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Comparative study of offset plate tone value reproduction using different measuring and image processing tools

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The quality of tone values on offset printing plate is one of the crucial factors affecting the printed product quality. By implementing Computer to Plate systems tonal values are first formed on a printing plate's surface and therefore their size and shape are one of the crucial factors affecting the printed product quality. In particular, when producing printing plates, a rigorous quality control has to be performed, since any bulk and surface imperfection can have a large detrimental effect on tone value reproduction and thus on print sharpness, contrast, nonuniformity and other print properties.

The aim of this paper was to analyse measured results of two different measuring instruments and two different image processing software, determined by two different assessment methods. For direct analysis, of tone value parameters on the printing plate, we have used Techkon spectroplate measuring device with built-in software for image analysis. For indirect analysis, we have used Vitiny VT-300 digital microscope for image recording and microDot software (CC dot) for image analysis. Tools independent software-based image analysis, on all recorded images from both measuring devices, was accomplished using ImageJ, a public domain Java image processing program. This study has shown that indirect and independent image analysis-based evaluation methods proved to be a viable alternative to the established ones on built-in software method with Techkon spectroplate measuring device, providing a reliable tool for the monitoring of the tone value reproduction parameters of offset printing plate.

Key words: offset printing plate, measuring device, image-based software, TV reproduction

INTRODUCTION

Although the market share of the offset printing is in recent years slightly decreasing mostly due to the emerging technologies of digital printing and flexography, it is still the market leader. The main advantages of the offset printing are relatively quick workflow and especially printing quality which stands as a standard which other technologies aim to achieve [1,2].

The offset printing is more complex in comparison to the other conventional printing techniques as gravure printing, flexography or letterset as the selective ink adsorption on the printing plate is achieved by different chemical properties of the printing and nonprinting areas. The printing areas are oleophilic and attract oil based printing ink, and the nonprinting areas are hydrophilic to adsorb water based fountain solution which prevents adsorption of the printing ink [3]. The main advantages of offset printing over other mentioned conventional printing technologies are plate price and the plate making process, which is relatively simple including, in principle, two step procedure, imaging and chemical processing [4,5]. Even more, recently plate producers put onto market processless printing plates which are processed in a printing machine, meaning only imaging is done offline, in a platesetter [6].

With the Computer to Plate systems implementation the printing plate became first material to be used in the reproduction chain of the graphic product. One should control the platemaking process by visual and apparatus control to avoid any defects which would lead to reproduction outside standard tolerances, i.e. unacceptable final product quality [7]. Several possible unexpected costs in reproduction, before the printing process starts, could be detected and corrected with the standardized procedure of control [8]. To enable quick control of the produced printing plate and standardize procedures institutes and producers developed various control wedges. One of the first developed was the Ugra/Fogra Digital Plate Wedge [9]. Another problem to solve was to standardize measuring devices in order to solve various problems as a single plate may vary in contrast, tonal surface, the way of screening and their physical characteristics. Measuring devices called Plate Readers are used to control the tonal values in the halftone patches on printing plates [10]. There are many of these devices present on

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the market, but they operate on the same principle: they are equipped with a digital camera which records detail image of halftone structure with high resolution. The obtained digital image is then processes and analysed using image processing software integrated in the measuring device. Depending on the software, beside the percentage of coverage of the plate with halftone dot, units can give information about on the corner and line screens of conventional halftone, dot diameter and magnified view of halftone images. In addition, as formation of new ink receptive layers are developed the Plate Readers were equipped with additional light sources which enable better contrast and more precision in measurements. The additional development of the measuring units made them more expensive and therefore less present in smaller print houses, which makes finding of the alternative plate making process control very important.

MATERIALS AND METHODS

For the purpose of this research a set of three printing plates was made. The plates were chosen to include various system present on the market, a conventional plate imaged in a platesetter (CtCP plate), the Ipagsa CtcP Eco 88S (Ipagsa) – UV positive working plate (meaning the imaged areas are removed during chemical processing of the plate), thermal CtP plate, the Fuji Brillia LH-PCE (Fuji), also positive working and photopolymer CtP plate, the Kodak Violet Print (Kodak), negative working plate (meaning the imaged areas stay on the aluminium base after chemical processing of the plate). All printing plates were imaged and chemically processed in defined conditions according to the producer's recommendations. The standardized Fogra CtP test form with tone value control strip was used (Fig 1). On the all prepared printing plates same control strip was analyzed (Fig 1, red marked). The control strip consisted of 21 test fields covering the tone value interval from 0 – 100 % with the step of 5 %.

In order to determine the printing plate's quality level, i.e. formation of the printing elements, the surface coverage value was analyzed. The coverage values were measured by the use of two hand-held units, one with built in software for image analysis, the Techkon spectroplate (Fig 2a, Techkon) and the other with commercial software for image analysis, the Vitiny VT-300 digital microscope (Fig 2 b., Vitiny). The Vitiny records the image which is analyzed by microDot software (CC dot). Both of these are easy to use and give instant results of the coverage values [11,12].

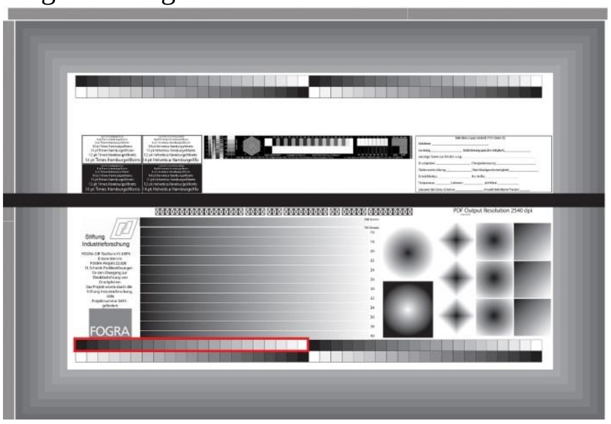

Figure 1. FOGRA CtP test form

(a) *(b)*

Figure 2. Measuring devices: a) Techkon spectroplate; b) Vitiny VT-300 digital microscope.

As an alternative, the coverage values were obtained from image analysis using tools independent software-based image analysis, the Wayne Rasband's ImageJ 1.5, a public domain Java image processing program [13] The image analysis was performed on images recorded by both measuring devices, the Techkon and the Vitiny.

The ImageJ procedure for measuring coverage values consists of generally two steps. First images are converted into a black&white mode and in second step software calculates fraction of black/white pixels. In addition, as the surface of the printing plate is rough, some pixels could be too bright/dark leading to the need of removing these defects.

There are several methods to convert images in ImageJ, in this study two different approaches/methods were used: in method 1 (M1) the function “Make Binary” (Process > Binary > Make Binary) was used to convert image to black&white. Correction of small defects was then made using function “Despecle” (Process > Noise > Despeckle) three times. In the method 2 (M2) additional correction was included due to the unevenness of the lightness on the surface when using microscope, function “Subtract Background” (Process> Subtract Background) and then the function “Make Binary” (Process > Binary > Make Binary) followed by the function “Remove Outliers” to remove defects (Process > Noise > Remove Outliers). The function “Subtract Background” was set to use the Rolling ball method with radius of 50 pixels and the function “Remove Outliers” was set by radius 2 pixels and threshold 50, to remove defects (white or black holes in the printing area or nonprinting areas, respectively) smaller than 2 pixels.

The printing plate evaluation was conducted in few steps, first printing plate was cleaned of gum and each test field of the control strip was measured five times using Techkon by moving the camera opening inside the test field. Each image was also saved on the computer. The same procedure was conducted using Vitiny. The recorded images were processed with the ImageJ.

RESULTS AND DISCUSSION

In Figure 3 one could see the difference between average measured values of the coverage values on the investigated printing plate samples using two commercial measuring systems, the Techkon and the Vitiny with microdot software. The difference (Δ_{TV}) was calculated using (1).

$$\Delta_{SV} = CV_{Sp} - CV_V \ [\%] \tag{1}$$

where CV_{Sp} is the coverage value (tone value) measured by Techkon and CV_V is the coverage value (tone value) measured by Vitiny with microdot software.

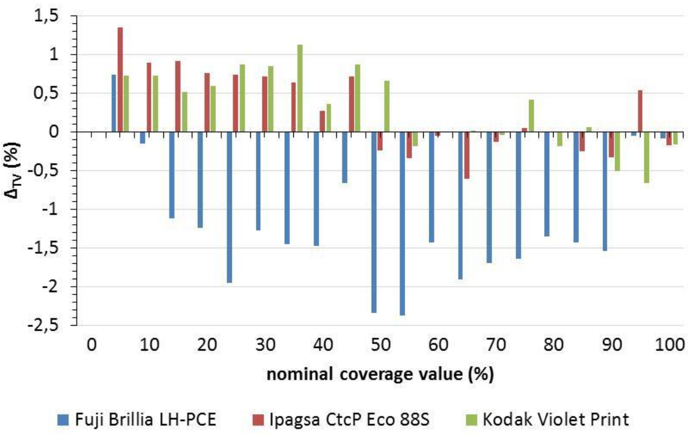

Figure 3. Differences in measured coverage values by using two commercial systems on all plate samples

The highest difference between values obtained from two measuring systems, the Techkon and the Vitiny with microdot software is visible by Fuji in the mid tonal range (round nominal value of 50%). The coverage values measured by the Techkon are lower than the values measured by the Vitiny with microdot software on the Fuji while on the other plates in lower nominal coverage values (under 50%) they are higher, and in higher nominal coverage values (over 50%) are lower. Furthermore, by the Ipagsa and the Kodak almost all differences in coverage values over nominal value of 50% are up to 0.5% which is repeatability of the Techkon [14].

The differences in measured values between two measuring systems could be the consequence of the optical systems and illumination both units use. Observing Figures 4 and 5 one could see that Techkon images appear darker.

(a) (b) (c)

Figure 4. Images of 30% nominal coverage value field obtained by Spectroplate, a) Fuji, b) Ipagsa, c) Kodak

(a) (b) (c)

Figure 5. Images of 30% nominal coverage value field obtained by Vitiny. a) Fuji, b) Ipagsa, c) Kodak

Furthermore, the aluminium-oxide areas (nonprinting areas) are by Techkon dark bluish (Figure 4), while by the Vitiny they appear reddish (Figure 5). By the Fuji plate this improves contrast between the printing and the nonprinting areas by the images obtained from Vitiny making it easier to determine coverage value (algorithm of coverage values determination includes converting the image into a binary image). On the other two plates (Ipagsa and Kodak) the printing areas are at the Techkon images darker (Ipagsa, Figure 4b) or more to the cyan (Kodak, Figure 4c) which improves contrast of the image, i.e. difference between printing and the nonprinting areas. This in the end leads to the more similar results of the coverage values measured by both systems (Figure 3).

Differences between coverage values obtained from Techkon and from image analysis by ImageJ are calculated using equation (2).

$$\Delta_{TM} = CV_{Sp} - CV_{Mi} \ [\%] \qquad (2)$$

where CV_{Sp} is the coverage value (tone value) measured by Techkon and CV_{Mi} is the coverage value (tone value) measured by ImageJ, i = 1 means use of the method M1 and i = 2 means use of the method M2.

In Figure 6 one could see the difference between coverage values obtained from Techkon and coverage values obtained from ImageJ analysis. The both ImageJ methods (M1 and M2) calculate higher results than Techkon.

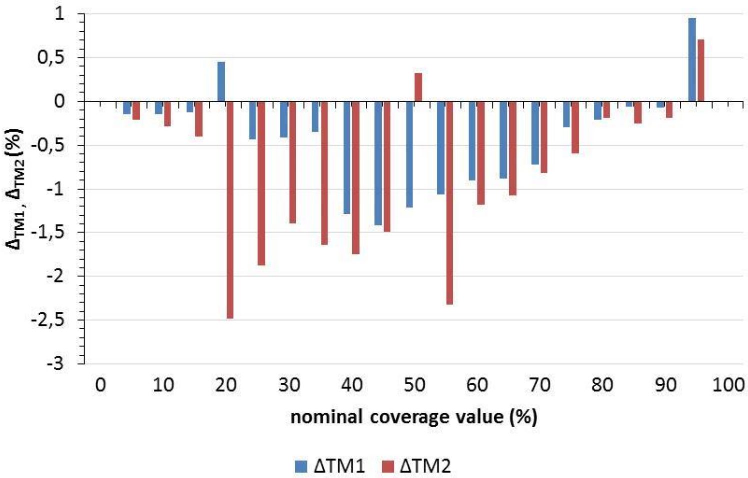

Figure 6. Differences in measured coverage values obtained from Techkon and ImageJ analysis of images recorded by Techkon on Fuji.

Higher differences can be noticed in the middle range of coverage values (30-70%), furthermore, M2 computes higher values than M1 at almost all control fields (Figure 6).

The coverage values calculated by ImageJ analysis using M1, except ones measured on fileds with nominal coverage value of 5 and 95%, are nearly the same to the ones measured by Techkon on the Ipagsa (Figure 7), i.e. they are in the range of repeatability of Techkon [14]. The calculation of coverage values using M2 resulted with higher coverage values than Techkon. Higher differences (1-1.5%) can be seen at nominal coverage values between 50 and 70%.

The calculation of coverage values on Kodak differentiates to the values obtained by Techkon more than other two plates (Figures 6-8). Furthermore, on this plate values calculated using M2 are lower than the ones calculated using M1 at nominal coverage values from 20 – 100%. The difference between coverage value at control field on 5 and 95% nominal value are nearly 14% and go over the range presented in the graph in Figure 8.

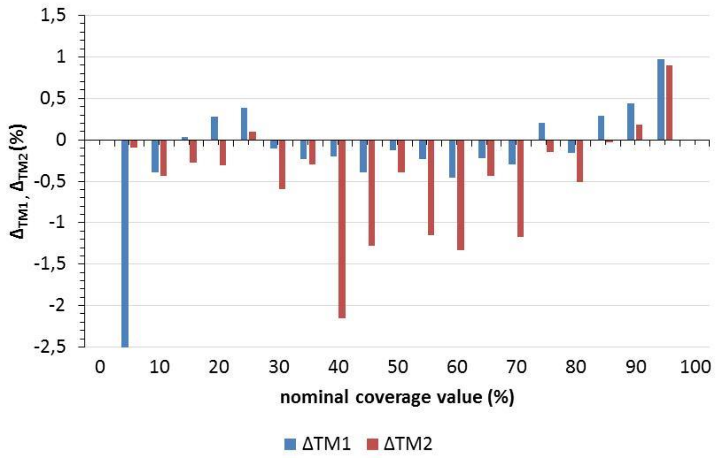

Figure 7. Differences in measured coverage values obtained from Techkon and ImageJ analysis of images recorded by Techkon on Ipagsa

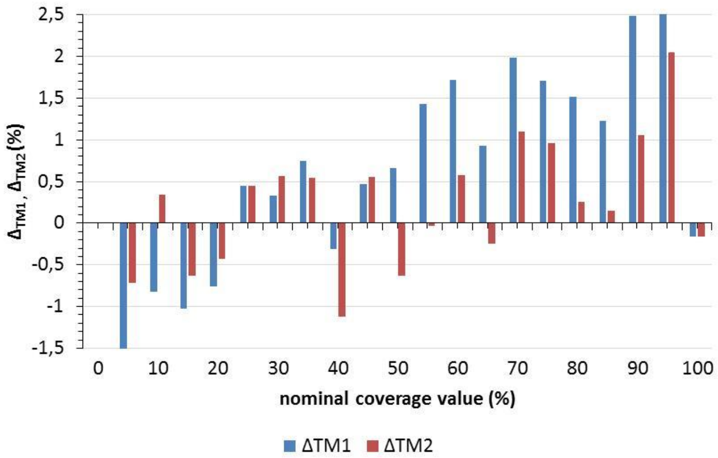

Figure 8. Differences in measured coverage values obtained from Techkon and ImageJ analysis of images recorded by Techkon on Kodak.

The ImageJ analysis using M2 significantly differ to the M1, as is mentioned before. Use of the "Subtract background" function removes a certain value of each pixel and is used at images with uneven illuminated background [15]. Although subtracting background should decrease coverage values, on Fuji and Ipagsa results show opposite. Reason for these results could lay in the second difference, use of the "Remove Outliers" instead of the "Despecle" function. The "Despecle" function replaces each pixel with the median value in its 3×3 neighbourhood [15], so if the defect is larger this could mean that this function would not remove it. On the other hand, function "Remove Outliers" detects defects of certain size (which is defined by user) and replaces a pixel by the median of the pixels in the surrounding if it deviates from the median by more than a certain value (the threshold) [15].

Although both ImageJ methods could be used when analysing Techkon images, the uneven illumination of surface used by the Vinity (Figure 5) makes M1 unusable for analyse of its images, especially in the low and high nominal coverage value where differences are 10 or more percent (Figure 9).

The ImageJ function "Subtract Background" makes the image recorded by Vitiny even and could be analysed. In contrast to the values obtained by analyse of Techkon images, one can see that analyse of Vitiny images results with coverage values lower than Techkon's on Fuji plate (Figures 7 and 10).

The values measured by Techkon and calculated using M2 are similar on Kodak with the difference to -1% in nominal coverage values lower than 50 and +1% in nominal coverage values over 50%. The same trend, values obtained by ImageJ M2 higher than the ones obtained by Techkon in nominal coverage values under 50% and lower in nominal coverage values over 50%, can also be noticed on Ipagsa (Figure 10).

The images recorded by Vitiny are brighter than the ones recorded by Techkon (Figures 4 and 5) which results with higher minimal and maximal grey values of an image, but also with higher contrast in an image (example on Fuji nominal value of 30% the difference between min and max grey value is 141 and 164 on images recorded by Techkon and by Vitiny, respectively). Smallest contrast was seen at images recorded by Techkon on the Fuji and this probably results with higher coverage values as it is more difficult to detect the edge of the printing areas.Moreover, due to the characteristics of the laser beam [16] the printing elements on its edge has a bit lower colour intensity than in the middle. In images with higher contrast these edge areas will probably be assigned as black when converting image into Black&white. Lower differences in image contrast between images recorded by Techkon and Vitiny results with lower differences in coverage values as could be seen on Ipagsa and Kodak.

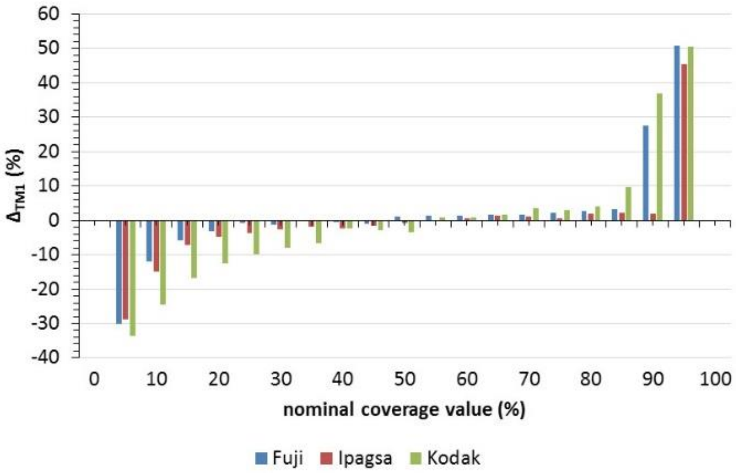

Figure 9. Differences in measured coverage values obtained from Techkon and ImageJ M1 analysis of images recorded by Vitiny on all plate samples

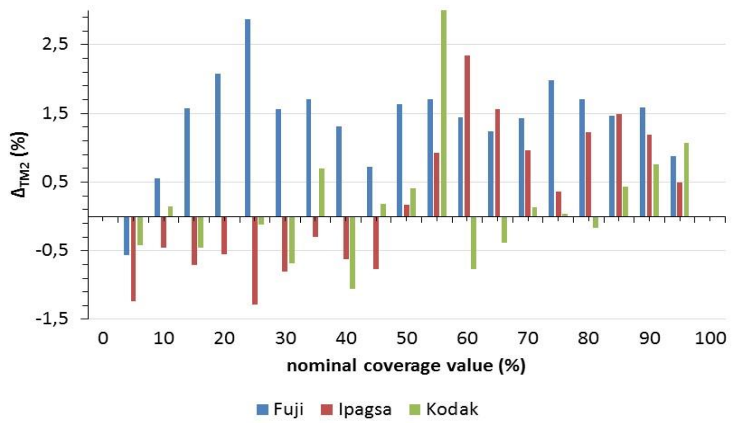

Figure 10. Differences in measured coverage values obtained from Techkon and ImageJ M2 analysis of images recorded by Vitiny on all plate samples.

CONCLUSIONS

This research was conducted in order to investigate the usability of the alternative method in printing plate making process control. For the purpose of the research three different printing plates were prepared by imaging the UGRA/FOGRA test form. The prepared printing plates were then controlled using three different tools, hand held platereader Techkon spectroplate with built-in image analysis software, Vitiny VT-300 digital microscope for image recording and commercial software microDot and ImageJ, free software for image analysis to analyse images recorded by both mentioned devices.

The results of this research showed that printing plate highly influences measurement of the coverage values. Comparing commercial devices differences between them are more than 1% on Fuji plate, but on other investigated plates is lower than 1%, moreover, almost negligible at control field of over 50% nominal coverage value. Comparison of ImageJ proposed methods to the Techkon measurements showed that better results (meaning closer to the Techkon values) are obtained when analysing Techkon images, where by the use M1 on Ipagsa differences are in the repeatability range of Techkon spectroplate. Analyse of the Vitiny images showed inability to use M1 as these images were uneven illuminated during recoding, which is especially visible in lowed (to 30%) and higher (over 80%) nominal coverage values.

This investigation proved the high impact of the printing plate to be measured and the influence of the image recording unit on the determination of the coverage values on a printing plate. Furthermore, the results have confirmed that ImageJ software could be used in control of the coverage values on a printing plate, but the image analysis procedure should be more tuned to diminish the variances in measurements and more adjusted it to enable use of ImageJ on all types of the offset printing plates, making it affordable alternative in printing plate control.

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СРАВНИТЕЛЕН АНАЛИЗ НА ТОЧНОСТТА НА ВЪЗПРОИЗВЕЖДАНЕ НА РАСТЕРОВИЯ ТОН НА ПЕЧАТНИТЕ ФОРМИ ИЗПОЛЗВАЙКИ РАЗЛИЧНИ МЕТОДИ ЗА ИЗМЕРВАНЕ И ОБРАБОТКА НА ИЗОБРАЖЕНИЯТА

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(Резюме)

Точността на възпроизвеждане на растеровия тон на печатната форма е един от най-важните фактори за постигане на предвидими резултати и качество на печат. При съвременните технологии за директна експонация Компютър-Печатна форма, растеровите елементи се формират директно на повърхността на формата като от изключителна важност е коректното задаване на тяхната форма и размер. При експонирането на печатните форми е необходимо да се извършва строг и постоянен контрол по цялата им площ. Дори и най-малкото отклонение в някой от качествените показатели на експонацията може да доведе до неточност в растеровия тон, неравномерност по площта, липса на острота, контраст и др.

Целта на настоящата статия е да анализира резултатите от измерванията получени от две устройства и два различни метода и софтуера за анализ на изображенията. За директен анализ на печатните форми е използван прибор за измерване и заснемане - Techkon със вградения в него софтуер. За индиректен анализ е използван дигитален микроскоп Vitiny VT-300 със софтуер microDot (CC dot). Като допълнение е използван и независим от устройството софтуер за анализ на заснетите изображения- ImageJ. В статията са анализирани и сравнени получените резултати от различните методи и софтуери и е установена надеждността на алтернативните методи за анализ на качеството на печатните форми.