The transient process of flexographic printing with parallelink supply

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The problem of modeling and transient analysis of flexographic printer's ink system with parallel ink feeding into the form is enlightened. Printing material has been singled out.

Problem setting

Flexography printing process began to be applied for the production of newspapers and print magazines which are competitive with the offset as a result of the development and improvement of the forming and printing processes. Usually embossed flexible forms are used for printing. They convey good paint images on printing materials that work as a deckle and therefore provide printing without any supplement that simplifies debugging machine. Flexible forms allow to print any material virtually, including one that is easily deformed (polymer films, corrugated cardboard). The usage of the anilox color substantial device provides the ink dosing on the printer's ink system's entrance that improved the equability of scanning the imprint coating paint [9-11].

In flexographic printer's ink system complex processes may occur. These processes are connected with the serving of the anilox ink substantial device and modulation of the painting flow by the raster printing form and also with creating an imprint in the form of paint. The imprint transmission from the raster ink shapes on printing materials is now the focus of specialists – polygraphists. Mostly experimental research processes of the ink devices dominate according to their complexity. They demand complex and expensive test equipments, money, materials and time. Thus the urgent task of theoretical research of printer's ink system arose, including modeling and transient analysis.

Recent research analysis

The ink sets of the flexographic machines in their structure and design differ from ink-feeding blade-type traditional devices of the offset printing machines significantly. They have no means to regulate zonal ink feed, but provide the required coating thickness equability of the raster print [9-11]. This issue is theoretically justified by this time.

The [10] presented work contains the research of the graphic distortions of the flexographic imprints depending on the factors that determine the properties of the ink in printing contact strip, including screening of paint, depending on the viscosity, the length of the contact element and the size of the printing ink layer thickness on the form. The anilox cylinder usage in the offset printing on newsprint production on the roll machines was done by analogy with flexography. Mathematical models of systems with anilox short ink printing cylinder for the offset machines are singled out in the works [1, 2, 5-7]. This is the basis for the characteristics of raster prints coating. In addition the accuracy of the mathematical models has been determined. It must be noticed that the work contains mathematical models of systems with anilox short color printing cylinder for the offset presses. The qualities of coating halftone prints with ink determined their accuracy. The offset printing method differs significantly from flexography. There is a direct transfer of images from a bitmap ink shapes on the imprinting materials instead of going offset mediocre transfer through the cylinder offset (offset panel) in flexography. Therefore, the constructed model of short ink printing offset can not be directly used to analyze the dynamic properties of flexographic printing system itself.

The aim of research is to simulate and analyze transients flexographic printer's ink system with parallel ink feeding to the form and printing material, that is solved by mathematical modeling and computer simulation.

Mathematical model nstruction

Considering one of the most common ink sets in flexographic printing machine with closed ink chamber and parallel ink feeding to the form with two rolling up cylinders, the circuit of which is shown in Fig. 1.

The ink that is located in a closed cell K under its pressure fills in the raster nutshell of the anilox axle A that rotates. The overage ink from the surface of the roller is rolled up by the Raquel P and equable ink flow is being transmitted gradualy to the first and second rolling up cylinders. These cylinders roll the paint on raster printing plate ϕ, which carries the modulation of the ink flow. The ink creates the imprint on the form and is transferred into printing material. Some ink that was not accepted by the form due to printing elements creates the paint backflow on the rolling up cylinders, that influence ink equal transmission on the imprint.

On entering the contact zone ink flows are imposed (added) on the footprint pins entance, while on the output they are splited (divided) into two parts . It is supposed that the division of such flows is instantaneous and flows movements between the zones of contact occurs with the constant speed [1, 2]. The flows transmission in the printer's ink system is continuous and discrete process, which we use to describe the known methods for the discrete models of continuous objects constructing [4, 8]. Under these conditionsas as well as under the methods for the discrete models printer's ink system constructing with spatial period length quantization of the paint flows corresponds the lengths of the circles arcs, ink rollers and forming cylinders served with integers of the spatial period [1,2].

According to Fig. 1 the thick streams system equations of ink balance is made for all points of contact rollers and forming cylinders, taking into account the spatial relocation and transfer to z-transformations:

$x1(z) = Pa1\ (z)\ Va(z) + R1(z)x3(z)$
$x2(z) = Pa\ (z)\ x1(z) + R2(z)x4(z)$
$H0(z) = Rq(z)x2(z)$
$x3(z) = P1\ (z)\ x1(z) + F3(z)x4(z)$
$x4(z) = P2\ (z)\ x2(z) + F2(z)x5(z)$
$x5(z) = F1(z)x3(z)$

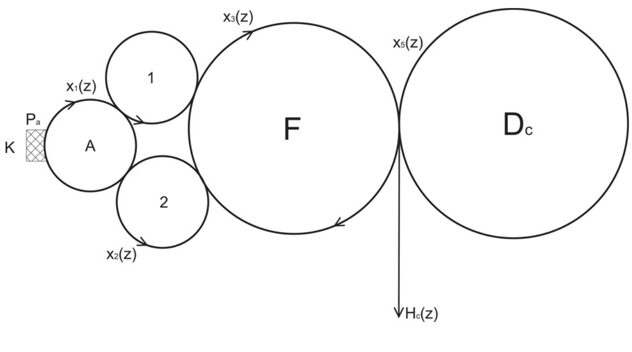

Fig. 1. The Scheme of printer's ink system

$Hcp(z) = Pc2(z)x5(z)$
$Hca(z)=Pc1(z)x5(z),$ (1)

where xi(z) - z – is the thickness transformation of the ink flow at the points of contact rollers and forming cylinder. Hcp(z) τa Hca(z) – z – is the transformation of the average and amplitude meaning of ink thickness on the printing materials, Va(z) —is the image capacity of anilox cylinder, H0(z) — z — is the backflow thickness transformation of the ink that comes back into the paint cell, Pi(z) and Ri(z) —the transmission operators of the forward and backward ink on rollers, Fi(z) — transmission operators of the forward and backward ink modulated by the raster printing plates.

Transmission operators of the forward and backward flows of paint are determined by such expressions:

$Pi(z) = \alpha i\ z\text{-}Pi$
$Ri(z) = (1\text{-}\gamma i\ S)z\text{-}ri$
$Pci(z) = z\text{-}c1,$
$Pci(z) = \beta\ z\text{-}c1,$ (2)

where αi and γi are the transfer factor (coefficient) of the forward and backward flows of paint at their exit from the contact points and ridges form. β is the paint transfer factor (coefficient) on the printing material. S is the fill in forms factor (coefficient) of the printing elements. pi and ri symbolize the length of the arc forms between the rollers and the contact zones (the forward and backward flows), that are expressed by the relative units fractions of the spatial quantization period.

Transmission operators are modulated by the raster printing plate of the forward and backward ink flows:

$F1(z) = \alpha\ S\ z\text{-}P1$
$F2(z) = (1\text{-}\ \beta)\ z\text{-}P2$
$F3(z) = \alpha\ S\ z\text{-}P3\ ,$ (3)

where pi is the length of the arc shape in some areas. Transmission operators z-P1 and z-ri have a clear physical meaning and correspond shift (delay) of ink streams on pi or ri periods in the spatial quantization period. Solving the system of equations (1) it has to be determined that the color transition function in the printing system is time-consuming. Therefore, a graph of the flexographic printing system is constructed, which is shown in Fig. 2 to simplify the task of applicable computer simulation. It is based on the material shown in the circuit in Fig. 1 and equations (1).

The vertex of the graph is labeled by xi(z) and Hi(z) and correspond z-transformation of the ink flows thickness at rollers' points of contact and forming cylinder as well as printing material. The arcs of the graph correspond transmission operators Pi(z) and Ri(z) of the forward and reverse flow of ink. The arrows on the arcs indicate the direction of feed paint flow. It is possible to determine the relationship between the images of the flow thickness in any area of contact and the inlet into system directly behind the graph. For example, according the graph in Fig. 2, images define the dependence of the amplitude values of the paint thickness on printing materials for a given capacity of the anilox cylinder.

Hca (z) = [Pa1(z) P1(z) F1(z) Pc1(z) [1-P2(z) R2(z)] + Pa1(z) Pa(z) P2(z) F3(z) F1(z) Pc1(z)] Δ-1(z) Va(z) (4)

The graph determinant that characterizes its outline part is possible to single out with the basis of Mezon's formula [2].

Δ (z) =1-P1(z) R1(z) - P2(z) R2(z) - F1(z) F2(z) F3(z) - P2(z) F3(z) R1(z) Pa(z) - R1(z) Pa(z) P2(z) F3(z) +P1(z) R1(z) P2(z) R2(z) (5)

Similarly, the thickness of the ink flow at the point of contact of the first roller and forms can be defined by the following way:

x3(z) = [Pa1(z) P1(z) [1-P2(z) R2(z)] + Pa1(z) Pa(z) P2(z) F3(z)] Δ-1(z) Va(z) (6)

From the above stated material it is possible to conclude the complexity of the analytical analysis of transients in flexographic printer's ink system. That is why the method of computer simulating is being used. To do this the graph is built to block the diagram of model printer's ink system according to the system of equations (1). The aggregate simulating model in the Simulink software package is constructed on its basis for transient's flexographic printer's ink system box. This is depicted in Fig. 3.

The top part is a block diagram model of printer's ink system. The main elements of which are blocks of Discrete Transfer Fon that serve as operators of transmission for the forward and reverse flow of ink. On the inputs of the accumulators the forward and backward flow of paint are fed. The value of capacity of the anilox shaft is given by the unit Step, which mimics the paint flow at the inlet of system. Three models are used for the parallel modulation of ink systems with different parameters . They are hidden for the compactness and placed in subunits of the Atomic Subsystem. The objective of the values input streams is made up by blocks Step. Multiplexer Mux provides simultaneous output of the numerical transients on power of visualization and Scope Display. That is how the parallel computing and the construction of four transients is made for different system's parameters.

The following numeric data lengths of ink rollers arcs were used to construct the transitional characteristics : P1=5, r1=7, P2=5, r2=10 and forms: P1=P2=15, P3=10 as well as the anilox shaft P4 = 108,0. Modeling debug of the nominal transferratios ink flows: αi = γi = 0,5, β = 0,8. With the help of step blocks capacity of the anilox shaft was set Va = 6 sm^3/m^2.

The results of computer modeling as four printer's ink system for the different tone transmission are described by the relative area coverage of the raster printing plate elements for S = 1, 0.5, 0.25 and 0.125. They are shown in Fig. 4 with the average values of the paint thickness on the printing material.

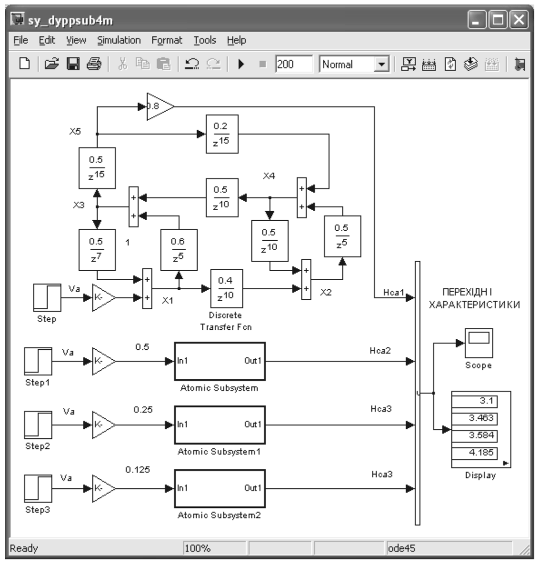

Fig. 3. The model window of printer's ink system for the construction of transitional characteristics

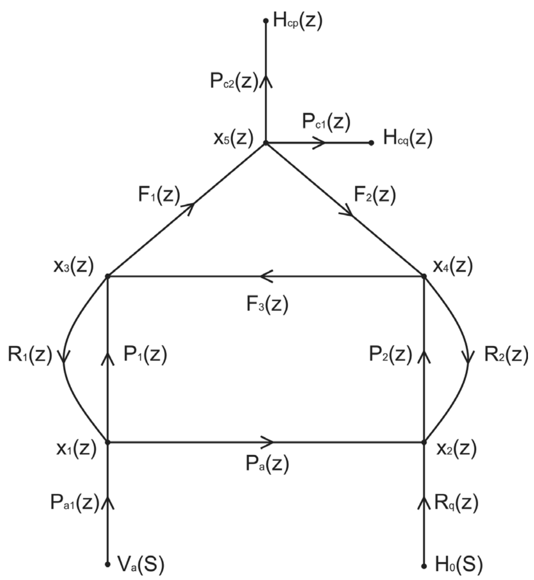

Fig. 2. The graph of printer's ink system

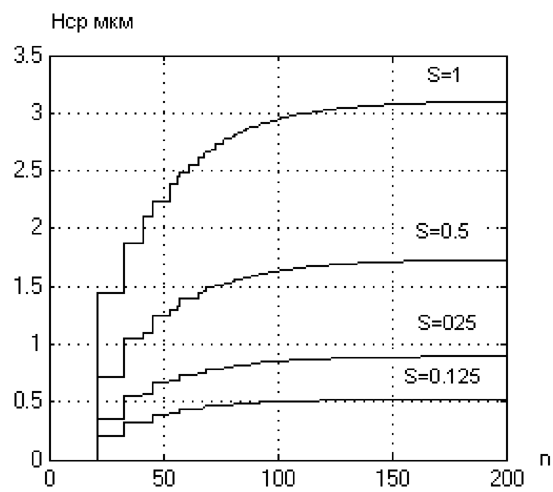

Fig. 4. Transfer characteristics of printer's ink system presented by the average values of paint thickness for different relative raster form areas cover

Tab. 1. The paint thickness dependence on the material of the relative surface area of the raster form

Relative area/ The paint thickness, um	S acting			
	1	0,5	0,25	0,13
H_{cp} ΔH_{cp}	3,1 0	1,731 1,369	0,8961 2,2039	0,5231 2,5762
H_a ΔH_a	3,1 0	3,463 0,369	3,584 0,2039	4,185 0,5762

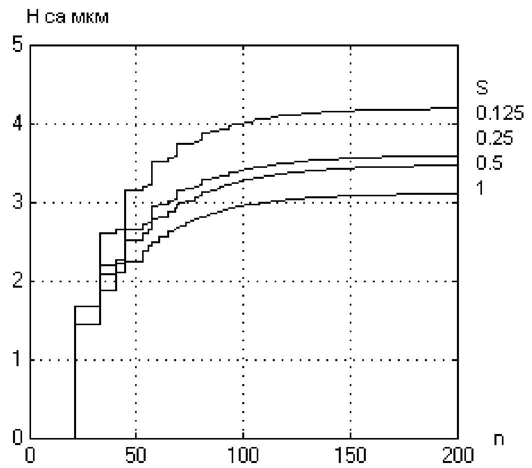

Fig. 5. The printer's ink transfer characteristics given by the amplitude of the paint thickness on the material

Transfer characteristics of printer's ink system are presented by the average values of the paint thickness on printing materials and have an initial offset acting as 21 , which is caused by the passage of time, paint flow from input to output of the system. Stepwise increasing flow thickness and reach steady mode for four turns forming cylinders (160 acting length). The factory default average paint thickness on the material flow is largely dependent on the relative surface area of the raster form and is within 3.1 |- 0.5231 microns. Deviation of the ink thickness on the maximum value is within 1,369 - 2,576 mm. More complete data of computer simulation is presented in the table.

The value of the transient response degree depends on the surface area of the raster form for S = 1, the first stage is 1.49 microns, the second one is 1.872 microns. In the contrast to the area S = 0,125 thickness of the first stage is 0.25 m, and the second is 0,325 microns.

The results of computer modeling of the printer's ink transient characteristics amplitude values of the paint thickness on printing materials relative areas for field raster elements are submitted with S=1; 0,5; 0,25 and 0,125 as described in Fig. 5.

Transfer characteristics are given by the amplitude value of the paint thickness are much different from the previous ones. The default amplitude values of the paint thickness on the material is less dependent on the surface area forms the print elements and are within 3.1 - 4.185 microns. On the bright and dark field scanning print of paint thickness is greater. In the dark shadows of the fields and the thickness of the paint is less. A complete simulation results are given in the table. It is possible to conclude that the bright and light areas of the print are darkened as a result of the second series of simulations, while the midtones and shadows are enlightened.

Conclusions

1. The printer's ink systems of flexographic machines are kind of discrete-continuous systems, dynamic properties and are described with the help of discrete transfer functions presented as z-transformations.
2. A block diagram of the printer's ink system model package Simulink is developed and analyzed by the transient properties of the system.
3. Printed on flexion printing system with parallel feed paint bright and light areas bitmaps are darkened, while midtones and shadows are enlightened.

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