Journal of Materials Science and Engineering B 3 (8) (2013) 545-549

Adjustment of Ink and Water Supply in Offset Printing

Bogdan Kushlyk

Reprography Department, The Publishing and Printing Institute of the National Technical University of Ukraine "Kyiv Polytechnic Institute", Kyiv 03056, Ukraine

Received: December 30, 2012 / Accepted: February 01, 2013 / Published: August 25, 2013.

Abstract: The stochasticity of the ink-water balance in the offset printing process is actually a fact. We have only the rotating speed of the duct dampening roller adjustment to apply the water to the printing plate, and against we have the ink zones which can be opened differently depending on the printing elements quantity. This means that in any way of settings we will definitely have a certain constant amount of water emulsified in a different quantity of ink. This should be so far acceptable as long as we have the wide-latitude inks in terms of tackiness, water acceptance and other rheological properties. As nowadays all modern inks are a little changed in terms of ISO 12647-2 dot gain requirements and they are now more sensitive to the very exact ink/water regulations. If looking in the very idle printing element we can consider it as a figure filled with ink-water emulsion. The water-ink flow can be described with the Ostrogradsky-Gauss formulae: $\iiint_{(\nu)} div\,\vec{a}dxdydz = \iint_{(\Omega)}(\vec{a}\,d\vec{\Omega})$. A divergence parameter shows the flow density in the field ν which is limited by Ω_1 and Ω_2 surfaces on the continuously-differentiated vector-function $\vec{a}$ which should be determinative in this very point of the field. In terms of vector field flow we can explain the ink/water emulsion transfer from the printing plate to the blanket and afterwards to the imprint using also the theory of mathematical delays concerning the instability of regulations feedback. Therefore we can predict the outcome for ink emulsification in the very exact point in the printing plate and in general also.

Key words: Ink/water balance, vector field flow, emulsification, rheological properties of ink.

1. Introduction

When having a close look at quality on the imprints, we find that the ability to correct the qualitative parameters of the imprint is available due to the integrated control systems in modern printing machines. For the moment there are enough decisions provided by world equipment manufacturers (MAN Roland, Heidelberg, KBA, Komori and others). The main feature of those systems is the ability to control the values in real time mode. For this the printing machine is equipped with the cameras able to scan the image or the part of it and find if there are some defects. Also they may provide a special signal for the printer if there are some casualties and some of them may also trash defective imprints. All systems are characterized with the special measuring device availability (spectrophotometer, densitometer, spectrodensitometer) which is connected with a system that supplies ink and fountain solution [1-4].

However, when analyzing the working cycles of those systems, the trend common to all of the systems may be encountered. The conclusion about the similar algorithm (Fig. 1) of the systems work may be done.

Basically the start of work is when the data for printing is entered without matter which way of entering it was used either via automated system using CIP3/CIP4 protocol or manual. There is no typical end of job as practically the work of the system ends when the machine is stopped.

"Printing some amount of imprints" means the necessary quantity of sheets each automated system requires to calculate if there is a need to change the ink supply on the ink zones. In case of having a table-based system in sheetfed presses the number of the needed imprints is defined by the printer, so here we might have some uncertainties.

Corresponding author: Bogdan Kushlyk, Ph.D. candidate, research fields: offset printing technology, ink-water balance and transfer in offset printing, offset printing process reliability. E-mail: bodo_kush@hotmail.com.

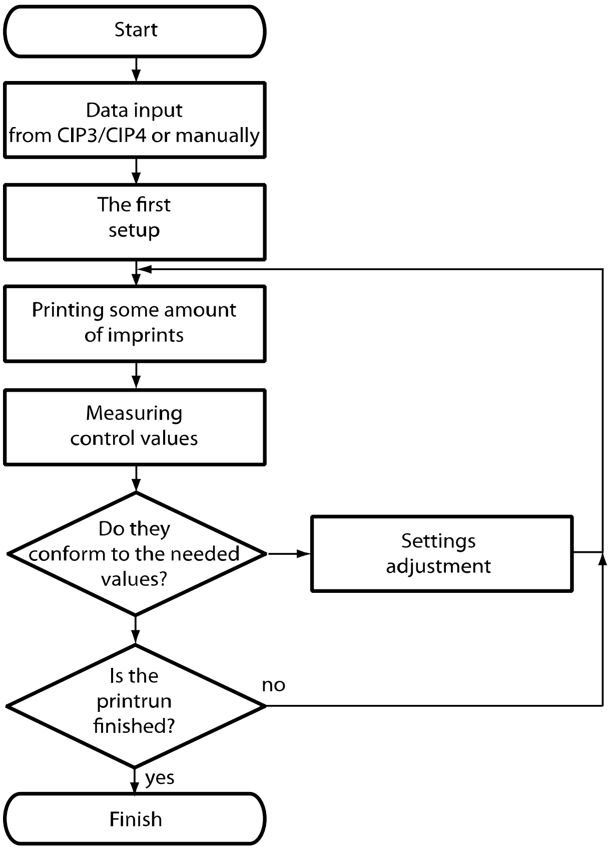

Fig. 1 The generalized working algorithm of the automated imprint control systems.

The algorithm is of cyclic type; this may be explained by the instability of the process itself and because of the adjusting parameters caused by the stochasticity of the technological process. Once the printing parameters in terms of water and ink supply on the stable printing speed were set in some time some qualitative changes on the imprint will be experienced, as it is not possible to achieve a similar level of water-ink balance stability in all of the very exact printing elements on the plate.

2. Theoretical Aspects of Printing Element Consideration According to the Field Theory

As a printing element has got a determined space, it can be defined as a scalar field which should be transferred to the printing surface. The very idle printing element, or basically the amount of ink on it, can be described by the Ostrogradski-Gauss formulae as a volume that has got a determined basis square and

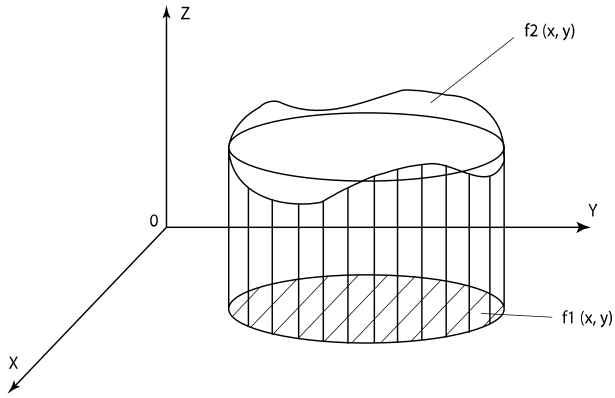

Fig. 2 The body (a printing element) (v), limited by the surface from top (Ω_2), equation of which is z = f2(x, y), and from below with a surface (Ω_1), equation of which is z = f1(x, y), and from the sides is limited by the cylindrical surface (Ω_3) generating lines of which are parallel to OZ axle.

some type of the surface limiting it from the top. This formula determines a correlation between the triple integral on the space figure and the surface integral of the second type for the surface that is limiting this figure (Fig. 2).

The formulae:

$$\iiint_{(v)} div\,\vec{a}\,dxdydz = \iint_{(\Omega)} (\vec{a}d\vec{\Omega}) \qquad (1)$$

is a vector writing of the Ostrogradsky-Gauss formulae and is read as follows: “The volume integral from the divergence of the vector field is equal to the vector field flow through the surface that is limiting this surface”. With the help of this formula the invariant divergence definition can be done which is as follows:

$$div\,\vec{a}\,(M_0) = \lim_{\lambda(T)\to 0} \frac{\iint_{(\Omega^+)} (\vec{a}d\vec{\Omega}^+)}{T} \qquad (2)$$

where, $\vec{a}$ is non-stop-differentiable vector-function function $\vec{a} = \vec{a}(x, y, z)$; The dot $M_0(x_0, y_0, z_0) \in (v)$, where v is area, where the vector-function $\vec{a}$ is determinable; (T) is area with the piecewise-smooth surface (Ω), which is limiting (T) and where $M_0 \in (T)$, also ($\bar{T}$) $\subset$ (v) and for it the Ostrogradsky-Gauss formula is true; (Ω^+) is surface (Ω), which is oriented with the help of the outer normal; $\lambda(T)$ is the diameter of the surface (T); T is the diameter of the body (T).

As in the right part of the Eq. (2) the quantities, which are under the limit sign does not depend on the coordinate system choice, this means that in the left part (the divergence in the dot M_0) does not depend on the coordinate system choice also.

Admitting the vector-function $\vec{a} = \vec{a}(M)$ as given and non-stop-differentiable in the cubic area (v) with the volume v, which is limited by the smooth surface (Ω). Considering that the dot $M \in (v)$. Then the relationship:

$$\frac{\iint\limits_{(\Omega^+)} (\vec{a}d\vec{\Omega})}{v} \tag{3}$$

of the vector field flow to the volume of this area may be worshipped as an average source (or drain) density, meaning the quantity of liquid which appears (disappears) for the moment of time in the certain volume area (v).

The limit of the average density

$$\lim_{\lambda(v)\to 0} \frac{\iint\limits_{(\Omega)} \vec{a}\, d\vec{v}}{v} = div\,\vec{a}\,(M) \tag{4}$$

where, $\lambda(v)$ is a diameter of the area (v), or a $div\vec{a}(M)$, is then named as an average flow density in the dot M.

According to the Eqs. (1) and (4) the vector field flow Π through the closed surface Ω to its outer side is equal to the triple integral from the divergence of this field via area v limited by the surface Ω [5, 6].

The characteristic of what is going inside the printing element is as follows. When using the offset printing with dampening the achievability of the ink/water balance is a must. With this the liquid that is transferred from the printing plate to the blanket is a kind of emulsion containing ink and a dampening solution. In the first contact zone "plate-blanket" zone two sources which supply ink and fountain solution are available, and also one drain is available where this emulsion is transferred using the pressure mechanism. In the second contact zone "blanket-substrate", the drain from the former scheme is the source and the drain is the ink transfer from the blanket to the substrate also using the pressure mechanism.

The fountain solution emulsification into the ink is a must and is not stable. The amount of fount which emulsifies into the ink may be from around 10 up to 25% from the ink volume (this is the data supplied by ink manufacturers), which influences on the rheological and thixotropic parameters of the ink, so also the character of the emulsion transferred to the next contact zone differs [7].

Theoretically when reaching the ideal values of ink and fountain solution supply when having a stable printing speed the process should remain stable. But practically it is never possible to achieve the ideally equal correlative ink and fountain solution supply rates only because the ink may be supplied zonal and the fountain solution may not according to nowadays used dampening systems.

3. The Task Solution of Choosing the Optimal Operation for the System Controlling the Ink or Fountain Solution Dosing

It is very important to solve the optimal operation search task, which may be applied to model the needed changes in ink and fountain solution supply to the printed element. The device doing a supply job (basically is a source of the vector field) may be called an emptying device on the beginning of the first contact zone, similarly the drain of the first contact zone which is a source for a second contact zone will be an emptying device for it. We should solve the task of searching the optimal operation in general taking into the fact that the stochasticity of the ink transfer indefinitely has got a delay.

Admitting the movement of the dot on the emptying device of the printing machine is described with the system of linear differential equations containing delays:

$$\begin{cases} \dfrac{dx_1(t)}{dt} = x_2(t) \\ \dfrac{dx_2(t)}{dt} = -x_1(t-\Delta) + U(t) \end{cases} \tag{5}$$

where, sectionally continuous $U(t)$ is limited by absolute value of $|U(t)| \le 1$, the delay Δ is constant: Δ = const.

And the starting requirement is applied:

$$x_1(t) = 0 \quad \text{where} \quad t \in [-\Delta; 0] \qquad (6)$$

Examining the phase limit as a condition of the moment of time availability $t_1 > 0$, when before reaching the point (b, c) the followed inequality is accomplished:

$$x_2(t_1) \le 0 \qquad (7)$$

The task of synthesis the optimal operation for the system of Eq. (5) including the limits Eqs. (6) and (7) may be solved with the help of construction the Hamiltonian corresponded to the system (5):

$$H = \Psi_1(t) \cdot x_2(t) - \Psi_2(t) \cdot (x_1(t-\Delta) - U(t)) \qquad (8)$$

and analyzing the suited for it system of equations with advance [8].

The most controlling objects in the printing equipment have got a clear transport delay, so it is actual developing and improvement the algorithm to operate the objects having a delay.

On the very last timeline $t_k - \Delta < t \le t_k$ the Hamiltonian (8) may be obtained in an easier look:

$$H = C_1 x_2(t) - C_2(x_1(t-\Delta) - u(t)) \qquad (9)$$

According to Pontryagin maximum principle [9] the optimal operation $u(t)$ should provide the Hamiltonian with the maximum value:

$$H(x_1, x_2, \Psi_1, \Psi_2, u) \to \max \qquad (10)$$

Base on Eq. (9), and the limit of control $|u(t)| \le 1$, we get that on the last timeline $t_k - \Delta < t \le t_k$ the optimal operation $u(t)$ depends on the sign of the constant C_2:

$$u(t) = signC_2 \qquad (11)$$

so $u(t) = 1$, if $C_2 < 0$ and $u(t) = -1$, if $C_2 < 0$.

After making some mathematical transformations, the searched solution for Eq. (5) when $0 < t \le \Delta$ is defined by the set of functions:

$$\begin{cases} x_1(t) = \frac{1}{2}t^2 + at \\ x_2(t) = t + a \end{cases} \qquad (12)$$

The Eq. (12) defines the dot's movement trajectory of the emptying device in the printing machine in parametric view. Making a transformation as follows:

$$x_1(t) = \frac{1}{2}(t+a)^2 - \frac{a^2}{2} = \frac{1}{2}x_2{}^2(t) - \frac{a^2}{2}$$

we may get this transformation in an analytic view:

$$x_1 = \frac{1}{2}x_2{}^2 - \frac{a^2}{2} \qquad (13)$$

So the movement trajectory from the starting point $t = 0$ up to the moment of time defined by the delay value $t = \Delta$ is a part of a quadratic parabola, which can be shown on a graph in a phase flat $\{x_1, x_2\}$ (Fig. 3). If the set point (b, c) belongs to the line (13) when $a \le x_2 \le a + \Delta$, we may count the optimal operation search task as solved.

So, when the operation is $u = -1$ the trajectory (12) is changed with this:

$$\begin{cases} x_1(t) = at - \frac{1}{2}t^2 \\ x_2(t) = a - t \end{cases} \qquad (14)$$

Such a trajectory written in parametric view also is a parabola but it is formulae differs against Eq. (13) with the sign:

$$x_1 = \frac{a^2}{2} - \frac{1}{2}x_2{}^2$$

where, $a - \Delta \le x_2 \le a$.

If $\Delta < a$, then the graphical view of this function is a part of parabola shown on Fig. 4.

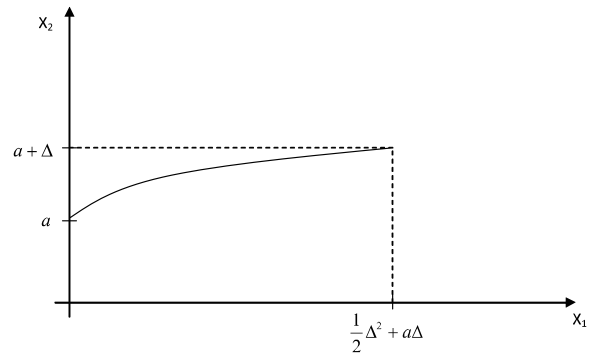

Fig. 3 The dot's movement trajectory of the emptying device starting from the firstly set moment of time which is defined by the delay according to the maximum available operation *u* = +1.

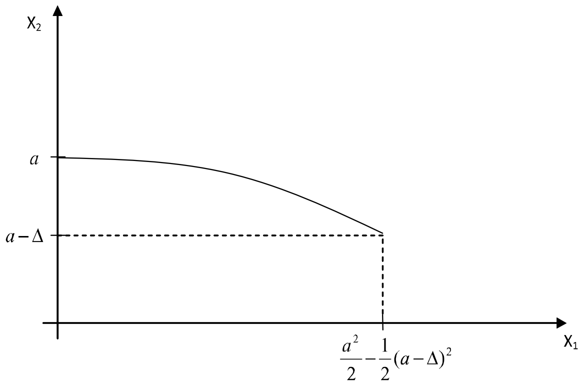

Fig. 4 The dot's movement trajectory of the machine's emptying device from the first time moment which is defined by the delay when having a minimum available operation *u* = -1.

4. Conclusions

The provided theoretical research shows the availability to set the process of reaching and continuously keeping stable the ink/water balance, when having some values of ink and dampening solution supply according to the number (or total square) of this elements on the printing plate. The mechanism that may define the amount of ink and fountain solution which form an emulsion transferred to the substrate in the every idle printing element should be researched. When having some operating systems that may check and control the mentioned above values in the real-time mode the economical effect will be visual basically grounding on shortening waste on the start of the printing and on the machine's restarts after the technical or technological stops.

Acknowledgments

The author shows his gratitude for the support provided to the "YAM Service Ukraine" Ltd. company, the distributor of Komori printing machines and Fujifilm PS plates: www.yam.com.ua; www.yam.ru.

References

[1] V. Reznik, Knowledge to the mass!, PrintPlus 6 (2009) 16-22.

[2] A.E. Ivanova, The identification of automated processes in printing industry, Ph.D. Thesis, Moskow State University of Printing, Moskow, 2006.

[3] M.J. Murabak, The automated system to control the regional servicing of the Printshop equipment, Moskow State University of Printing, Ph.D. Thesis, Moskow, 2008.

[4] Velychko, Treatment of the information flow when elements of the printing contact interact [Monograph], Kyiv University, Ukraine, 2005.

[5] N.I. Shkil, The mathematical analysis, part II, Kyiv, the USSR: Vysha shkola, the main publisher, 1981, p. 456.

[6] A.P. Ryabushko, V.V. Barkhatov, V.V. Derzhavets, I.E. Yurut, A collection of individual tasks of higher mathematics, Minsk, Belarus, Vyshejshaya shkola, 1991, p288.

[7] B. Kushlyk, The mathematical description of the printing element dot in the offset printing contact zone, Collection of scientific works, Technology and Techniques of Printing 4 (30) (2010) 92-100, ttp://druk.kpi.ua/content/matematichnii-opis-tochki-drukuvalnogo-elementu-u-drukarskomu-kontakt%D1%96-ofsetnogo-druku.

[8] B. Kushlyk, O. Kushlyk-Dyvulska, The task of optimal operation with delays in mechanical movements of the printing equipment, in: Proceedings of the XIII International Conference Named after Academician M. Kravchuk, Ukraine, 2010, p. 239.

[9] L.S. Pontryagin, V.G. Boltyanskiy, R.V. Gamkrelidze, E.F. Mishenko, Mathematical theory of optimal processes, Moskow, the USSR: Nauka, 1969, p. 384.