Blanket distortion effect and graphical accuracy in printing

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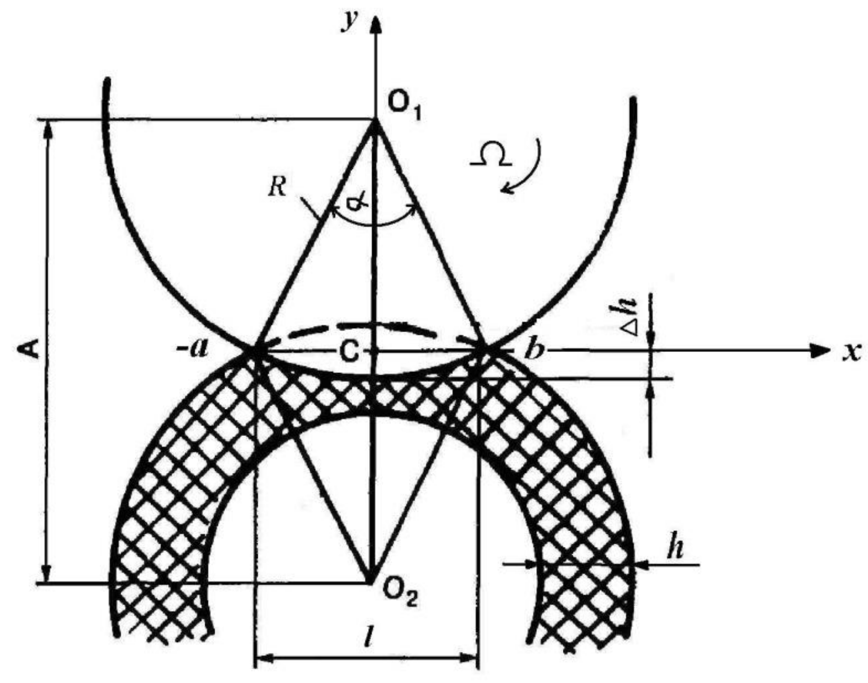
Analytical model of nip area width



Geometry of cylinder nip area in presses

- The width of the nip area is determined in general cases according to the formula

$$l = 2\sqrt{\frac{2 \cdot R_1 \cdot R_2}{R_1 + R_2}\lambda}$$

- where l – width of the nip area;
- R1 –radius of the offset cylinder;
- R2 – radius of the plate cylinder;
- λ – absolute deformation of the blanket under pressure.
- In a particular case where $R_1 = R_2 = R$

$$\Rightarrow \quad l = 2\sqrt{R\lambda}$$

- In a study by Moginov (Moginov, R.G. Theoretical fundamentals and calculation of sheet-fed systems in presses. – Moscow: BINOM. 2008) , the width of the nip area is evaluated using a method put forward by L.A.Galin and according to the general solution of the Riemann-Gilbert task.
- In doing so, the nip area performance on the sliding motion of a cylindrical body at the boundary of a rigid half-space is examined.
- From the condition of pressure limitedness on nip area edges of a smooth roller with a resilient half plane follows that pressure in these spots comes down to zero. Knowing the length of the nip area, it is possible to determine its shifting motion. It can be calculated based on the fact that the adhesion component of friction increases the shifting motion of the nip area relative to the axis of roller symmetry and does not affect the size of the nip area

$$l = \sqrt{\frac{4RP\left(1 - v^2\right)}{\pi E\left(\frac{1}{4} - \theta^2\right)}}$$

- where l – width of nip area;
- R – cylinder radius;
- ν – Poisson ratio;
- E – elastic modulus;
- P – pressure.

$$\theta = \frac{1}{\pi} \cdot arctg\mu \frac{1 - 2v}{2 - 2v} \quad \text{by } 0<\theta<1/2$$

- where μ – shear modulus
- θ - angle of shear.

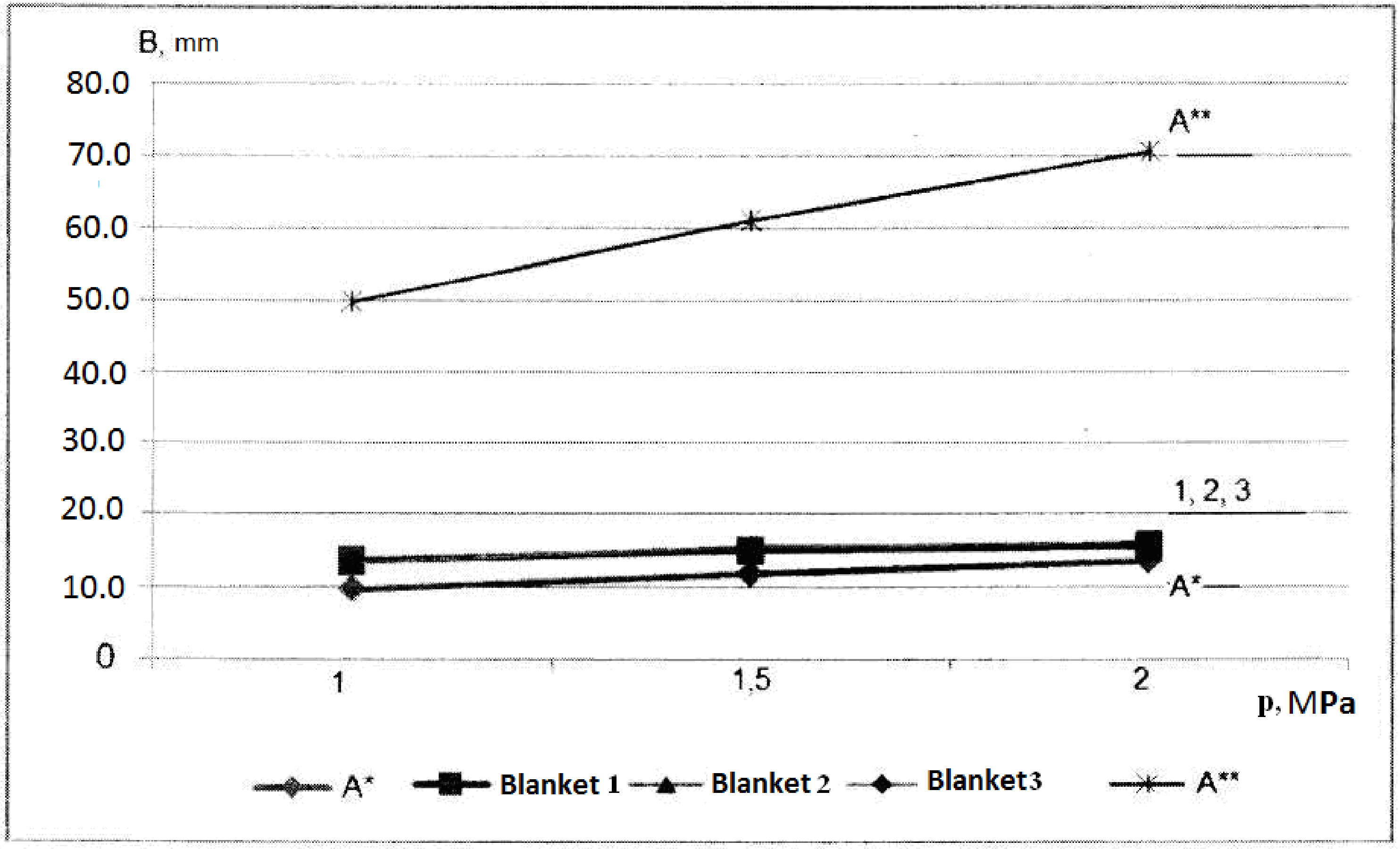
Experimental research of cylinder contact value

- A hydraulic press allowed us to develop pressure between two surfaces. The pressure between cylinders was given as 1.0, 1.5 and 2.0 MPa.
- Two cylinders of 126.5 mm diameter and 73.6 mm length were used as contacting surfaces.
- A blanket was glued on one of the two cylinders with the help of two-sided scotch tape.
- Three different types of rubber blankets were used in this experiment.

The experimentally determined and calculated values of the nip area width

Pressure , MPa	Nip area width, calculated according to mathematical models (as proposed by Moginov and Tyurin) and experimental results				
	R.G.Moginov	**A.A.Tyurin**	Blanket 1	Blanket 2	Blanket 3
1.0	9.600127	49.896782	13.55	13.32	13.38
1.5	11.757707	61.110828	15.01	15.35	15.60
2.0	13.57663	70.564706	15.75	16.10	15.92

The relationship between nip area width and pressure



A* - Moginov's mathematical model; A** - Tyurin' mathematical model

The cross section of the plate cylinder surface is described by the equation

$$x^2 + (y - R)^2 = R^2$$

$$y = R - \sqrt{R^2 - x^2} = R - R\sqrt{1 - \frac{x^2}{R^2}} = R - R(1 - \frac{x^2}{2R^2} + \frac{\frac{1}{2}\left(\frac{1}{2} - 1\right)}{2!}\frac{x^4}{R^4} + \frac{\frac{1}{2}\left(\frac{1}{2} - 1\right)\left(\frac{1}{2} - 2\right)}{3!}\frac{x^6}{R^6} + \ldots) =$$

$$= R - R + \frac{x^2}{2R} - \frac{1}{8}\frac{x^4}{R^3} + \ldots \qquad \text{where} \qquad \left|\frac{x}{R}\right| \langle 1$$

Because the cylinders nip zone is small, it is possible to consider $|x| \ll R$ as a first approximation.

$$y \cong \frac{x^2}{2R}$$

The configuration of the nipping surface is described by a parabola.

The distortion value of the offset cylinder surface in the nipping zone

- The distortion factor of the blanket configuration can be determined by

$$K_{uc} = \frac{l}{a+b}$$

- where l - the length of the stretched nipping area segment,
- a+b – the length of the distorted rubber blanket segment

Calculation of the length a+b is is made according to Moginov, from where we obtain the equation

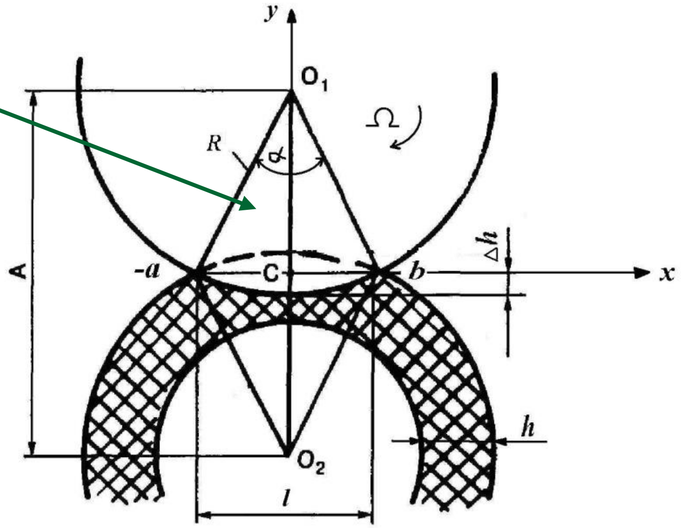
$$(a+b)^2 = \frac{4RP\left(1-\nu^2\right)}{\pi E\left(1-4\eta^2\right)}$$

where

η- coefficient of distortion angle accept $|\eta|\langle\frac{1}{2}$,

P – printing pressure.

The value of expanded segment is determined from the triangle O(-a) b



$$\sin\frac{\alpha}{2} = \frac{a+b}{2R}$$

where $$\alpha = 2\arcsin\frac{a+b}{2R}$$

$$l = 2R\arcsin\left(\frac{a+b}{2R}\right).$$

$$K_{uc}=\frac{l}{(a+b)}=\frac{2R\arcsin\left(\dfrac{a+b}{2R}\right)}{(a+b)}=\frac{2R\arcsin\left[\dfrac{\sqrt{\dfrac{4RP(1-\nu^2)}{\pi E(1-4\eta^2)}}}{2R}\right]}{\sqrt{\dfrac{4RP(1-\nu^2)}{\pi E(1-4\eta^2)}}}=$$

$$=2R\sqrt{\frac{\pi E(1-4\eta^2)}{4RP(1-\nu^2)}}\cdot\arcsin\left[\frac{\sqrt{\dfrac{4RP(1-\nu^2)}{\pi E(1-4\eta^2)}}}{2R}\right]=R\sqrt{\frac{\pi E(1-4\eta^2)}{RP(1-\nu^2)}}\cdot\arcsin\left[\sqrt{\frac{4RP(1-\nu^2)}{\pi E(1-4\eta^2)}}\div\frac{1}{2R}\right]=$$

$$=R\sqrt{\frac{\pi E(1-4\eta^2)}{RP(1-\nu^2)}}\cdot\arcsin\left[\frac{1}{R}\sqrt{\frac{RP(1-\nu^2)}{\pi E(1-4\eta^2)}}\right]=\sqrt{\frac{R\pi E(1-4\eta^2)}{P(1-\nu^2)}}\cdot\arcsin\left[\frac{1}{R}\sqrt{\frac{R^2P(1-\nu^2)}{R\pi E(1-4\eta^2)}}\right]=$$

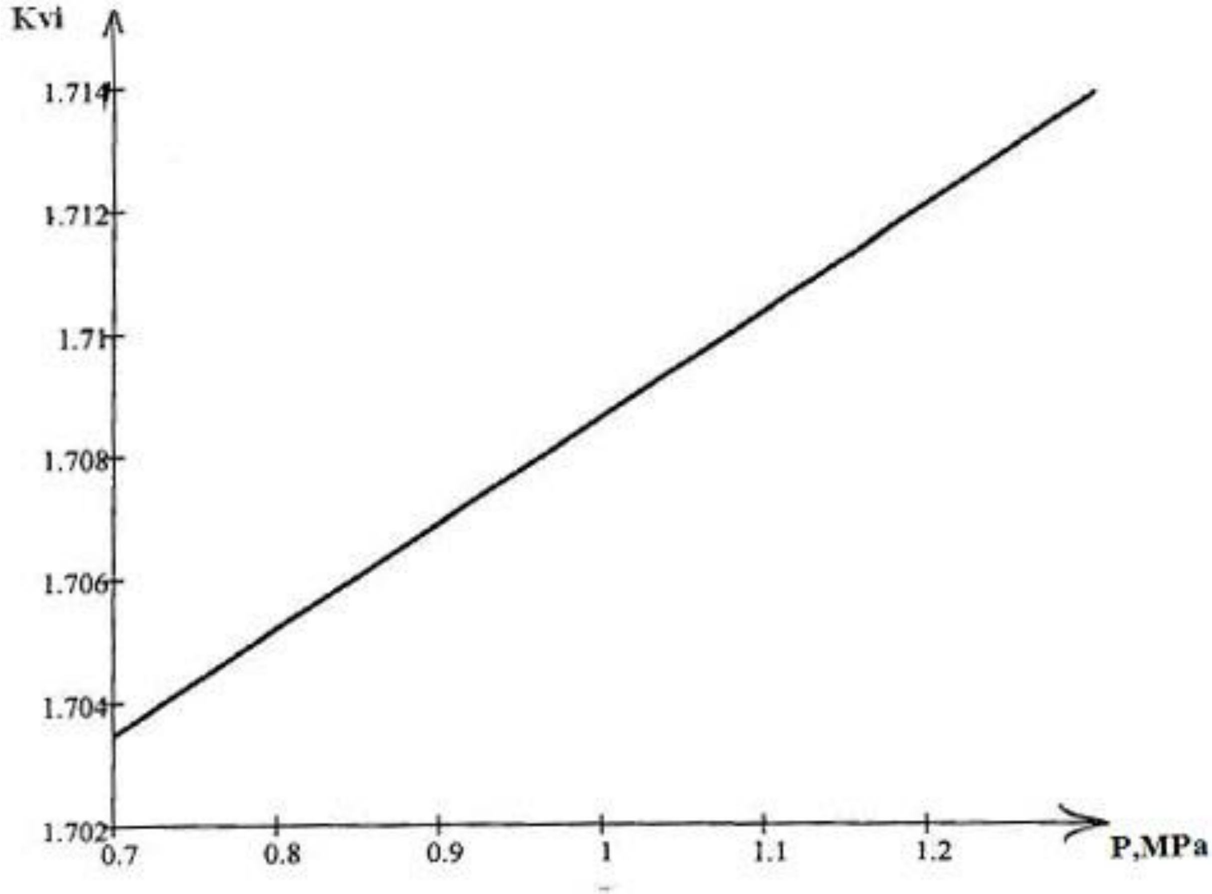
$$=\sqrt{\frac{R\pi E(1-4\eta^2)}{P(1-\nu^2)}}\cdot\arcsin\left[\sqrt{\frac{P(1-\nu^2)}{R\pi E(1-4\eta^2)}}\right].$$

$$\Rightarrow\quad K_{uc}=\frac{2R\arcsin\left(\dfrac{a+b}{2R}\right)}{\sqrt{\dfrac{4RP\left(1-\nu^2\right)}{\pi E\left(1-4\eta^2\right)}}}=\sqrt{\frac{R\pi E\left(1-4\eta^2\right)}{P\left(1-\nu^2\right)}}\arcsin\left(\frac{\sqrt{P\left(1-\nu^2\right)}}{\sqrt{\pi E\left(1-4\eta^2\right)}}\right)$$

The relationship between distortion coefficient and pressure

- Numerical experiments to study the influence of the force of pressure on the distortion coefficient of an offset cylinder surface were made for the following values:
- $P = 0,7 \ldots 1,3$ MPa
- $R = 83.0$ mm
- $\eta = 0,25$
- $\nu = 0,47$
- $E = 29.0$ MPa.

Relationship between distortion coefficient Kυi and pressure P



Summary

- One of the known mathematical models, namely the model suggested by Moginov, has demonstrated an accuracy considerably closer to the real data than the model proposed by Tyurin. A linear dependence of nip area width on the pressure in the printing couple has been observed in all cases. With growth of pressure, the nip area width increases from 10.0 mm at P = 1.0 MPa up to 16.0 mm at P = 2.0 MPa. Thus, a dependence of the nip area width on pressure in the printing zone has been analytically determined.
- As shown, with increasing of pressure we observe increasing of distortion coefficient, that leads to deformation growth and dot and line gain.
- The results of this work can be used to calculate the distortion of graphical elements in offset printing.

Thank you for your attention!

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