject to be recognized. With this understanding of the visual perception process it is logical to control a reproduction of the image on by its characteristic indications/features (the areas with equal half-tone characteristics), and not just by its separate elements.

One of the primary problems of the given research was the development of the segmentation algorithm of the half-tone image based on the processing of the analyzed image by a multiple threshold. In a basis of the definition of threshold values have been assumed threshold density values of the discriminating sensitivity of the eye. Therefore, being based on the postulates offered above, the algorithm of the segmentation of images on in areas with equal half-tone and chromatic parameters has been developed and mustered experimentally.

The execution algorithm of the given operation represents the cyclic processing of the analyzed image by means of a vector-mask which values represent a multiple threshold. Then the image is divided into channels. In each of such images, following the developed algorithm, we gate out the areas having equal intensity. As a result the image massif is divided into layers in compliance with a vector of threshold values, which contain the information about the distribution on the areas sections with various brightness thresholds.

Further we compute the areas (the area value corresponds to the quantity of pixels) which occupy the sections with equal half-tone and chromatic characteristics, using the gained matrixes. Thus, from the gained distribution of values of half-tone and chromatic characteristics on the image area, we construct a graph; on the axis OX we plot the value of the half-tone characteristics of the image, and on the axis OY - the value of the area occupied with this half-tone.

For the reference image (the approved print in relation to which we install the quality of the printing image) we define an interval of admissible deviations for the values defined above the areas. For this purpose we create two additional images for which the colour difference in any point corresponds to the requirements of standards in the field of quality of a print production. To define the upper bound of the tolerance of the reference image we increase the value in colour system CIELab for the channel L by 1,5 units, and values of channels a and b by 1 unit. To define the lower bound of the tolerance of the reference image we reduce the value for channel L by 1,5 units, and we reduce the value for channels a and b by 1 unit. As a result, we receive two images, with the minimum and the maximum admissible (considering that ΔE should be no more than 4 units) values of half-tone and chromatic characteristics. For the gained images we perform the operations of image segmentation on the sections having equal brightness. We define the values of the areas with the set parameters. We build one profile for two distributions of the analyzed characteristics (max and min) which have been received, on the axis OX we plot the values of the graded characteristic of the image, and on the axis OY - the value of the area occupied with this half-tone [4]. The interval of values which keeps within a zone contoured by profiles is a required gamut of the admissible change of controllable parameter for analyzed images; being in its limits, we can draw a conclusion about the identity of the investigated image to a reference print.



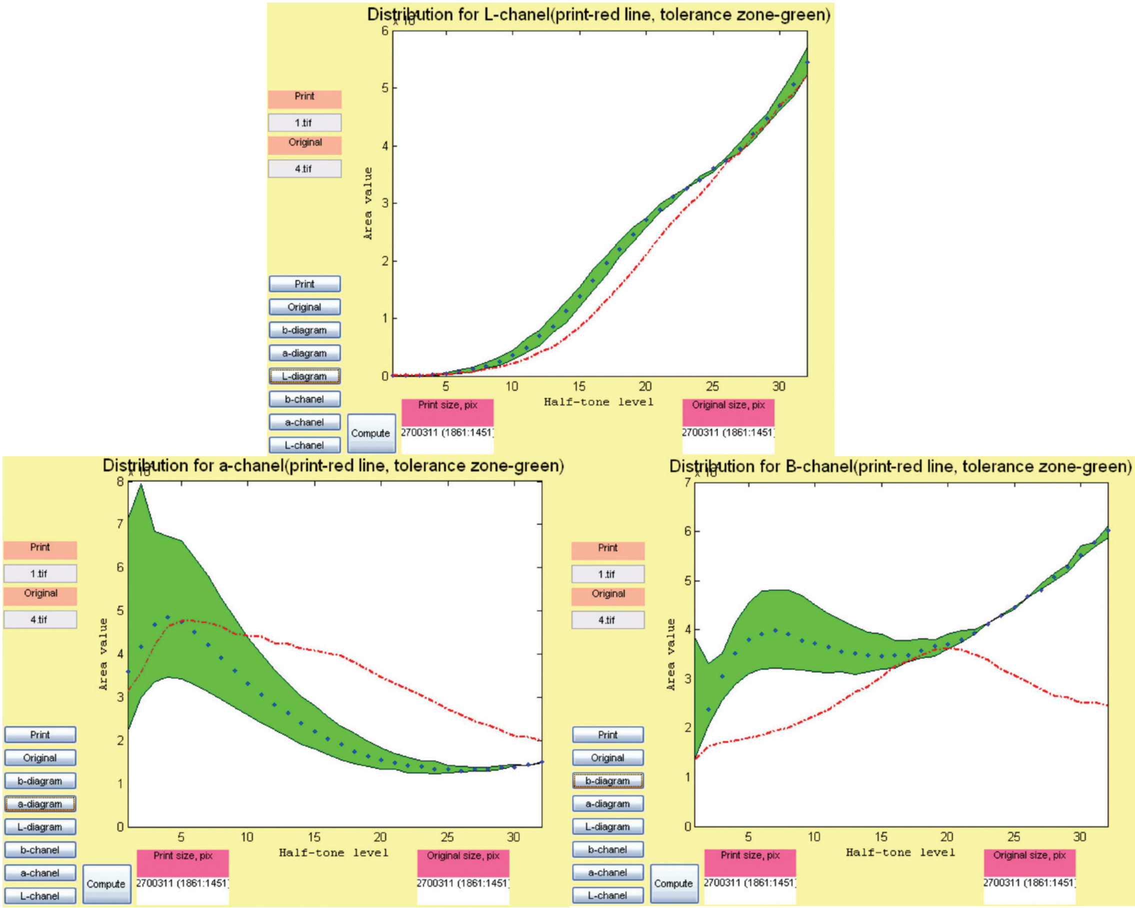


Figure. 2. Distribution of the areas of half-tone and chromatic characteristics for analyzed images for each of processed channels in the system CIELab; it represents also the interval of a legitimate value for the defined characteristics. The resulted dependences allow to draw a conclusion about the conformity of analyzed images to the reference sample.

3. SUMMARY OF RESULTS

The research has revealed that an analyzed parameter: value of the area with equal half-tone characteristics, clearly indicate the deviations of qualitative characteristics of the image in the same manner as the human sight - the less is the value of the disturbing factor (colour misconvergence, a difference of screen ruling, differences between the form of a screen dot, dot gain), the less is the difference between the gained dependences. During the experiments it was also possible to gain the dependences which allow characterizing objectively parameters of the transformation and the distortion on the analyzed images. The result of the performed research is the conclusion that the offered method of quality control and identification of print is possible and can be practically realized [6].

The check of the operation of the offered technique on the print produced with use of various technological conditions (speed of printing, the quantity of a paint transferred to a pressing, combination of paints on a pressing) has been performed. As a result, the coincidence of data on the quality of the investigated images gained with use of the offered technique, and meanings gained by means of traditional research techniques is obtained.

The developed technique can be applied in any existing production engineering of printing, with little changes at the stage of reception of the digital model of the printing image, and with the correction of an interval of a legitimate value for a compared parameter.

4. CONCLUSIONS.

1. On the basis of the analysis of technological features of the processes of quality surveillance of a printed matter and of the questions challenges connected with identification of the printing image an actual problem has been put and solved - a new technique for the control of conformity of the reproduction of the printing image to the confirmed sample has been developed. It was found that to prepare the conclusion about the conformity of the reproduction of the printing image to the reference sample it is possible to use the value of half-tone and chromatic characteristics restricted by a certain ambit having fixed coordinates on an image plane. The control of the image by means of the values defined thereby is more in line with the visual perception process than the control of quantitative analysis of brightness or colour coordinates on separate image elements [7].

2. The way of segmentation of the model of the printing image on areas with equal half-tone and chromatic characteristics has been offered.

3. The way of calculating of a zone of legitimate values for an investigated parameter has been proposed and experimentally verified.

4. The software product that performs a complex data processing and a visualization of research results, needed to draw the conclusion about the quality of the printing image, has been developed.

5. The experimental research of the influence of the basic technology factors on the accuracy of the estimation of the statistical parameters characterizing the quality of duplicating process has been performed.

6. The results of the research may be widely used in the production when manufacturing polygraphic products and for reengineering of production processes.

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DIFFERENCES IN COLORIMETRIC VALUES OF CONVENTIONAL AND HYBRID INKS AFTER BEING EXPOSED ELEVATED RELATIVE HUMIDITY AND TEMPERATURE

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Ana Keler, FTN, Grafičko inženjerstvo i dizajn, Novi Sad

Summary

The hybrid technology is relatively new in the printing industry, and just like all new technologies, they have some manufacturing parameters that are not fully explored. The aim of this study is to determine the changing of CIA Lab colour values of process under the influence of elevated humidity and temperature, and to determine changes in calculating ΔE for samples printed by conventional and hybrid colours. The scanning of the surface structure of printed material, with hybrid and conventional inks, and non-printed surfaces using SEM device (Scanning Electron Microscope) was also done. The results indicated that there are differences in the surface structure, the CIA Lab and ΔE values.
Key words: conventional inks, hybrid inks

1. INTRODUCTION

Conventional inks

These colours are used for printing brochures with offset or lithographic printing technique. The thickness of layers of ink is very small, sediment thickness is up to 2μm. Because of this feature, colour print by offset technique must contain a sufficient amount of pigments, as well as very high intensity ink. When printing, it is possible for emulsification to appear, where water and ink can emulgate. The amount of water as a percentage of emulgation must not be greater than 20%. If it exceeds this value, then this phenomenon does not lead to desired effects such as painting of hydrophobic surfaces and fading of the prints themselves. If a longer period of time kept in the package, inks can attain higher viscosity, become very thick, and it is possible to create the appearance of ”thickened” part of ink so-called ”foreskin”. These paintings have a smaller amount of solvents and they are less evaporative. The inks must be such that would not begin to dry or even dry in ink tray. Their solvents have a higher evaporating temperature, which ranges from 260oC and up to 320°C.

They can dry in a number of ways:

• Absorption (physical mechanism of drying)

Part of the ink is absorbed by the inner part of the printed material, while on the surface of the material the pigment and resin remain in the gel state (that would not come back until the next coating of the sheets).

• Evaporation or thermal fixing

Drying is done in a drying chamber with higher temperatures, where with heat parts of colours are merging.

• Oxypolimerization (chemical mechanism)

Vegetable oils, contained in certain inks, which are environmentally more acceptable for offset printing, react with oxygen and polymerize merging components of colour. The speed of drying of these methods is balanced with the addition of a catalyst.

• Photo polymerization

This method subjects the printed material to UV rays, while passing through the special UV chamber, where the material is exposed to radiation and gets the energy you needed for polymerization. This is also a chemical mechanism.

Ink requirements for offset printing are higher than for other techniques. It must be of such specifications to influence, as much as possible, preventing emulgation between water that is for wetting and printing inks, also can not be neither too sticky so that it would not cause tearing parts of the material from the surface of printing substrate. Print inks are very different than other colours. They are made from pigment, binder, solvent (or carrier) and secondary resources, ie. additives. A typical composition of inks for offset printing is: pigment with additives, combined with the binder resin, oil, siccatives and additives. Composition in percentage is given in the table below. [1]

Table 1: Print ink composition for offset printing

Print ink composition for offset printing	
Pigments	10 – 35% (50% for white covering colour)
Binders:	
• Natural resins	20 – 50%
• Alkyd resins	0 – 20%
• Plant oils	0 – 30%
• Mineral oils	20 – 40%
• Additives	0 – 5%
• Solvents (carriers)	0%

Hybrid inks

Hybrid inks incorporate two different chemical drying properties: they dry by oxidation and penetration like conventional oil-based inks, and harden under UV radiation. Inks that dry purely by oxidation and those that dry by a combination of oxidation and penetration have a high percentage of alkyd resins and colophonies (or rosins), but need oil as a solvent to help them flow. Radiation-cured inks and coatings require no oils or other volatile substances.

During the curing process, UV radiation causes the photoinitiator molecules to decompose into radical or complex cations. The products arising from this decomposition cross-link the monomers and oligomers to create a polymer.

In the binder used for radiationhardened inks, simple and complex resin molecules – called monomers and oligomers for convenience – assume the function of both resin and oil. Oligomers, which are compounds cross-linked into small chains (prepolymers), influence the gloss, hardness, abrasion and chemical resistance of the polymers subsequently formed. Photoinitiators are relatively aggressive components, but since hybrid inks contain far fewer than UV inks, the printing units do not have to be specially protected. Odour remains a problem, though this is less noticeable in hybrid inks than in radical UV inks.

Hybrid inks are available with pigments whose concentration, agglomeration and chemical parameters are largely the same as those in conventional printing inks, so they are basically closer to conventional inks than to UV inks.

And whereas pure UV inks and washes require special equipment because they are so aggressive, hybrid inks are relatively mild, so the chemical and physical resistance of the standard rubber rollers and universal blankets specified for conventional inks is perfectly adequate. [2]

UV inks

UV curing printing inks have a completely different structure than conventional printing inks. They are predominantly used in the printing of non-absorbent materials such as plastics and metal sheets, but also for high-grade card products and labels. There are UV inks for all conventional printing technologies as well as for the ink jet technology. UV curing printing inks are made up of:

- monomers,
- prepolymers/oligomers,
- pigments,
- additives,
- photo-initiators/synergists.

UV ink has a specific odor that recedes strongly after the hardening of the ink. However, the odor is trapped in the image. Systems based on cationic curing are more favorable than radical systems in terms of odor produced, but also take longer to dry. It is better for varnish since there is less tendency to fissuring. [3]

2. EXPERIMENT

For this experiment, the test chart was used printed with hybrid and conventional inks by ISO 12647:2004 standard. The experiment was conducted using the gloss coated paper (Fedrigoni 130 g/m^2), conventional inks (Hartman) and hybrid inks (SunChemical) The samples were printed on sheet fed machine Rapida 74, while the colour order was KCMY. The chamber that was used in order to keep the humidity was Slovenian made from IZR manufacturer, type EPZ 6043. Its features are the temperature maintenance from 15^{o}C to 90^{o}C ± 2 ^{o}C. Centigrade, control of relative humidity from 20% to 90% with possibility of regulation within 5%, where the lower threshold is limited with dew point temperature. The maximum pressure which can be obtained within the chamber is 16.0 Bar. The measurements were done after one, two, three, six and twelve days.

For measuring CIE Lab values of process colours the GretagMacbeth EyeOne spectrophotometer was used. During measurements, the standard viewer 2^o was used as well as standard lighting D50. The gided measuring geometry of this apparatus is 0/45^o, for measurements of surface structure of the material, the SEM (Scanning Electron Microscope) was used.

3. RESULTS

Based on the calculated values of ΔE changes on the samples before and after the samples sp

ent time in the chamber with elevated humidity and temperature (80°C and 65% of relative humidity), it can be seen that the results of the prints printed with conventional inks are as follows:

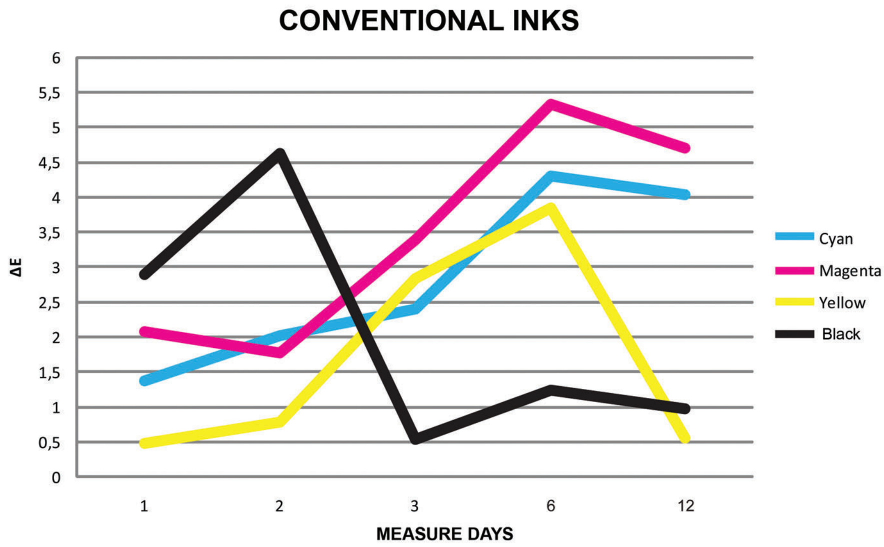

Figure 1: Values of ΔE changes on the samples before and after the samples spent time in the chamber with elevated humidity and temperature

Cyan conventional ink, while at the chamber for the purpose of conducting the Moise test, has shown the signs of deviations from the minimal value of ΔE of 1.378 after the first day, which represents a very insignificant visual difference between two colours. The max value of ΔE of 4.3 which was detected by spectrophotometer after the sixth days, was a significant difference.

Conventional magenta ink has shown its minimal ΔE value of 1.773 after the second day in the chamber and it is a very small visual difference between two colours. The max value of ΔE is 5.326 and it represents the massive visual difference between two samples where one sample has spent six days in the chamber, while the other one has not.

The minimum value of ΔE found in conventional yellow ink, after the first day was 0.478 and represents the difference which cannot be visually determined. The max value has reached its peak after the sixth day and it was 3.85. That is a significant visual difference between two inks.

During measurement of conventional black ink, the minimal values obtained were after the third day. The value of ΔE was 0.538 and this value represents the difference which cannot be visually detected. The max value was measured after the second day when the value of ΔE was 4.625, and this represents a significant visual difference between two inks.

Based on the calculated values of ΔE changes on the samples before and after the samples spent time in the chamber with elevated humidity and temperature (80°C i 65% of relative humidity), it can be seen that the results of the prints printed with hybrid inks are as follows:

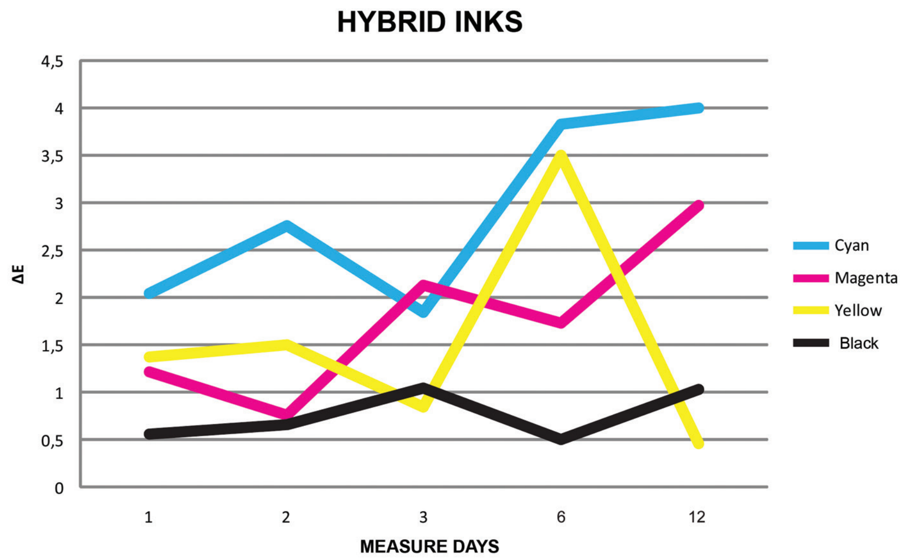

Figure 2: Values of ΔE changes on the samples before and after the samples spent time in the chamber with elevated humidity and temperature

Cyan hybrid ink while at the chamber for the purpose of conducting the Moise test, has shown the signs of deviations from the minimal value of ΔE of 1,85, after the third day which represents very small visual difference between two colours. The max value of ΔE of 4.003, which was detected by spectrophotometer after the twelfth day, represents a significant difference.

Hybrid magenta ink has shown its minimal ΔE value of 0,762 after the second day in the chamber and it cannot be visually distinguished. The max value of ΔE is 2,972 and it represents the average visual difference between the samples that have spent some time in the camber and samples that have not.

The minimum value of ΔE found in hybrid yellow ink after the twelfth day in chamber is 0.467 and represents the difference which cannot be visually distinguished. The max value has reached its peak after day six and it was 3.5. That is a significant visual difference between two inks.

During measurement of hybrid black ink, the minimal values obtained were after the sixth day. The value of ΔE was 0.498 and this value represents the difference which cannot be visually detected. The max value was measured after the third day when the value of ΔE was1.053, which represents a very small visual difference between two inks.

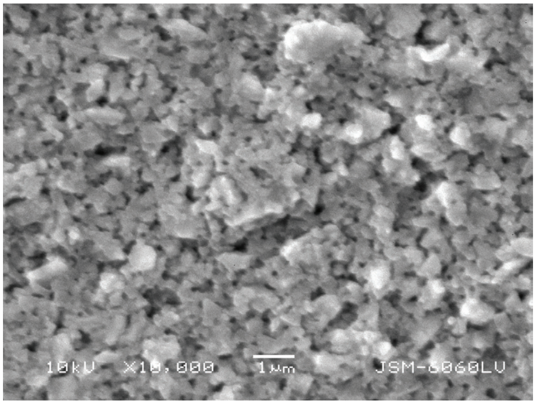

Figure 3: The surface structure of the paper without the printing ink

The figure 3 shows the surface structure of the paper without the printing ink. It can be seen that the paper structure shows a lot of bumps and dips to which the ink adheres. The Roughness average (Ra) is 0.0438μm, the maximum roughness valley depth (Rv) is 0.2109μm, while the maximum roughness peak height (Rp) is 0.1712 μm.

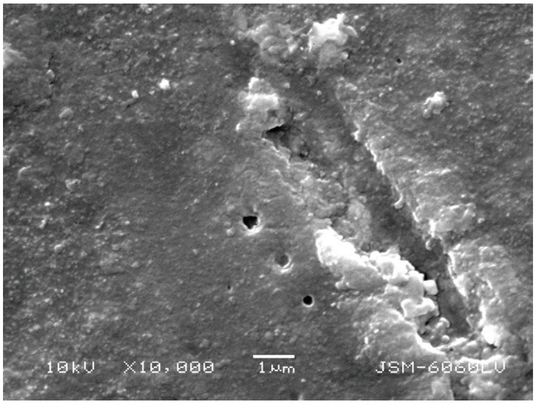

Figure 4: The surface structure of the paper with conventional black ink

The figure 4 shows the surface structure of the paper with conventional black ink applied. It is established that ink had filled cracks and dips creating a film which has smoothened the surface relieves. The Roughness average (Ra) is 0.052μm, the maximum roughness valley depth (Rv) is 0.245μm, while the maximum roughness peak (Rp) is 0.2243 μm. It can be noticed that the values Ra, Rv and Rp have increased in relation to paper without applied ink.

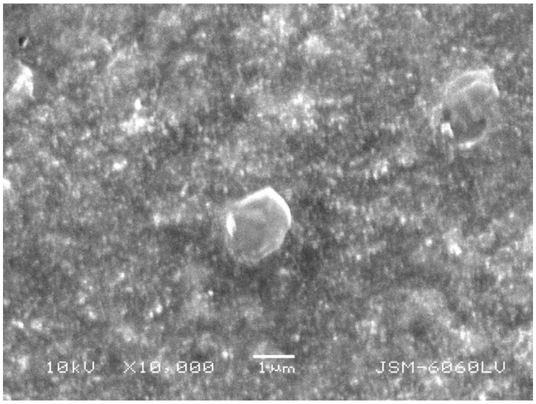

Figure 5: The surface structure of the paper with conventional black ink after 12 days

The figure 5 shows the surface structure of the paper with conventional black ink applied. The print was kept for 12 days in the chamber with increased temperature and humidity. It can be noticed that cracks and dips have enlarged. The Roughness average (Ra) is 0.0635μm, the maximum roughness valley depth (Rv) is 0.2519µm, while the maximum roughness peak (Rp) is 0.2622µm. The values Ra, Rv and Rp have increased in relation to paper with conventional ink which had not been kept in the chamber.

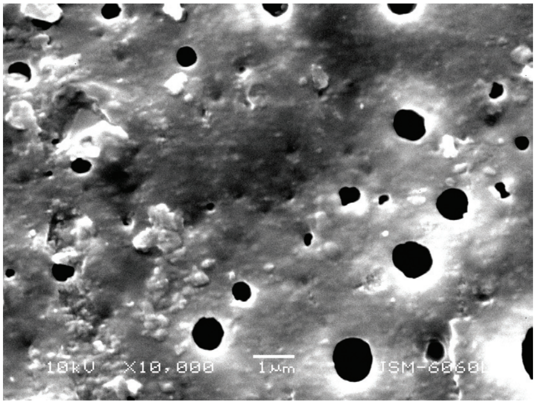

Figure 6: The surface structure of the paper with hybrid black ink

The figure 6 shows the surface structure of the paper with hybrid black ink applied. The same paper was used as in the case of conventional inks. Large number of pits and dips can be noticed. The Roughness average (Ra) is 0.0643µm, the maximum roughness valley depth (Rv) is 0.3967µm, while the maximum roughness peak (Rp) is 0.4459µm. The values have considerably increased compared to surface structure of the paper without ink applied.

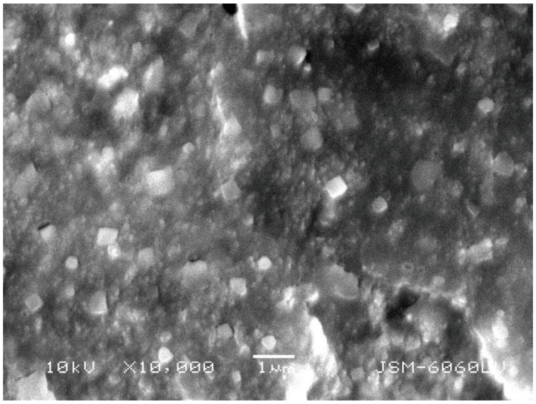

Figure 7: The surface structure of the paper with hybrid black ink after 12 days

The picture shows the surface structure of the paper with hybrid black ink applied. The print was kept for 12 days in the chamber with increased temperature and humidity. It can be seen that there are still some dips on the surface, but because of the poorly focused picture, they are not as visible as before. The Roughness average (Ra) is 0.0505µm, the maximum roughness valley depth (Rv) is 0.2284µm, while the maximum roughness peak (Rp) is 0.2015µm. The values of Ra, Rv i Rp have fallen compared to the paper with black hybrid ink which had not been kept in the chamber.

4. CONCLUSION

Upon the completion of spectrophotometer measurements of the samples printed with conventional and hybrid inks and who spent twelve days in the chamber with elevated relative humidity and temperature, it is established that the minimum values, between the conventional and hybrid samples ΔE approximately equal, except for magenta where the difference ΔE is much higher than the approximate values. The differences between the max ΔE are approximately the same regarding cyan and yellow, while for magenta and black the value of ΔE are considerably higher that approximate values.

We have noticed that at maximum and minimum values of ΔE, there are considerable differences regarding magenta, while at the maximum values it has been noticed that black show considerable difference in ΔE. Accordingly, it can be said that the magenta is the least resistant to surface values of relative humidity and temperature.

The visual evaluation of the photograph created by the electron microscope, it is established that the changes in the surface structure of the material are most noticeable with samples printed with black and magenta ink. The changes in the average coarseness, compared to unprinted paper, are approximately equal in the range of ± 1µm. It is also established that the average coarseness is elevated after twelve days in the chamber with elevated relative humidity and temperature. Hence, the samples printed with conventional and hybrid inks contain more relieves after being kept in the chamber than before.

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XML NORMIZATION OF POST-PRESS MACHINES

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Abstract

In the modern world, the request for the automatization of the entire workflow in all the different types of industries is growing. As the other industries have already implemented automatization workflow, graphic industry is still at the beginning. Because of the specific and unique production, there is no developed software that can be used in general. There are no two similar printing houses with similar problems and work staff. Due to the much bigger production, automatization in graphic industry is becoming a necessity. For automatization and developing of the programs, different programming languages are used. We have chosen XML as a language for definition of normization tables for two post-press machines. We have also included all the parameters that can influence the printing production.
Key words: Post-press, XML, XSLT

1. INTRODUCTION

Graphical industry is one of the most complex industries today. That is evident according to thousands of various products which are every day around us. These graphical products are results of the huge numbers of combinations between processes and capacities. Consequently, these are the reasons why we are today researching for possibilities of processes automation in this industrial branch. The processes of developing a graphical product consist of: prepress technology, printing technology, and post-press technology. In all of these three phases there are the huge numbers of possibilities of executions and mutual chaining of processes. It is necessary to introduce integration and automation in complex systems of graphical industry because of necessity to reduce work execution time and execution more complex works.[1]

To optimize and automatize graphic production it is necessary to define the right normative for every machine in the printing process. It is vital that this normative database is easily changeable and updatable when necessary, and that is why XML (eXtensible Mark-up Language) is used for the normization.

Complex systems of graphical industry introduce integration and automation because of necessity to reduce work execution time. Ending goal of this kind of development is continuing automatic production, financial work processing, work monitoring, and financial work analysis.

The post-press has been a marginal point for many printer-houses. The automatization of post-press operations speeds up production decisions and presentations of their financial consequences.

The XML was recognized as new language of data description and data transferring between applications and systems from various producers (manufacturers or makers). That provides creations of individual solutions in automation of graphical production and possibility of knowledge integration between the normative provisions and standards in graphical industry which came from various sources. [5]

2. XML AND XSL

XML is a markup language designed to carry data, not to display data. That means that it is not involved with the presentation of certain content, but it is interested in its structural and hierarchical organization – with the end goal of achieving the simplest and easiest manipulation of these data. XML was designed to transport and store data, with focus on what data is. By the separation of content and its presentation the higher level of organization and data manipulation is achieved. The appearance, or the presentation of the certain XML document, is defined by XSL (eXstensible Stylesheet Language).

XML tags are not predefined, so the author can define his own tags and his own document structure – XML is designed to be self-descriptive. XML was created to structure, store, and transport information. In the real world, computer systems and databases contain data in incompatible formats. With XML, data can easily be exchanged between incompatible systems. XML data is stored in plain text format. This provides a software- and hardware-independent way of storing data.

Main component of every XML document is the element. Every XML element begins with a start-tag and ends with a matching end-tag. XML elements can have attributes in the start tag. Attributes provide additional information about elements. For example: <JOB

id=”1”>…</JOB> – a XML element, JOB, has an attribute id with a value “1”. It is important that attribute values are enclosed in quotes.

XML documents form a tree structure. They must contain a <root> element. This element is the parent element of all other elements. The elements in the XML document form a document tree – the tree starts at the root and branches to the lowest level of the tree (child elements). For example:

```
<root>
        <child>
                <subchild>.....</subchild>
        </child>
</root>
```

All XML elements, except <root> element, have their parent element (only one), and every element has one or more child elements. The terms parent, child, and siblings are used to describe the relationships between the elements. Parents have children. Children on the same level are called siblings (brothers or sisters).

It is very important that XML documents are well-formed. A well-formed XML document follows these rules of XML syntax: XML documents must have a root element, XML documents must have a closing tag (elements must start with start tag, and end with end or closing tag), XML tags are case sensitive, XML elements must be properly nested within each other, and XML attribute values must be quoted.

XML does not use predefined tags (tags are defined by the author), and therefore the meaning of each tag is not well understood and browser does not know how to display it. XSL (eXtensible Stylesheet Language) describes how the XML document should be displayed.

XSLT (XSL Transformations) is the most important part of XSL as it transforms XML document into another XML document, or another type of document that is recognized by the browser. With XSLT we can add or remove elements and attributes to or from the output file. We can also rearrange and sort elements, perform tests and make decisions about which elements to hide and display, and lot more. [7]

XML document consists of two parts. The first part is the head of the document where the information describing certain XML document is provided. These information include XML recommendation according to which the document has been created (<?xml version=”1.0”?>), as well as the processing instrucions – a link to the XSL document that carries the presentation description of the XML document, and without which the XML code could not be visible as a table (<?xml-stylesheet type=”text/xsl” href=”presentation.xsl”?>).

The other part of the XML document is the body of the document which consists of the XML content.

While creating the XML documents for post-press machines' normization, we defined the XML elements of preparation time and preparation price, and for the price of the single working hour. In this from the end user can easily calculate time and price for any part of production. We have also defined certain parameters that occur in post-press processes, and any of these parameters can be chosen and used, depending of job that is being done. Parameters have certain identification number (CATEGORY cat_id=”1”).

After that the table which includes already given parameters through identification number follows, and it combines them with new parameters – quantity in our case. The new parameters were also given their identification numbers (<ELEMENT el_id=”1” cat1_id=”1”>).

All this parameters and names we defined in XML code, we used in XSLT code. With XSLT we choose how those parameters will be shown and arranged.

3. XML NORMIZATION

The basic condition is to provide a systematic approach to norm setting for all the elements that are part of the graphic production. Description of certain postpress machines requires the setting of a functional dependence of parameters that are specific for that certain machine. There are several hundred different types of machines used in postpress. The norm setting system is based on the measured periods of time that are defined by the influence of various types of material used, edition quantity and the respective prepress prices and prices for machine/per hour use.

A database construction is based on the belonging tables definition for each single postpress machine. The database contains values needed for initial calculations and production control. These are numerical and concrete machine production norms. From each table there is an XML description created for each machine separately, with defined and described specific characteristics. [6]

4. XML NORMIZATION OF THREAD SEWING MACHINE

Thread sewing machines are typically used for the production of high quality books, as well as reference books which are heavily strained during use. Despite the development of new adhesives and new processes in adhesive binding, thread sewing remains the industry standard for high binding quality. [3]

Conventional thread sewing machines comprises two main units: the sewing unit and the automated feeding unit. Very important part of this machine is a sewing saddle which has two positions. First is a feeding position when the gathered sheets (or book block sections) are fed into the machine. Other is a sewing position when sewing saddle leans against the sewing head. Book block sections are then aligned with the sewing head. This is presented on Figure 1. Sewing unit is used for perforating the book block section along the fold gutter. Through these holes the thread will ran binding two book block sections together. When the sewing is complete, the thread is automatically cut, and finally, the finished book block is delivered on the delivery table.Book block sections are sewn together successively – one by one, and that means that the number of book block sections, that are being sewn together, will be very important for the normization of the thread sewing machine. [4] The normization table for thread sewing machine is presented on the Figure 2.

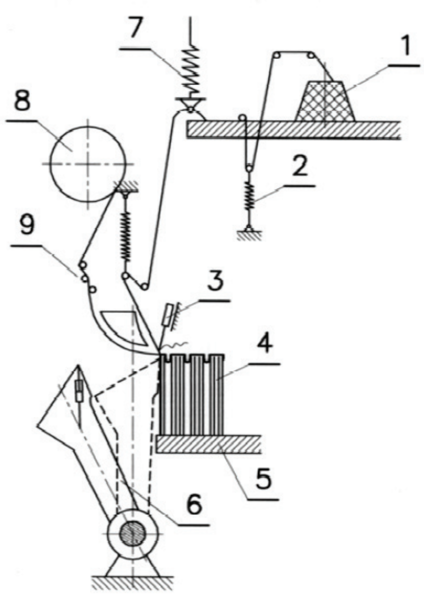

Figure 1. Basic principles of thread sewing machine: 1 reel of thread, 2 thread managing mechanism, 3 sewing head, 4 thread-sewn book block sections, 5 delivery table for discharging the sewn book blocks, 6sewing saddle with piercing needles , 7 brake, 8 reel of gauze, 9 gauze straightening

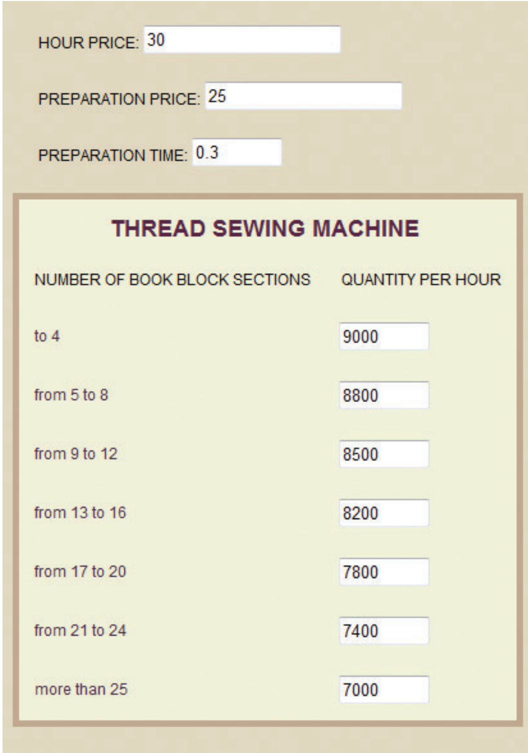

Figure 2. The normization table for thread sewing machine

The normization table translated into XML language is defined this way:

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="thread_sewing_machine.xsl"?>

<root xmlns:sql="urn:schemas-microsoft-com:xml-sql">
        <JOB id="1" name="THREAD SEWING MACHINE" preparation_id="1">
                <NORMATIVE_NAME>QUANTITY PER HOUR</NORMATIVE_NAME>
                <HOUR_PRICE>30</HOUR_PRICE>
```

```
<PREPARATION_TIME>0.3</PREPARATION_TIME>
<PREPARATION_PRICE>25</PREPARATION_PRICE>

<CATEGORIES id=”1” type_id=”1” level_id=”1” name=”NUMBER OF BOOK
    BLOCK SECTIONS”  mod=”auto” type=”int”
source_type=”num_book_block_sec”  source=”” min=”2” max=”40”>
        <CATEGORY cat_id=”1” name=”to 4” min=”2” max=”4”/>
        <CATEGORY cat_id=”2” name=”from 5 to 8” min=”5” max=”8”/>
        <CATEGORY cat_id=”3” name=”from 9 to 12” min=”9”
    max=”12”/>
        <CATEGORY cat_id=”4” name=”from 13 to 16” min=”13”
    max=”16”/>
        <CATEGORY cat_id=”5” name=”from 17 to 20” min=”17”
    max=”20”/>
        <CATEGORY cat_id=”6” name=”from 21 to 24” min=”21”
    max=”24”/>
        <CATEGORY cat_id=”7” name=”more than 25” min=”25”
    max=”40”/>
</CATEGORIES>

<TABLE>
        <ELEMENT el_id=”1” cat1_id=”1”><QUANTITY>9000</QUANTITY>
        </ELEMENT>
        <ELEMENT el_id=”2” cat1_id=”2”><QUANTITY>8800</QUANTITY>
        </ELEMENT>
        <ELEMENT el_id=”3” cat1_id=”3”><QUANTITY>8500</QUANTITY>
        </ELEMENT>
        <ELEMENT el_id=”4” cat1_id=”4”><QUANTITY>8200</QUANTITY>
        </ELEMENT>
```

```
            <ELEMENT el_id=”5” cat1_id=”5”><QUANTITY>7800</QUANTITY>
            </ELEMENT>
            <ELEMENT el_id=”6” cat1_id=”6”><QUANTITY>7400</QUANTITY>
            </ELEMENT>
            <ELEMENT el_id=”7” cat1_id=”7”><QUANTITY>7000</QUANTITY>
            </ELEMENT>
        </TABLE>
    </JOB>
</root>
```

5. XML NORMIZATION OF PLASTIFICATION MACHINE

Plastification is proces of placing film on one or both sides of paper. It is giving final shine to the printed paper, providing protection in addition. Such products are waterproof and resistant to abration. Film for plastification accept decorative function, have also function to protect. They are made in such a way to provide longer products lifetime. Many films for plastification are available in different thickness and final editing, from transparent and shiney to the blurred. Films are made from three basic materials:

Polyester – great combination of optical, physical, mehanical, thermic and chemical properties, suitable for any kind of specific needs

Polypropylene – film for thermic plastification with high constraint resistance, can contain dyes, stabilizers, additives and special coating for better efficiency

Nylon – exceptional resistance to scratching and bending. Wide usage of nylon is in lamination of book wraps.

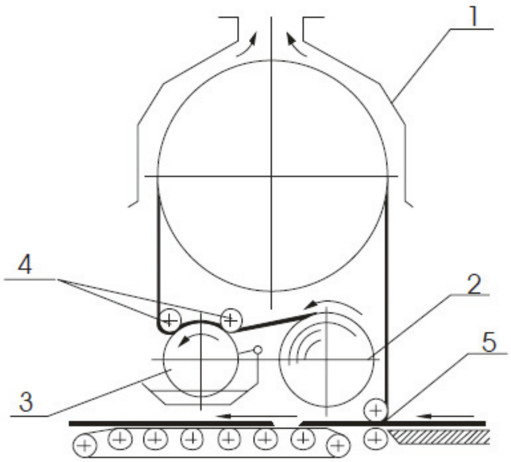

Figure 3. Basic principles of plastification machine: 1. venthole for steam od diluting adhesive, 2. reel of plastic film, 3. roll for laying adhesive on plastic film, 4. binding place of film and paper, 5. paper pass

During plastification, product is cut from the printed paper. In further authomatization processes: pneumatic lift of sheet from the table, linear feeding, printing powder removal, applyment of special adhesive, putting microthin film on sheet, heating on cylinder, protracting, separating sheets and putting on palette. The principle of plastification is presented on Figure 3.

Principle of plastification machines is simple. The paper is load between two films with dried adhesive and it is going through machine in which film, under impact of heat and pressure, is attached to the sheet. By cooling the sheet, adhesive solidifies and does not leave any marks on the printed sheet. On speed of plastification only influence size of the paper. [9] The normization table for plastification machine is presented on the Figure 4.

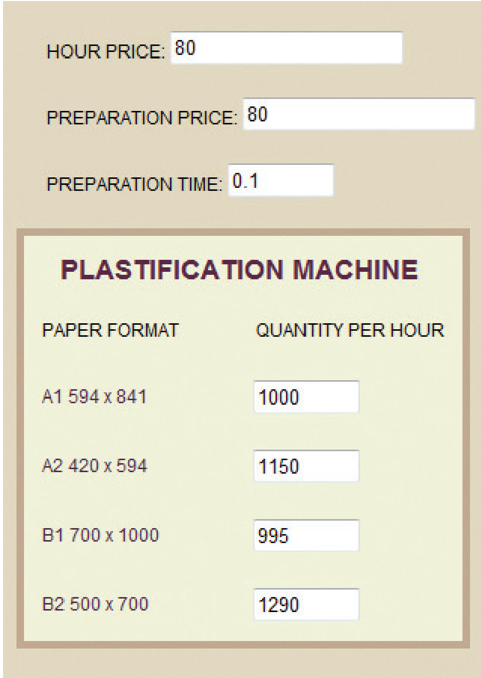

Figure 4. The normization table for plastification machine

The normization table translated into XML language is defined this way:

```
<?xml-stylesheet type=”text/xsl” href=”plastification_machine.xsl”?>
<root xmlns:sql=”urn:schemas-microsoft-com:xml-sql”>
    <JOB id=”01” name=”PLASTIFICATION MACHINE” preparation_id=”1”>>
        <NORMATIVE_NAME> QUANTITY PER HOUR</NORMATIVE_NAME>
        <HOUR_PRICE>80</HOUR_PRICE>
        <PREPARATION_TIME>0.1</PREPARATION_TIME>
        <PREPARATION_PRICE>80</PREPARATION_PRICE>
        <CATEGORIES id=”1” type_id=”1” level_id=”1” name=”PAPER FORMAT”
    mod=”auto” type=”int” min=”340” max=”1200”>
            <CATEGORY cat_id=”1” name=” A1 594 x 841” min=”594”
max=”841”/>
```

```
            <CATEGORY cat_id="2" name=" A2 420 x 594 " min="420"
max="594"/>
            <CATEGORY cat_id="3" name=" B1 700 x 1000" min="700"
         max="1000"/>
            <CATEGORY cat_id="4" name=" B2 500 x 700 " min="500"
max="700"/>
        </CATEGORIES>
        <TABLE>
            <ELEMENT el_id="1" cat1_id="1"><QUANTITY>1000</QUANTITY>
            </ELEMENT>
            <ELEMENT el_id="2" cat1_id="2"><QUANTITY>1150</QUANTITY>
            </ELEMENT>
            <ELEMENT el_id="3" cat1_id="3"><QUANTITY>995</QUANTITY>
        </ELEMENT>
            <ELEMENT el_id="4" cat1_id="4"><QUANTITY>1290</QUANTITY>
            </ELEMENT>

        </TABLE>
    </JOB>
 </root>
```

6. IMPLEMENTATION

It is possible to develop programming model/workflow based on XML, and only term for that is to make normative provision description of all production process factors. The whole model is established on normative provision basis, where all operations and capacities are described in detail. [1] Developed model is based on relational database where all necessary normative provisions and prices are saved, and which have developed XML system with XML Schemes. Data acquisition in relational database and acquisition in XML data is accomplishing throughout XSLT technology, as presenting and interfacing technology with goal to work throughout browser. [5] The part of the workflow appearance based on XML is shown on the Figure 5.

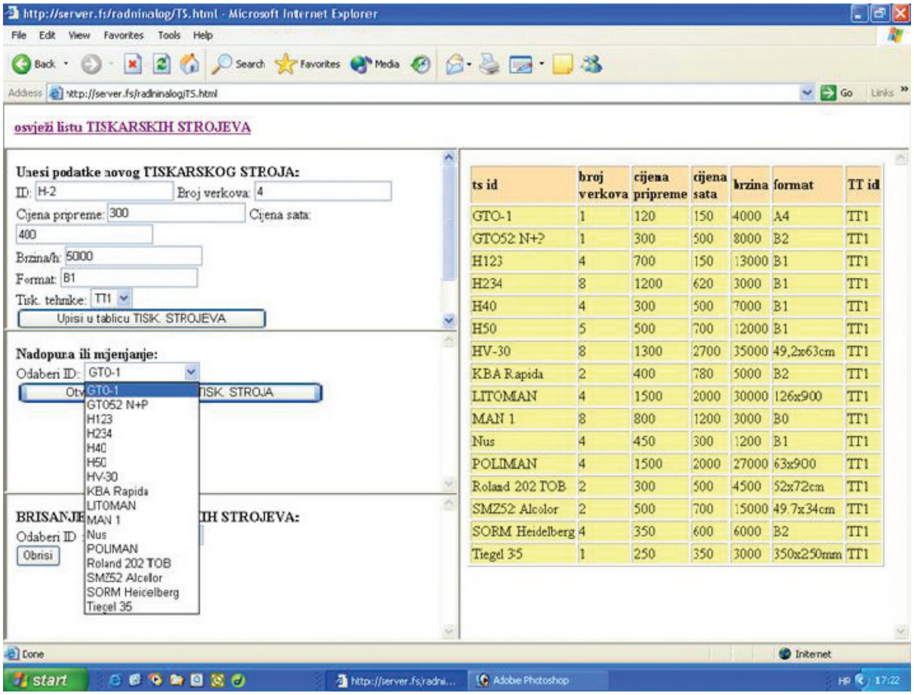

Figure 5. Workflow based on XML normization (in Croatian)

7. CONCLUSION

We concluded that XML as language is very appropriate for organizing and storing large quantities of data, and also very easy to use and very easy to manipulate. User can create his own language, and then follow the main structure or XML Schema. Any XML code can be easily edited with XSLT which provides visible interface anyone can use.

Automatization in graphic industry is a main goal which must be pursued. With automatization it is much easier to control the workflow, the production is accelerated, the possibility of human error is reduced, and the complete insight of production in its every stage is provided. The presence of engineer on the site is not essential because the production can be controlled from any remote spot. Except controlling and organizing machines and their work, by developing workflows it is easier to oversee the work staff. [8] The only downside of organizing the production in this way is that this system is appliable only for repeatable and constant parts of production that can be predicted. When unexpectant event or a failure in production occurs, workflow is not useable.

The XML normative tables that are presented in the work are just a part of the whole interface which also includes prepress and printing processes and normatives. They are the base for automating and normizating production in the printing press. The very nature of XML enables constant updating and editing the system. While XML is used for organizing and storing data, XSL can make this data look more appealing and accessible for the end user.

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TO DEVELOP A METHOD OF ESTIMATING SPECTRAL REFLECTANCE FROM CAMERA RGB VALUES

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Summary

Spectral reflectance represents physical information of an object surface. This work will give an effort to reconstruct spectral reflectance of an imaging surface by using RGB camera signals as an input. The camera has been characterized by direct measurement of the camera sensitivity curves and three of the most used printing technologies are employed to obtain test samples. By using decomposition and dimension reduction techniques like PCA and Wiener estimate and the domain of linear algebra, evaluation of a method performance by varying different parameters will be performed. Additional optimization will be introduced to try to model for used printed samples. Observations show that if most of the parameters are carefully controlled that spectral reflectance is more or less satisfying and that is dependable on the sample used. Improvements in the analysis have given better approximations and after optimization have been employed, the reconstruction method could be used in many applications in graphic arts area.
Key words: spectral reflectance reconstruction, camera characterization, spectral colour management

1. INTRODUCTION

In a conventional colour management system the spectral reflectance will be converted to the common space which will describe object tristimulus value or how will that particular colour will look under some of the standard illuminants or real light sources. However, many applications will require the object reflection to be known and independent on the viewing illuminant. The imaging sensor is essentially linear device in terms opto-electronical conversion. If all noise sources would be eliminated, it should be possible to establish linear relation with the input signal. This would effectively provide a possibility to use a camera instead spectrophotometer. Possibility like this is usually reserved for the field of multispectral imaging or trichromatic camera equipped with selected set of filters. Usually this equipment is rather expensive and not ready available. This work has intention to develop a method of spectral reflectance reconstruction from RGB digital counts using just lower class SLR digital camera and available light source. If the accuracy of the reconstruction good enough, then printers characterization and profiling could be made using the camera as an input instrument. Spectrophotometers are also expensive and slow, especially if the characterization targets containing over 900 colour patches.

Offset machine Heidelberg Speedmaster was used to print on two different surfaces: regular offset paper and cardboard. Glossy paper was fed to Epson ProPhoto 4000 ink jet printer to give high reflective print sample, but in the contrast, same technology is used make a print on cotton with Myake Texjet printer. This surface has the least mean reflectance of all used in this project and this is due to its translucency. Finally, laser or electrophotography technology representative was Xerox Docucolor and it used regular paper as a surface. All the prints included IT87-3 CMYK target with 940 patches.

2. METHOD

Spectral characterization of the imaging system (*Canon 300 D*) was perform by direct measurement using the monochromatic light outputted from *Bentham Dm150* double monochromator. The wavelength step was set to 10nm range where for each of these steps, five images were acquired. To discover spectral sensitivity curves the average values were extracted from multiple images.

Obtaining an imaging sensor sensitivity curves requires on board non – linear processing to be turned off. For this purpose the *dcraw* utility has served as it provided with possibility not only to switch off some of the post processing, it has also provided with possibility to change some of parameters.

When image is formed on the sensor as black and white, light information, interpolation techniques are employed to recover colour information. Other processing like, white balance, gamma correction, colour space conversion have been switched off and the final outputted image was saved as 16bit TIFF.

One of the conditions if camera system was to be used as a measuring instrument is that it should exhibits linear response on the input signal.

Other is to make sure that input is coming in form of some stable signal, the outside illumination conditions also should be controlled. With inclusion of flare and illumination uniformity measurement it is believed that all the conditions are controlled. To obtain magnitude of these, the *Gretag Macbeth DC* test chart with outside in central patches have been measured *Minolta CS-1000* telespectroradiometer and imaged with the camera. For light source, two tungsten lamps were positioned 45° to the imaging surface (*Figure 1*).

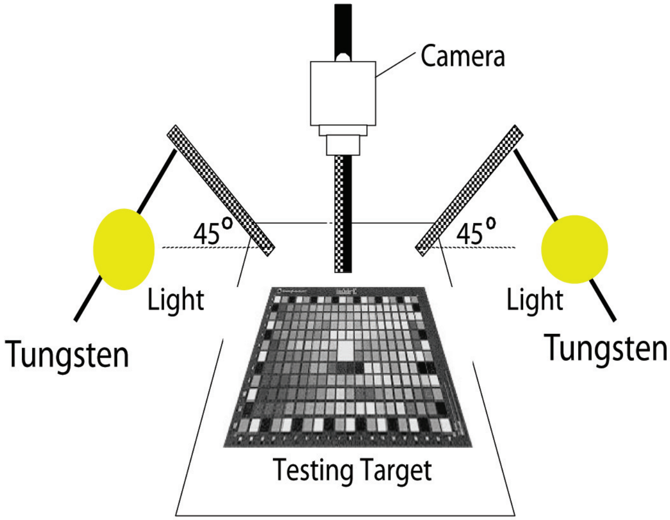


Figure 1. Imaging setup

Once an image was created, it needs to be corrected for non – uniformity, noise and flare. If the image is denoted as *I (x,y)* then normalized image would be:

$$In(x,y) = k * (I(x,y) - noise - flare) / (L(x,y) - noise - flare)$$

where *k* is normalizing constant chosen that maximum pixel value of the normalized image is not higher than maximum measured value for white of the surface, and *L* is luminance profile (*Figure 2*).

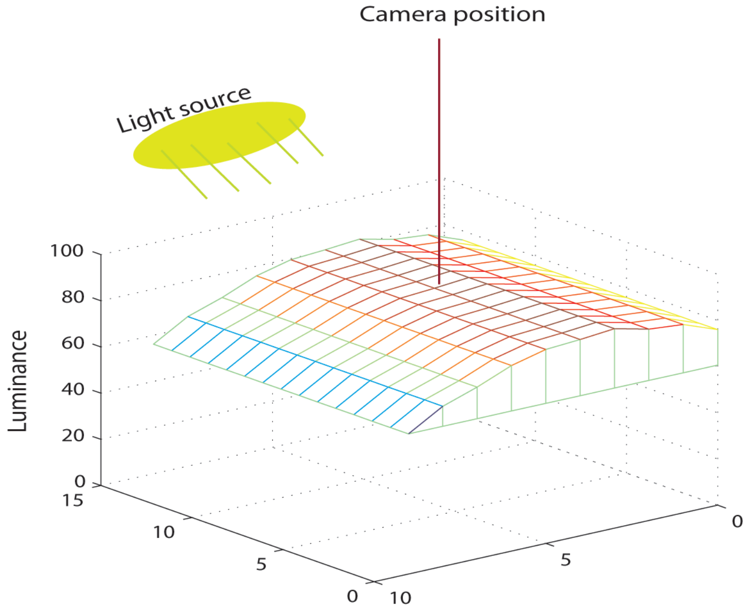


Figure 2. Luminance profile of the imaged area

3. RESULTS

Spectral reflectance reconstruction is based on the prior knowledge about reflectance properties of imaged object. Whole spectrum could be represented with just three basis vectors. Prints were measured using *Gretag Macbeth Spectrolino* and the reflectance have been put through principal component analysis to obtain characteristic vectors for all used samples. Special care will be taken for media dependence, number of colour patches involved in analysis and ability of PCA to include enough variability needed for accurate reconstruction. To form an input for PCA, four primaries (CMYK) tone scale from the IT87-3 test chart are chosen to represent whole variability within the spectrum. These are referred as training set. For the test samples, any of the secondary on the test chart could be used where chart could be divided regard to lightness on to dark and light regions. The first three principal components of the test samples are shown on *Figure 3*.

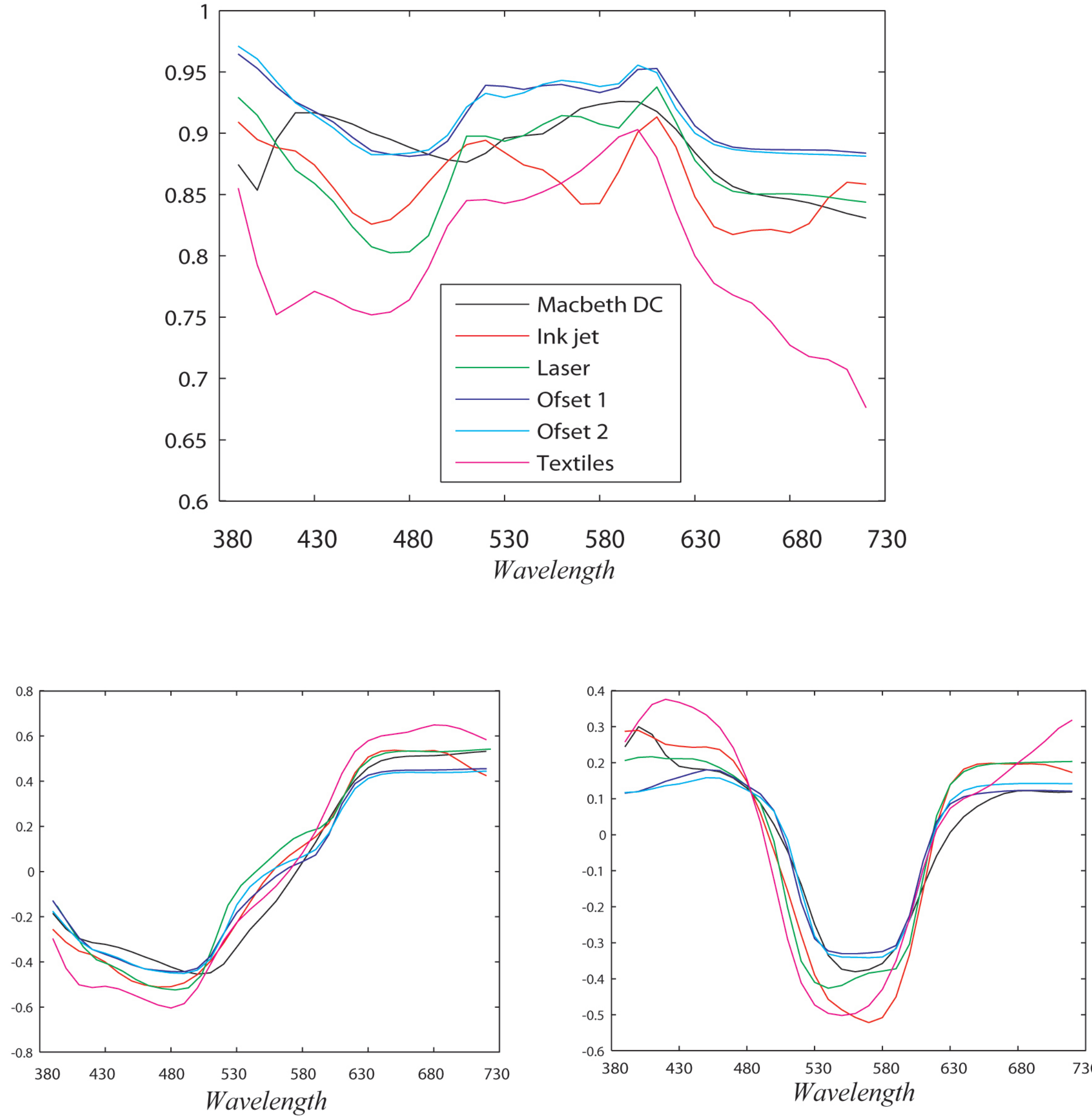


Figure 3. Principal components extracted from the measured prints

By using imaging sensor, as an inherently linear device, it could be said that RGB digital values are formed in a much same manner like CIE XYZ coordinates and then the output RGB digital values can be represented in the form of linear algebra as:

$$T = S * I * R$$

where *T* is the *3 x m* matrix of RGB values, *S* is *3 x n* spectral sensitivity matrix, *I* is an *1 x n* illumination source vector and *R* is *n x m* matrix of reflectance. Index *m* stands for number of colour patches or samples, and *n* stands for number of sampling points within the visible spectrum.

Matrix *R* of spectral reflectance could be represented with just three principal components used where dimension reduction from *n* to *3* is performed using PCA. The newly formed matrix *B* has a size of *3 x n*. Reconstruction of the input spectrum can be presented then as the product of the principal component matrix and the matrix of coefficients *C:*

$$Rrec = k * B * C$$

where k is normalizing constant used to normalize reconstructed spectrum on the given maximum reflectance value of the media.

Matrix *C* is formed from the system response on the given reflectance and is obtained through matrix inversion process:

$$C = inv\ (SI_T * B) * T_T$$

The mean error Δr gained in a spectrum reconstruction is calculated as:

$$\Delta r = \Sigma\ (Rrec - R)\ /\ n$$

Where n is the number of sampling points.

Standard deviation is computed as

$$\Delta rstd = [\ (\Sigma\ Rrec – R)2\ /\ n\ ]\ ½$$

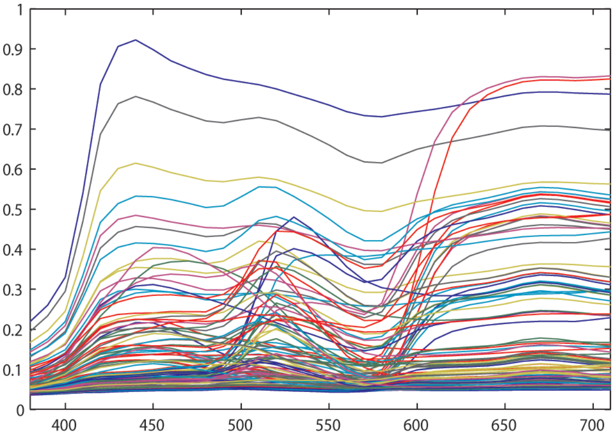
The error derived from spectrum reconstruction can also be expressed as the colour difference *ΔE** in *CIELab* space.

Results have been calculated from training input set and have been evaluated with the test colour set within each of the used samples. The error metric is reported as mean and standard deviation of ΔR reconstruction difference in reflectance space and as mean, max and min CIE2000 ΔE colour difference formula (*Table 1*). This formula agrees better with visual colour differences for small to medium colour differences than the other formulae. Colour difference has been computed for CIE 1931 observer and A illuminant. Transformation form reflectance to XYZ coordinates has included D65 as a viewing illuminant.

	Textiles	*Offset 1*	*Offset 2*	*Ink jet gloss*	*Laser*
ΔR	*0.01*	*0.024*	*0.031*	*0.037*	*0.028*
ΔR std	*0.018*	*0.029*	*0.028*	*0.032*	*0.038*
*mean ΔE**	*2.2*	*3*	*4.4*	*4.8*	*3.1*
*max ΔE**	*6.3*	*8.1*	*9.6*	*10.2*	*7.03*
*min ΔE**	*0.73*	*0.37*	*1.2*	*1.3*	*0.85*

Table 1. Results of the reconstruction expressed as a mean difference, standard deviation and colorimetric difference

It can be seen here that the reconstruction error is a function of mean reflectance values within samples where those with highest mean reflectance value have the largest reconstruction er-ror. This implies that high gamut/dynamic range media caries a large variation in reflectance within colours and that PCA have no ability to adapt. Original and measured spectrum for test colours is represented on the *Figures 4 and 5*.



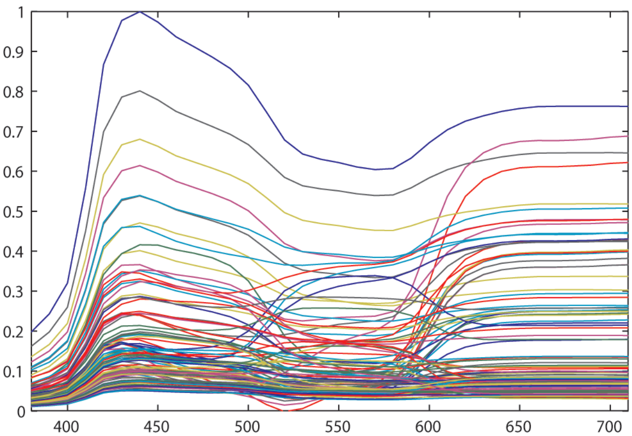


Figure 5 and 6. Measured (top) and reconstructed spectrum (bottom)

4. DISCUSSION AND CONCLUSIONS

Finally, when all parameters have been evaluated, the question is what is the right combination to achieve the aim of the highest possible accuracy in the reconstruction process?

It is found that overall precision of the reconstruction is depending on the average luminance or mean reflectance values of the surfaces, where those with higher luminance values will yield less precise reconstruction results. One of the reasons for this could be that principal components can not carry enough variability to describe high reflective surface – pigments combinations. This also applies and confirms the assumption made before that low reflective surfaces could be accurately reconstructed from the input basis vectors formed from high reflective surfaces. This could reduce the number of measurements radically and if the reconstruction gives satisfying accuracy, the possibility of obtaining the hundreds of reflectance functions out of one shot of the camera.

If the high level of reconstruction accuracy want to be achieved, some sort of optimization is necessary if using trichromatic camera. The process of optimization should provide a fit with all samples and they all should be analysed prior optimization had been performed. This would effectively give global optimum that will work for all prints and this will be one of the next improvements in the future.

5. FURTHER WORK

By finding the relation between sensitivity curves and reconstruction they produce, it would be possible to build spectral reconstruction model that can be applied on the variety of the surfaces and pigments combinations. Also, with variety of the illumination sources being evaluated for reconstruction process, it is possible to make an illuminant independent reconstruction model which has great importance when the camera systems are involved.

More attention will be dedicated in creating a model that might work for all prints. Especially optimization part is the one to improve, as well as approach in forming PC and seeking for the one set that can be used to represent variety of colors and substrates.

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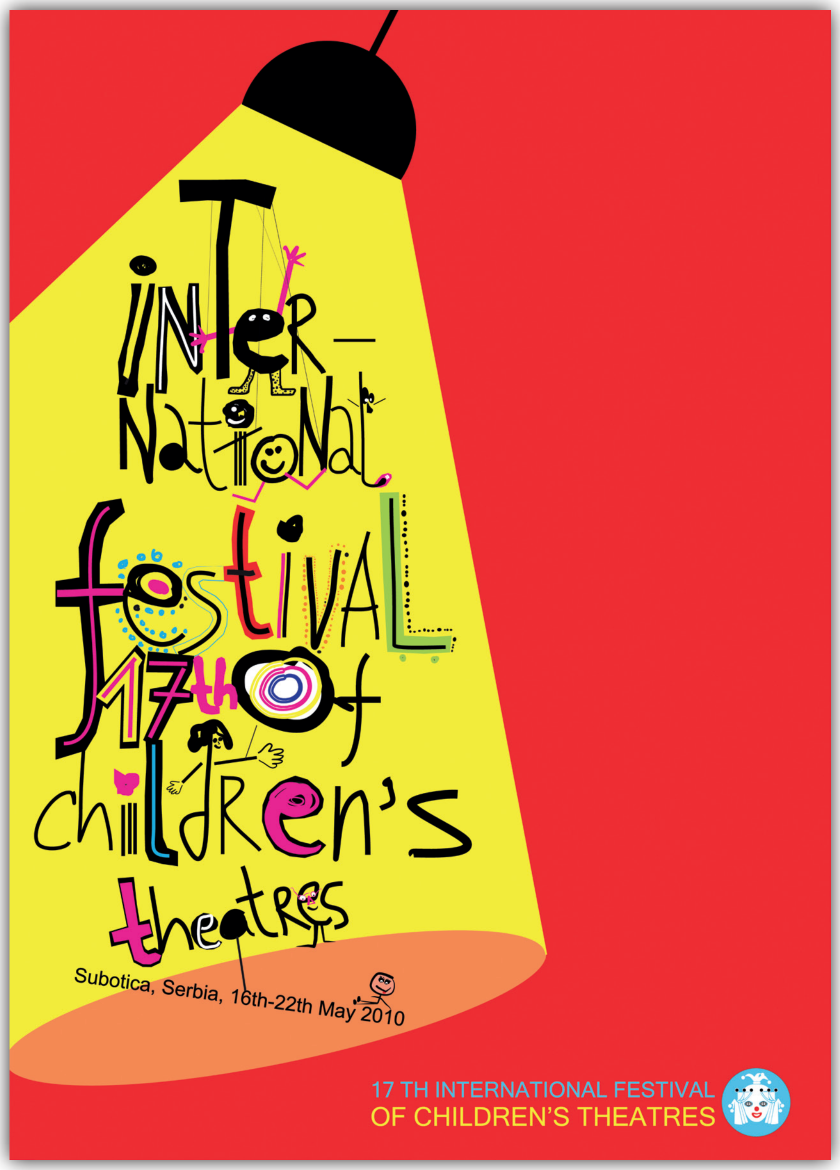

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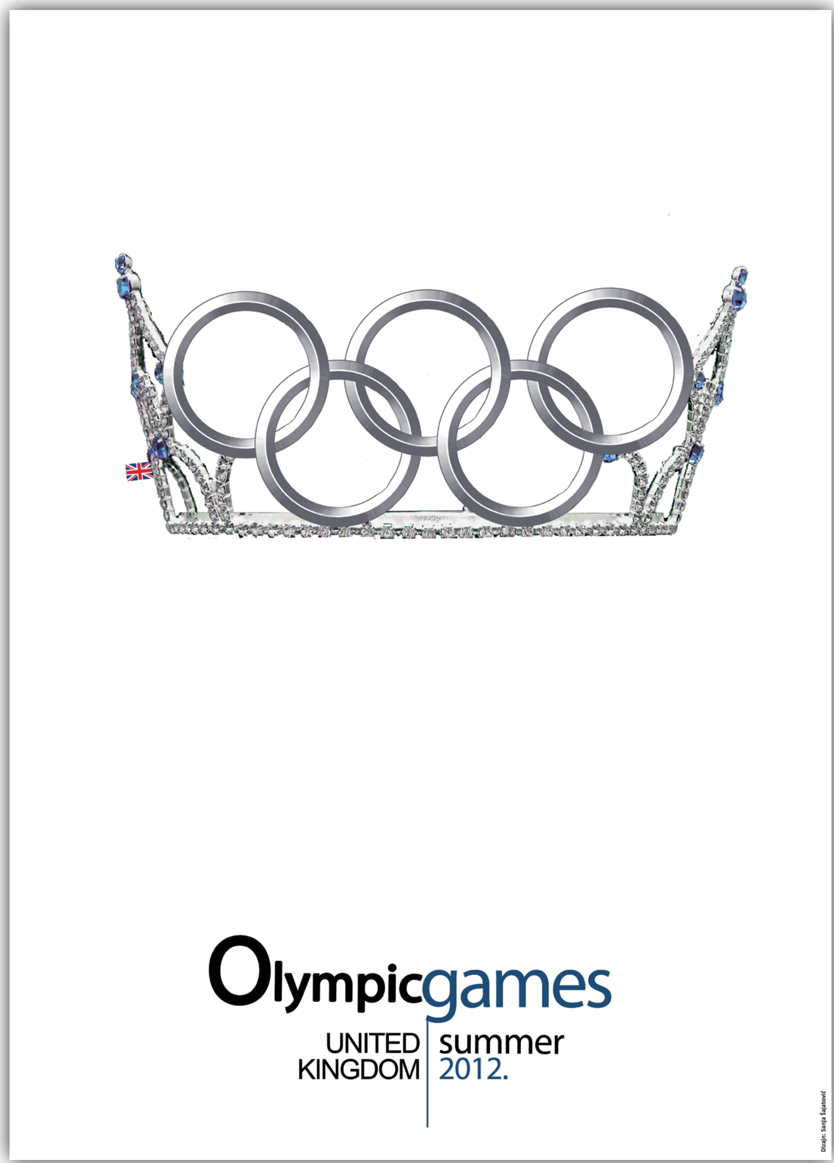

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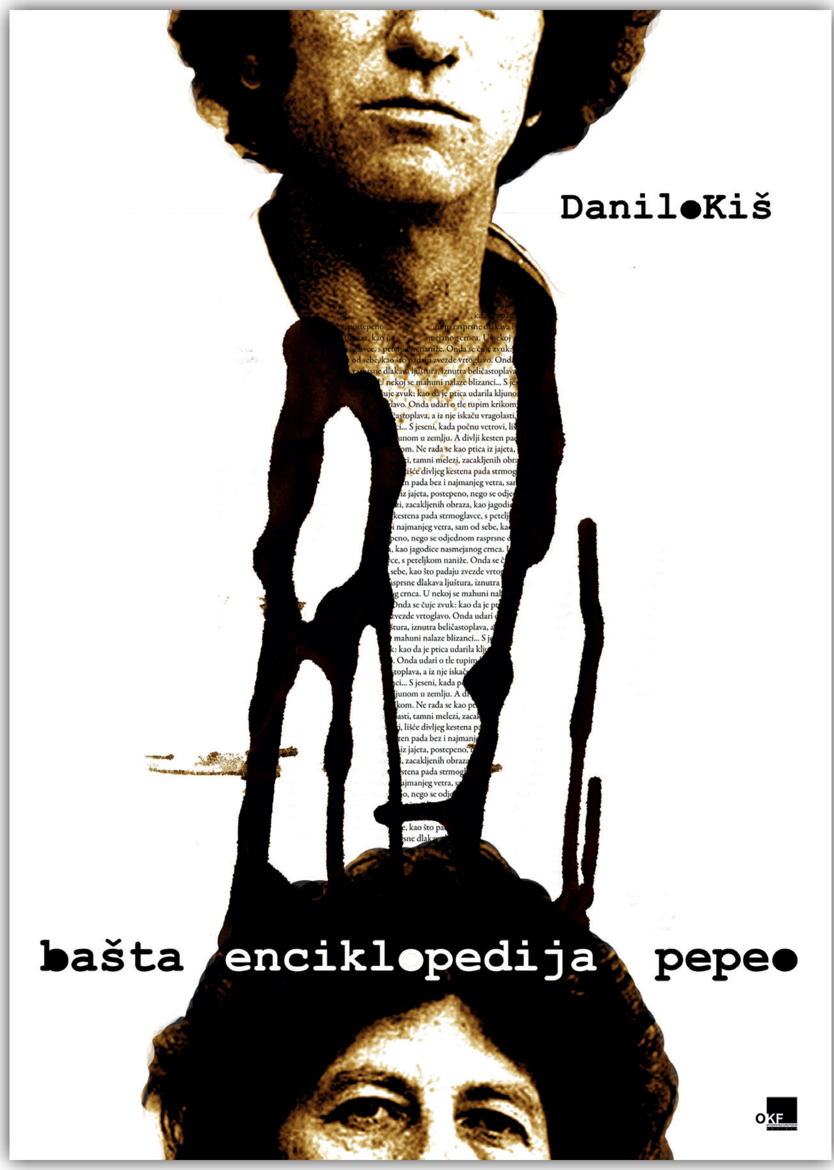

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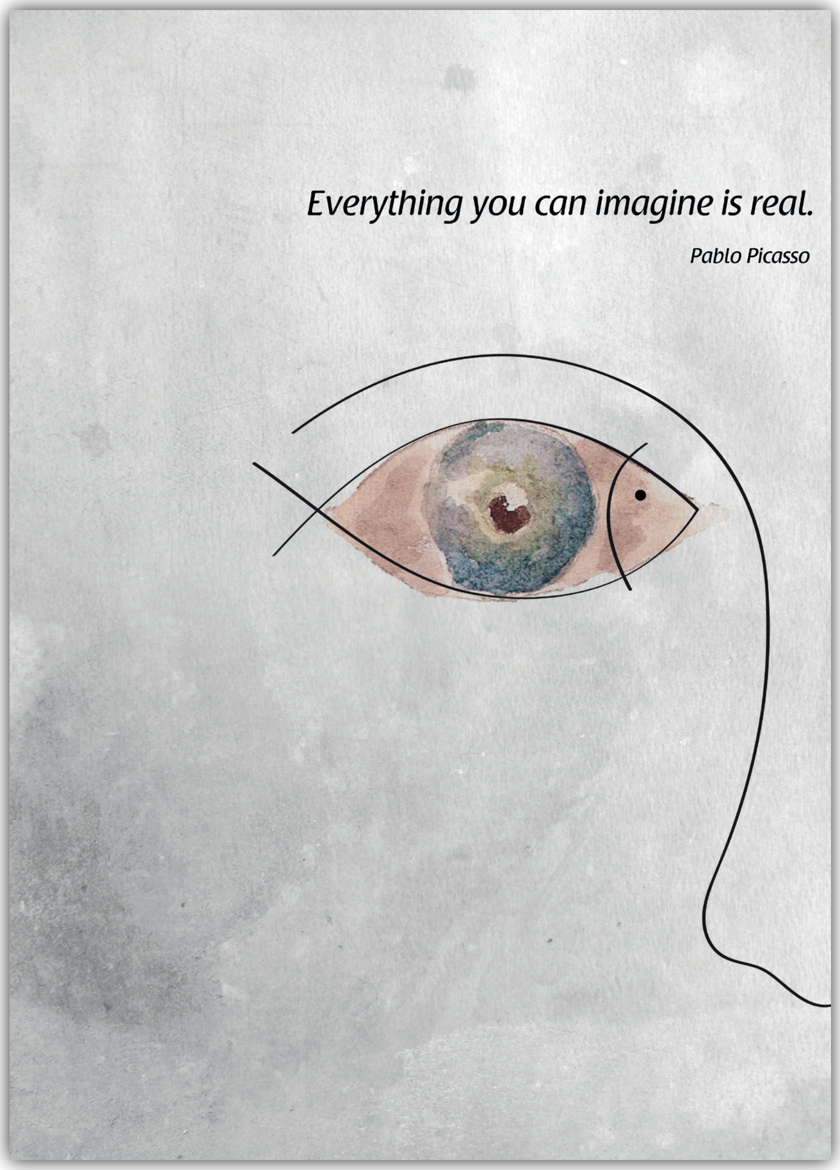

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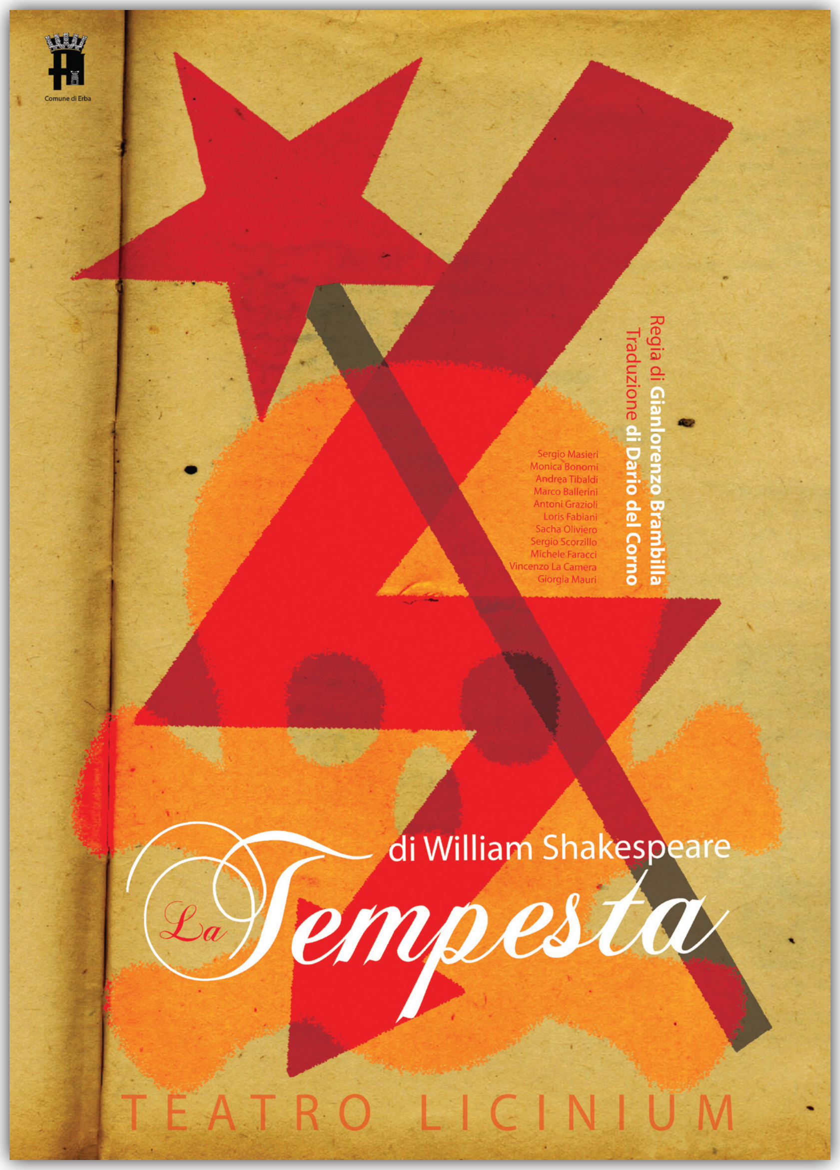

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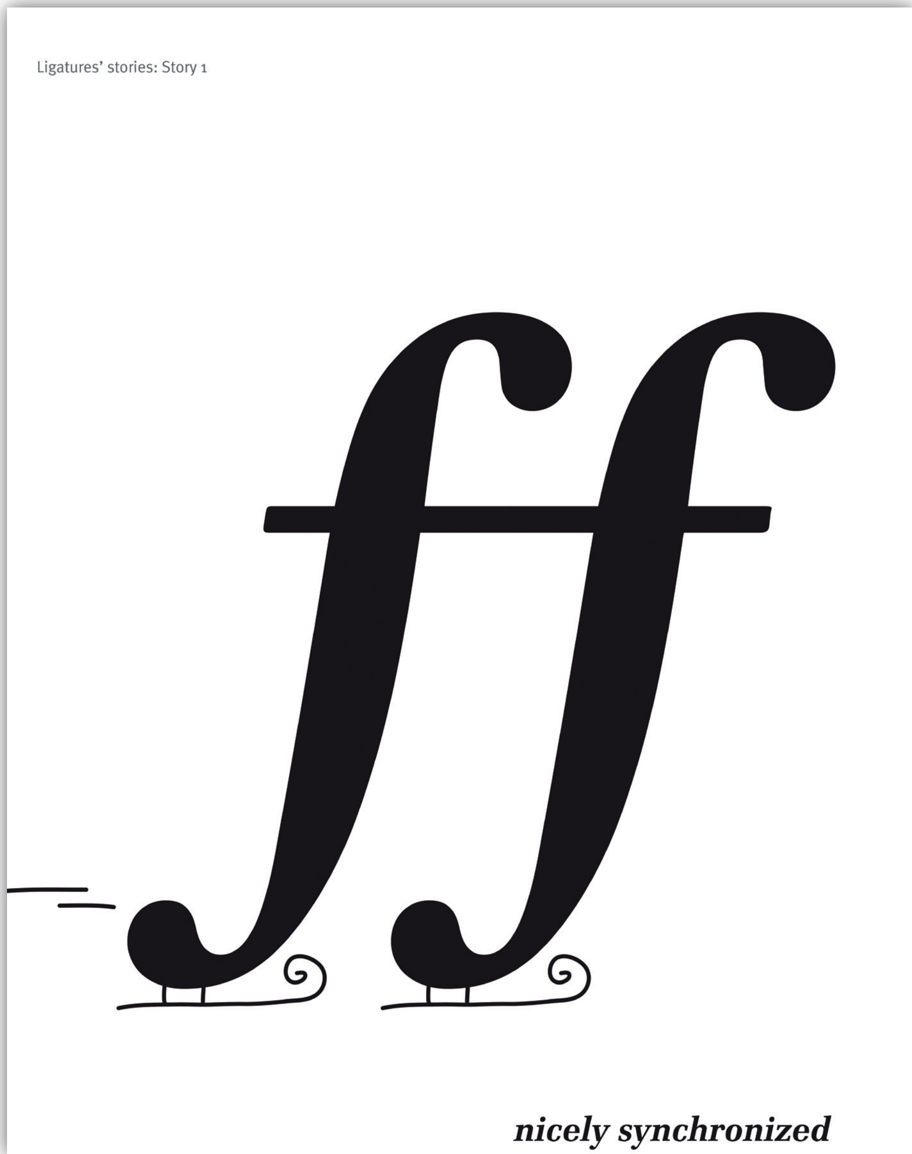

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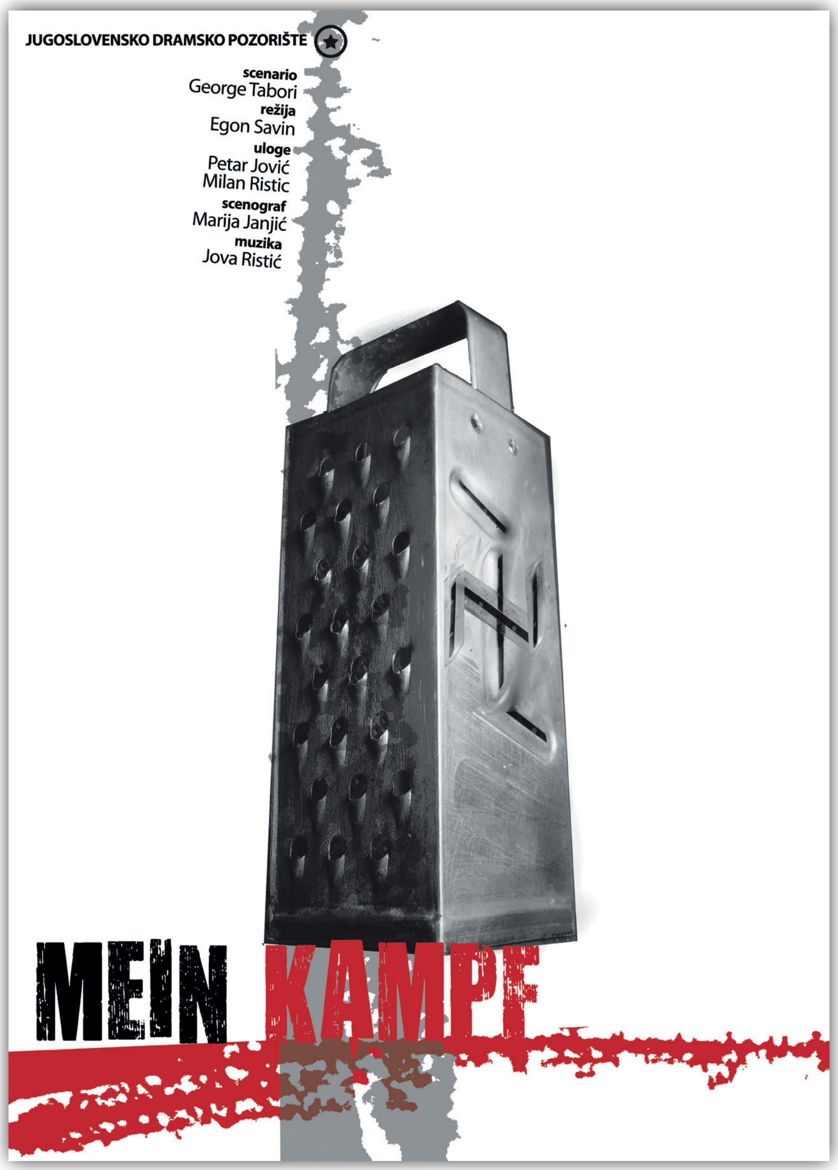

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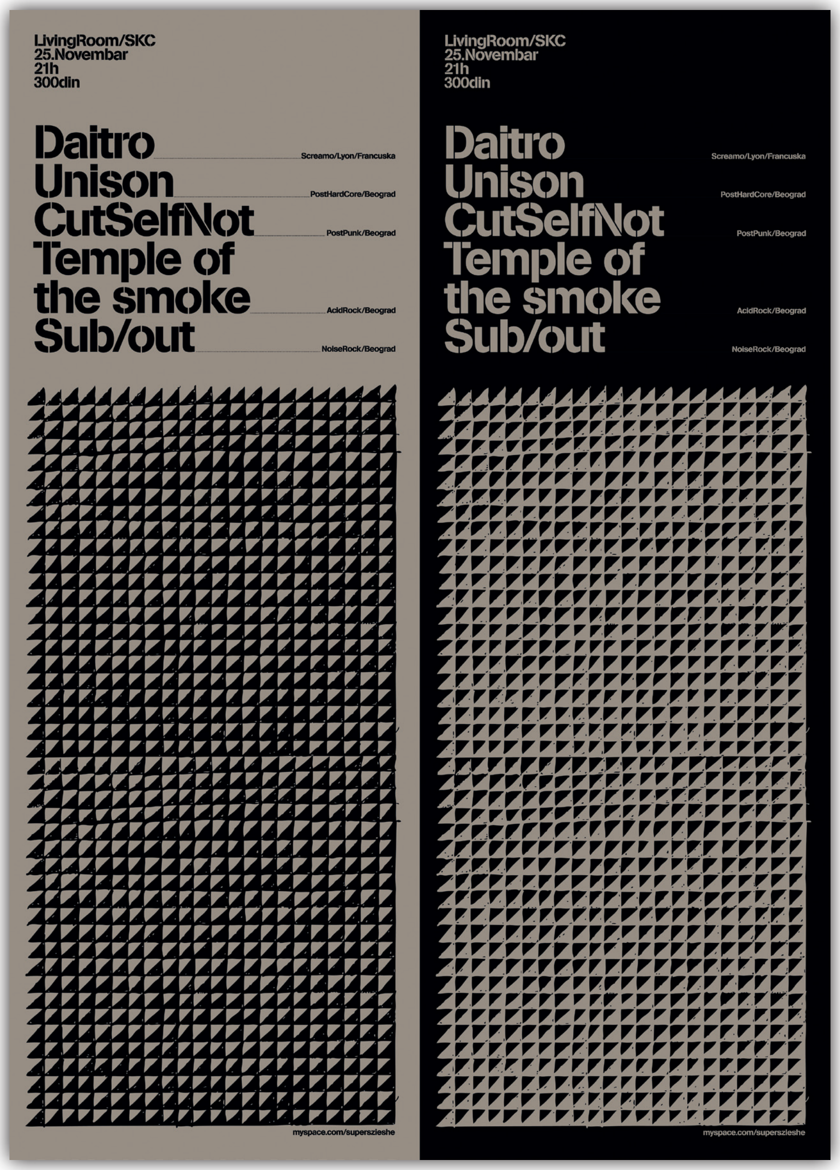

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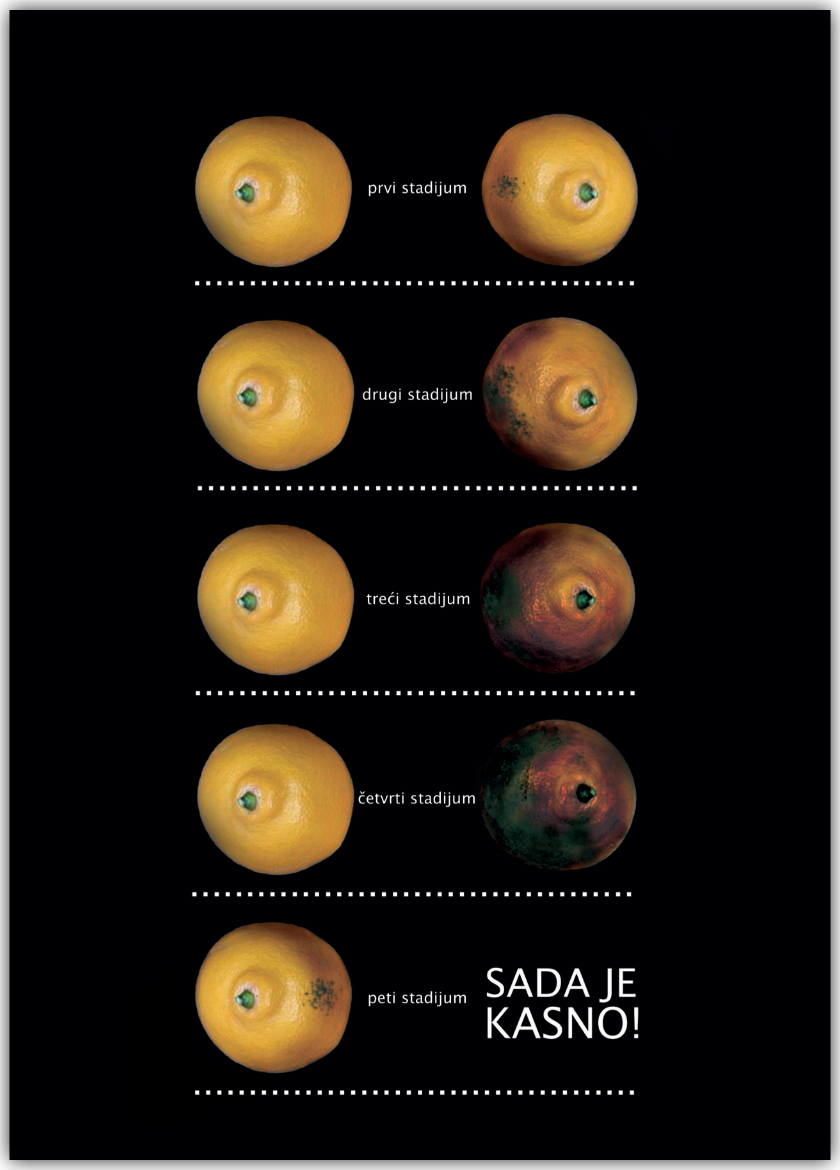

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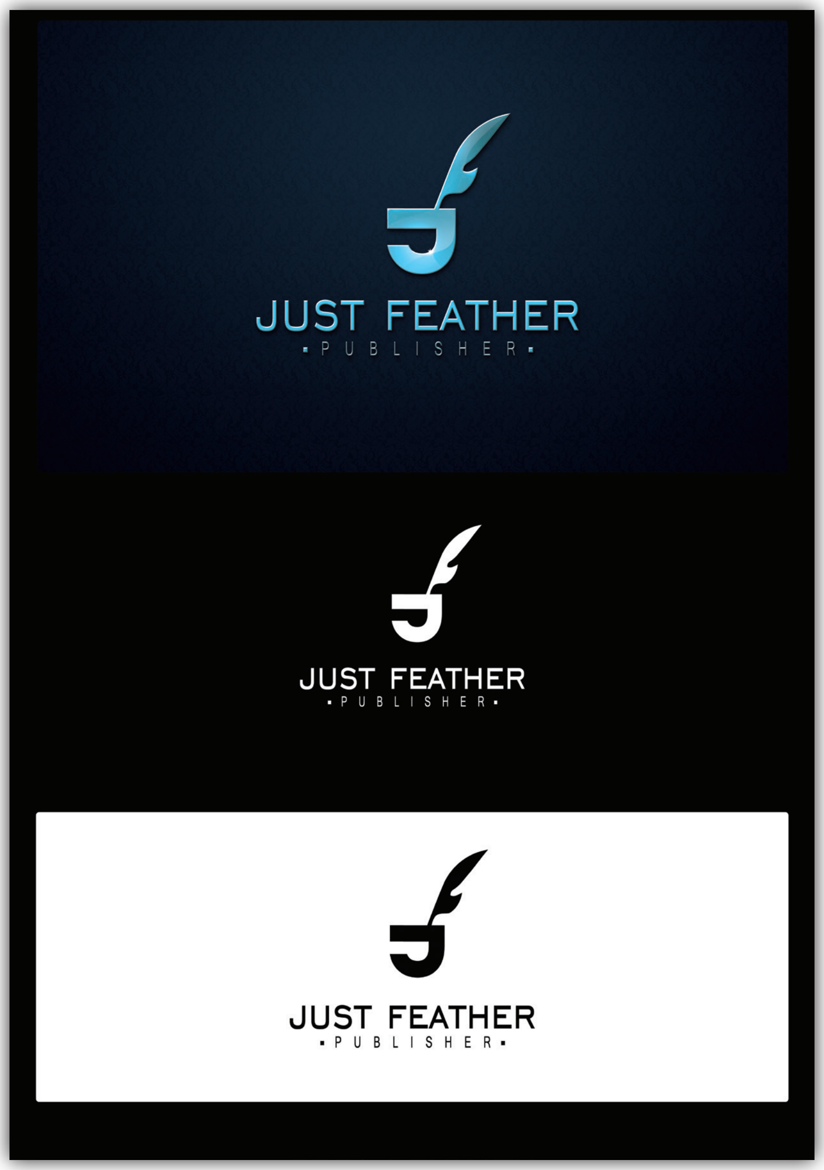

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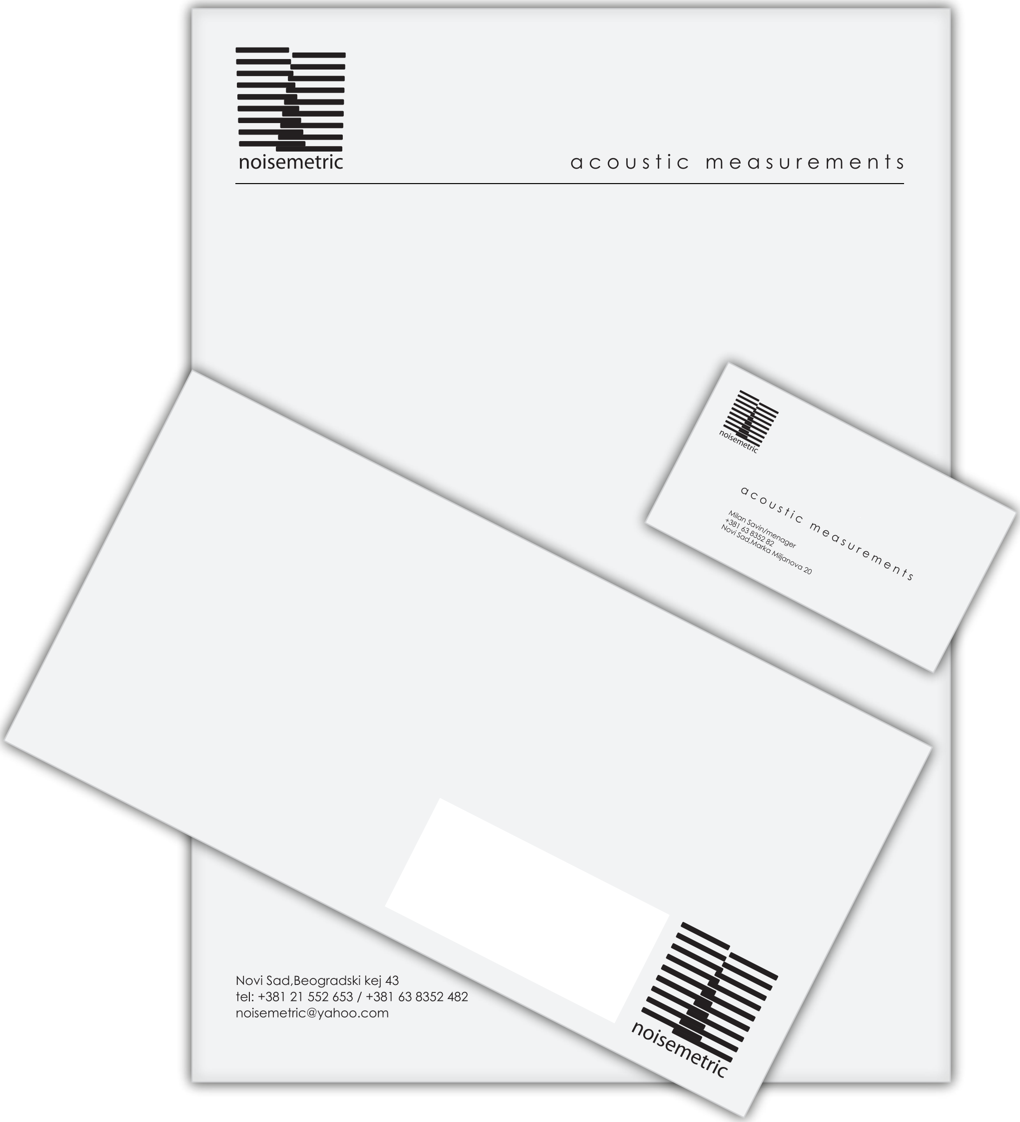

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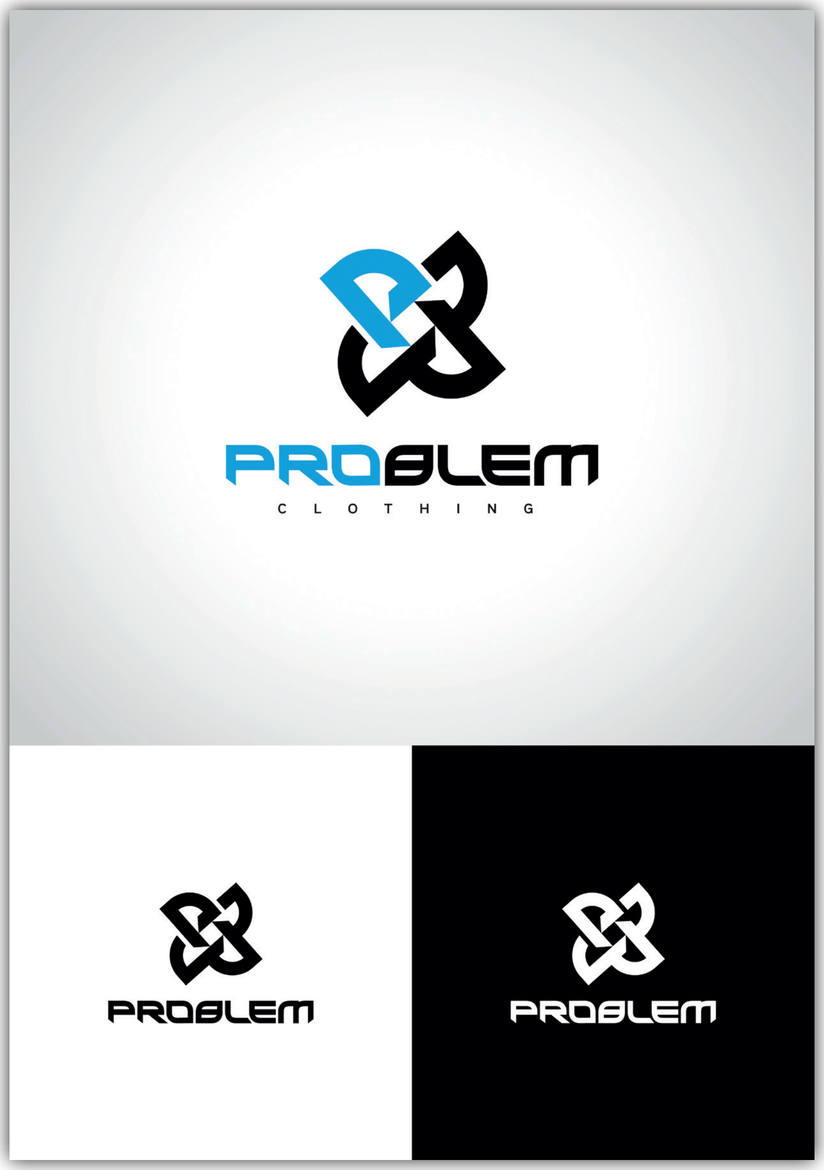

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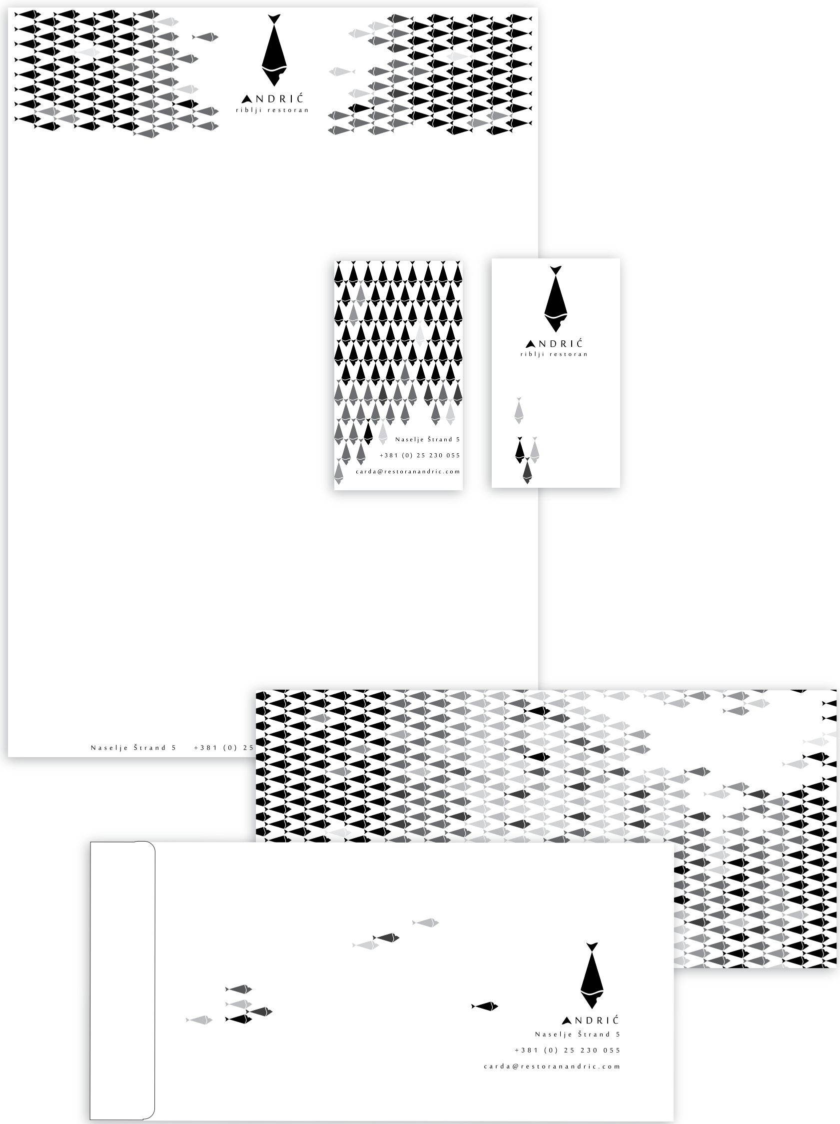

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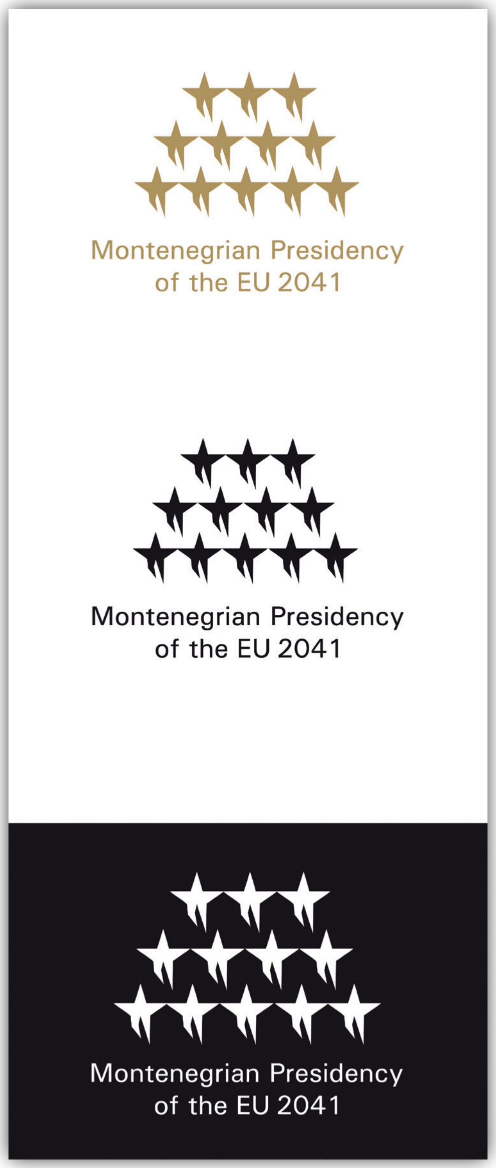

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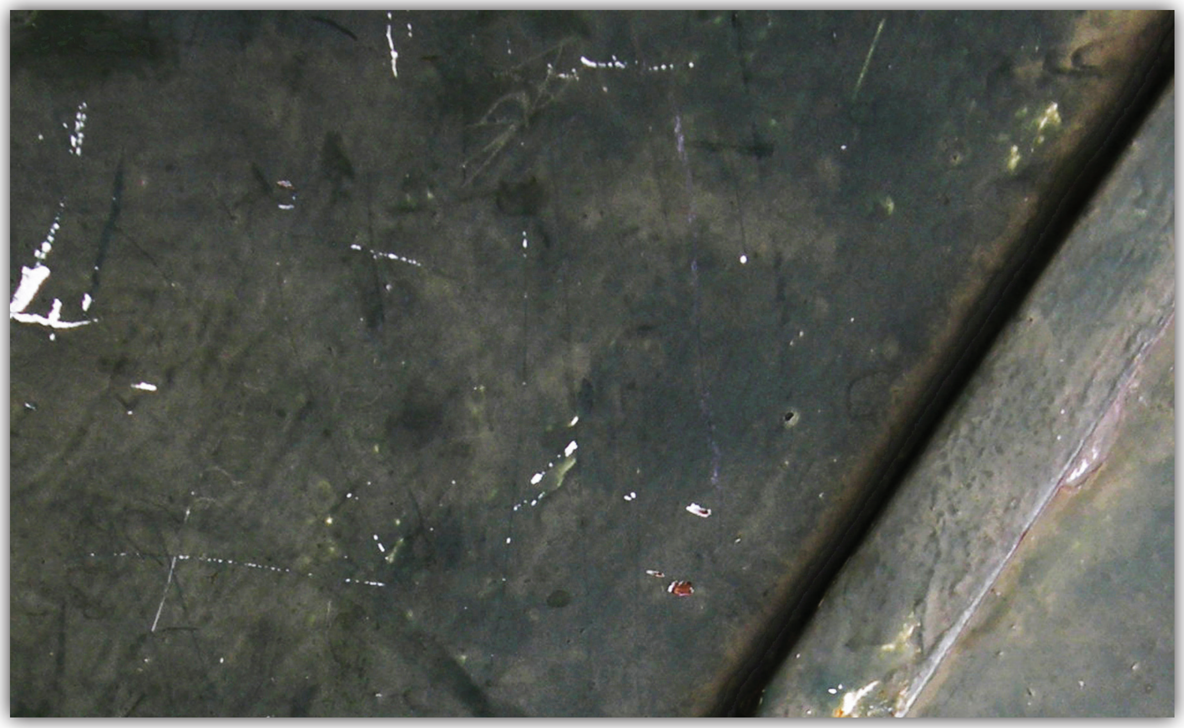

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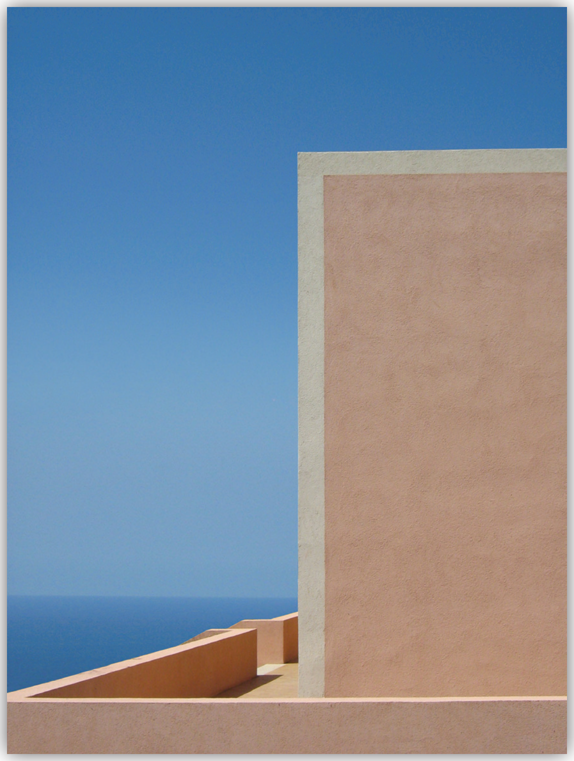

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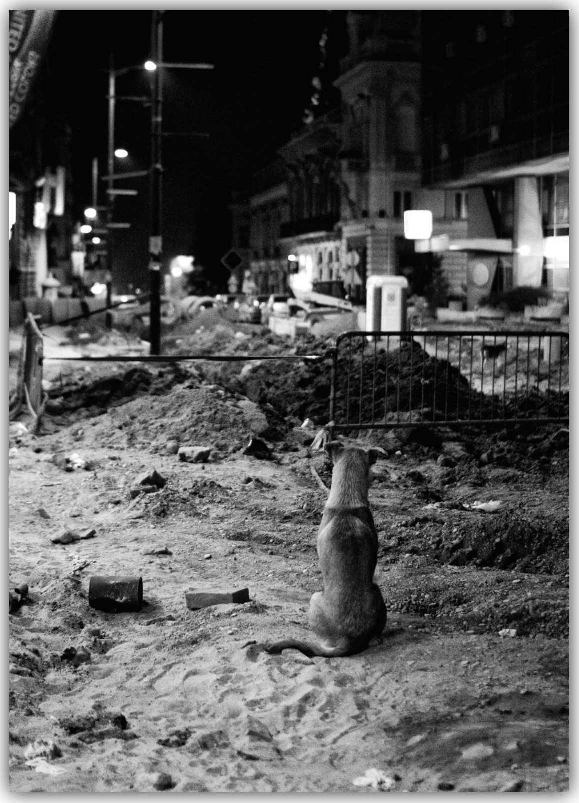

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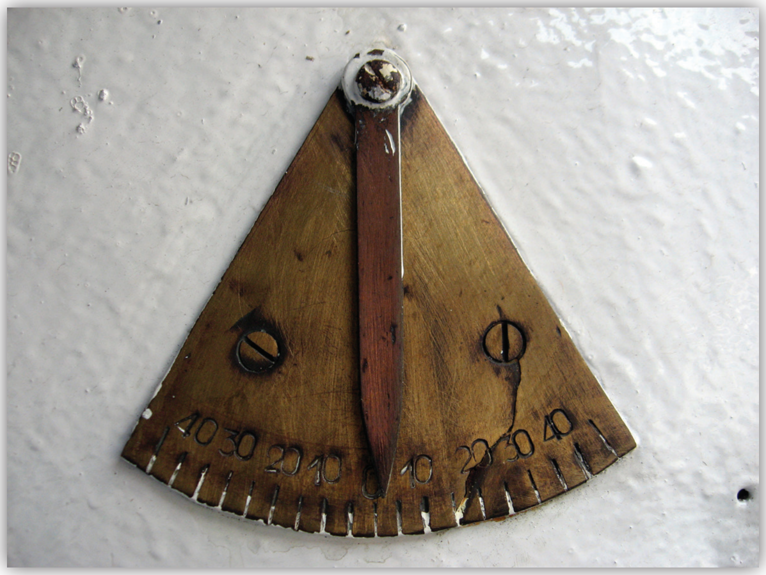

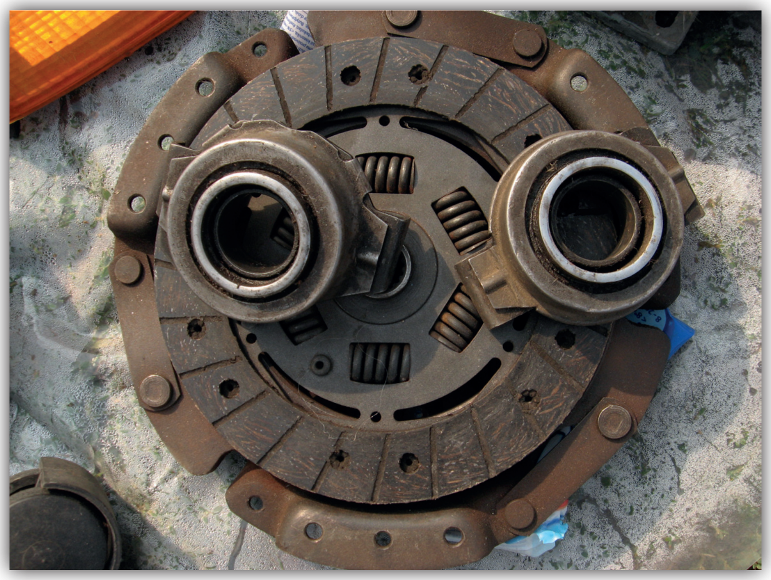

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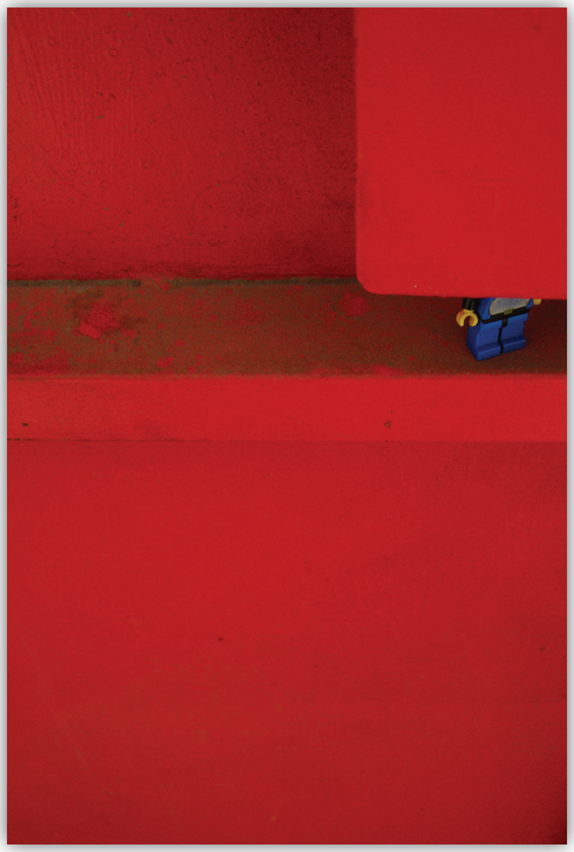

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