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METHOD OF OPERATING A PUNCH PRESS DURING START-UP AND STOPPING

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The invention relates to a method of operating a punch press during the start-up and stopping operation thereof, which punch press includes an eccentric shaft driven by a positionable drive via the coupling unit of a coupling/brake device, a push rod driven by the eccentric shaft for supporting at least an upper tool and a punch press table for supporting at least one lower tool, by means of which tools a strip-like workpiece located therebetween is worked upon, which punch press, due to the total inertia moment of the moving structural members of the punch press and due to the driving torque transmitted by the coupling unit onto the eccentric shaft, rotates during its acceleration from standstill to the rotating at the operationally rated number of strokes through a start-up angle and a first contact between the tools and the strip occurs at a predetermined operation angle position of the eccentric press.

In high-speed punch presses the as such known increasing of the forces of inertia of the accelerating structural members pose a large problem at an increasing rotational speed, which has specifically an influence onto the quality and preciseness of products produced by such high-speed punch presses. Due to the accelerations and decelerations of the predominantly oscillating structural members and due to the counterforces produced during the working of a respective workpiece the punch press and specifically its moving parts suffer elastic deformations and displacements occur, furthermore, in the bear-



ings, which conditions have quite a negative influence on the preciseness at the produced products.

The precision of a punched product depends among others strongly from the respective height position of the ram. As is generally known, this height position of the ram determines the closed tool height position or the depth of penetration, resp., at the operating of the machine.

If a fixed height position of the ram is set for given embossing and cutting operations at a given number of strokes, the embossments do not reach the design depth when the punch press operates at a relatively low number of strokes, the embossings have a too large depth or the depth of penetration of the punching tools, respectively, is too large at a higher number of strokes which leads, as is generally known, to undesirably large wear at the corresponding tool members.

A variety of procedures for a controlling of the height position of the ram or depth of penetration, respectively, based on the number of strokes, have become known. Reference is made here for instance to the CH-A-676 445.

During punching operations, and specifically with multiple press tools, no waste should be produced also during the start-up and stopping of the punch press due to the above mentioned forces of inertia and specifically in case of high-speed punch presses the start-up and stopping operation causes considerable troubles in this respect.

When starting a punch press up, the eccentric shaft is coupled by a closing of the coupling to the drive motor rotating already at a rated operational speed and specifically to the fly-wheel and accordingly accelerated from the state of stand-still up to the rated ro-



tational speed. The dynamic behavior of the punch press during the first working operation, e.g. the first punching operation, is thereby defined first punch behavior and it is this first punch behavior which determines the quality of the first product punched.

At the known start-up methods of high-speed punch presses, this first punch behavior is now such that the first punching operation is not made at the rated operating number of strokes such as during the next subsequent punching operations, i.e. the dynamic behavior of the punch press during the first stroke is different from the subsequent strokes which has a negative effect regarding the precision of the first part produced.

A reduction of the operating number of strokes eliminates this drawback, but then the production is decreased, i.e. the number of products produced within a given time span is lower.

Here, the invention intends to provide a remedy. The invention, such as characterized in the claims, solves the object to provide a method of operating a punch press during its start-up and stopping in which after having stopped, the eccentric shaft is rotated back into a start-up angle position, according to which at a subsequent start-up after it has passed through the start-up angle for accelerating up to the operational number of strokes rotates at the operational number of strokes before the first working contact between the tool and the workpiece takes place.

The advantages gained by the invention are seen predominantly in that the first punching stroke occurs at a dynamical behavior of the punch press which is the same as during the continuous operation. Therefore, during the start-up an exact production working of the

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web to be worked upon occurs already at the first working stroke, such that no waste is produced.

In the following, the invention will be explained based on drawings illustrating merely one embodiment.
5 ment.

Figure 1 illustrates schematically a punch press with the structural units facilitating the understanding of the invention,

Fig. 2 is a diagram illustrating the behavior of a punch press during start-up,
10 of a punch press during start-up,

Fig. 3 illustrates schematically the position of a punch press operated in accordance with the inventive method after having stopped, and

Fig. 4 illustrates schematically the position of a punch press operated in accordance with the inventive method prior to the start-up.
15 of a punch press operated in accordance with the inventive method prior to the start-up.

Fig. 1 illustrates schematically a punch press. This punch press includes a positionable drive 1. Such a positionable drive 1 includes an electromotor
20 which can be controlled so that it can be controlled to rest at any desired angular position, and which drives the flywheel of the high-speed punch press via a belt drive in accordance with generally known designs. The flywheel is coupled to a coupling/brake device 2, 3 which
25 in turn is connected to the eccentric shaft 5 supported in the machine frame 4.

The coupling/brake device 2,3 includes a coupling unit 2, by means of which the eccentric shaft 5 can be coupled to the drive 1, i.e. its flywheel; and conversely can be uncoupled therefrom, and includes a braking unit 3 having a brake disc 14, by means of which
30 brake discs 14 the eccentric shaft 5 can be braked against the frame 4 of the machine. Particulars of this coupling/brake device are disclosed in the CH-A-546 141 or



the US-A-3 804 931. Important to note here is that the coupling unit 2 and the braking unit 3 are force locking designs, i.e. when the coupling is closed and when the brake is applied, a sliding behavior occurs.

5 The eccentric shaft 5 supports connecting rods 6, which in turn support the ram 7. The upper tool 8 is mounted to this ram 7. Fig. 1 illustrates, furthermore, the table 10 of the punch press which supports the lower tool 9. Reference numeral 11 identifies in a general manner the balancing weight structures which balance
10 the rotating and oscillating forces occurring during the operation of the punch press.

 In operation the eccentric shaft rotates through all angular positions of a 360° angle, and due to
15 the positionable drive, the shaft can be brought to a standstill at any desired angular position. In punch presses it is common to define for their eccentric shafts an upper dead center position UD and a lower dead center position LD, whereby the structural reference for these
20 positions is taken to be the pivotal point of the connecting rod(s) at the eccentric shaft 5. In the upper dead center position UD the ram 7 is at the largest and in the lower dead center position LD the ram 7 is at the smallest distance from the table 10 of the punch press.
25 These positions UD and LD are illustrated in Figs. 3 and 4.

 In order to interrupt the operation, it is common to bring the punch press to rest, i.e. positioned at least approximately in its upper dead center position
30 UD. The distance between the ram 7 and the punch press table 10 is at its largest in this position of the punch press and the tool (consisting of upper tool 8 and lower tool 9) is in its open state. When interrupting the operation the coupling unit 2 is opened and the braking



unit 3 is closed, i.e. the eccentric shaft 5 is decoupled from the drive 1, while the drive 1 and the flywheel keep on idling at the rated operating speed and the eccentric shaft 5 remains at rest.

5 Reference is now made to Fig. 2. The abscissa refers to the angular position α of the eccentric shaft 5 the ordinate to the speed of rotation n thereof!

When the drive is rotating at the rated operational speed n_B and the eccentric shaft is at rest in
 10 the upper dead center position UD and the braking unit is opened and the coupling unit closed, the rotational speed n of the eccentric shaft begins to increase from zero under the influence of the torque transmitted via the coupling onto the eccentric shaft. This increasing rota-
 15 tional speed n relative to the angular position α of the eccentric shaft is illustrated in Fig. 2 by the curved line. After a certain time, i.e. passing through a certain angle α_B of rotation, the rated operational speed n_B is arrived at. The change of the speed of rotation proceeds, thereby, according to the formula
 20

$$n = \sqrt{\frac{\alpha \cdot M \cdot 10}{J \cdot \pi}},$$

whereby

25 M = is the driving torque output of the coupling [Nm],

J = the moment of inertia of the moving structural members of the punch press [kgm²]

α = Start-up or stopping angle in degrees.

30 The closing of the tool, i.e. the contact between the upper tool and the strip to be worked upon, occurs shortly ahead of the lower dead center position LD, at which the eccentric shaft has rotated through an angle of rotation, i.e. a start-up angle, α_A , whereby in Fig.



2 the distance between the start-up angle α_A and the angle $\alpha = 180^\circ$ is visible.

Accordingly, the rated operational speed n_A must be arrived at, at the latest by the start-up angle α_A if the first punching at the start-up shall be performed at the same dynamic conditions as will prevail at the next and subsequent stamping operations. Thus, at any rated operational speed $\leq n_A$, no difficulties occur.

If the rated operational speed n_B is larger than n_A , i.e. $n_B \leq n_A$, which condition occurs in high-speed punch presses, a start-up angle α_B is needed which is larger than α_A when the first punching operation shall have again the same dynamic conditions as present at the next and subsequent punching operations.

When stopping the punch press the same thoughts are to be made. A decrease of the number of strokes can be initiated only after the lower dead center LD has been passed, whereby the complete standstill must have been reached prior to a rotation of 360° , before a further contact between tool and metal strip is made.

The parameters M (driving torque or operating torque) and J (moment of inertia) of a punch press can be changed only with great difficulties or not at all. Accordingly, the inventive method is used which will now be explained based on Figs. 3 and 4.

Because the rated operational speed of rotation n and the machine parameters M and J are known, it is possible to calculate e.g. in a control apparatus for the punch press the start-up angle α_B and correspondingly also the stopping angle.

When shutting the punch press down it is brought to rest not in the upper dead center position UD but rather at the angular position C (Fig. 3), which is located by the angle



$$\frac{\alpha_B}{2}$$

after the upper dead center UD.

Obviously, the size of

5 $\frac{\alpha_B}{2}$

can be maximally that large that the lower dead center LD is not reached and accordingly a further punching is avoided. When stopping a punch press the coupling is
10 opened and the brake is closed, whereby the drive including the flywheel continues rotating at the rated operational speed.

After the punch press, i.e. the eccentric shaft, has been brought to rest, the drive is also
15 stopped. Thereafter the drive is operated in the direction of rotation opposite of the normal direction of the rotation and thereafter the eccentric shaft is coupled to the drive and then the eccentric shaft is rotated by the angle

20 $2 \times \frac{\alpha_B}{2} = \alpha_B$

backwards into the angular position D illustrated in Fig. 4. After having arrived at the angular position D, the coupling 2 is opened and the drive 5 brought to rotate up
25 to the rated operational speed of rotation n_B . The eccentric shaft 5 is at rest in the angular position D and accordingly an enlarged start-up angle α_B is now available for a coupling on and starting.

It has been common practice to stop the punch
30 press at the upper dead center UD allowing a manipulating in the opened tool. When the press, i.e. the eccentric shaft, is rotated backwards from the position C to the



position D, it is possible, if it is desired to do so, to bring the eccentric shaft 5 to a temporary standstill at the upper dead center UD (intermediate holding).

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PATENT CLAIMS

1. Method of operating a punch press during
 5 the start-up and stopping of same, which punch press in-
 cludes an eccentric shaft (5) driven from a positionable
 drive (1) via a coupling/brake device (2; 3), a ram (7)
 driven by the eccentric shaft (5) for supporting at least
 one upper tool (8), and a punch press table (10) for sup-
 10 porting at least one lower tool (9), by means of which
 tools (8; 9) a strip (12) located therebetween is worked
 upon, which punch press due to the total inertia of the
 moving parts and the driving torque transmitted by the
 coupling unit (2) onto the eccentric shaft (5) moves for
 15 the acceleration from standstill up to the rated opera-
 tional speed through a start-up angle (α_A) and the con-
 tact between the tool part (15) and the strip (12) begins
 at a preset operation angle position (C) of the eccentric
 shaft (5), characterized in that after having brought the
 20 punch press to rest the eccentric shaft (5) is rotated
 for a start-up without passing through its lower dead
 center position (LD) into a start-up angular position
 (D), according to which it after an anewed start-up after
 passing through the start-up angle (α_B) in direction of
 25 the operating rotation is ahead of the operation angle
 position (C) at its operational speed of rotation.

2. Method according to claim 1, in which the
 contact between the tools (8; 9) and the metal strip (12)
 ends at a predetermined release angle position (D) after
 30 passing through the lower dead center position (LD) in
 direction (13) of the rotation of operation, and the ec-
 centric shaft (5) upon stopping of the punch press passes
 due to the total inertia of the moving structural members
 and the breaking torque exerted by the breaking unit (3)





of the coupling/brake device (3; 4) for decelerating the rotational speed of the eccentric shaft (5) from the rated operational number of strokes to the standstill through a stopping angle, characterized in that the deceleration of the eccentric shaft (5) by the breaking unit (3) is initiated directly after passing through the release angle position (D) in the direction of the operational rotation.

3. Method according to claim 1 or 2, in which the stopping angle (α_A) is larger than the angle between the release angle position (D) and the upper dead center position (LD) of the eccentric shaft (5) seen in direction of operational rotation, characterized in that the eccentric shaft (5) is rotated back by a driving by the drive (1) in a direction opposite to the direction of operation through the upper dead center position (LD) into the start-up angle position (D).

4. Method according to one of the preceding claims, characterized in that the eccentric shaft during the rotating back to the start-up angle position is stopped temporarily in the upper dead center position (UD).

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