Sectional design of the pressure plate in the die-cutting press with wedging mechanisms: justification of application

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Abstract.
The reasons for high technological loads during die-cutting and the design schemes of punching presses are analyzed. Based on the analysis of scientific research, it was found that minimizing the contact area between the pressure plate and the cardboard is necessary to reduce technological efforts. An original pressure plate drive design scheme with sectional construction is proposed. The nature of the joint movement of the sections of the pressure plate is analyzed, and the advantages of the offered die-cutting press are outlined.

Keywords:
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Packaging experts predict that the market for paper and cardboard packaging will grow at a CAGR of 4.8% during 2022-2027 [1]. To meet the market’s demands, equipment for manufacturing cardboard blanks is utilized, including die-cutting presses. They perform an essential operation in the technological process—die-cutting of cardboard blanks to create cardboard packaging (Fig. 1). Die-cutting involves cutting out the A contour of the packaging and its flaps and scoring the B lines for future folding into a three-dimensional structure.

![Figure 1](image)

**Figure 1**

*Scheme of manufacturing a cardboard sweep in a die-cutting press*

The die-cutting equipment belongs to the heavy-duty category. The press drive overcomes significant technological efforts due to cutting the contours of the blanks and folding the bending lines. For example, the Bobst SP 102-EO press with a format of 1020×720 mm develops a force load of up to 250 tons during die-cutting cardboard blanks [2].

There are two principles of building die-cutting presses: a stationary plate with a die-cutting form and a movable pressure plate or a movable plate with a die-cutting form and a fixed support plate. When using a movable pressure plate, it performs vertical movement from bottom to top. In the case...
of a stationary support plate, the movable plate with the die-cutting form moves from top to bottom. Each press construction scheme has advantages and disadvantages [3].

Various mechanisms are used to move the movable pressure plate in the die-cutting press. The most common mechanism is two paired wedging mechanisms driven by eccentric shafts. This mechanism provides a high force transmission coefficient and can overcome considerable technological efforts in die-cutting presses [3].

In work [4], a combined mechanism using a "screw-nut" transmission is proposed for driving the pressure plate. An experimental stand demonstrated the effectiveness of such a mechanism for moving the pressure plate.

Large technological forces in die-cutting presses are caused by simultaneous contact between the die and the cardboard over the entire surface of the cardboard blank and destruction due to compressive stresses. To reduce the contact area between the die-cutting form and the cardboard, a segmented pressure device is proposed in [5]. Such a design of the die-cutting press provides a small technological force that is evenly distributed as the segment rolls over the die. In work [6], contour cutting of the cardboard blank is proposed to be carried out by shearing. In this case, the cardboard is destroyed due to the stresses of the cut, which are much less than the compressive stresses that occur during cutting.

In this work, the cardboard blank is proposed to be die-cut in stages to minimize technological efforts. This is achieved due to the sectional construction of the pressure plate. The scheme of a die-cutting press that implements this idea is shown in Fig. 2. The press drive consists of an upper stationary plate 1, fixed to the frame, with a flat die-cutting form 2; movable sections of the right 3_1 and left 3_2, relative to the direction of movement of the cardboard blank CB, of the pressure plate, limited by vertical guides 4 and 4'; hinged upper 5_1, 5_2 and lower 6_1, 6_2 levers of the left contour of the wedging mechanisms of the right 3_1 and left 3_2 sections of the pressure plate; hinged upper 5'_1, 5'_2 and lower 6'_1, 6'_2 levers of the right contour of the wedging mechanisms of the right 3_1 and left 3_2 sections of the pressure plate.
The die-cutting machine's press works as follows. In the initial position, sections 3₁ and 3₂ of the pressure plate are in the lower position. During the clockwise rotation of eccentric disks 8₁, 8₂, they drive the cranks 7₁ and 7₁'. The cranks 7₁ and 7₁' wedge the levers 5₁, 6₁ of the left circuit and the levers 5₁', 6₁' of the right circuit. This lifts the right section 3₁ of the pressure plate. When the cranks 7₁ and 7₁' are horizontally positioned, the right section 3₁ occupies the maximum upper position, which ensures die-cutting of the right area of the cardboard blank CB. Since the eccentric disks 8₂ and 8₂' are displaced by an angle Δφ relative to the eccentric disks 8₁, 8₁', the horizontal working surface of the left section 3₂ is lower than the right section 3₁ by the thickness Δ of the cardboard blank CB.

Further clockwise rotation of the eccentric disks 8₁, 8₁' and 8₂, 8₂' causes the right section 3₁ to drop and the left
section $3_2$ to rise to the maximum upper position. This ensures die-cutting of the left area of the cardboard blank $CB$. After die-cutting the cardboard blank $CB$ is completed, the right $3_1$ and left $3_2$ sections are lowered to output the die-cut material and feed a new blank. The vertical movement of the right $3_1$ and left $3_2$ areas of the pressure plate is carried out in guides 4 and 4’.

The joint motion of the right and left sections of the pressure plate was analyzed. To do this, the known dependence [7] was used. Graphical dependencies $S_i=f(\phi)$ of the displacement invariants $S_i$ from the angle $\phi$ of rotation of the eccentrics were constructed (Fig. 3).

The dependencies $S_i=f(\phi)$ are conditionally divided into several sections (Fig. 3). For curve 1 – $A_1B_1$, $B_1C_1$, which corresponds to the displacement of the right section $3_1$ of the pressing plate (Fig. 2) and for curve 2 – $A_2B_2$, $B_2C_2$, which corresponds to the removal of the left section $3_2$ of the pressing plate. The thickness of the cardboard is represented on the graph by the value $\Delta$. At point $A_i$, when the angle of rotation of the eccentric $\phi_i$ is $\phi=\phi_i$ (Fig. 2), the drive mechanism of the right section of the pressing plate comes into contact with the cardboard blank $CB$, and punching begins. At point $B_i$, the right area of the pressing plate reaches the extreme upper position, and the die-cutting of the cardboard blank is completed. At the same time, at point $A_j$, when $\phi=\phi_j$,
the left section of the pressing plate comes into contact with the cardboard blank $CB$. In area $A_2B_2$, the cardboard blank $CB$ is die-cut by the left section of the pressing plate. The angle of rotation of the eccentrics $\Delta \varphi = \varphi_2 - \varphi_1$ corresponds to the angular displacement of the eccentrics $8_1$, $8'_1$ and $8_2$, $8'_2$ of the drive mechanisms of the right $3_1$ and left $3_2$ sections of the pressing plate (Fig. 2). At points $C_1$ and $C_2$, the right and left sections of the pressing plate come out of contact with the cardboard.

**Conclusion.** Analysis of scientific publications has shown that die-cutting presses are improved by creating conditions for minimizing technological efforts. One such direction is reducing the contact area between the pressure plate (die-cutting form) and the cardboard. The article’s proposed sectional design scheme of the pressure plate reduces technological effort when die-cutting cardboard blanks. This is achieved through the discrete die-cutting of cardboard by sections of the pressure plate. As a result, the drive's power consumption, the metal content, and the dimensions of the die-cutting press are reduced.

**References:**


