PRELIMINARY COMMUNICATION

ACTA GRAPHICA 233

Comparision of Two Thermal Decomposition Offset Printing Plates

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Abstract:

The aim of our research was to investigate two digital plates based on the same type of thermal sensitive coating produced by different manufactures and compare their quality, run length, ecological and economical aspects and user experience in the offset press. It was found out that with both plates the same quality of prints was attained according to the measurements of tone values on the plates and prints. The spectrophotometric measurements also showed that the prints were almost identical, except for minor differences in lightness. The microscopic image analysis showed that one plate had finer graining and thereby gave better and more accurate representation of half-tone dot and this plate was also more environmentally–friendly with lower consumption of chemicals for the plate developing, more durable with longer run lengths and as well more economical and user–friendly. The obtained results were useful for the offset printing company in its choosing the better thermal plate with reduced production costs.

Keywords:

Offset Printing, Digital Offset Plate, Thermal Printing Plate, Tone Value, Quality, Run Length, Ecological Aspect, Economical Aspect

1. Introduction

The offset printing is the most widely used printing technology and because of that various printing plates are available on the market. The base material of the offset plates is aluminium which is firstly electrochemically grained by the manufacturer to obtain a higher specific surface area which enables the higher adsorption of the light-sensitive coating (during printing plate production), the gumming agent (during printing plate making) and the dampening solution (during printing). The grained aluminium surface is then electrochemically anodized

- oxidized to gain hydrophilic character, chemical treated and coated with different coatings which could be sensitive to UV radiation (at the conventional plates), visible light or thermal radiation (at the digital plates). In the offset press, during platemaking process the printing plate is exposed to appropriate light source, developed, optionally baked and finally gummed.

Among offset printing plates for the computer to plate (CtP) imaging, thermal-sensitive plates are the most important. The thermal-sensitive plates have a lot of good properties. For example, they do not need a safelight because they are insensitive to visible light. They have a distinctive threshold characteristic during imaging; only if the thermal energy goes over a certain threshold, the thermal-sensitive coating changes completely and any further increase in energy remains of insignificant effect with regard to dot quality (Kipphan, 2001). The thermal digital printing plates are classified according to their imaging technology. This can be polymerisation (cross-linking), thermal decomposition, ablation, physical phase change and change of the surface property.

Among the scientific literature in the field of digital offset printing plates only articles that describe innovations in the market of digital offset printing plates, could be found (Srivats, 2012; Štefan, 2012). Manufacturers of printing plates themselves are doing more researches for the purposes of laboratory testing of their own products and developing new and better products and technologies (Cinkarna, 2013, Fujifilm, 2013).

The detailed explanations of the plate composition, manufacturing and the making of printing plates can be found in many patents (Zhong, et al., 1999; Hallman, et al., 1997; Lewis, et al., 1993; Patel, et al., 2002).

In the literature more theoretical bases of the plates, types, characteristics and process of preparation, could be found. Author Marko Kumar in his book represented the production of printing plates for offset printing, standardization process, and also referred to the processes of evaluating the quality of the plates (Kumar, 1978). Author Kenneth F. Hird described the processes of plate manufacture, method of plate imaging and types of plates (Kenneth, 2000). The processes of making conventional and digital plates are also presented in details. Author Gabrijela Novak in her book collected all the material and knowledge of printing plates from different sources (Novak, 2004). Similar to the aforementioned book of Helmut Kipphan describing offset plates and the technology of platemaking and printing (Kipphan, 2001).

In our research, two digital positive-working offset printing plates with the same thermal-sensitive polymer coating were investigated during platemaking and printing. The process of platemaking of these kind of thermal plates is shown in Figure 1. The upper thermal-sensitive polymer layer of the plates reacts by decomposition under the exposure of thermal (830 nm) laser beams. In the following development process, the exposed upper polymer layer and polymer layer underneath are removed and water-accepting non-image areas are revealed.

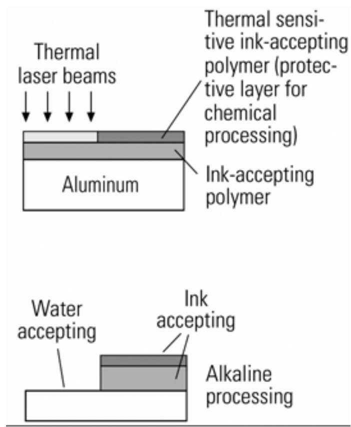

Figure 1. The process of platemaking of the thermal decomposition polymer plate: imaging and developing (Kipphan, 2001)

The aim of our research was the comparison of these thermal plates of the same type of sensitive coating produced by different manufacturers by their quality, durability, ecological and economical aspects and user experience in one offset printing company in Slovenia.

2. Experimental

2.1 Materials and equipment for making of printing plates

The two digital thermal positive-working offset printing plates produced by different manufactures were used. They both have on the electrochemically grained and anodized aluminium, the same thermal-sensitive polymer coating sensitive to 830 nm (800-850 nm) wavelength. The plate 1 requires laser energy of 130-150 mJ/cm^2 and the plate 2 requires 100-120 mJ/cm^2 and both plates can be used either baked or non-baked.

For digital imaging of the plates the same imagesetter PlateRite Niagara PT-R8200 (Dainippon Screen Mfg.Co. Ltd.) with an external drum with 84-channel laser diodes was used.

Further development of the exposed printing plates was carried out in different processors; for the plate 1 in Mizar TH 68/85 by OVIT and for the plate 2 in FLH-Z 125 CD by Glunz&Jensen with chemicals suitable for the particular printing plate suggested by the plate manufacturers. For gumming of the plates, the commercial products of gumming solutions specifically recommended by the plate manufacturers were used.

2.2 Materials and equipment for printing

The prints on the paper Biogloss (130 g/m^2 by B&B, Papirnica Vevče) were made with both printing plates on the same offset sheet-fed printing machine Heidelberg Speedmaster CD 102-6+LX UV/IR (with maximum printing format B1) at the same press conditions.

For printing, the printing ink Premium Print Black by Epple Druckfarben was used. The Premium print ink is free of mineral oil and based on renewable raw materials. Only one colour (black) was applied, because only the printing quality of the plates and the transfer of information from the plate to the paper were the study of interest. The dampening solution was prepared by 4% of buffer solution Acedin DH 2010 (Fujifilm Europe NV) and 1-2% of isopropyl alcohol P-43 (Cinkarna Celje PE Grafika).

In order to measure the durability of plates the web offset printing machine Goebel Multiforma FRR 560 was used. In the printing company with this offset press the highest impressions were made on the newsprint paper SOF (45 g/m^2 by Vipap Videm Krško) and the printing plates of B2 format were used.

2.3 Materials and equipment for plate analysis

A densitometer D19 from Gretag Macbeth (now X-Rite) was used for measuring a raster tonal value (A) on the prints and the plates. Measurements of the raster tonal values were made on the left side and the right side and on the middle of the sheet or the plate. A spectrophotometer Eye One (X-Rite) was used for measurements of reflectance and CIEL*a*b* values of grey fields on the prints and for colour shade of the printing paper. For calculations of the colour difference ΔE^*_{ab}, the CIEL*a*b* values were determined with an eyedropper for each grey field in Adobe InDesign where the test form was prepared. For microscopic analysis, grey fields of the plates and the prints were captured with the Microscope Leica EZ 40.

2.4 Mathematical calculations

For calculations of colour differences of each grey fields on the prints, the CIELAB equation ΔE^*_{ab} was used.

According to the assumption that the colour shade of the white paper had an influence on the change of colour shade at lower tonal values of the prints, the colour shade of paper whiteness was calculated.

For calculation of colour shade of white paper the equation (1) was used:

$$T_W = 1000(x_o - x) - 650(y_o - y) \quad (1)$$

where T_W is the colour shade of white paper, x_o, y_o are the chromatic coordinates for an ideal white body and x, y are the chromatic coordinates of white paper.

3. Results and discussion

3.1 Imaging

During exposure, the thermal laser beams of 830 nm wavelength cause decomposition in the upper thermal-sensitive layer of plate coating. The plate 2 was exposed for 4 minutes and 15 seconds, which was faster than the plate 1 which was exposed for 5 minutes and 50 seconds. The exposure time depends on sensitivity of top layer of the plate, hence the layer of the plate 2 was a little more sensitive than that of the plate 1. The power of imaging in the imagesetter PlateRite Niagara PT-R8200 for each plate was also compared. At the plate 1 the power of exposure was set on 100%, therefore the imagesetter was very loaded, which negatively influenced on its operation and lifetime and it used more electrical energy as well. The plate 2 used only 80% of exposure power and according to that also less electrical energy.

3.2 Developing and gumming

For the development of the plates, the alkaline developer recommended by the producer of the plate was used. The alkaline developer can penetrate through the exposed decomposed top layer of the plate and dissolves the lower coating layer from nonimage areas, while unexposed image areas are protected from the developer by the top layer.

For development of the plate 1, it was also necessary to use an antifoaming agent, because the developer foamed. The plate 2 did not need for the processing an antifoaming agent, but a replenisher, which was added in small amount into the developer. The replenisher is mixed with small amount of water and therefore only 5 litters of water per week were consumed, which did not cause any significant cost of processing. After development the plates were gummed.

The chemicals used for processing and gumming of the plates consumed in time of 9 months are shown in Table 1.

Table 1. Amounts of chemicals required for the development and gumming of 1m² plate surface

Chemicals	Quantity (L) for	
	1 m² of plate 1	1 m² of plate 2
developer	0.24	0.03
replenisher	/	0.02
antifoaming agent	0.002	/
gumming agent	0.03	0.002

It was found out that for the plate 2 less chemicals for processing and gumming were needed, which is more economical and environmental safer, with less amounts of dangerous waste chemicals and because of that with less costs for handling the dangerous waste. The price of all processing chemicals and gumming agent for the plate 2 was for 49% higher than for plate 1, although the consumption of the chemicals was for 6 times lower than for plate 1. When the price of all consumed chemicals was considered, it was noticed that 0.33 EUR was spent for developing and gumming 1m² surface of the plate 1 and only 0.17 EUR was spent for 1m² surface of the plate 2.

3.3 Raster tonal values of printing plate (A_{PL})

The best results of raster tonal values (Fig. 2) were obtained on the plate 1 which had on fields from 20% to 100% less deviation from ideal values than the plate 2. The plate 2 was better from 2% to 10% at lower tones where its values better matched with the ideal ones. The differences

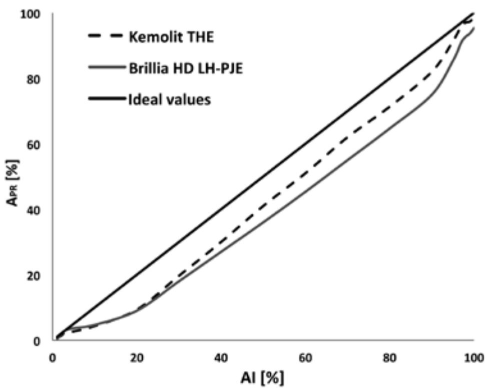

Figure 2. Raster tonal values (A_{PL}) of the plates 1 and 2 in dependence on ideal raster tonal values (A_I)

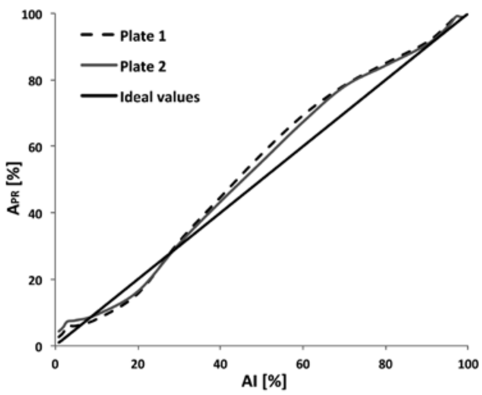

Figure 3. Dependence of raster tonal values of prints (A_{PR}) on the ideal raster tonal values (A_I)

between plates were probably result of different developing conditions and chemicals used, however the chemicals only recommended from the plate manufactures were used. The results showed that the quality of exposure of both plates was quite the same and that plates have the same type and similar sensitivity of the layers.

3.4 RASTER TONAL VALUES OF PRINTS (A_{PR})

Measurements of raster tonal values on prints showed, that there was almost no difference between prints (Fig. 3). The prints made with both plates were almost identical; no matter that the differences of raster tonal values on plates were bigger. However, the plate 2 performed better at tones from 10% to 95% and at lover tones the plate 1 was better. At tones over 97% the results were the same for prints of both plates. It was found out that the curves of both plates (Fig. 3) mostly passed above the curve of ideal values, except at tones from 10% to 20%. Despite of many negative properties and troubles, that the plate 1 caused in the printing process, its printing quality was good and could also be used for printing pretentious matters. The prints made with the plates 1 and 2 were almost the same.

3.5 MICROSCOPIC ANALYSIS OF THE PLATES

In Figures 4 and 5 it is seen that plate 2 is more finely grained than the plate 1. It is obvious at 0% raster tonal field, where the layer of the plate was completely removed, representing nonimage area and the grained aluminium as a base of the offset plates is seen. In Figures 4 and 5 it is noticed that the plate 2 has smaller points than the plate 1. The plate 2, which is finely grained, has larger specific surface area and hence larger adsorbing ability for coating layers,

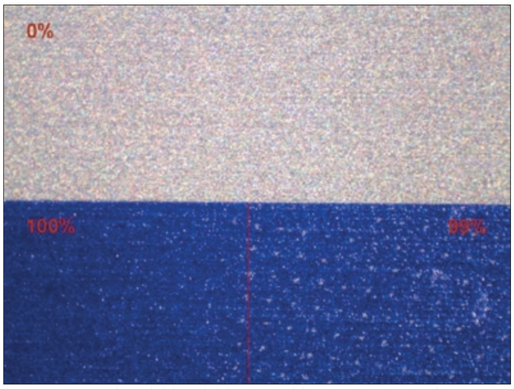

Figure 4. 100%, 99% and 0% raster tonal field on the plate 1

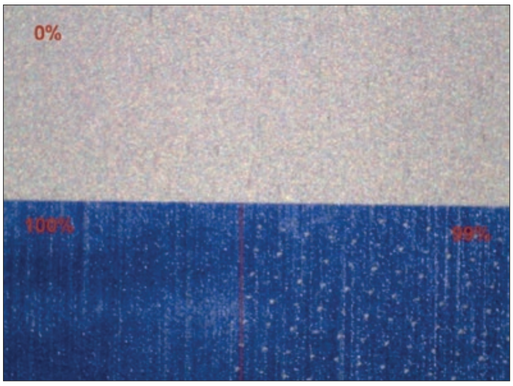

Figure 5. 100%, 99% and 0% raster tonal field on the plate 2

gumming agent and fountain solution. On the plate 2 the raster points on 99% raster tonal field are more visible and more specific. The points on the plate 2 are round or square and have clear and sharp edges. Differences between individual raster fields can be well seen, especially at the lowest and the highest tones. At lowest tones, points on the plate 1 was not so good imaged and noticeable than on the plate 2 and the tonal values of these plate 1 were not so matched with the ideal values (Fig. 2). Any difference between plates could cause the different quality of prints.

3.6 MICROSCOPIC ANALYSIS OF THE PRINTS

Prints made with both plates were almost identical at visual evaluation and also at measurements of tonal values on prints (Fig. 3), which was also confirmed by microscopic analysis, where the prints were not so much different. It was found out that the prints made by the plate 2 were more steady, more accurate and had better shaped raster points than that of the plate 1, which are well seen in Figures 6 and 7.

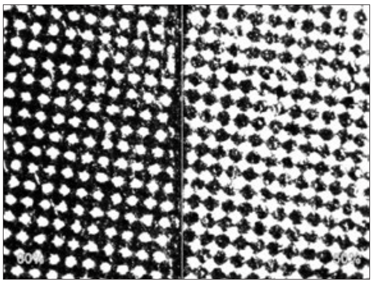

Figure 6. 60% and 50% raster tonal fields on print of the plate 1

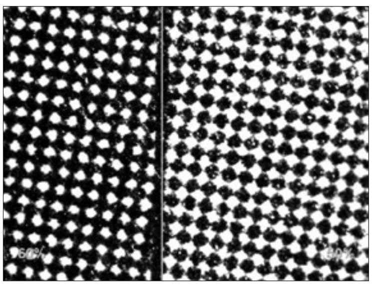

Figure 7. 60% and 50% raster tonal fields on print of the plate 2

3.7 REFLECTION SPECTRA OF THE PRINTS

The reflection values on the prints (Figs. 8 and 9) made by the plates 1 and 2 were almost identical, what also confirmed the results of visual evaluation of the prints and measurements of raster tonal values of the prints (Fig. 3). At all raster tonal values, except at 100% the reflection values of print made with the plate 1 were a little higher than with the plate 2. It was also noticed that the curves of reflection spectra of 50%, 5% and 1% raster tonal values in the range of 480 nm to 640 nm slightly decreased. This is the range of yellow colour. From what it can be concluded that the whiteness of the paper, which probably was not 100% white, influenced on the reflection measurements.

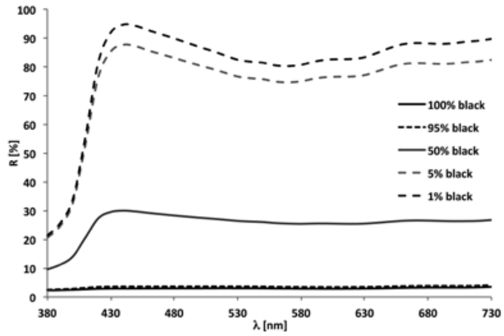

Figure 8. Reflection spectra for different raster tonal values of black colour on print made with the plate 1

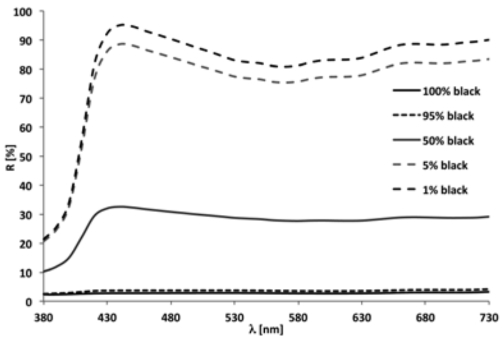

Figure 9. Reflection spectra for different raster tonal values of black colour on print made with the plate 2

3.8 Colour shade of white paper

It was assumed that the whiteness of the paper had an influence on the results of raster tonal values from 0% to 50% and because of that, the colour shade (T_W) of printing material (i.e. paper used) was calculated by equation (1). In Table 2, the spectrophotometrically measured chromatic coordinates and the calculated colour shade of the paper are shown.

Table 2. Chromatic coordinates for ideal white body (x_0, y_0) under illuminant D65 and chromatic coordinate of sample (x, y) with shade of white sample

x	y	x_0	y_0	TW
0.3393	0.3480	0.3127	0.3290	-14.25

A negative value of the colour shade of white printing material showed that the paper was red-white. It was confirmed that the colour shade of whiteness of the paper, and not the plates, affected on the values of spectrophotometrical measurements of the prints.

3.9 CIEL*a*b* values and colour differences of the prints

The measurements of CIEL*a*b* values of the black colour at different tone values on the prints showed also minimal difference between both plates (Table 3). The values of colour lightness (L*) increased with decreasing of the raster tonal values. The values of a* of black colour at 1% and 5% of raster tonal values were slightly shifted to red colour on the red-green axis. The values of b*, at 1%, 5% and 50% of raster tonal values quite exceeded, meaning that at these raster tonal values the measured colour was little shifted to blue colour on the yellow-blue axis. It was also concluded, that the shade of whiteness of the paper influenced on the colour of the print at lower raster tonal values.

As it was already mentioned, the prints printed with the plates 1 and 2, were not distinguished between themselves. This was confirmed with all spectrophotometrical measurements. All

*Table 3. The CIEL*a*b* values for particular tone values (RTV) of black colour of the prints made by the plates 1 and 2 and standard L_s*a_s*b_s* values defined in Adobe Indesign program*

Position of measurement on the print	RTV [%]	L*		L_s*	a*		a_s*	b*		bs*
		Plate 2	Plate 1		Plate 2	Plate 1		Plate 2	Plate 1	
left	100%	18.59	18.89	11	-0.64	-0.66	-1.00	-0.33	-0.36	1
	95%	21.90	21.17	15	-0.64	-0.64	-1.00	-0.63	-0.51	0
	50%	58.53	55.93	55	0.04	-0.01	0.00	-4.22	-4.26	0
	5%	90.26	89.65	96	1.54	1.58	0.00	-5.61	-5.82	0
	1%	92.98	92.75	99	1.79	1.80	0.00	-5.97	-6.04	0
middle	100%	19.01	19.80	11	-0.60	-0.58	-1.00	-0.08	0.05	1
	95%	22.37	22.12	15	-0.59	-0.58	-1.00	-0.32	-0.31	0
	50%	60.22	58.13	55	0.11	0.05	0.00	-4.38	-4.29	0
	5%	90.54	90.19	96	1.54	1.55	0.00	-5.72	-5.67	0
	1%	93.09	92.87	99	1.72	1.77	0.00	-5.87	-5.95	0
right	100%	18.78	18.86	11	-0.64	-0.62	-1.00	-0.33	-0.24	1
	95%	21.76	21.26	15	-0.62	-0.60	-1.00	-0.60	-0.45	0
	50%	58.62	56.59	55	0.04	-0.02	0.00	-4.25	-4.08	0
	5%	90.29	89.99	96	1.52	1.50	0.00	-5.69	-5.52	0
	1%	92.94	92.95	99	1.73	1.76	0.00	-5.89	-5.89	0

colour differences; in lightness, chroma, hue and the overall colour difference between the prints made by the plates 1 and 2 were very small (Table 4), almost everywhere on the prints were values of differences smaller than 1. Only at 50% of the raster tonal value of black colour the lightness difference was higher than 2 (ΔL* was between 2.03 and 2.6), consequently, value of ΔE^*_{ab} was also between 2.04 and 2.6. This could be explained with the fact that the dot gain reaches a maximum at 50 % of raster tonal value.

3.10 PLATE PERFORMANCE AND USER EXPERIENCE

The practical use of the plates in the offset press showed more trouble with the plate 1. First, at the plate imagesetter which has manual delivering of the plates. The plate 1 was slightly bent and because of that, the bigger format of 1030 mm x 790 mm of the plate 1 delivered sideways into the imagesetter and it needed a lot of tries to set the plate right to be imaged. It was time-consuming and awkward. The time of exposure of the plate 1 was also longer, the imagesetter was more loaded, which all led to higher production costs. However, there was no such problem with the plate 2.

The time of processing of the plate 1 was also longer and consumption of the processing chemicals was higher than at the plate 2 and the processor of the plate 1 had to be cleaned every two months compared to the plate 2 where the processor was cleaned only once in five months.

After first few prints when the press was stopped, the plate 1 sometimes even scummed leading to additional costs of making new printing plate.

Measurements of durability were done only on the plates of B2 format. Ten tests of durability for each plate were made. The producer of the plate 1 in its specifications claims that the plate without post-baking offers up to 100.000 prints. The maximal number of prints obtained with the plate 1 was 48.000, so the producer's statement is overestimated, probably because its specifications were made at laboratory conditions.

Table 4. The difference in coordinate on the red-green axis Δa, the difference in coordinate on the yellow-blue axis Δb*, the lightness difference ΔL*, the chroma difference ΔC^*_{ab}, the hue difference ΔH^*_{ab} and the overall colour difference ΔE^*_{ab} between the prints made by the plates 1 and 2*

Position of measurement on the print	RTV [%]	Δa*	Δb*	ΔL*	ΔC^*_{ab}	ΔH^*_{ab}	ΔE^*_{ab}
left	100%	0.02	0.03	-0.30	-0.04	0.02	0.30
	95%	0.00	-0.12	0.73	0.08	0.09	0.74
	50%	0.04	0.05	2.60	-0.05	0.04	2.60
	5%	-0.04	0.21	0.61	-0.22	0.02	0.64
	1%	-0.01	0.07	0.23	-0.07	0.01	0.24
middle	100%	-0.02	-0.13	-0.79	0.02	0.13	0.80
	95%	0.00	-0.01	0.25	0.01	0.00	0.25
	50%	0.05	-0.08	2.60	0.08	0.05	2.10
	5%	-0.01	-0.04	0.36	0.04	0.02	0.36
	1%	-0.05	0.09	0.23	-0.10	0.02	0.25
right	100%	-0.02	-0.09	-0.08	0.06	0.07	0.12
	95%	-0.02	-0.16	0.50	0.12	0.11	0.53
	50%	0.05	-0.17	2.03	0.17	0.05	2.04
	5%	0.02	-0.16	0.30	0.16	0.02	0.34
	1%	-0.03	0.00	-0.01	-0.01	0.03	0.03

An average run length of the plate 1 was 38.300 prints. However, with the plate 2 where its producer states that the plate offers up to 200.000 prints, 172.000 prints were on average made. The plate 2 achieved maximal 250.000 prints, which was unexpected high and shows the high quality of the plate 2. The plate of B1 format, because it is bigger and more exposed to wear, probably would not achieve as high number of prints as the plate of B2 format.

The durability of the plate 2 was higher and the archiving of the plate 2 was also more successful compared to plate 1 where the archiving was mostly unsuccessful.

The price of purchasing the plate 2 is for about 7% higher than the plate 1 and the price of all processing chemicals and gumming agent for the plate 2 was also higher than for the plate 1; however the time and energy of imaging and the consumption of the processing chemicals and of the printing plates and according to that the production costs for the plate 2 were much lower. The workers in the printing company were also more satisfied with the plate 2 because there was no trouble with the plate 2 in manual delivering to the imagesetter and at the printing press.

4. Conclusions

When buying the right printing plate the price of its purchasing is not mainly important, but the time-consuming and production costs for platemaking and printing, and of course the quality of prints. In our research, these aspects between two thermal offset plates based on the same type of sensitive coating were compared. It was found out that with both plates the same quality of prints was attained according to the measurements of tone values on the plates and prints. The spectrophotometric measurements also showed that the prints were almost identical, except for minor differences in lightness. The microscopic image analysis showed that the plate 2 had finer graining and thereby gave better and more accurate representation of halftone dot and this plate 2 was also more environmentally–friendly with lower consumption of chemicals for the plate processing, more durable with longer run lengths and as well more economical and user–friendly. The obtained results were very useful for the offset printing company in its choosing the better thermal plate with reduced production costs.

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