

The present invention relates to a punch press with a number of strokes adjustment and a control and regulating, respectively, device comprising a design value characteristic curve, by means of which signals are producible for an adjusting apparatus in accordance with the design value characteristic curve, and by which adjusting apparatus a setting of the penetration depth of the punch of the punch press takes place at the running punch press dependent from the signals coming from the control and regulating, respectively, device.

The invention relates further to a punch press with a number of strokes adjustment and a control and regulating, respectively, device comprising a design value characteristic curve, by means of which signals are producible for an adjusting apparatus in accordance with the design value characteristic curve, and by means of which an adjustment of the feeding length of the material to be punched takes place at the running punch press dependent from the signals coming from the control and regulating, respectively, device.

In punch presses, changes of operating parameters such as e.g. number of strokes, tools and work-pieces basically give rise to deviations from set design values. Changes of the numbers of strokes follow in that the forces of inertia change, e.g. the forces of inertia rise together with rising numbers of strokes. This leads to the generation of small elastic changes of dimensions of moving parts of the press and also to a change of the clearances in bearings, changes of the closing height of the tool and the penetration depth, respectively, of the tools. Different tools, which differ from each other regarding their masses, cause also varying forces of inertia during the operation, which possibly, added to the above mentioned forces of inertia, lead to further deviations of the set design values. Specifically regarding the penetration depth, the characteristics of the raw material to be worked on, e.g. its metallurgical characteristics and also the production itself,

i.e. the shape of the product to be produced, have a large influence.

Deviations from design values occur also in the feeding apparatus in which the measure of the feeding length deviates from a respective set design value, whereby here an increased number of strokes and the accelerated mass of the band form further sources of errors.

According to the DE-PS 27 31 084 it is known to equip a punch press in which the penetration depth of the punch or tool, respectively, which can be adjusted when the press is running, with a control and regulating, respectively, device. A characteristic curve is stored in this control and regulating, respectively, device, which is to give the function penetration depth in dependency from the number of strokes per minute of the punch press. This characteristic curve is used as design value. The measured actual value of the penetration depth is compared with this design value. If the actual value deviates, a correction in the direction toward the design value is made by the control and regulating, respectively, device.

The practice has, however, revealed that such a controlling or regulating does not always lead to satisfactory results. This is due to the fact that the actual values of the operation of a press are subject to quite complex changes when running through the range of number of strokes, which will be explained more in detail below. Oftentimes, thus the mentioned control and regulating, respectively, device is not in a position to supply satisfactory results within the entire range of number of strokes. This is of a still greater importance because there is the wish to be able to produce products made by punch presses having a still higher precision.

Here the invention intends to provide a remedy. The invention, such as characterized in the claims, solves the object to provide a punch press in which the mentioned drawbacks no longer exist, and by means of which it is possible to produce with every tool parts having the desired

precision within the entire range of number of strokes in that the control and regulating, respectively device includes an input means by means of which a value for the penetration depth deviating from the design value characteristic curves is inputable at an arbitrary number of strokes, and the control and regulating, respectively, device is designed for the production of the signals in such a manner that the input value is adjustable in dependency from the number of strokes and is combinable with the design value characteristic curve.

As described above, there exists basically the same object also relative to the feeding length for the material to be punched. This object is solved for the feeding length by means of the same general inventive idea at a punch press of the above second mentioned kind in that the control and regulating, respectively, device includes an input means by means of which a value for the feeding length deviating from the design value characteristic curve is inputable at an arbitrary number of strokes, and in that the control and regulating, respectively, device is designed for the production of the signals in such a manner that the input value is adjustable in dependency from the number of strokes and is combinable with the design value characteristic curve.

By means of the inventive punch press, it is possible to produce precise punched products over the entire range of number of strokes. If - as generally known - the punch press is run from a low number of strokes of e.g. 100 strokes per minute as machine setting stroke number along the tool-specific design characteristic curve up to the desired number of strokes the errors of the penetration depth at a high number of strokes become visible and measurable at the punched products. By the input of a value as correction for the penetration depth, the error at the operational number of strokes can be reduced visibly and measurably. The control or regulating operation leaves thereby the design value characteristic curve. If now the

number of strokes is changed again, a new design value is set by the control and regulating device, respectively. Thereby, the input value is changed by the device and used together with the fixed design value characteristic curve for determining the penetration depth which is suitable for the new number of strokes.

For the changing of the design value of the feeding length, the control and regulating, respectively, device operates similarly.

The invention will hereafter be explained in detail based on drawings illustrating merely one embodiment.

There is shown in :

Figures 1 - 4 schematically the main moving parts of a punch press;

figure 5 a diagram of a known regulating device;

figure 6 a regulating device structured in accordance with the invention, and

figure 7 a characteristic curve for illustrating the effect of the regulating device according to figure 6.

Initially, the problems regarding the penetration depth will be explained based on figures 1 - 4, which illustrate in a simplified manner the most important parts of a punch press in order to give an understanding of the invention. The figures illustrate the crank arm 1, the levers 2, the adjusting spindles 3, the driving rods 4, the punch 5 and the table 6 of the punch press. WHS designates the closing height of the tool. Furthermore, the extent of the elastic deformation F and the free motion S are illustrated schematically corresponding to the respective conditions of the operation of the press.

Now, in figure 1 a punch press is illustrated which is running at a number of strokes of 100 H/min and without tool. Thereby the various bearings 7 are designed as pivot bearings and the clearance therein is vastly exaggerated. All structural members, specifically the levers 2, act as rigid structural members, that is they are not deformed. The relative position of bearing pivot and bearing bushing,

thus the location of the clearance of a motion of a bearing, is determined exclusively by the punch 5, i.e. by its weight. As can be seen, all structural members are "pulled downwards" by the punch 5. The closing height of the tool WSH corresponds to the set design-closing height.

In figure 2, the same machine is illustrated running at a relatively high rotation speed, i.e. high number of strokes, for instance 1500 H/min and again without tool in the lower dead point position, and again designed in a simplified manner. Due to this high number of strokes elastic deformations of structural members are produced, so-called dynamic spring elastic behaviour. This behaviour is illustrated in figure 2 schematically as a bending of the lever 2. Now, however, the closing height of the tool WSH must be kept at a constant value because this measure has final effects regarding the penetration depth. In order to keep this closing height of the tool WSH at the illustrated dynamic spring elastic behaviour at a constant value it is, therefore, necessary to make a correction of the height position of the punch of that value which corresponds to the dynamic spring elastic behaviour. This means that it would be necessary to make a correction of the height which equals the value of the spring elastic deformation value.

Figure 3 illustrates the same machine which is punching at a number of strokes of 100 H/min. The rotational speed, therefore, is again the same as the one of figure 1. Additionally now, the upper tool 8, the lower tool 9 and the workpiece, i.e. the web 10, from which the product is punched and embossed are illustrated. The reference numeral 13 designates a punched piece of material.

Due to the low rotational speed of e.g. 100 H/min, no dynamic forces occur in the machine similar to the state illustrated in figure 1. However, due to the punching, the embossing, i.e. due to the working, forces are produced which are directed, based on the illustration of figure 3, upwards, which condition is illustrated in the schematic

illustrations of the individual bearings and the position of the levers. The source of error is here due to the clearances, specifically in the bearings. In order now to be able to produce a correct punching, it would be necessary to initially eliminate the total clearance. Because here the punch is pressed "upwards", it would be conclusively necessary to adjust the punch adjustment apparatus downwards by the measure s such that again the given closing height of the tool WSH can be maintained.

Figure 4 illustrates the machine running at a high number of strokes, thus analogue to the number of strokes of figure 2. Due to the high dynamic forces (at about 300 - 400 H/min) the clearances are run through and again the dynamic spring elastic behaviour analogue to figure 2 occurs. In order now to again keep the closing height of the tool WSH constant, it would be necessary to correct, by means of the adjustment of the punch, the penetration depth by the measure $F + S$.

The above explanations reveal accordingly that depending from the number of strokes, from the tool and also from the workpiece (e.g. metallurgical properties), the punch must be at a respective different height position. It must also be noted that the height position, when making measurements of the penetration depth without a punching operation, are not precise.

Figure 5 illustrates schematically a block circuit of a known regulating apparatus which is basically based on figure 1 of the DE-PS 27 31 084. The number of strokes is thereby fed from a corresponding sensor 26 to a first unit 20, in which a design value characteristic curve is stored. For every tool used such a design value characteristic curve is foreseen. The design value characteristic curve can be programmed via an input 21. The design value characteristic curve represents e.g. the penetration depth as function of the number of strokes. In a second unit 22, a comparator, the design value penetration depth emitted from the unit 20 is compared with the actual penetration

depth which is sensed by a sensor 25 at the motor 24 of the penetration depth adjusting device. If the adjustment of the actual penetration depth deviates by a set threshold value from the design penetration depth, the unit 22 activates one of the switches 23 in order to operate the motor of the penetration depth adjustment device for setting the punch or tool, respectively, at a higher or lower position. The operating proceeds until the actual value corresponds again to the design value within the framework of the precision of control.

Figure 6 illustrates on a rough schematic basis how the regulating device of an inventive punch press can be embodied. Only one unit 30 of the regulating device is shown hereby, which corresponds basically to the unit 20 of figure 5. For the sake of simplicity, the further units of figure 5 are not illustrated in figure 6. These units 22, 23, 24, 25 are designed at the regulating device according to figure 6 basically in the same manner such as at the known regulating device according to figure 5.

The unit 30 also comprises a tool-specific design value characteristic curve of a known kind, which has been programmed via the input 21. It also includes an input for a stroke number dependent signal from a sensor 26. However, only one input or input means 31, respectively, is foreseen by means of which a value can be input, according to which the penetration depth of the momentarily active number of strokes can be corrected. This shall be explained more in detail with reference to figure 7, which illustrates a design value characteristic curve 40 in a penetration depth/number of strokes diagram. This design value characteristic curve is designed as straight line for reasons of simplicity. Whereas this is correct for a feeding apparatus, the design value characteristic curve for the penetration depth will, however, extend as a rule parabolically. The schematic design value characteristic curve illustrates to which value of the penetration depth the regulating is made at a respective number of strokes.

Based on the above discussion of figures 1 - 4, it can, however, be recognized that the design value characteristic curve can be nothing more but an imperfect representation of the complex real function. Correspondingly, the parts punched in accordance with the design value characteristic curve may display considerable deviations from the desired precision tolerance of the production also - and specifically because - the regulating device according to figure 5 follows the design value characteristic curve 40. The control device of the inventive punch press includes, therefore, the input 31 via which a value can be input, according to which magnitude the control device separates itself from the design value characteristic curve.

Figure 7 illustrates how this operates in the penetration depth-number of strokes diagram. At the number of strokes H_1 the operator of the punch press was able to see that the operation at the corresponding point 42 of the characteristic curve does not lead to the desired precision of the punched parts. It is now possible to input a corrective value W via the input 31 into the regulating device. Then, the punch press operates in the operation point 41, which is determined by the design value characteristic curve 40 together with the input correction value W . The value W can be input by various means, e.g. by a numeric keyboard as digital value, by an adjustable resistance as analogue value or by $\pm$ - keys in predetermined small steps. The kind of the input is thereby dependent from the design of the regulating device.

The illustrated example shows the value W only in a basic nature; quite obviously W can be larger or smaller or can become active also at the other side of the characteristic curve, such that an operating point 43 would be obtained. In case the precision of the parts obtained at the new operation point 41 is not satisfactory, naturally a different value for W can be input.

If now the number of strokes is changed, the

value W is automatically changed by the regulating device. This can proceed on a continuous basis such that again a continuous curve (illustrated by broken lines as curve 44) is obtained between the number of strokes H_1 to H_4 or $H_{\max}$ to $H_{\min}$, respectively. This can proceed in such a manner that an additional characteristic curve is calculated from the known parameters of the design value characteristic curve, which line runs in the illustrated example through the new operation point 41 and contacts or intersects at a minimal number of strokes the characteristic curve. It is, however, also possible to form adjusted correction values W_2 to W_4 for only individual numbers of strokes H_2 to H_4 , whereby the newly produced "operation corrective curve" extends e.g. in a step-like manner or is formed as a straight line extending between the points.

The design value characteristic curve 40 for the penetration depth extends preferably parabolically and upon the change of the penetration depth all parameters of the parabolic line are newly calculated from the value W set for an arbitrary number of strokes and a new design value characteristic curve will be formed therewith. For such a case, the regulating device is obviously formed preferably by a digital process controller which conducts the necessary calculations and regulates accordingly.

In figure 6, however, it is illustrated on an exemplary basis how an inventive design of the controlling device can be arrived at basically at small expenditure. The signal at the output 33 to the comparator 22 is thereby in such a manner that an adding/subtraction unit 35 combines the base value from the design value characteristic curve with the input value W in order to obtain a new operation point. When the number of strokes changes, a second adding/subtraction unit 36 is activated, which subtracts from the hitherto new operation point 41 e.g. a constant K when the number of strokes decreases or adds the constant K , respectively, when the number of strokes increases.

Because the values W or the new design value characteristic curve, respectively, for a given tool are as a rule applicable over a longer time-span, the controlling device is equipped preferably with a memory in which at least one value W and possibly the entire new design value characteristic curve and a number corresponding to the specific tool can be stored. By means of this, it is possible to retrieve, for a tool which has already been used and which has been operated at a changed design value characteristic curve, this curve again directly and to start the operation exactly at this amended curve.

What has been said above regarding the penetration depth is also true for the feeding length. The corresponding design value characteristic curve can, thereby, be a straight line. The principle of the correcting and the means used thereto remain, however, the same. Quite obviously it is possible to embody at a punch press only one of the correcting procedures, thus either of the feeding length or of the penetration depth. Preferably, however, both possibilities are foreseen in the same punch press.



Patent Claims

1. Punch press with a number of strokes adjustment and a control and regulating device (30), respectively, comprising a design value characteristic curve (40), by means of which signals are producible for an adjusting apparatus in accordance with the design value characteristic curve (40), and by which adjusting apparatus a setting of the penetration depth of the punch (5) of the punch press takes place at the running punch press dependent from the signals coming from the control and regulating device, respectively, characterized in that the control and regulating device (30), respectively, includes an input means (31) by means of which a value for the penetration depth deviating from the design value characteristic curve (40) is inputable at an arbitrary number of strokes (H), and in that the control and regulating device, respectively, is designed for the production of the signals in such a manner that the input value (W) is adjustable in dependency from the number of strokes and is combinable with the design value characteristic curve (40).

2. Punch press according to claim 1, characterized in that the control and regulating device (30), respectively, includes a storage unit in which at least one input value is storable.

3. Punch press according to claim 1, characterized in that the control and regulating device (30), respectively, includes a characterizing value for the utilized punching tool for the combining of the input value.

4. Punch press according to one of the claims 1 to 3, characterized in that a design value characteristic curve in form of a parabola is storable in the control and regulating device (30), respectively, and in that the control and regulating device (30), respectively, is designed for a stroke number dependent adjustment of all parameters of the parabola.



5. Punch press according to one of the claims 1 to 4, characterized in that signals for a feeding apparatus of the punch press according to a second design value characteristic curve are producible by the control and regulating, respectively, device (30), that a value for the feeding length of the material to be punched deviating from the second design value characteristic curve is inputable by the input means (31), and in that the control and regulating, respectively, device is designed for the production of the signals for the feeding apparatus in such a manner, that the input value is adjustable dependent from the stroke and combinable with the design value characteristic curve.

6. Punch press with a number of strokes adjustment and a control and regulating, respectively, device (30) comprising a design value characteristic curve (40), by means of which signals are producible for an adjusting apparatus in accordance with the design value characteristic curve (40) and by means of which an adjustment of the feeding length of the material to be punched takes place at the running punch press dependent from signals coming from the control and regulating, respectively, device (30), characterized in that the control and regulating, respectively, device (30) includes an input means (31), by means of which a value (W) for the feeding length deviating from the design value characteristic curve (40) is inputable at an arbitrary number of strokes (H), and in that the control and regulating, respectively, device (30) is designed for the production of the signals in such a manner that the input value (W) is adjustable in dependency from the number of strokes and is combinable with the design value characteristic curve (40).

7. Punch press according to claim 6, characterized in that the control and regulating, respectively, device (30) includes a storage unit in which at least one input value is storable.

8. Punch press according to claim 7,



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characterized in that the control and regulating, respectively, device (30) is designed to combine an input value with a characteristic value for the punching tool used.