Studying the Influence of the Recording Process Factors on the Half-Tone Dots Quality Parameters

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The series of ISO 12647 standards define the quality parameters of the half-tone dots and set requirements to them. A model of optical pixel-by-pixel recording process of the half-tone dots has been designed. The basis of the model is the efficient irradiance distribution in the recording spot obtained from the experimental densitometric data. The mechanisms of the formation of half-tone dots quality parameters have been studied on the basis of the model, as well as the influence of the recording process factors on them has been evaluated.

Introduction

In the graphic industry, screening technologies are applied for the reproduction of halftones. Aiming at the highest possible quality to improve the visual results, Esko-Artwork now offers its customers a new technology: concentric screening. This is said to be a major halftone screening technology innovation and was the subject of Barbara Detavernier's final paper with which she graduated at the Arteveldehogeschool. She won the golden Joris Lannooprijs and the silver Febelgraprijs 2007. In this article she provides a summary of the project's conclusions and takes a close look at this technology.

The development of new CtP systems and their application in industry has been accompanied by the discussion of the correct choice of such systems. The competitiveness of the CtP systems is certainly defined first of all by their cost and the cost of their further maintenance, by the cost of the materials used. However, in the process of making our choice, along with the economic factors the quality parameters of the system are of great significance, among which the main ones are the precision and stability of reproduction of the half-tone pattern. To date, CtP systems have not had quality criteria clearly developed, such as, e.g. those for the image setters specified by the series of ISO 12647 standards [1]. The development of technological solutions, concerning the methods of achieving optimum quality results, is also important. To create a starting point for such developments on the CtP systems, it is necessary to make methodical solutions which will be used as the basis.

When choosing methodical solutions it is advisable to take the develop-ments introduced in the series of ISO 12647 as the basis. These standards define the quality parameters of half-tone dots and set requirements to them. However, the standards do not show how to affect these quality parameters and what tech-niques provide obtaining optimum results.

Because of essentially common technical solutions for CtP systems and image setters and due to image setters being still widely applied, with the photomaterial being very convenient as a recording medium from the methodical point of view, it is advisable to begin the development with studying image setters. The task of this paper is to investigate the mechanism of the half-tone dots quality parameters formation and to evaluate the degree of influence of different factors of the recording process on these parameters.

Methods

To solve the task a calculation technique of the half-tone dots formation on the basis of a spatial model for the optical pixel-by-pixel half-tone image re-cording process has been suggested [2, 3].

The model is based on the efficient irradiance distribution in the recording spot, which takes into account all the stages of passing of light emission from the source to scattering in the recording material and therefore, it takes into account all the factors of the recording process. To find the efficient irradiance dis-tribution in the recording spot, one can use the photometric properties of the photomaterial: according to the darkening density one can always find the expo-sure (irradiance) which has brought it about. Such irradiance is called efficient.

The key elements of this model are as follows:

1. The calculation method of the edge response function, i.e. of the distri-bution of efficient irradiance at the boundary of the half-plane, for slow scan di-rection has been suggested. The edge response function (Fig.1b) is calculated by equation (1) from the experimental densitometric data obtained by measuring the patch with a ruled pattern (Fig.1a) recorded onto a half-tone film with expo-sure sequence.

$$x_i = l \times \frac{\tau_t - 0{,}5(\tau_s + \tau_0)}{\tau_s - \tau_0}, \quad h_i = \frac{0{,}5 \times H_0}{H_i} \qquad (1)$$

where: x_i is the abscissa of the edge response function – the line edge gain;
h_i is the ordinate of the edge response function;
l is the linewidth;
τ_0 is the transmittance of the clear half-tone film;
τ_s is the transmittance of the solid;
τ_t is the transmittance of the half-tone;
H_0 is the exposure without the linewidth gain;
H_i is the exposure corresponding to x_i.

2. Mathematical processing of the data calculated by equation (1) is carried out, which results in finding the efficient irradiance distribution in the recording spot.
3. On the basis of the efficient irradiance distribution in the recording spot obtained it is possible to calculate the half-tone dots for which, firstly, one calculates the efficient irradiance distribution in the pixel forming half-tone dots; secondly, according to the dot matrix one calculates successively the distribution of relative and absolute efficient irradiance in the half-tone cell and then the density distribution.
4. According to the density distribution the quality parameters of half-tone dots: the core density and the fringe width are calculated. The calculation of the half-tone pattern with different screen frequencies was made according to the model developed. The efficient irradiance distribu-tion in the recording spot calculated for resolutions of 800, 1000 and 1333 cm^{-1} was studied. To test it experimentally, half-tone wedges with different recording spots diameters and resolutions were recorded in the image setters. The repro-duction of the half-tone dots was controlled on the printing forme made from these half-tone films under standard conditions. The influence of the following factors of the recording process: exposure, resolution, the diameter of the re-cording spot – the irradiance distribution in the recording spot, screen frequency – the size of the dot matrix on the half-tone dots quality parameters was studied.

Results

The mechanisms of the formation of the half-tone dots quality pa-rameters were studied and the cri-teria of evaluation of the degree of influence of the recording process factors on them were chosen.

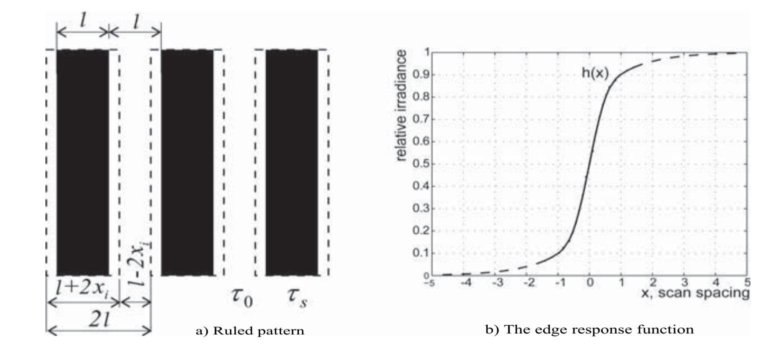

Figure 1: The calculation of the edge response function

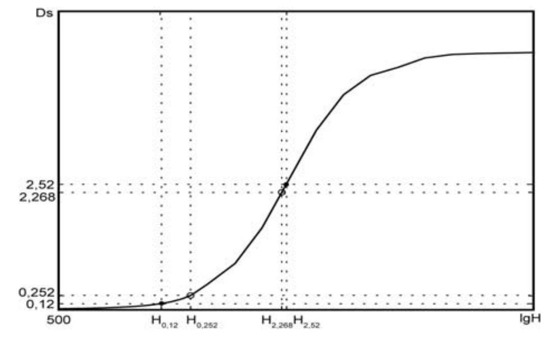

Figure 2. Density curve

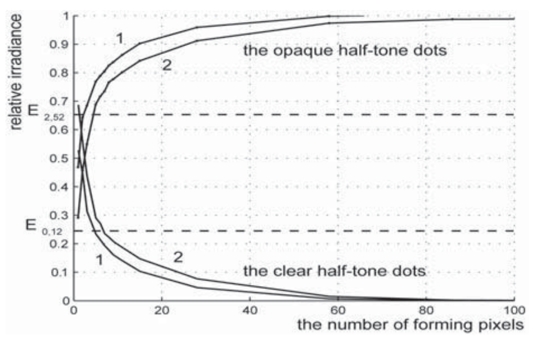

Figure 3: The dependence of the relative irradiance in the centre of the half-tone dots on the number of forming pixels and on the irradiance distribution in the pixel

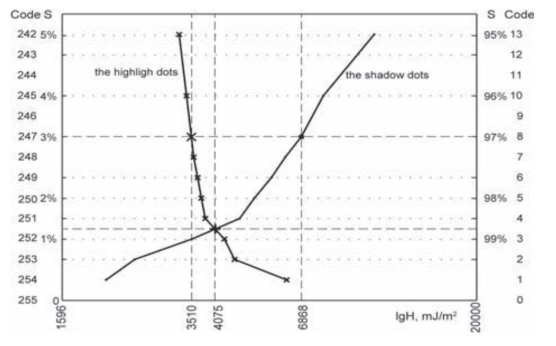

Figure 4: The graphic method of calculation of the maximum tone-value reproduction limits and of the optimum exposure

Core density

ISO 12647-2 sets the minimum core density 2,52 and the maximum value in the centre of clear half-tone dots 0,12 for the density of the clear film 0,02. These values correspond to the permissible values of the relative irradiance in the centre of the half-tone dots $E_{2,52}$ и $E_{0,12}$, which can be found by the density curve (Fig. 2) and equation (2).

$$E_{2,52} = \frac{H_{2,52}}{H}, \quad E_{0,12} = \frac{H_{0,12}}{H} \qquad (2)$$

Where H is the selected exposure; $H_{2,52}$, $H_{0,12}$ are exposures, corresponding to the solid density 2,52 and 0,12.

Relative irradiance in the centre of half-tone dots is determined by the number of the pixels (Fig. 3) forming the dot and by the character of the irradi-ance distribution in the pixel with respect to the scan spacing (curves 1 and 2, Fig.3 correspond to different distributions).

The half-tone dots with the permissible values of the density form the tone-value reproduction limits on the half-tone film. The following criteria of the quality assessment of the half-tone dots reproduction according to the given parameter were chosen: the permissible exposure latitude, within which the half-tone dots with the tone value of 3 to 97% are reproduced, and the maximum tone-value reproduction limits with optimum exposure. The permissible expo-sure latitude for 3-97% is calculated by the equation:

$$\Delta H = \frac{H_{0,12}}{E_{97\%}} - \frac{H_{2,52}}{E_{3\%}} \qquad (3)$$

Where $E_{3\%}$ and $E_{97\%}$ are relative irradiance values in the centre of the half-tone dots 3% and 97%, calculated according to the model.

The maximum tone-value reproduction limits and the optimum exposure are found with the help of the graphic method (Fig. 4).

Fringe width

ISO 12674-2 defines the fringe width as an average distance between the density contour lines corresponding to 10% and 90% of the minimum core den-sity, for the given example these values are 0,252 and 2,268 respectively. The permissible fringe width is determined by the screen frequency. The fringe width δ is determined by the relative irradiance profile of the half-tone dot (Fig. 5), as well as by the exposure and density curve (Fig. 2) which, according to equation (4), determine the location of the fringe in the profile:

$$\Delta E = \frac{H_{0,252}}{H} - \frac{H_{2,268}}{H} \quad (4)$$

Where H is the selected exposure; H0,252, H2,268 are exposures, corresponding to the solid density 0,252 and 2,268.

To evaluate the effect of the recording factors on the fringe width, the fol-lowing criteria were chosen: the permissible exposure latitude for given screen frequency and the minimum fringe width with optimum exposure (Fig. 6).

Thus, the main factors forming and governing the half-tone dots quality parameters is exposure. There is optimum exposure with which each parameter reaches its best values and there is permissible exposure latitude under which it is within the limits normalized according to ISO 12647.

While considering the effect of such factors of the recording process as the irradiance distribution in the recording spot and resolution on the quality parameters of half-tone dots, it is necessary to take into account the fact that one can change proportionally to the resolution only the distribution of the irradiance superimposed on the recording material. The contribution to the efficient irradi-ance from scattering in the recording layer changes little, thus, the efficient ir-radiance distribution will not change proportionally to the superimposed irradiance (Fig. 7).

This phenomenon results in significant weakening the influence of the ir-radiance distribution in the spot and resolution on the quality parameters of half-tone dots and the effect can be very small (Tables 1, 2, 3).

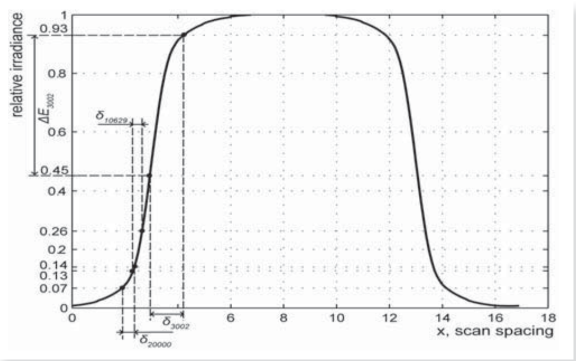

Figure 5: Transmittance density profile of a half-tone dot on a half-tone film

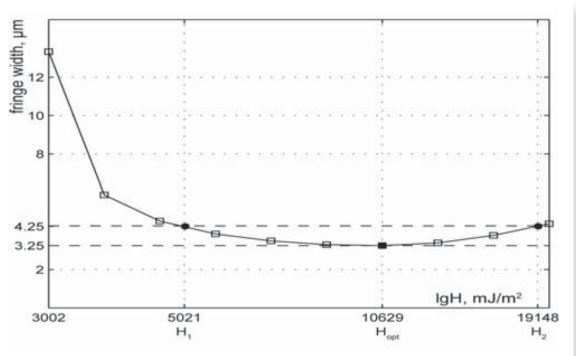

Figure 6. The dependence of the fringe width on the exposure

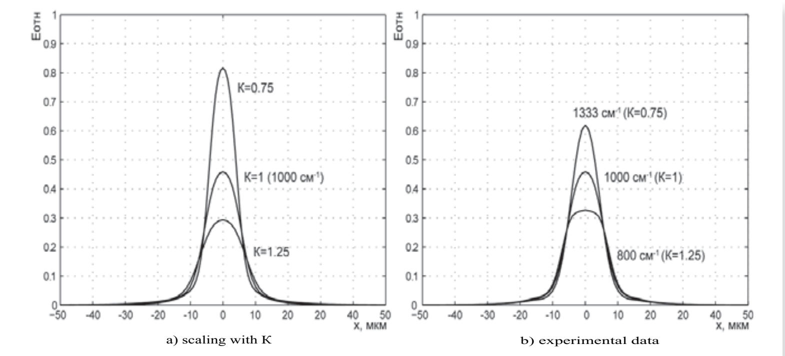

Figure 7: Efficient irradiance distribution in the recording spot (K is the coefficient of scaling used in re-counting of the irradiance distribution proportionally to resolution)

Table 1

The permissible exposure latitude and maximum tone-value reproduction limits with different distribution in the recording spot

a) for irradiance distribution obtained by scaling

K (resolution, cm^{-1})	Exposure latitude, mJ/m^2	Optimum exposure, mJ/m^2	Tone-value reproduction limits, % (code)	The width of the limits, %
1,31 (765)	3781-5312	4096	3-97 (249,9-5,1)	95 (244)
1 (1000)	3510-6868	4075	2-98 (251,5-3,5)	97 (248)
0,74 (1353)	3900-11190	3900	1-99 (254,0-3,0)	99 (252)

b) for irradiance distribution calculated according to the model from the experimental data

Resolution, cm^{-1}	Exposure latitude, mJ/m^2	Optimum exposure, mJ/m^2	Tone-value reproduction limits, % (code)	The width of the limits, %
800	3927-6975	4373	2-98 (250,4-4,6)	97 (246)
1000	3973-6886	4456	2-98 (250,8-4,2)	97 (246)
1333	3738-6004	4204	2-98 (251,0-4,0)	97 (248)

Table 2

The permissible exposure latitude and maximum tone-value reproduction limits with different resolution and the same distribution in the recording spot

a) according to the model investigation

Resolution, cm^{-1}	Screen frequency, cm^{-1}	Exposure latitude, mJ/m^2	Optimum exposure, mJ/m^2	Tone-value reproduction limits, % (code)
765	59	3800-6197	3800	1-98 (252,0-4,0)
1000	59	3510-6868	4075	2-98 (251,5-3,5)
1353	59	3483-7907	4123	2-98 (251,8-3,2)

б) according to the experimental data, evaluation on the printing forme

Resolution, cm^{-1}	Screen frequency, cm^{-1}	Exposure latitude, unit is 1	Optimum exposure, unit is 1	Tone-value reproduction limits, % (code)
800	62	54-128	-	3-99% (249-3)
1000	59	46-90	-	2-98% (251-4)
1200	60	43-90	-	2-98% (250-4)

Table 3

The permissible exposure latitude and maximum tone-value reproduction limits with different resolution and distribution in the recording spot

a) according to the model investigation

Resolution, cm^{-1}	Screen frequency, cm^{-1}	Exposure latitude, mJ/m^2	Optimum exposure, mJ/m^2	Tone-value reproduction limits, % (code)
800	62	4282-5778	4595	3-97 (249,3-5,7)
1000	59	3973-6886	4556	2-98 (250,8-4,2)
1333	58	3875-7026	4371	2-98 (250,9-4,1)

b) according to the experimental data, evaluation on the printing forme

Resolution, cm^{-1}	Screen frequency, cm^{-1}	Exposure latitude, mJ/m^2	Optimum exposure, mJ/m^2	Tone-value reproduction limits, % (code)
800	62	4575-10629	-	3-99 (249-3)
1000	59	3706-13122	-	2-99 (250-3)
1333	58	4575-13122	-	2-99 (250-3)

Conclusions

1. To evaluate the influence of the recording factors, the following criteria have been introduced: the permissible exposure latitude of reproducing half-tone dots with the tone values of 3-97% and the maximum tone-value reproduction limits when the normalized density is maintained in the centre; the permissible exposure latitude with the permissible fringe width for the given screen fre-quency and the minimum fringe width.
2. The main factor forming and governing the quality parameters of the half-tone dots is exposure. There is optimum exposure, with which the parame-ter reaches its best values and the permissible exposure latitude with which the parameter is within normalized limits.
3. The increase of the resolution with proportional to it change of the dis-tribution of superimposed irradiance in the recording spot and less blurred dis-tribution of the superimposed irradiance in the recording spot improve the qual-ity parameters of the half-tone dots. However, the effect significantly depends on the radiation energy scattering in the recording layer and can be very small. Increasing the resolution of recording without changing the distribution of su-perimposed irradiance in the recording spot does not improve the quality pa-rameters of the half-tone dots.

References

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[3] Andreev Yu., Sevryugin V. Spatial Model of optical pixel-by-pixel half-tone image recording process // Conference Proceedings of VIIIth Seminar in Graphic Arts 19th and 20th September 2007.– Pardubice, Czech Republic: University Pardubice.– 2007.– C. 125-130.

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