NEW TYPE CAM-SCREW MECHANICAL PRESS

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Abstract. The article deals with the original design of a new type mechanical press – a cam-screw press. The proposed press has several advantages over the crank press: high efficiency, simple structure, reliable performance, high fixity. On the basis of the considered scheme there is proposed a new scheme of a sheet-bending machine.

Keywords: mechanical press, crank press, cam-screw press, punching\press forming, sheet bending machine.

Introduction

Currently the machine building industry uses 4 types of presses for metal forming: crank, cam, screw and hydraulic. They have a long history and have been used for years. Each has advantages and disadvantages. A crank press is the most widely one used in mechanical engineering. It is simple in design, has speed of operation, but it also has some disadvantages [1].

A new type of a mechanical press has been developed in this study – a cam-screw type - propeller howl, which in his view has some serious advantages over the crank press and may easily replace it in production [2-3].

Materials and Methods

A cam-screw press consists of the following components (see Fig. 1): the drive shaft 1, the cylinder 2, which is coaxially fixed on the drive shaft. The cylinder has a conical screw surface 3 with an angle of inclination of ruling AE relative to the drive shaft axis 1 equal to α. The surface has a bevel with angle of inclination β relative to the horizontal [4]. A slide 4 is fixed under the cylinder 2. It can freely and vertically move around the axis in the housing 5. The upper part of the slider 4 has a concave surface 6 that can contact with the screw surface 3 and has a tilt angle to the horizontal equal to β. Fig. 2 shows a general view of the press.

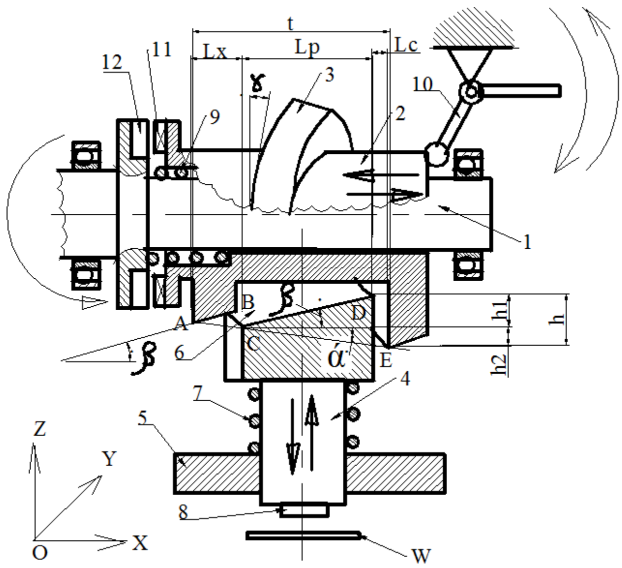

Fig. 1. **Scheme of the press**

The drive shaft 1 together with the cylinder 2 rotates by a drive. A low ruling AB of a screw surface 3 moves along the axis of the shaft 1 approaching the surface 6. When AB moves at a distance Lx it comes into contact with the ruling CD of the surface 6. The screw or helical surface 3 and the surface 6 come into contact forming a contact area. Helical surface 3 presses on the surface 6 and slide 4, which moves downward and compresses the spring 7. The instrument 8 moves together with the slide 4, the slide makes a push into the workpiece W. Slider 4 moves down until point A of the ruling

AB coincides with point D of the ruling CD. The low ruling AB at that time passes the working length L_P.

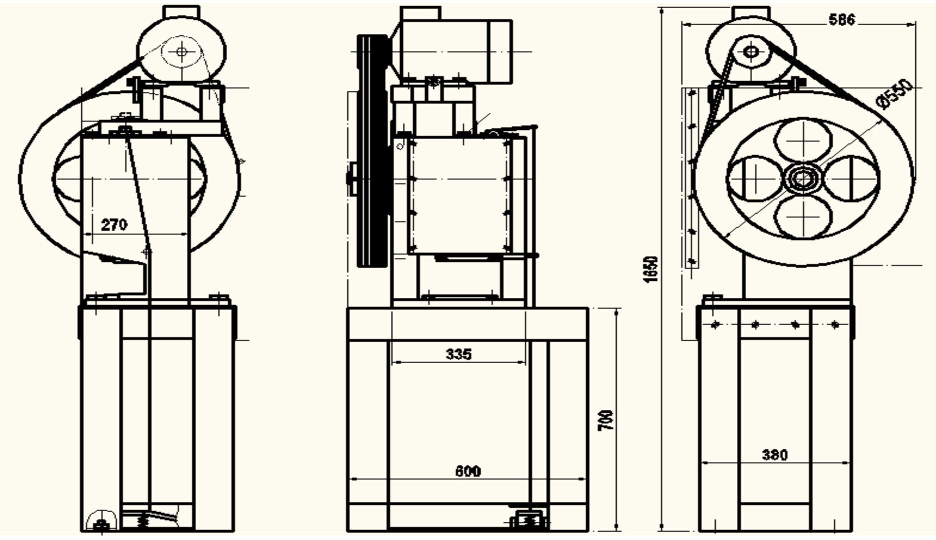

Fig. 2. **Press general view**

Thereafter, the contact of the surface 3 and 6 moves apparat making the slide 4 in tandem with the surface 6 and the instrument 8 by the action of the spring 7 rises up to take its initial position. After that point A is still going through the distance equal to Lc, after which the helical surface 3 completes one full turn and the whole cycle repeats again. These surfaces are constantly lubricated for them to move freely relative to each other and reduce frictional force [6-7].

To turn off the press for it not to work in idle conditions one should turn the cylinder 2 to the right by the switching mechanism 10. The cylinder cams 11 are disengaged from slots 12 of the clutch and the cylinder 2 out of engagement with the grooves 12 of the coupling half and the cylinder 2 freely rotates regarding the shaft 1. If to press the cylinder 2 by the screw 9 designed to bring it out of engagement with the shaft 1, the surfaces 3 and 6 contact opening will be happening automatically after each cycle. Closing of jaws 11 slots 12 is produced by turning the mechanism 10 to the left.

As the proposed mechanism has the properties of the power one, it can be regarded as a three-lobe mechanism: one lobe is inclination at the angle γ, the second lobe is the helix angle α_a of Archimedes' spiral in the plane YOZ (see Fig 3), the third lobe – bevel of a helical surface itself at the angle. The values of the resulting power P_0 depending on the rotary force Q are equal to:

$$P_0 = \frac{Q \cdot \frac{h_1}{h}}{tg\gamma \cdot tg(\beta + \psi)} + \frac{Q \cdot \frac{h_2}{h}}{tg(\alpha_a + \psi)} \tag{1}$$

$$tg\alpha_a \approx \frac{\Delta R}{2\pi \cdot Ricp} = \frac{t \cdot tg\alpha}{2\pi \cdot Ricp} \tag{2}$$

where $h_1 = L_P \cdot \mathrm{tg}\beta$;
$h_2 = L_P \cdot \mathrm{tg}\alpha$;
ψ – angle of friction;
R_{icp} – average radius of Archimedes' spiral;
ΔR – increase of Archimedes' spiral radius in one revolution (see Fig. 3).

Express the power P_0 through the torque M:

$$P_0 = \frac{M \cdot \frac{h_1}{h}}{\left(R_0 + \frac{t \cdot tg\alpha \cdot \varphi_i}{360^\circ}\right) tg\gamma \cdot tg(\beta + \psi)} + \frac{M \cdot \frac{h_2}{h}}{\left(R_0 + \frac{t \cdot tg\alpha \cdot \varphi_i}{360^\circ}\right) tg(\alpha_a + \psi)} \tag{3}$$

where R_0 – initial vector-radius;
φ_i – shaft degree.

For example, let us define R_0 with the following initial data: M = 100 Nm, R_0 = 0.1 m , α = 15º, β = 15º, ψ = 5.5º, φ_i = 180º, t = 0.08 m $t = 0.08$ m. Power P_0 is equal to 13222 N, the slider mechanism stroke is 42.9 mm.

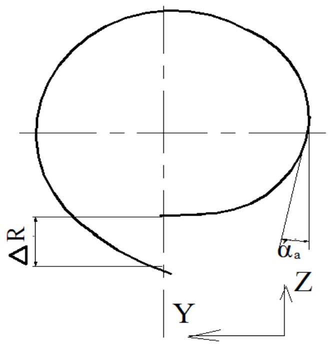

Fig. 3. **Archimedes' spiral of a conic screw surface in the YOZ plane**

Experimental Setup

The proposed press markedly outperforms the existing crank press.

1. This press, depending on the type of processing, consumes electric power 1.5 -2 times less than the crank press, because the push applied on the slide during the entire working cycle is transmitted uniformly and is not lossy [8]. As for a crank-slider, in a crank press it on the contrary practically does not transmit its efforts on the slider at the beginning and at the end of a stroke due to having small values of the power angle. The effective phase of power transmission in this mechanism makes up approximately 90º φ of the crank angle. As an example, let us consider the following crank press parameters: throw of crank – 40 mm, crank length 800 mm, rolling force of the crank attached at its end and perpendicular – 50000 N. Let us cite computed data for determination of the force P_0 acting on the workpiece. The table shows that P_{0max} = 49875 N, the rotary angle is 90º. The effective phase of the crank rolling is 60-150º (see Fig. 3).

Table 1

Design parameters of the press machine

Crank angle of rotation, degree	0	30	60	90	120	150	160	170	180
Power P_0, N	0	23902	42139	49875	44301	26067	17899	9109	0

2. The press has a short idling time equal to 15-20 %, the crank press has a share of idle time equal to 50 % (see Fig. 4), consequently, the performance of the new press will be higher [10].
3. The slide of the press moves uniformly during the working stroke and the slide of the crank press moves uniformly and with acceleration. The uniform movement of the slider reduces the wear rate of the tool by approximately 20 %.
4. The operating force of the new press slider during the entire stroke is kept uniform and at the end of the stroke it is likely to increase without hard braking of the flywheel. This greatly reduces the probability of the press entry into "stupor regime". Also, at the approach of the slider to the most downward position the spring force becomes maximized and the contact opening of the slider and the helical surface force of the spring allow the slide to recover place, overcoming the resistance of the machined workpiece. In contrast, the design of the crank press has a return force equal to zero in the lowermost position [9]. When the press approaches the lowermost position its pressing force tends to zero. The press just may come short of enough force to force in the last millimeter of the workpiece. If, however, the press was able to go to its lowest position, then in theory the crank press cannot take off the slider together with the tool after its forcing into the work piece. But in practice, due to elastic deformation of links, gaps, the force of inertia of the flywheel rotation, etc., there remains a little portion of force. It makes just a small percentage of the force

attached to the shaft of the press. This force returns the slider to its original position, but as it was mentioned the value of the force is small, and the press can come into a stupor position. Also, at that time the efficiency of the press is extremely small – it is about 2-3 % (see Fig. 4).

5. Kinematic diagram of the press has no special brake assembly as the crank press; its functions are performed by surfaces 3 and 6. The press mechanism provides automatic trip out of the slider in its topmost position in the press. This improves the press stopping reliability, reduces energy costs on mechanism braking and reduces wear.
6. Work of the press clutch carried out in relaxed conditions and when you turn it on, undergoes dynamic efforts twice as weakened. Reduction of dynamic forces is achieved by the fact that the new press does not need stop the press shaft, which has constant rotation due to the absence of the connecting rod in the press.
7. The press has no connecting rod that enables to reduce the overall height of the press by approximately 15-20 %.
8. Kinematic chain of the new press has only two links – a screw cylinder and a slider. The crank press has three links – a crank, a connecting rod and a slider. The new press is expected to have high stiffness, thus increasing its accuracy and durability.

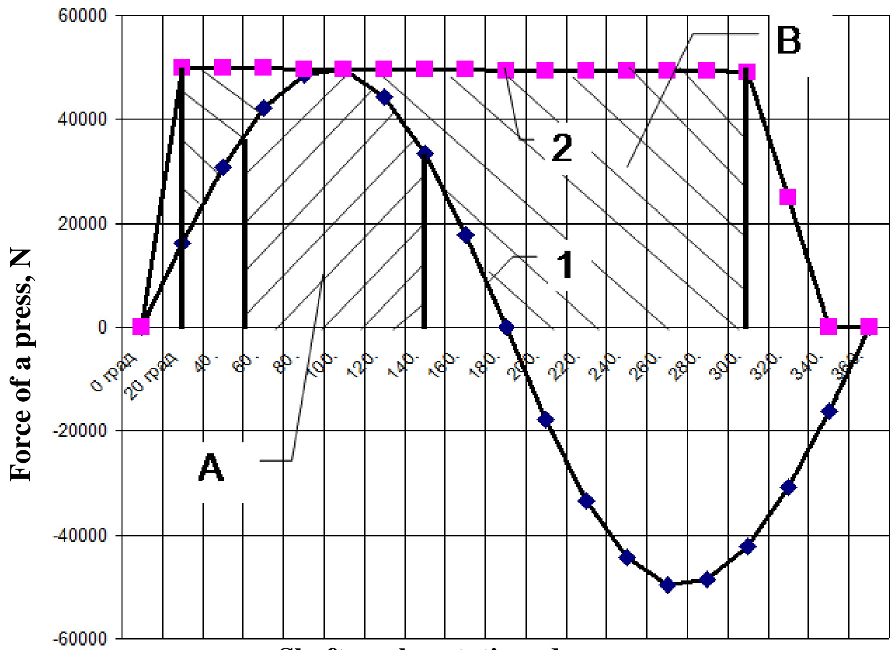

Fig. 4. **Dependence of power of the press on the shaft angle of rotation:** 1 – crank press; 2 – new press. Effective zone of work: A – crank press, B – new press

According to the proposed scheme, there was produced a working press. Fig. 5 shows a drawing of the press general view. Fig. 6 – a general view of photo of the press.

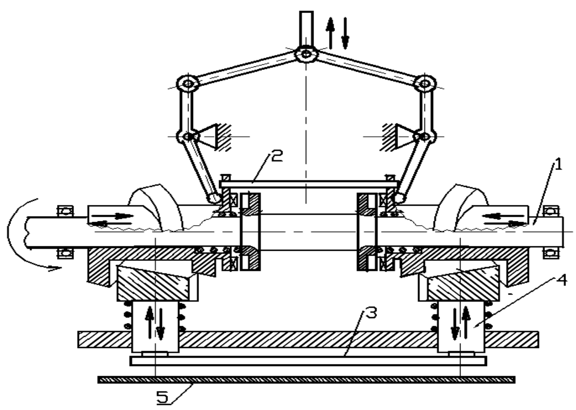

Fig. 5. **Scheme of a sheet bending machine**

Fig. 6. **Photo of a general view of the press**

Press features: force 50-55 kN, drive power 1.5 kW, slider stroke 35 mm, shaft speed 120 min^{-1}, rate of rotation 600x586x1650 mm. Successful tests of the press – pressure forming of steel billets 2 mm thick, width 36 mm, depth of drawing 32 mm, stainless steel (see Fig. 7).

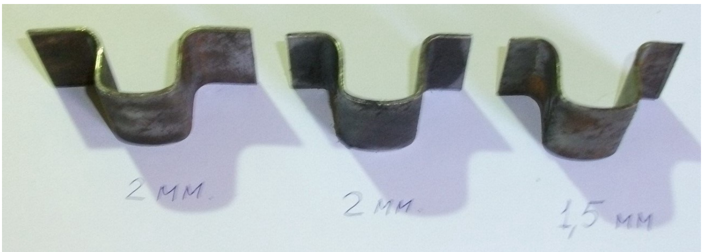

Fig. 7. **Photo of stamped products**

Results and discussion

The proposed scheme of the press can be used in the construction of a sheet bending machine. In this scheme, it is necessary to use two identical mechanisms working synchronously. As shown in Fig. 5, the design of thick bending machine consists of two identical mechanisms fixed dosimetrically on the same shaft 1.To synchronize rotation of cylinders they are connected by the connecting rod 2, but can move axially regarding each other. A common tool 3 is placed on two slides 4, which puts pressure on the work piece 5.

Dissymmetrical arrangement of two mechanisms enables to destroy horizontal axial components of forces produced by slides 4, which are multidirectional and have the same value.

Conclusions

1. A new type of mechanical press with at least 8 improvements compared with the basic type presses – the crank one.
2. A prototype of a new type press is manufactured and successfully tested.
3. A design of a new sheet pressing machine is offered with use of a new type press mechanism.

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