Computer visualization of the results for calculating the Ink «dusting»

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Abstract. The paper presents the results of the numerical modeling of the quantitative assessment of the offset printing ink "dusting" index at the outlet of the printing contact zone while transferring it to the substrates having various surface characteristics. The modelling was carried out with the help of finite-difference methods. The paper considers the results of practical implementation of the software calculating the printing ink "dusting". The result of the ink filaments splitting into many fine particles and the intensive spraying these particles into the surrounding space by the centrifugal force reduces the print quality. Creating new concepts of reducing the level of "dusting" in offset printing and its quantitative assessment is important. A new approach to solving the problem of reducing the "dusting", which is characterized by the influence on the ink in the engagement zone of the idle pulse of varying power, is suggested. To quantify the ink transferred into noodles and participating in the formation of ink "dusting", process numerical modeling techniques using solution finite difference methods are applied. Graphic visualization of the given solution results on the basis of the graphic modeling is presented. The practical implementation of this method improves the quality of the final printing product, and allows to predict the quantitative assessment of the "dusting" indices directly in the process of preparing the order for printing and to optimize the selection of the printing system components.

1. Introduction
Dusting is a result of the ink filaments splitting into many fine particles and the intensive spraying these particles into the surrounding space by the centrifugal force. The disadvantages of this process are the reduced quality of printing and high environmental safety risk.

Finding the solutions for managing the flows of the viscous fluid relatively to the rotating cylinders [1-3] is still urgent nowadays.
An ink preset model for offset press based on least squares support vector machine optimized by chaotic bee colony (combining with the least squares support vector machine) was proposed in [4] to solve the adverse effects for the lateral ink flow due to the movement of the vibrator rollers.

According to [5] it can calculate ink distribution on the paper by the use of computer simulation, hence a matrix that reflects ink flow characteristics of the inking system under the current image coverage can be established.

In [6] emphasis is placed on seeking the optimal control of time-averaged forces on the cylinder surface using the rotation rate as a control parameter. However, ink "dusting" parameters are not discussed in this study.

Together with the previously known methods of "dusting" preventing, i.e. the group of electro physical methods and the group of methods based on using various chemical additives, some new approaches are suggested by scientists [7, 8].

Here for the quantitative analysis of the image, obtained with the help of so-called "dusting" eliminator, is used. Such "dusting" eliminator is made of a paper sheet, installed around the upper element of the roll. The image was scanned and analyzed by measuring the ink "dusting" drops distribution and its total area, using special software at the end of the experiment.

Reducing the ink "dusting" is achieved by "splitting" the filament until its forming by positioning a wire or a blade into the gap between the rolls in parallel with them.

The results, obtained in [7, 8] have shown, that the blade reduces the dusting level by 92% in average and is more efficient at higher speeds.

The wire, in contrast, acts better at low speeds, while at higher speeds the wire vibration causes an increase in the force, so it cannot be installed close to the point of rupture at high printing speeds.

Despite these positive trends in "dusting" reducing, it should be noted that there is the difficulty of defining the "dusting", because the increase in speed or cut-off of the distributing shaft vibration have a significant impact on the dusting index. The image obtained by the eliminator depends on the accuracy of its mounting and fixation, its shape, size, etc.

The analysis of the periodic literature on the subject has revealed that the creation of new concepts concerning the reducing of the "dusting" level in offset printing and its quantitative evaluation is relevant currently; that is why it is the aim of the present study.

2. Statement of the problem

Based on the analysis of papers [1, 2, 7, 8] it was revealed that using of additional devices into the printing engagement zone has some limitations taking into account that:

- structure complication and, consequently, increase in the price of the printing equipment;
- direct dependency of the image obtained by using eliminator on the accuracy of its installation and fixing, its shape, size, etc.

The direction of the development of new approaches to solving the problem of reducing ink "dusting" and quantification of this index, due to high complexity of its definition, is now of both scientific and practical interest and is the purpose of the given study.

3. Theory

In the proposed technical solution, by using mathematical modeling and mathematical statistics methods, in the controlled area of the ink transfer upon offset printed imaging the area with separate ink noodles having the highest "dusting" probability is determined; while in a controlled area of the printed image the area a the control zone, having the highest "dusting" probability is determined.

To quantify the printing ink transferred into the ink noodles and participating in the formation of the ink "dusting", the methods of numerical and graphical process modeling [9-11] using the solution finite difference methods are applied.

For calculating the fluid flows between the cylinders the following formula was used (1) [11]:
\[
X_c = \frac{r^2}{H^2} \left[ (P_1 - P_0) \frac{E H}{H^2} \right] \pm \sqrt{\frac{r^2}{H^2} \left[ (P_1 - P_0) \frac{E H}{H^2} \right] + \left[ 1 + \frac{r^2}{H^2} \right] \frac{1}{r^2} x_{ct}^2}
\]

where \( \Delta r \) is the value of the boundary deformation at a time point, \( H \) is the initial thickness of the deformable layer, \( \rho \) is the fluid density, \( E \) is the Young's modulus of rubber or a substrate, \( P_0 \) is the external atmospheric pressure, \( P_1 \) is the pressure on the deformable material surface.

The ink "dusting" index was determined using the developed numerical modeling algorithm as the difference between the following parameters (indices): the total number of ink transferred from the ink-offsetting surface onto the coated material and remaining on the ink-offsetting surface after transfer and the ink splitting in the printing engagement zone.

At the outlet of the printing engagement zone the "dusting" reduction, carried out by cross-cutting the ink noodles by using thermal effect of infrared laser beam was controlled.

4. Experimental results
In this setting numerical and graphical modeling of transferring the ink between the contacting surfaces and the control of the "dusting" index was carried out up to a certain time value at the stages of printing contact and at the outlet of the printing engagement zone.

The input data for the modeling includes the following: the cylinders diameters in the printing unit (offset and printing) \( R_1 = R_2 = 0.30 \text{ m} \), \( P = P_{atm} = 10^5 \text{ N/m}^2 \) is the ambient pressure; kinematic viscosity \( \nu = 0.012 \text{ m}^2/\text{s} \), density \( \rho = 10^3 \text{ kg/m}^3 \), surface tension coefficient \( \sigma = 0.03 \text{ N/m} \).

Numerical solutions on the grid 80×80 are given at the angular rate equal to 10 rad/s for different time points. The experiment was carried out with substrates having surface roughness indices \( R_a = 0.3 \pm 0.02 \) (substrate 1) and 2.8 ± 0.3 (substrate 2) correspondingly.

The modeling was carried out with regard to the contacting surfaces deformation. Elasticity modules are: of rubber \( E_1 = 2.9 \times 10^7 \text{ N/m}^2 \), of the substrate \( E_2 = 4.8 \times 10^6 \text{ N/m}^2 \).

Pulse strength of the pulse guided into the engagement zone was varied from 0 to 7.0 W.d.

5. Results and discussion
The results of the numerical modeling for the "dusting" assessment are given in Figure 1.

**Figure 1.** The results of numerical modeling of the laser power influence on the "dusting" index: ■ - substrate roughness 0.3±0.02; □ - substrate roughness 2.8±0.3.
The results of the graphic modeling of the "dusting" control are given in Figure 2 (where 1 is standard offset printing, 2 is printing with introducing the additional pulse into the printing engagement zone for time period \( t = 0.38 \times 10^{-5} \) s) for substrate 1.

Figure 3 presents the process of full ink layer splitting while transferring onto the substrate 1 (1 – without additional pulse effect, 2 – under additional pulse effect).

The transfer of the printing ink onto the substrate in the printing engagement zone (the very moment of the ink splitting centers forming) is shown.

The positive effect of the practical application of the developed method for reducing ink "dusting" is visually demonstrated in Figure 3 (position 2).

As it can be observed, the quantity of the ink, transferred into the "dusting", which is shown in the form of separate graphic pixels, is considerably reduced.
The analysis of the research results has shown that the strength of additional pulse, under which the effect of reducing the ink "dusting" when it is splitting at the outlet of the printing engagement zone occurs, depends on the characteristics of microgeometry of the ink-carrying surface.

For substrates with low surface roughness and low porosity the ink layer splitting occurs in practice between the ink-carrying and the ink-absorbing surfaces.

Increasing the surface roughness and the substrate porosity increases the ink "dusting".

The amount of ink, transferred into the "dusting" for substrate 2 is considerably higher than for substrate 1, which can be explained by the composition of the test samples.

It is found out that, taking into account the guide pulse effect on the ink in the contact zone, the amount of ink transferred into the "dusting" with the pulse power increase on the estimated cell up to 1.50 W is reduced by 2.4 times (from 1.55 to 0.64%), the process of ink splitting goes faster (Figure 1).

With the further increase in the pulse power, on the other hand, there is an growth in this index, which is probably caused by the rising in cavitation.

It should be noted that the amount of ink on the offset cylinder after the splitting with the additional pulse into the engagement zone increases slightly with increasing the pulse power due to the "dusting" reducing.

6. Conclusions
The practical importance of the suggested approach on the basis of the selected criteria for the specific components of the printing system is the following.

The proposed solution allows controlling and predicting the quantitative assessment of the "dusting" index directly in the process of preparing the order for printing as well as optimizing the selection of the printing system components, and reduces the labor intensity due to the use of information processing technical means.

Besides, the implementation of this approach allows to control the influence of surface and structure indices on the changes in the ink layer at different stages of the printing process in the into engagement zone.

It also contributes to the environmental protection component of the printing unit of the printing press, and improves the quality of the final product of the multicolor transfer of images to a substrate.

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