Estimation of Efficiency of Process of Developing at a Digital Printing

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Abstract

Electrophotographic technology of a digital printing of a type "Computer-to-Print" is based[1] on a reversible developing of an discharged electrophotographic covering with laser beam. An imaging of separated Lines (Line Development) of a Text Information is formed on a surface of the electrophot6ographic covering. This imaging is a fine point structure. The superposition of these Lines in the form of a raster creates a fine spatial lattice of filled fields (Large-area Development) of halftone imaging information (Large-area Development). Digital printing is a totality of these elements on the outputing document that visual perceived as imaging. The estimation method of developing conditions of an imaging basic element (rarefied trace of a separated Line) at digital printing is offered. For this purpose so-called "Zero Line" (ZL) of the electrostatic field in a zone of developing is used.

Introduction

Effectiveness of a latent image developing process usually estimates[2,3] by calculation of an electrostatic field in the developing zone. The electrostatic field is restricted from an one side with the surface of electrophotographic covering and from the other side - with a counter-electrode of the developing unit. An value of normal component of the field Ez allows to estimate of an directed force that precipitates of charged toner particles on discharged parts of a photoreceptor. An configuration Ez=f(x) depends on a distance up to a surface of a photoreceptor. The disturbing influence of a discharged section vanishes on a long distance and the field becomes practically homogeneous and the process of precipitation of charged particles ceases be effective. It is needs so to create a family of Ez=f(x) curves at different values of coordinate z for estimation of developing conditions on whole zone of developing (Figure 1a, curves 1-3). However the determination of only the configuration Ez=f(x) don't allows to visually judge about the height of distribution Ez within the bounds of the whole zone, particularly at a changing of parameters of the developing process (the displacement potential on a counter-electrode Vk, the width of the discharged Line 2a and so on). With a purpose of visual presentation of developing process we suggest a conception of "zero line". "Zero line" (ZL) is a geometrical site of the points within the bounds of the whole developing zone, where Ez=0. A toner particles that are on an one side of that ZL deposits on photoreceptor but particles that are on the other side of ZL – push off and remain unused.

The Curve of a Zero Line of Field

For a simplification of ZL field calculation instead Gauss-like form (Figure 1b, curve 4) accepted rectangular form of discharged region (curve 5). In that way it is accepted that one-dimensional charge on a photoreceptor has a next value:

$$\sigma_{(x)} = \begin{cases} 0, |x| < a \\ \sigma_0, |x| \ge a \end{cases} \qquad (1)$$

where: σ_0 - maximum surface charge density of photoreceptor; **a** - half-width of discharged line.

In this case the equation of normal component of electrostatic field in a zone of developing is presented[4]:

$$E_z = \frac{U-V}{D+\frac{\varepsilon_2}{\varepsilon_1}d} - \frac{U}{2\Pi d}\left\{arcg\frac{a-x}{z} + arctg\frac{a+x}{z} - arctg\frac{a-x}{2d+z} - arctg\frac{a+x}{2d+z}\right\}, \qquad (2)$$

where: **U** - the potential of charging of photoreceptor; **V** - the potential of displacement on a counter-electrode; **D** - width of developing zone; **d** - width of photoreceptor covering; ε_1, ε_2 - relative dielectric constant of photoreceptor covering and of a developer correspondingly; **x, z** - coordinates.

At **Ez=0** we have an equation of Zero Line[1] (3):

$$\frac{1-\frac{V}{U}}{\frac{D}{d}+\frac{\varepsilon_2}{\varepsilon_1}}-\frac{1}{2\Pi}\left\{arctg\frac{a-x}{z}+arctg\frac{a+x}{z}-arctg\frac{a-x}{2d+z}-arctg\frac{a+x}{2d+z}\right\}=0 \qquad (3)$$

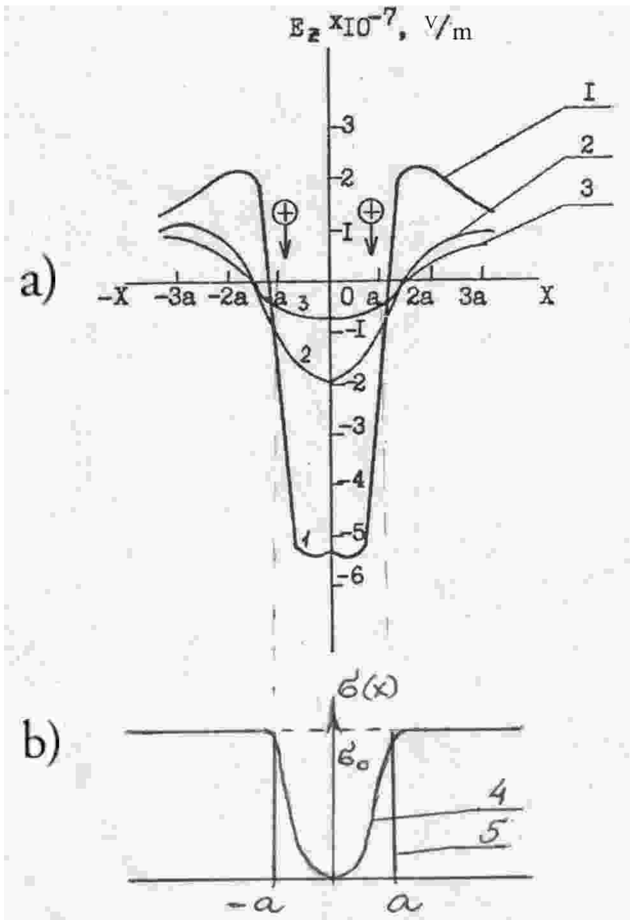

*Figure 1. The configuration of normal component **Ez** under the surface of a photoreceptor and across of a discharged Gauss-like line of width 20 μm (a), and a Form of positive charges disposition σ(x); (b): a- half-width of discharged line (a = 10 μm); 1- the distance from surface of photoreceptor is equal 0,5 μm; 2 - 5 μm; 3 - 10 μm; 4 – Gauss-like discharged Line; 5 – rectangular discharged Line; ⊕ - positive charged toner particle.*

Configuration of Zero Line and it's Dinamic

A calculation of ZL configuration with the equation (3) done for transparent photoreceptors – single using organic electrophotographic films at the next parameters:

U = 300 V; V = 0 ÷ 350 V; ε_1 = 3; ε_z = 2,44;
d = 5 μm; D = 10, 100 and 1000 μm; a = 10 μm.

The width of discharged line **2a = 20 μm** corresponds to a diameter of light spot practically using in digital printing as well as maximum resolution on the level of 1200 dpi.

The configuration of Zero Line for symmetrical half-width of discharged region is shown on Figure 2. In the same place the dynamic of ZL at variation of displacement potential values V is shown too (is marked on the curves). For better understanding of these the direction of ZL is marked conditionally: clockwise on the Line (2) on left side the Zone of Extracting (3) of positive charged toner particles is displaced (**Ez < 0**), on the right side – Ballast Zone is displaced (**Ez > 0**).

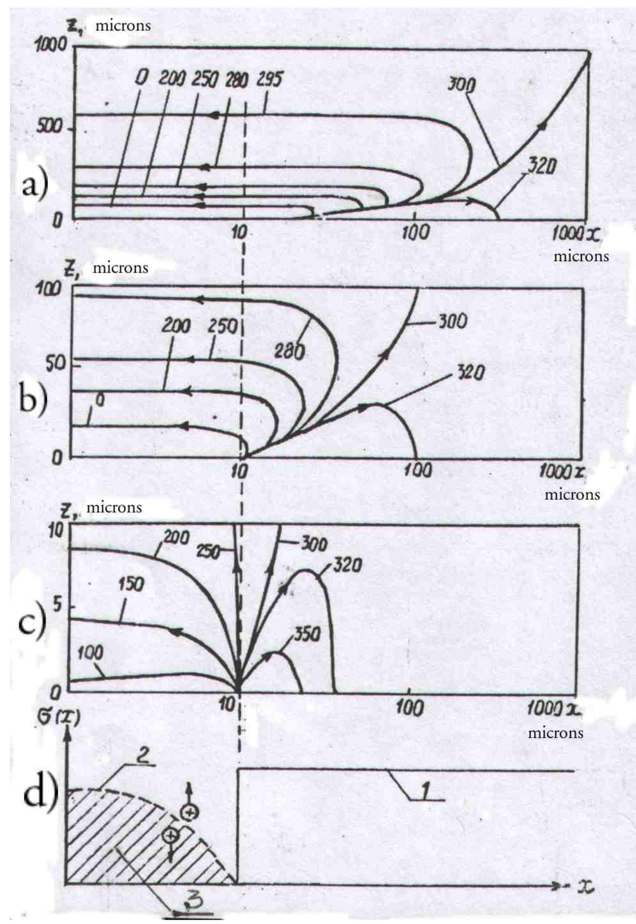

*Figure 2. The changing of a Zero Lines's form in a Zone of Developing vs a potential of displacement (is shown in drawings, B). the distance up to a counter-electrode is 1000 μm; b) 100 μm; c) 10 μm; d) the scheme of surface charge distribution of photoreceptor (1), zero line (2) and zone of extraction (3). **a** – half-width of discharged line; **z** - height on the photoreceptor's surface; **x** – coordinate; τ - surface charge; ⊕ - positive charged toner particle.*

One can see that a character of ZL significantly depend on the width of developing zone **D** (the distance **z** up to the counter-electrode) and on the potential **V**. For situation where **D >> d** (Figure 2, a, b) the width of a Zone of Extraction deforms and exceeds of the width of discharged region. For **D ≥ d** (Figure 2, b) at **V ≤ 300 V** the width of Zone of Extraction practically corresponds to a width of the Line.

A change of the **V** value allows to transfer ZL along a whole Zone of Developing, with the exception of its penetration on neighboring regions and a generating of a background.

The offering method of estimation of developing process efficiency and the obtained results can be easily transformed for thick-walled reusable photoreceptors too as since with the increasing of width **d** the potential of charging **U** is increasing pro rata.

Conclusion

The offering method of field's Zero Line determination allows to visually clear up the zone of toner particles extraction and to determine an efficiency of developing process. If ZL includes all width of a zone of developing and doesn't transgress the coordinate **x** of discharged line – this is evidence of the most effective conditions of passing of developing process. For selected conditions of calculation the width of zone of developing doesn't exceed the width of photoreceptor's covering more than in a few times, and the potential of a counter-electrode must be within the bounds of (0,9 – 1,0) U.

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Biography

Oleg R. Kharin (b. 1946) graduated in 1978 from the Vilnius's (Lithuania) State Technical University. 1965 – 1984 – researcher at the Institute of Electrography in Vilnius. 1984 – 1997 – chief of the department of Institute of Electrography in Vilnius, since 1997 Deputy Director General on Science – Scientific Research Phototechnical Institute on Slavich Co. Director (Nifti – Slavich, Pereslavl– Zalessky). Dr. of Techn. Sci. (1990). Cca 70 publications and patents. Contact fax. +7(08535) 22926.

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