

Construction of cylinders in offset printing presses and its vibratory consequences

Juliusz Krzyżkowski, Yuriy Pyryev

Warsaw University of Technology, Institute of Mechanics and Printing, Division of Graphic Art Technology,
e-mail: j.krzyzkowski@wip.pw.edu.pl; y.pyryev@wip.pw.edu.pl

Vibrations in offset printing presses are serious problem, which beside influence on machines' parts, are also source of problems with printing process and achieving prints of right quality.

In this paper construction of offset printing unit is presented. Reasons of vibrations and their types in printing units are shortly described. Moreover, this article shows the role, which some of printing unit's elements play in resisting of vibrations appearance.

There is model of printing unit of sheet-fed offset printing machine presented in here. Model is described by the system of differential parametric equations. There were computer simulations realized, that pointed conditions, which should be fulfilled, so the parametric vibrations occurred.

Keywords and phrases: offset printing, printing press, parametric vibrations, model.

Introduction

Offset printing because of its inexpensive technology, high productivity of the machines and supreme printouts quality become the most widely used technique in graphic industry. It is used everywhere, where combination of those three elements is required, i.e. in production newspapers, colorful magazines, catalogues, packaging, promotional materials etc.

Printing unit of sheet-fed offset printing press consists of three cylinders: plate cylinder, blanket cylinder and impression one (Fig. 1).

Printing plate with the picture, which is going to be printed is mounted on the plate cylinder. After moistening of the picture with the ink it is transferred to the offset blanket, which is spread on the blanket cylinder. After that the picture is printed on the printing substrate, paper, for instance.

Offset blankets consist of several layers of a fabric and rubber, which have different features and play different role in the printing process. In the Fig. 2 standard offset blanket is presented.

In the Fig. 1 are also, so called, cylinder bearers (contact rings) shown. They are made of steel of high hardness. They enlarge stiffness of the printing unit,

what increase its eigenfrequencies. Effects of their work is presented below in this paper.

Vibrations in offset printing units

Among many sources of vibrations in the printing presses, the most important for printing process run and quality of the printouts are those, which occur in printing units. They are mostly related to construction of the cylinders.

Cylinders in many printing machines are 2 m long and their diameters count barely about 300 mm. Those two parameters and big mass of the cylinders cause deflections, which may excite flexural vibrations while printing.

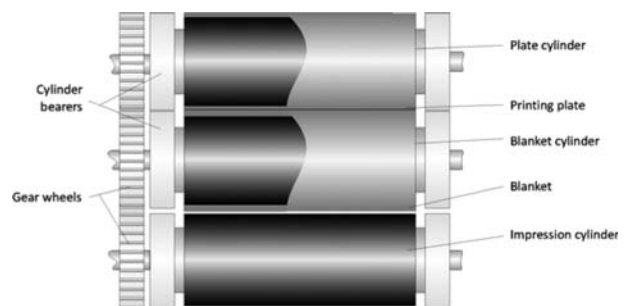


Fig. 1. Printing unit of sheet-fed offset printing press.

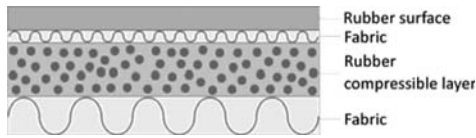


Fig. 2. Offset blanket.

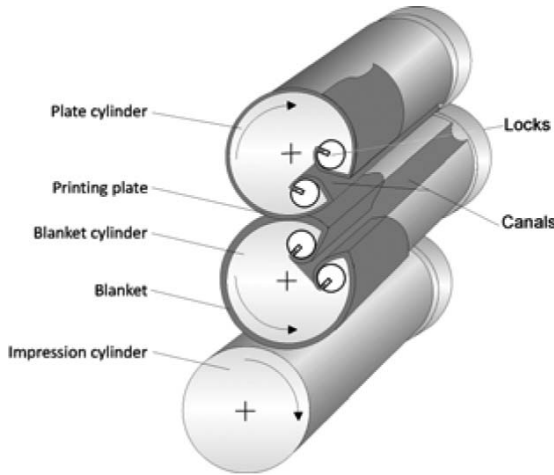


Fig. 3. Canals in plate and blanket cylinder.

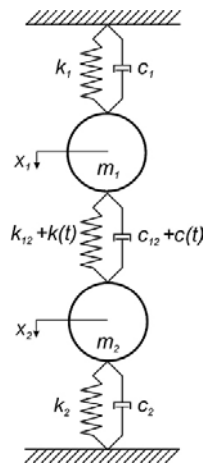


Fig. 4. Model of offset printing unit.

Another type of vibrations in printing units are the torsional ones. On the one hand their reason lies, similarly to flexural vibrations, in construction of the cylinders and their big inertia, but on the other hand in driving system of the printing unit, where power from the engine is transferred to the cylinders by the gearwheels mounted only on their one end (see Fig. 1).

The third type of vibrations is vertical relative vibrations of the cylinders. The most frequently mentioned reason of their appearance are canals in plate and blanket cylinder, in which locks for fixing plate and blanket, respectively, are situated [1–3]. Canals are shown in Fig. 3.

While rolling over those canals each other, it comes to sudden fall of pressure between cylinders and fall

of system stiffness as well. Vibration exciting force occurs.

To avoid vibrations caused by “canal effect”, on the both edges of the plate and blanket cylinders, cylinder bearers are mounted (Fig. 1) [4]. The bearers enlarge stiffness of the printing unit, equalize loading of the bearings [4, 5] and prevent cylinders from displacement in the moment of stiffness fall.

Worth of mentioning is that some damping properties have also offset blankets.

Model of offset printing unit

Printing unit of offset sheet-fed printing press, as it is shown in the picture 1, consists of three cylinders. However, there is initial tension only between two of them — plate and blanket cylinder. Because of it, printing unit may be modeled by the system of only two masses, instead of three ones. Moreover, when we take under consideration only vertical relative vibrations of the cylinders, there can be two degree-of-freedom system considered (Fig. 4.)

Variations of cylinders’ loading as a result of periodic changes of the stiffness and viscosity of the blanket can be modeled by the following force:

$$F(t) = k(t)(x_1 - x_2) + c(t)(\dot{x}_1 - \dot{x}_2), \tag{1}$$

$$k(t) = kf(t), \quad c(t) = cf(t).$$

Form of function $f(t)$ is presented in Fig. 5

Consisting of two masses m_1, m_2 and three springs k_1, k_2, k_3 system (Fig. 4), which vibrates in result of variations of stiffness $k(t)$ and viscosity $c(t)$ of the blanket, may be described in the following way:

$$\begin{cases} m_1 \ddot{x}_1 + (c_1 + c_{12} + c(t))\dot{x}_1 + (k_1 + k_{12} + k(t))x_1 - (c_{12} + c(t))\dot{x}_2 - (k_{12} + k(t))x_2 = 0 \\ m_2 \ddot{x}_2 + (c_2 + c_{12} + c(t))\dot{x}_2 + (k_2 + k_{12} + k(t))x_2 - (c_{12} + c(t))\dot{x}_1 - (k_{12} + k(t))x_1 = 0 \end{cases} \tag{2}$$

where: m_1, m_2 — masses of the plate and blanket cylinder, respectively; c_{12}, c_1, c_2 , — viscous damping coefficients, which represent damping properties of the cylinder bearers and the press frame, respectively; k_{12}, k_1, k_2 , — stiffness coefficients, which represent stiffness of the cylinder bearers and the press frame, respectively;

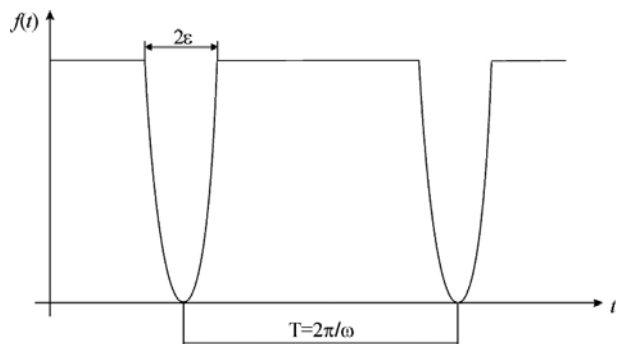


Fig. 5. Force modeling variations of cylinders’ loading.

$k(t)$ — force changing in time stiffness of the blanket;
 $c(t)$ — force changing in time viscosity of the blanket.

Parametric vibrations are oscillatory moves, which take place in mechanical system, because of changing in time such parameters as inertia or stiffness [6–8].

For complicated systems, such as printing unit, instability areas should be sought for parameters, which fulfill condition:

$$\omega = \frac{2\Omega_{\max}}{n}, \quad n = 1, 2, 3, \dots, \quad (3)$$

where $\Omega_{\max} = \max\{\Omega_1, \Omega_2\}$, Ω_i — eigenfrequencies of modified two degree-of freedom system, $i = \{1, 2\}$.

In considered case, stiffness and viscosity of the system changes periodically. What are eigenfrequencies of the system? How we can calculate them?

We have modified system in the following way: exciting force $f(t)$, characteristic of which is shown in Fig. 5, was developed in Fourier series (4). We took under consideration only its first element $ka_0/2$, $ca_0/2$. It let us calculate eigenfrequencies of the modified system with constant parameters.

$$f(t) = \frac{a_0}{2} + \sum_{n=1}^{\infty} (a_n \cos(n\omega t) + b_n \sin(n\omega t)) \quad (4)$$

where:

$$a_0 = \frac{2}{T} \int_0^T f(t) dt, \quad a_n = \frac{2}{T} \int_0^T f(t) \cos(n\omega t) dt, \quad (5)$$

$$b_n = \frac{2}{T} \int_0^T f(t) \sin(n\omega t) dt$$

For function $f(t)$, integral (5) was calculated. After that coefficient a_0 could have been calculated as well.

$$\frac{a_0}{2} = 1 - \frac{\varepsilon\omega}{2\pi} = 1 - \frac{\varepsilon}{T} \quad (6)$$

For $\varepsilon = T/16$ coefficient $a_0/2 = 15/16$.

Eigenfrequencies and roots of characteristic equation of modified system were calculated numerically.

In Fig. 6–8 numerical analysis for the following parameters is presented: $m_1 = 190$ kg, $m_2 = 210$ kg, $k_1 = k_2 = 10,0 \cdot 10^6$ Nm⁻¹, $k = 7,5 \cdot 10^6$ Nm⁻¹, $c_1 = c_2 = 1,9$ Ns²m⁻¹, $c_{12} = 0$, $c = 7,5$ Ns²m⁻¹. Different values of parameters k_{12} , Ω_1 , Ω_2 , ω and n were used. For calculation, following initial conditions were used: $z_1(0) = 0,1$ mm, $z_2(0) = 0$, $\dot{z}_1(0) = 0$, $\dot{z}_2(0) = 0$.

As we can see in the Fig. 6, if there are not cylinder bearers in the printing unit (they do not enlarge stiffness of the system, $k_{12} = 0$) and if we take $\Omega_{\max} = \max\{\Omega_1, \Omega_2\} = 230,274$ s⁻¹, for calculations of ω , parametric resonance occurs.

However, if work frequency is equal to lower of the eigenfrequencies, i.e. $\Omega_{\max} = \max\{\Omega_1, \Omega_2\} = 218,928$ s⁻¹, parametric resonance almost never occurs.

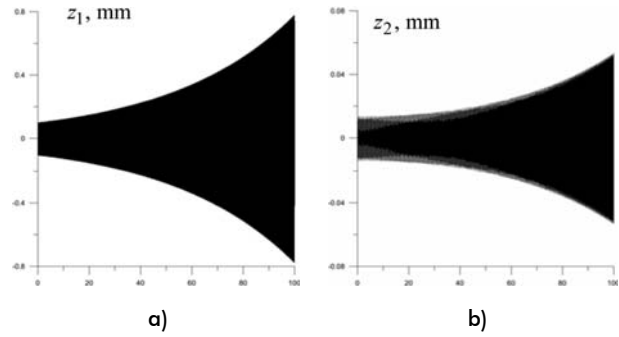


Fig. 6. Displacements of plate cylinder $z_1(t)$ (a) and blanket cylinder $z_2(t)$ (b) for parameters $k_{12} = 0$, $\Omega_1 = 218,928$ s⁻¹, $\Omega_2 = 230,274$ s⁻¹, $n = 5$, $\omega = (2 \times 230,274 / 5)$ s⁻¹ = 92,1096 s⁻¹.

If we enlarge stiffness of the system by adding cylinder bearers ($k_{12} > 0$), even for $\Omega_{\max} = \max\{\Omega_1, \Omega_2\}$ parametric resonance will not occur (Fig. 7).

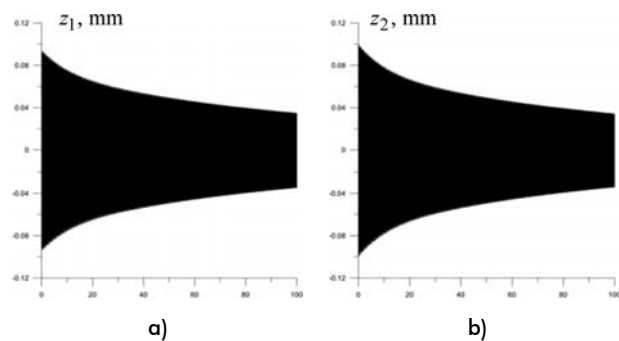


Fig. 7. Displacements of plate cylinder $z_1(t)$ (a) and blanket cylinder $z_2(t)$ (b) for parameters $k_{12} = 10 \cdot 10^6$ Nm⁻¹, $\Omega_1 = 223,468$ s⁻¹, $\Omega_2 = 388,932$ s⁻¹, $n = 9$, $\omega = (2 \times 388,932 / 9)$ s⁻¹ = 86,4293 s⁻¹.

Conclusion

Parametric resonance may occur in the system only, if its maximal eigenfrequency is multiplicity of work frequency of the printing press.

Cylinder bearers enlarge values of eigenfrequencies to the level, which printing presses doesn't achieve while printing. Parametric resonance can not appear then.

Damping properties of the offset blanket cause damping of the vibrations, which appeared as a result of “canal effect”.

References

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