

10. INTERNATIONAL SYMPOSIUM **GRAPHIC ENGINEERING AND DESIGN**

 $\overline{}$



INVESTIGATIONS ON BOOK CUTTING BY CIRCULAR KNIFE WITH ECCENTRIC BLADE MOVEMENT

Georgij Petriaszwili¹, Piotr Janicki², Serhii Komarov³

¹ Warsaw University of Technology, Institute of Mechanics and Printing, Poland; ² Drukarnia Wydawnicza im. W.L. Anczyca S.A., Kraków, Poland; ³ Ukrainian Academy of Printing, Lviv, Ukraine

Introduction

Paper cutting operations are widely applied in the implementation of the printing process: before printing, as well as the treatment of the final book blocks. Until recently, cutting the paper was to be regarded as secondary operation and auxiliary. But today, applied to the much more attention, as it is proven that the correct cutting largely influences on the smooth running of other technological operations, which has a large impact on the quality of the final product and the cost of production. The most part of the modern trimmers realized a knife cutting movement as a combined motion (saber movement). However, this cutting process is characterized by relatively large values of cutting force and it reduces the processing speed. There is a need to look for the possibility of using other cutting methods.

Results

When cutting with the circular knife cutter (Figure 1), the real cutting angle is calculated with the following formula [4]:

$$a_T = \arctan \tan(a_0) \frac{v_0 \cos(j)}{\sqrt{[v_R \sin(j) - v_0]^2 + [v_R \cos(j)]^2}}$$

where: v- actual cutting speed, v_0 - feed speed, v_R linear speed of the circular knife, a_0 - angle of sharpened edge, j - rotating angle of knife at the point of cutting.





main component of cutting force during the reverse cutting of books with an eccentric circular knife:

Problem Description

Most of the research on paper cutting processes is devoted to single-knife cutting process [1]. The process of cutting paper stacks and books with a circular knife is relatively poorly researched [2]. The forces and quality of the trimming of brochures largely depend on the thickness of the block, the feed rate, and the rotary speed and direction of rotation of the circular knife. Some performed studies also indicated the possibility of vibration trimming of paper stacks [3]. These studies showed a significant reduction in the cutting forces of paper stacks and an improvement in the quality of cutting. However, for the implementation of vibratory cutting it is necessary to use special vibrators to drive the knife. In order to reduce the cutting forces, without using vibrators, an eccentric setting of the rotary knife was proposed [4]. The purpose of this work is to analyze the possibility of the streamline book cutting using special circular knife with eccentric blade movement and to test the possibility of new method of book cutting.

Methods

During the process of cutting using circular knife, a kinematic transformation of the cutting angle occurs – the mentioned transformation depends on kinematic and geometrical parameters of the cutting process as: cutter angular speed and rotation direction, feed rate,

Figure 2

Scheme of book cutting with eccentric circular knife *left– forward cutting, right – reverse cutting* v_0 - feed speed, v_R - linear speed of the circular knife, ω - rotating speed of the knife,

e – *value of eccentric, R* – *radius of circular knife*

The kinematic analysis has been carried out for two rotation directions of the circular knife (figure 2): forward cutting – takes place when the cutter rotation direction is synchronous to the movement direction of the book, and reverse cutting – takes place when the cutter rotation direction is anti-synchronous to the feed direction of book. Figure 3 shows the calculated graphs of changes of the actual cutting angle in the cycle of one full rotation of the circular knife with the eccentricity e for various ratios v_R/v_0 . The value 20^o of the knife sharpening angle was used. The vertical dashed lines in both graphs indicate the knife position when the cutting process interrupted.



Changes of real cutting angle in the cycle of full rotation of circular knife with eccentric blade movement e for different ratios v_R/v_0 . left – forward cutting, right – reverse cutting $1 - v_R/v_0 = 5; 2 - v_R/v_0 = 8; 3 - v_R/v_0 = 20; 4 - v_R/v_0 = 80$



Figure 4

Changes of the longitudinal component of cutting force during cutting the book with an eccentric circular knife (e = *1 mm). Right – interrupted cutting, left – continuous cutting*

In the interrupted mode, the force on the knife drops practically to zero when the blade is detached from the paper and increases again when the knife's cutting edge comes into contact with the paper. The intermittent nature of the cutting increases the efficiency of the processing by reducing the temperature in the knife's cutting zone, due to the periodic lack of contact between the cutter blade and the paper.

Conclusion



The conducted experimental studies confirm the analytical conclusions of the performed kinematic analysis of the cutting process on the implementation of two cutting modes: continuous cutting – with the constant contact between cutting edge and cut material, and interrupted cutting process - with the impulse action on paper block. The choice of cutting mode can be determined depending on the selected parameters of the machining process. Using the special circular knife with eccentric blade movement it becomes possible to implement book-flow-cutting in automatic lines for producing books.

REFERENCES

knife diameter and book thickness. The kinematics of



the cutting process with a circular knife differs from the kinematics of cutting with a straight knife. The effective cutting angle value (the kinematic one) becomes smaller, than actual sharpened edge angle. It also causes a significant decreasing of cutting forces (Figure 1):

Figure 1

Transformation of real cutting angle a_T of circular knife during cutting process

Analysis of kinematic parameters of cutting shows, that the cutting process may be realized in two different modes: continuous cutting, when the knife's blade is in constant contact with the book during the processing, and interrupted cutting - when the knife's blade comes out of contact with the paper in a certain phase of the rotation cycle. During the investigation, mathematical description of the interrupted and contiguous cutting was established. The equations allow calculating of the needed kinematic parameters for the interrupted cutting mode [5, 6]. The equations are transcendental, so all calculations and graphs were made using Mathcad. The calculations allow selecting of the kinematic parameters for interrupted cutting.

[1] Mordowin B.: "Buchbindereimaschinen I", VEB Verlag Technik, Berlin, 1962. [2] Krabisch K.: "Schneiden mit rotierendem Messern", IPM, Leipzig, 1962. [3] Komarov S., Petriaszwili, G.: "Dynamische Untersuchung des Vibrationsschneidens von Papier", Maschinenbautechnik, 1989, 11 (38), pages 503-506. [4] Petriaszwili, G., Janicki P., Komarov S. "Investigations on the trajectory of eccentric circular knife blade movement in book cutting process", Innovations in Publishing, Printing and Multimedia Technologies 2019, Kauno Kolegija, Kaunas, 2019 pages 47-53.

[5] Petriaszwili Georgij, Janicki Piotr: "The kinematic analysis of book blocks cutting process using eccentric circular cutting knife", Przegląd Papierniczy, 2017, vol. 875, nr 7, pages 468-472 (In Polish)

[6] Georgij Petriaszwili, Piotr Janicki, Sergei Komarov.: "Influence of the work parameters of the eccentrically set circular knife on the reducing during cutting the trajectory of contact of the blade with a book block", Przegląd Papierniczy, 2019, R. 75, nr 4, pages 253-257 (In Polish)

ACKNOWLEDGMENTS

This work was supported by the Serbian Ministry of Science and Technological Development, Grant No.:35027 "The development of software model for improvement of knowledge and production in graphic arts industry".