

**Method for warping the machine bed and/or the
press ram of a punching press and punching press**

Technical Field

5 The present invention relates to a method for
warping the machine bed and/or the press ram of a punch-
ing press to compensate at least partially a bending
caused by the punching force during punching operation
and a punching press, in particular to perform the
10 method, according the preambles of the independent
claims.

Background Art

15 For the industrial manufacturing of punching
parts from metal strips, fast running automatic punching
machines are used nowadays, at which an upper tool part
with punches is moved over a certain stroke towards a
lower tool part with dies and makes cuts and shapings at
the metal strip by doing so. The today's, so called pro-
20 gressive dies, which mostly comprise a larger quantity of
modules, which handle different tasks like cutting, bend-
ing, metal forming and stamping, call for more and more
longer installation spaces.

25 Correspondingly the length of the tool in-
stallation space of punching machines has practically
been doubled in the last three decades at unchanged ton-
nage, which leads to a corresponding growth of the moved
and unmoved masses due to the longer components and at
the same time to problems with the stiffness of the press
30 structure, because the stiffness typically decreasing due
to the increase of the length of some critical compo-
nents, in particular of the machine bed, cannot be arbi-
trarily compensated by corresponding increases of cross
section due to limited available space.

35 Hereby again there is the problem that it is
more and more difficult with increasing length of the

tool installation space to keep the deformations of the press structure and in particular the bending of the machine bed under punching load, which should be as small as possible for a high process precision and a little
5 tool wear within passable limits. At machine beds with an aperture for carrying away punching parts and rubbish, as it is used in today's automatic punching machines, there is a spatial bending of the machine bed during the punching operation because it is punched more or less over
10 this aperture, so that the bending in the area of the aperture is bigger than in the areas of the longitudinal sides of the machine bed. In particular for the case that punching work is performed in the rather unusual punching direction from back to front, these bendings are a big
15 problem.

For decreasing or compensating the bending by the process load at machine beds or tool clamping plates without aperture, it is known from prior art to warp the machine bed or the tool clamping plate, respectively,
20 against the bending direction, preferably such that this warping is just neutralized by the process load, or however to support the tool clamping plate dynamically with height adjustable supporting elements on a supporting structure possibly bending under the load, that even under
25 the punching load the tool clamping plate does not experience a substantial bending.

Like that, a press is known from EP 0 653 254 A2, at which support elements are arranged between the press bed and the tool clamping plate, which are adjustable in height. These support elements can be of a mechanical, electromechanical or hydraulic nature and can be
30 operated by a controller such that it is counteracted the deformation of the tool clamping plate under the working pressure of the press. It is also possible to produce
35 with these support elements a warp of the clamping plate to compensate tool characteristics.

A machine table with a tool clamping plate for presses in the sector of metal forming is known from DE 44 15 577 A1, at which a plurality of hydraulic compensation pistons are arranged between a base plate and a tool clamping plate. There are present range sensors or bending sensors, respectively, and a suitable controller to control the pressure in the compensation pistons such that it counteracts a deformation of the tool clamping plate under the working pressure of the press.

The systems known from EP 0 653 254 A2 and DE 44 15 577 A1 have basically the disadvantage that they are mechanically complex and therefore their production and maintenance is elaborate and cost-intensive and that they allow a relatively low structural stiffness for the needed construction height due to their construction principle with multiple punctual support of the tool clamping plate in the punching direction on a supporting structure lying under it. For the variants with hydraulic support elements/compensation pistons, there is the additional disadvantage that the supporting oil cushion has a low stiffness in the punching direction and that the inevitable deformations of the entire hydraulic system under the oil pressure produced by the supporting pressure lead to a deflection of the support under the punching load. For the variants, at which a bending of the tool clamping plates shall be avoided by a dynamic height adjustment of supporting elements, it is to say that, if realizable at reasonable costs, these possibly suit for very slow metal forming processes, but not for fast automatic punching machines for processing metal strips by the progressive die process.

A press is known from DE 100 10 197 A1, at which the machine bed can be warped in the direction towards the press ram by pre-loading of tie-rods longitudinally crossing the machine bed in the lower area to correct a bending of the press bed or to produce a warping

in the unloaded state. There is present a controller, by which the pre-loading of the tie-rods can be controlled depending on detected warps. This system avoids the disadvantages mentioned before of the two first mentioned
5 systems as far as possible.

None of the known systems solves the problem mentioned at the beginning of the spatial bending at machine beds with an aperture for carrying away punching parts and rubbish.

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Disclosure of the Invention

Therefore an objective is to provide a technical solution which at punching presses with a machine
15 bed with an aperture for carrying away punching parts and rubbish enables an at least partial compensation of a spatial bending of the machine bed caused by punching forces both in longitudinal and in cross direction of the machine bed and thereby does not show the previously men-
20 tioned disadvantages of the prior art or avoids these at least partially, respectively.

This objective is solved by the method and the punching press according to the independent claims.

According to these, a first aspect of the in-
25 vention concerns a method for warping the machine bed of a punching press, which machine bed has an aperture for carrying away punching parts and rubbish, for compensating at least partially a bending of the machine bed caused by punching forces during punching operation.

30 Thereby, according to the invention forces acting transverse to the punching force direction are introduced into the machine bed and/or forces acting transverse to the punching force direction are produced within the machine bed, by means of which the machine bed warps in the di-
35 rection towards the press ram, and in fact such that it

warps stronger in the area adjacent to the aperture than in the areas adjacent to its longitudinal sides.

Apertured machine beds of punching presses can be spatially pre-deformed by the method according to
5 the invention with very little expenses on the equipment side in order to at least partially compensate bendings caused by punching forces.

In a preferred embodiment of the method, the machine bed with tie-rods extending in its longitudinal
10 direction is set under compressive stress in its bottom area for warping the same in the direction towards the press ram. This method of the production of deformation forces has the advantage that it reaches without any time lag and that the deformation forces or the resulting de-
15 formations, respectively, are well controllable.

Thereby, it is preferred to arrange the tie-rods such that they cross the machine bed in its bottom part. Hereby, there is the advantage that practically no additional space is needed.

20 With advantage, a tie-rod is arranged at these embodiments in particular symmetrically at both sides of the aperture in each case such that the tie-rods in each case have a smaller distance to the aperture than to the respective longitudinal side of the machine bed.
25 Hereby a stronger warp can be reached in the area of the aperture than in the area of the longitudinal sides in an easy way.

In a further preferred embodiment of the method, a temperature gradient is specifically produced
30 within the machine bed or within a supporting structure for the lower tool parts of the press tool built with the machine bed by means of which the machine bed is warped in the direction towards the press ram as a consequence of locally different thermal expansion or thermal shrink-
35 age of the machine bed, respectively, and/or different thermal expansion or thermal shrinkage, respectively, of

components of the supporting structure for the lower tool parts built with the machine bed. This method of production of the deformation forces has the advantage that it can be applied without having to deviate from existing
5 and proven structural concepts. This is of outstanding significance particularly in the area of fast operating high performance automatic punching machines, because detail work for years is often needed here to optimize the press structure with respect to its dynamic behaviour and
10 to its life time. Additionally the method according to the invention can be applied with little effort also to existing presses.

Thereby, in a preferred embodiment of the method, the temperature gradient effecting the warp is
15 produced by heating the machine bed in the area of its side facing the press ram, wherein it is further preferred that it is stronger heated near to the boundaries of the aperture than near to the longitudinal sides of the machine bed. The local heating is a particularly simple and often also economical method to produce a temperature gradient, in particular because waste heat is often
20 available for free at production lines.

Alternatively or additionally it is preferred to produce the temperature gradient by cooling the machine bed in the area of its side facing away from the
25 press ram, wherein it is further preferred to stronger cool it near to the boundaries of the aperture than near to the longitudinal sides of the machine bed. This method is particularly appropriate if these machine components
30 get relative warm in operation and can be cooled locally in this way without having undershootings of dew point with condensation water at machine parts.

The introduction of heat and/or coldness into the parts can be performed in different ways.

35 For this, in a preferred embodiment of the method, flow channels arranged within the machine bed are

flowed through by a heated or cooled, respectively, gaseous or liquid medium.

For this for example, heated lubricating oil of a lubricating oil circuit of the press can be used
5 which is passed through the flow channels before cooling back. Last mentioned method has the advantage that no additional energy is needed for heating.

In a further preferred embodiment of the method, electrical heating elements are arranged within
10 the machine bed and are charged with electric current for producing heat. At this variant, there is the advantage that with very simple means a precise and specifically tailored to the particular operation control of the temperature gradient is possible.

15 In an even further preferred embodiment of the method, the temperature gradient is produced in that a clamping plate is arranged on the machine bed, which is heated.

In another preferred embodiment of the
20 method, a clamping plate is arranged on the machine bed and a heating device is arranged between the machine bed and the clamping plate, which is heated.

In this case, according to a preferred variant of these two last mentioned embodiments, the machine
25 bed is heated by the heated clamping plate or by the heating device arranged between the machine bed and the clamping plate at its side facing the ram, with the consequence that there is a warp of the machine bed in the direction towards the press ram.

30 According to another preferred variant of these two last mentioned embodiments, the clamping plate is connected in a shear stiff manner with the machine bed, directly or indirectly over the heating device. At this variant, the warp of the machine bed in the direction
35 towards the press ram can also be done exclusively

as a consequence of an introduction of shear forces, produced by a thermal expansion of the clamping plate, into the side of the machine bed facing the ram, or also as a consequence of a combination of shear forces produced by
5 a thermal expansion of the clamping plate into the side of the machine bed facing the ram with a heating of the machine bed by the clamping plate or the heating device, respectively.

In an even further preferred embodiment of
10 the method, the warp of the machine bed is adjusted depending on parameters of the punching process, for example depending on a pre-calculated or product-specific punching force, respectively, or depending on a maximal punching force measured during operation. Further it is
15 preferred that the warp is adjusted during the intended operation of the press. In this way, it can be accommodated the respective operating situation and possible changes, for example due to additional tool wear, particularly well.

20 A second aspect of the invention is related to a punching press which is suited for performing the method according to the first aspect of the invention. The punching press has a machine bed and a press ram working against the machine bed. The machine bed of the
25 punching press has an aperture for carrying away punching parts and rubbish. Further the punching press comprises means for warping the machine bed in the direction towards the press ram by introducing forces transverse to the punching force direction into the machine bed and/or
30 by producing forces acting transverse to the punching force direction within the machine bed. Thereby, these means are designed such that they warp the machine bed stronger in the area adjacent to the aperture than in the areas adjacent to the longitudinal sides of the machine
35 bed.

By the invention it becomes possible to provide cost effective, highly precise, fast running high performance punching presses with apertured machine beds.

In a preferred embodiment of the punching
5 press, the means for warping the machine bed comprise tie-rods extending in the longitudinal direction of the machine bed, by means of which the machine bed is set under compressive stress in its bottom area for warping the machine bed in the direction towards the press ram. This
10 method of production of deformation forces has the advantage that it works without any time lag and that the deformation forces or the resulting deformations, respectively, are well controllable.

Thereby, it is preferred to arrange the tie-
15 rods such that they cross the machine bed in its bottom area. Hereby, practically no additional space is needed.

With advantage, a tie-rod is arranged at these embodiments in particular symmetrically at both sides of the aperture in each case such that the tie-rods
20 in each case have a smaller distance to the aperture than to the respective longitudinal side of the machine bed. Hereby a stronger warp can be reached in the area of the aperture than in the area of the longitudinal sides in an easy way.

25 In a further preferred embodiment of the punching press, the means for warping the machine bed are designed to specifically producing a temperature gradient within the machine bed or within a supporting structure for the lower tool parts built with the machine bed, by
30 means of which the machine bed is warped in the direction towards the press ram as a consequence of locally different thermal expansion or thermal shrinkage of the machine bed, respectively, and/or different thermal expansion or thermal shrinkage, respectively, of components of the
35 supporting structure for the lower tool parts built with

the machine bed. This method of production of the deformation forces has the advantage that it can be realised without having to deviate from existing and proven structural concepts. As already mentioned, this is of outstanding significance particularly in the field of fast operating high performance automatic punching machines, because detail work for years is often needed here to optimize the press structure with respect to its dynamic behaviour and to its life time. Additionally the method according to the invention can be applied with little effort also to existing presses.

In a preferred embodiment of the punching press, the means for warping the machine bed are built such that the machine bed in the area of its side facing the press ram can be heated by them for effecting the warp due to a non-uniform heating with corresponding non-uniform spatial thermal expansion of them. Thereby, it is further preferred that the machine bed is stronger heated by these means near to the boundaries of the aperture than near to the longitudinal sides.

Alternatively or additionally the means for warping the machine bed are built such that the machine bed in the area of its side facing away from the press ram can be cooled by them for effecting the warp due to a non-uniform cooling with corresponding non-uniform spatial shrinkage of them. Thereby, it is further preferred that the machine bed is stronger cooled more by these means near to the boundaries of the aperture than near to the longitudinal sides.

For introducing heat or coldness, the punching press according to the invention can have different arrangements:

In a preferred embodiment of the punching press, flow channels are arranged within the machine bed, which are flowed through by a heated or cooled, gaseous

or liquid medium during intended operation for producing the temperature gradient.

With advantage, arrangements exist according to a preferred variant of this embodiment, by means of which heated lubricating oil of a lubricating oil circuit of the press can be passed through the flow channels during the intended operation of the press for producing the temperature gradient. This solution is energetically very advantageous because practically no heating energy is needed to provide the heat.

In a further preferred embodiment of the punching press, electric heating elements, in particular resistance heating elements, are arranged within the machine bed, which can be charged with electric current during the intended operation of the press for producing the temperature gradient effecting the warp. This construction allows a particularly good controllable production of the temperature gradient.

Preferably, one or more flow channels and/or electrical heating elements are arranged within the machine bed on both sides of the aperture of the machine bed in each case, preferably such that, per side, the sum of the distances of the flow channels and/or the heating elements to the aperture is smaller than the sum of the distances of the flow channels and/or heating elements to the respective longitudinal sides of the machine bed. Thereby, it is further preferred that the flow channels and/or heating elements are arranged symmetrically to both sides of the aperture. Hereby, the desired stronger warp of the machine bed in the area of the aperture can be effected in a simple way.

In an even further preferred embodiment, the punching press has a clamping plate arranged on its machine bed which clamping plate can be heated, in particular electrically, during the intended operation of the press.

In another preferred embodiment, the punching press has a clamping plate arranged on its machine bed, wherein an in particular electrical heating device, is arranged between the machine bed and the clamping plate
5 which can be operated during the intended operation of the press.

Thereby according to a preferred variant of these two embodiments, the clamping plate or the heating device arranged between the clamping plate and the machine bed, respectively, are connected with the machine
10 bed such that the clamping plate, if it is heated, or the heating device, if it is operated, respectively, heats the machine bed at the side facing the ram for producing the temperature gradient effecting the warp. Thereby, it
15 is preferred that the machine bed by the clamping plate or by the heating device, respectively, is heated stronger near to the boundaries of the aperture than near to its longitudinal sides.

According to another preferred variant of
20 these two embodiments, the clamping plate is connected with the machine bed in a shear stiff manner, directly or indirectly over the heating device.

Thereby according to a first preferred sub-variant, the heatable clamping plate or the heating device arranged between the clamping plate and the machine
25 bed, respectively, is basically thermally decoupled from the machine bed such that during heating the clamping plate or during operating the heating device, respectively, it comes basically to a heating up and a corresponding expansion of the clamping plate by means of
30 which the warp of the machine bed in the direction towards the press ram is caused in consequence of the shear stiff coupling of them to the machine bed.

The thermal decoupling can be realized expediently by a thermal insulation layer arranged between
35 the clamping plate and the machine bed, which effects a

reduction of the heat transfer from the clamping plate to the machine bed.

Thereby, in a preferred variant, this thermal insulation layer is present in the areas, which adjoin the longitudinal sides of the clamping plate or the machine bed, respectively, while in the areas, which adjoin the aperture, a layer is present between the clamping plate and the machine bed which has an essentially better thermal conductivity for privileging a heat transfer from the clamping plate to the machine bed in these areas. Also by this measure, the desired stronger warp of the machine bed in the area of the aperture can be effected in a simple way.

According to a second preferred sub-variant, the clamping plate is connected with the machine bed such that it, if it is heated, heats the machine bed at its side facing the ram or the heating device arranged between the clamping plate and the machine bed is connected with the clamping plate and the machine bed such that it, if it is operated, heats the clamping plate and warms up the machine bed at its side facing the ram. By this embodiment, during heating the clamping plate or during operating the heating device, respectively, the warp of the machine bed is caused by shear forces introduced by the clamping plate into the machine bed in combination with the non-uniform spatial thermal expansion of it resulting from the heating of the machine bed.

The use of heatable clamping plates or of heating devices arranged between the machine bed and the clamping plate is suited particularly well for the cost effective retrofit of existing punching presses.

With advantage, the means for warping the machine bed can be adjusted and indeed preferably during the intended operation of the press such that an adjustment of the warp of the machine bed, which is specific

and suited to the respective operating situation, is possible.

For this, the punching press has preferably a press control by means of which the warp of the machine bed is adjustable, preferably automatically, depending on parameters of the punching process, preferably depending on a calculated or product-specific punching force, respectively, or a maximal punching force measured during operation, and indeed preferably during the intended operation of the press. Hereby, a process control with automatic adjustment of the warp of the machine bed to the particular operating conditions becomes possible.

Brief Description of the Drawings

Further preferred embodiments of the invention result from the dependent claims and from the now following description by means of the figures. Thereby it show:

Fig. 1 a sectional view through an automatic punching machine with top drive;

Fig. 2 a section through the bottom part of the automatic punching machine along the line X-X in Fig. 1;

Fig. 3 a view like in Fig. 2 through the bottom structure of a first automatic punching machine according to the invention;

Fig. 4 a view like in Fig. 2 through the bottom structure of a second automatic punching machine according to the invention;

Fig. 5 a view like in Fig. 2 through the bottom structure of a third automatic punching machine according to the invention; and

Fig. 6 a section along the line A-A in Fig. 5.

Modes for Carrying Out the Invention

In Fig. 1, an automatic punching machine with top drive is shown wherein the top part of the machine with the drive unit 1, the ram 2 and the ram guides 3 is shown in section in longitudinal direction whereas the bottom part of the machine is shown not in section with the clamping plate 4 and the machine bed 5.

Fig. 2 shows a section through the bottom part of the automatic punching machine along the line X-X in Fig. 1, as designed according to prior art. As can be seen, the clamping plate 4 is arranged on the machine bed 5 and comprises centrally arranged an aperture 6a which leads in the direction of gravity into an aperture 6b arranged centrally in the machine bed 5. The apertures 6a, 6b serve for carrying away punching parts and rubbish out of the punching zone.

As can be seen further, the machine bed 5 to both sides of the aperture 6b in each case forms a closed cavity 7a, 7b, which cavity serves as a tank for the lubricating oil 8 of the lubricating oil circuit of the automatic punching machine. During operation, the machine bed 5 is in its lower part stronger heated by the heated lubricating oil 8 than in its upper part by means of which it already warps down without punching force load due to different thermal expansions. Under the load of the punching force, there is an additional bending of the machine bed 5 during operation, and subsequently there is a corresponding loss of precision and an increased tool wear.

Fig. 3 shows a section through the bottom part of the automatic punching machine along the line X-X in Fig. 1, as it is designed according to a first embodiment of the invention. As can be seen, the outer contours of the clamping plate 4 and of the machine bed 5 are identically here to the embodiment according to Fig. 2. However, the inner structure of the machine bed 5 differs

clearly from that in Fig. 2. In the present case, the machine bed 5 at both sides of the aperture 6b in each case forms two closed cavities 9a, 9b; 9c, 9d arranged one upon the other, out of which only the upper ones 9a, 9c in each case serve as tank for the lubricating oil 8 of the lubricating oil circuit of the automatic punching machine. Above the cavities 9a, 9b; 9c, 9d, the machine bed 5 at both sides each of the aperture 6b in each case comprises three flow channels 10a, 10b, 10c; 10d, 10e, 10f arranged side by side, out of which in each case the flow channels 10c, 10d arranged closest to the aperture 6b have a clearly bigger flow cross-section than the remaining flow channels 10a, 10b, 10e, 10f. The flow channels 10a-10f are flowed through by the heated lubricating oil 8 of the lubricating oil circuit of the automatic punching machine during operation, which lubricating oil is subsequently guided into the cavities 9a, 9c, wherefrom it is passed again to the lubricating points of the punching machine by the lubricating oil pump of the lubricating oil circuit, if applicable after previously going through a cooling device. Thereby, the heated lubricating oil 8 is passed firstly through the flow channels 10c, 10d arranged closest to the aperture 6b, then through the central flow channels 10b, 10e and at the end through the outer flow channels 10a, 10f, thereby transferring heat to the machine bed 5. Hereby, the machine bed 5 in its upper area is stronger heated than in its lower area during operation, by means of which machine bed due to of different thermal expansion warps upwards and therefore in the direction of the ram 2.

Thereby, the machine bed 5 is stronger heated in the areas adjacent to the aperture 6b than in the areas at its longitudinal sides as a consequence of the sequence of the flow through the flow channels and of the different flow channel cross-sections, which leads to a

stronger warp of it upwards in the areas adjacent to the aperture 6b than in the areas of its longitudinal sides.

The clamping plate 4, which is fixed on the machine bed 5 by a plurality of screw connections, follows the warp of the machine bed 5. During operation, under the load of the punching force there is a compensation of this warp caused by thermal expansion such that the machine bed 5 in the ideal case is flat under maximal punching force load both in longitudinal and in cross direction, i.e. not warped or not bended, respectively. Hereby, it can be counteracted a loss of punching precision and an increased tool wear effectively.

Fig. 4 shows a section through the bottom part of the automatic punching machine along the line X-X in Fig. 1, like it is designed according a second embodiment of the invention. As can be seen, the outer contours of the clamping plate 4 and of the machine bed 5 are identical here to the embodiment according to Fig. 2, and also the inner structure of the machine bed 5 is identical to that of the machine bed of Fig. 2. However, an intermediate plate 11 is arranged here between the clamping plate 4 and the machine bed 5 with a plurality of flow channels 10a-10l, which are flown through by a warm water circuit during operation, e.g. from a re-cooling device of the lubricating oil circuit of the automatic punching machine. Thereby, the warm water is passed first through the flow channels 10d, 10e, 10h, 10i which are closest to the boundaries of the aperture 6b in the machine bed 5, then through the inner and central flow channels 10c, 10f, 10g, 10j arranged beside them and at the end through the outer flow channels 10a, 10b, 10k, 10l. Thereby, the intermediate plate 11 is heated by the warm water circuit and heats on its part the contact faces of the machine bed 5 and the clamping plate 4 abutting to it. Hereby again, the machine bed 5 in its upper part is heated stronger than in its bottom part, by means of which it

warps upwards, i.e. in the direction towards the ram 2, as a consequence of different thermal expansion.

Because here the heating by the flow channels 10d, 10e, 10h, 10i arranged closest to the boundaries of the aperture 6b is the strongest, the machine bed 5 warps in the areas adjacent to the aperture 6b more upwards than in the areas of the longitudinal sides which are heated less strong by the outer flow channels 10a, 10b, 10k, 10l. The clamping plate 4, which is connected in a shear stiff manner with the machine bed 5 via the intermediate plate 11 and is made of a material which has a bigger heat expansion coefficient than the material of the machine bed 5, transfers additional shear forces into the machine bed 5 which increase the warp towards upwards. Like at the embodiment according to Fig. 3, there is a compensation of this warp during operation under the load by the punching force, which in ideal case leads to the situation that the machine bed 5 is flat both in longitudinal and in cross direction under maximal punching load, i.e. not warped or not bended, respectively. This solution has the advantage that existing machines with a corresponding intermediate plate 11 can be converted in a simple way into a punching press according to the invention.

Fig. 5 shows a section through the bottom part of the automatic punching machine along the Line X-X in Fig. 1, as it is designed according to a third embodiment of the invention. As can be seen, the outer contours of the clamping plate 4 and of the machine bed 5 are essentially identical here like at the embodiment according to Fig. 2, and also the inner structure of the machine bed 5 is basically identical with that one of the machine bed of Fig. 2. However, the machine bed 5 in its bottom part is crossed here by two tie-rods 19 expanding in longitudinal direction of the machine bed, by means of which the machine bed 5 is set under compressive stress in its

bottom part for warping the machine bed 5 in the direction towards the press ram 2. The tie-rods 19 are arranged symmetrically at both sides of the aperture 6b of the machine bed 5 such that in each case they have a
5 smaller distance to the aperture 6b than to the respective longitudinal side of the machine bed 5.

Because by this arrangement the tie-rod 19 the areas of the machine bed 5 which are arranged nearest to the boundary walls of the aperture 6b are set strongest under compressive stress by the tie-rod 19, the machine bed 5 warps in the areas adjacent to the aperture 6b stronger upwards than in the areas of the longitudinal sides. The clamping plate 4, which is connected with the machine bed 5 by a plurality of screws, warps together
15 with the machine bed 5. Like at the embodiments according to the figures 3 and 4, there is a compensation of this warp during operation under the load by the punching force, which warp ideally leads to the situation that the machine bed 5 is flat both in longitudinal and in cross
20 direction under maximal punching force load, i.e. not warped or not bended, respectively.

As could be seen in Fig. 6, which shows a longitudinal section through the bottom structure of Fig. 5 along the Line X-X in Fig. 5, the tie-rods 19 in each
25 case are set under tension stress between a nut 12 and an adjustable pre-loading device 13, 14, 15, 16, 17, 18. The pre-loading device 13, 14, 15, 16, 17, 18 comprises a clamping nut 13 with an actuating lever 16, which clamping nut can be twisted by a hydraulic cylinder 15 by
30 about 90°, for adjusting the tension stress of the tie-rod 19 and an unloading device with a hydraulic piston/cylinder arrangement 14, 17, 18 by means of which the tie-rod 19 can temporarily be hydraulically pre-loaded, for unloading the clamping nut 13 during adjustment of
35 it. After adjusting the clamping nut 13, the hydraulic

piston/cylinder arrangement 14, 17, 18 is switched ineffective for the operation of the press.

At the bottom side of the machine 5, a strain meter 20 is arranged below every tie-rod 19 by means of
5 which the length shortening of the machine bed 5 can be measured in this area as a consequence of the appliance of compressive stress by the tie-rod 19.

This third embodiment of the invention has the advantage that the adjustment of the warp of the machine bed 5 is without any time lag and that the deformation forces or the resulting deformations of the machine bed 5, respectively, are well controllable.
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Claims

1. Method for warping the machine bed (5) of a punching press to compensate at least partially a bending caused by the punching force during punching operation, wherein the machine bed (5) has an aperture (6b) for carrying away punching parts and rubbish,

characterised in that forces acting transverse to the punching force direction are introduced into the machine bed (5) or are created within the machine bed (5) for warping the machine bed (5) in the direction towards the press ram (2) such that the machine bed (5) is warped stronger in the area adjacent to the aperture (6b) than in the areas adjacent to the longitudinal sides.

2. Method according to claim 1, wherein the machine bed (3) with tie-rods (19) extending in its longitudinal direction is set under compressive stress in its lower area for warping the same in the direction towards the press ram (2).

3. Method according to claim 2, wherein the tie-rods (19) are arranged such that they cross the machine bed (5) in its lower area.

4. Method according to one of the claims 2 to 3, wherein on both sides of the aperture (6b) of the machine bed (5), in particular symmetrical to both sides of the aperture (6b), in each case a tie-rod (19) is arranged such that the tie-rod (6b) in each case has a smaller distance to the aperture (6b) than to the respective longitudinal side of the machine bed (5).

5. Method according to one of the preceding claims, wherein a temperature gradient is produced within the machine bed (5) or a supporting structure (4, 5, 11) for the lower tool parts built with the machine bed (5), by means of which the machine bed (5) warps in the direction towards the press ram (2).

6. Method according to claim 5, wherein the temperature gradient is produced by heating the machine bed (5) in the area of its side facing the press ram (2).

7. Method according to claim 6, wherein the machine bed (5) near to the boundaries of the aperture (6b) is heated stronger than near to the longitudinal sides.

8. Method according to one of the claim 5 to 7, wherein the temperature gradient is produced by cooling the machine bed (5) in the area of its side facing away from the press ram (2).

9. Method according to claim 8, wherein the machine bed is near to the boundaries of the aperture is cooled stronger than near to the longitudinal sides.

10. Method according to one of the claim 5 to 9, wherein flow channels (10a-19f) arranged within the machine bed (5) are flown through by a heated or cooled gaseous or liquid medium (8) for producing the temperature gradient.

11. Method according to claim 10, wherein heated lubricating oil (8) of a lubricating oil circuit of the press is passed through the flow channels (10a-10f).

12. Method according to one of the claim 5 to 11, wherein electricalheating elements arranged within the machine bed are charged with electric current for producing the temperature gradient.

13. Method according to one of the claim 5 to 12, wherein a clamping plate arranged on the machine bed is present which is heated for warping the machine bed in the direction towards the press ram as a consequence of a heating of it by the clamping plate on its side facing the ram and/or for warping the machine bed in the direction towards the press ram as a consequence of an introduction of shear forces produced by a thermal expansion

of the clamping plate into the side of the machine bed facing the ram.

14. Method according to one of the claims 5 to 11, wherein a clamping plate (4) arranged on the machine bed (5) is present and a heating device (11) arranged between the machine bed (5) and the clamping plate (4), which is heated for warping the machine bed (5) in the direction towards the press ram (2) as a consequence of a heating of it by the heating device (11) on its side facing the ram (2) and/or for warping the machine bed (5) in the direction towards the press ram (2) as a consequence of a heating of the clamping plate (4) by the heating device (11) and by an introduction of shear forces produced by a thermal expansion of the clamping plate (4) into the side of the machine bed (5) facing the ram (2).

15. Method according to one of the preceding claims, wherein the warp of the machine bed is adjusted depending on parameters of the punching process, in particular depending on a calculated or measured maximal punching force, and in particular, wherein the warp is adjusted during the intended operation of the press.

16. Punching press for performing the method according to claim 1, with a machine bed (5) and with a press ram (2) working against the machine bed (5), wherein means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) are present for warping the machine bed (5) in the direction towards the press ram (5) by an introduction of forces acting transverse to the punching force direction into the machine bed (5) and/or by producing forces acting transverse to the punching force direction within the machine bed (5),

wherein the machine bed (5) has an aperture (6b) for carrying away punching parts and rubbish and the means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) for warp-

ing the machine bed (5) are designed such that they warp the machine bed (5) stronger in the area adjacent to the aperture (6b) than in the areas adjacent to the longitudinal sides of the machine bed (5),

5 and wherein the means (12-19) for warping the machine bed comprise tie-rods (19) extending in longitudinal direction of the machine bed, by means of which the machine bed (5) can be set under compressive stress in its lower area for warping the machine bed (5) in the direction towards the press ram (2).

17. Punching press according to claim 16, wherein the tie-rods (19) cross the machine bed (5) in its lower area.

18. Punching press according to one of the
15 claims 16 to 17, wherein on both sides of the aperture (6b) of the machine bed (5) in each case a tie-rod (19) is arranged such that in each case the tie-rod (19) has a smaller distance to the aperture (6b) than to the respective longitudinal side of the machine bed (5).

19. Punching press according to claim 18,
20 wherein the both tie-rods (19) are arranged symmetrically to both sides of the aperture (6b).

20. Punching press for performing the method according to claim 1, with a machine bed (5) and with a
25 press ram (2) working against the machine bed (5),

 wherein means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) are present for warping the machine bed (5) in the direction towards the press ram (5) by introducing forces acting transverse to the punching force direction
30 into the machine bed (5) and/or by producing forces acting transverse to the punching force direction within the machine bed (5),

 wherein the machine bed (5) has an aperture (6b) for carrying away punching parts and rubbish and the
35 means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) for warping the machine bed (5) are designed such that they warp

the machine bed (5) in the area adjacent to the aperture (6b) stronger than in the areas adjacent to the longitudinal sides of the machine bed (5),

wherein the means (8, 9a, 9c, 10a-10f; 10a-10l, 11) for warping the machine bed (5) are designed for producing a temperature gradient within the machine bed (5) or a supporting structure (4, 5; 4, 5, 11) for the lower tool parts built with the machine bed (5), respectively, in order to produce the forces acting transverse to the punching force direction for warping the machine bed in the direction towards the press ram,

wherein the means (8, 9a, 9c, 10a-10f) for warping the machine bed (5) comprise flow channels (10a-10f) arranged within the machine bed (5), which can be flown through by a heated or cooled gaseous or liquid medium (8) during the intended operation of the press for producing the temperature gradient

and wherein the press comprises a lubricating oil circuit and the means for warping the machine bed comprise arrangements, by means of which heated lubricating oil of the lubricating oil circuit can be passed through the flow channels (10a-10f) during the intended operation of the press.

21. Punching press according to claim 20, wherein the means (8, 9a, 9c, 10a-10f; 10a-10l, 11) for warping the machine bed (5) are designed for heating the machine bed (5) in the area of its side facing the press ram (2).

22. Punching press according to claim 21, wherein the means (8, 9a, 9c, 10a-10f; 10a-10l, 11) for warping the machine bed (5) are designed to heat the machine bed (5) in the area of its side facing the press ram (2) stronger near to the boundaries of the aperture (6b) than near to its longitudinal sides.

23. Punching press according to one of the claims 20 to 22, wherein the means for warping the ma-

chine bed are designed to cool the machine bed in the area of its side facing away from the press ram.

24. Punching press according to claim 23, wherein the means for warping the machine bed are designed to cool the machine bed in the area of its side facing away from the press ram stronger near to the boundaries of the aperture than near to its longitudinal sides.

25. Punching press according to one of the claim 20 to 24, wherein the means for warping the machine bed comprise electrical heating elements arranged within the machine bed, which can be charged by electric current during the intended operation of the press for producing the temperature gradient.

26. Punching press according to one of the claims 20 to 25, wherein on both sides of the aperture of the machine bed in each case one or more flow channels and/or electrical heating elements are arranged within the machine bed such that, per side, the sum of the distances of the flow channels and/or the heating elements to the aperture is smaller than the sum of the distances of the flow channels and/or heating elements to the respective longitudinal sides of the machine bed.

27. Punching press according to claim 26, wherein the flow channels and/or the heating elements are arranged symmetrically to both sides of the aperture.

28. Punching press for performing the method according to claim 1, with a machine bed (5) and with a press ram (2) working against the machine bed (5),

wherein means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) are present for warping the machine bed (5) in the direction towards the press ram (5) by introducing forces acting transverse to the punching force direction into the machine bed (5) and/or by producing forces acting transverse to the punching force direction within the machine bed (5),

wherein the machine bed (5) has an aperture (6b) for carrying away punching parts and rubbish and the means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) for warping the machine bed (5) are designed such that they warp
5 the machine bed (5) in the area adjacent to the aperture (6b) stronger than in the areas adjacent to the longitudinal sides of the machine bed (5),

wherein the means (8, 9a, 9c, 10a-10f; 10a-10l, 11) for warping the machine bed (5) are designed for
10 the production of a temperature gradient within the machine bed (5) or a supporting structure (4, 5; 4, 5, 11) for the lower tool parts built with the machine bed (5), respectively, in order to produce the forces acting transverse to the punching force direction for warping
15 the machine bed in the direction towards the press ram, and

wherein a clamping plate arranged on the machine bed is present which can be heated by the means for warping the machine bed during the intended operation of
20 the press for producing the temperature gradient by heating the machine bed on its side facing the ram by the clamping plate.

29. Punching press for performing the method according to claim 1, with a machine bed (5) and with a
25 press ram (2) working against the machine bed (5),

wherein means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) are present for warping the machine bed (5) in the direction towards the press ram (5) by introducing forces acting transverse to the punching force direction
30 into the machine bed (5) and/or by producing forces acting transverse to the punching force direction within the machine bed (5),

wherein the machine bed (5) has an aperture (6b) for carrying away punching parts and rubbish and the
35 means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) for warping the machine bed (5) are designed such that they warp

the machine bed (5) in the area adjacent to the aperture (6b) stronger than in the areas adjacent to the longitudinal sides of the machine bed (5),

wherein the means (8, 9a, 9c, 10a-10f; 10a-10l, 11) for warping the machine bed (5) are designed for the production of a temperature gradient within the machine bed (5) or a supporting structure (4, 5; 4, 5, 11) for the lower tool parts built with the machine bed (5), respectively, in order to produce the forces acting transverse to the punching force direction for warping the machine bed in the direction towards the press ram, and wherein a clamping plate (4) arranged on the machine bed (5) is present which can be heated by the means (8, 9a, 9c, 10a-10f; 10a-10l, 11) for warping the machine bed (5) during the intended operation of the press and which is connected with the machine bed (5) such that it can transfer shear forces to the machine bed (5) for warping the machine bed (5) in the direction towards the press ram (2) as a consequence of an introduction of shear forces produced by a thermal expansion of the clamping plate (4) into the side of the machine bed facing the press ram (2).

30. Punching press according to claim 29, wherein a thermal insulation layer is present between the clamping plate and the machine bed for reducing a heat transfer from the clamping plate to the machine bed.

31. Punching press according to claim 30, wherein the thermal insulation layer is present in the areas, which adjoin the longitudinal sides of the clamping plate or of the machine bed, respectively, between the clamping plate and the machine bed and in the areas, which adjoin the aperture, a layer between the clamping plate and the machine bed is present which has an essentially better thermal conductivity for promoting a heat transfer from the clamping plate to the machine bed in these areas.

32. Punching press according to one of the claims 28 to 31, wherein the clamping plate can be heated by the means for warping the machine bed during the intended operation of the press such that it is warmer in
5 the areas which adjoin the aperture than in the areas which adjoin the longitudinal sides.

33. Punching press for performing the method according to claim 1, with a machine bed (5) and with a press ram (2) working against the machine bed (5),
10 wherein means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) are present for warping the machine bed (5) in the direction towards the press ram (5) by introducing forces acting transverse to the punching force direction into the machine bed (5) and/or by producing forces act-
15 ing transverse to the punching force direction within the machine bed (5),

wherein the machine bed (5) has an aperture (6b) for carrying away punching parts and rubbish and the means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) are de-
20 signed for warping the machine bed (5) such that they warp the machine bed (5) in the area adjacent to the aperture (6b) stronger than in the areas adjacent to the longitudinal sides of the machine bed (5),

wherein the means (8, 9a, 9c, 10a-10f; 10a-
25 10l, 11) for warping the machine bed (5) are designed for the production of a temperature gradient within the machine bed (5) or a supporting structure (4, 5; 4, 5, 11) for the lower tool parts built with the machine bed (5), respectively, in order to produce the forces acting
30 transverse to the punching force direction for warping the machine bed in the direction towards the press ram,

and wherein a clamping plate (4) arranged on the machine bed (5) is present and wherein the means (10a-10l, 11) for warping the machine bed (5) comprise a
35 heating device (11) arranged between the machine bed (5) and the clamping plate (4), which can be operated during

the intended operation of the press for warping the machine bed (5) as a consequence of a heating of it on its side facing the ram (2).

34. Punching press for performing the method
5 according to claim 1, with a machine bed (5) and with a press ram (2) working against the machine bed (5),
wherein means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) are present for warping the machine bed (5) in the direction towards the press ram (5) by introducing
10 forces acting transverse to the punching force direction into the machine bed (5) and/or by producing forces acting transverse to the punching force direction within the machine bed (5),

wherein the machine bed (5) has an aperture
15 (6b) for carrying away punching parts and rubbish and the means (8, 9a, 9c, 10a-10f; 10a-10l, 11; 12-19) for warping the machine bed (5) are designed such that they warp the machine bed (5) in the area adjacent to the aperture (6b) stronger than in the areas adjacent to the longitudinal
20 dinal sides of the machine bed (5),

wherein the means (8, 9a, 9c, 10a-10f; 10a-10l, 11) for warping the machine bed (5) are designed for the production of a temperature gradient within the machine bed (5) or a supporting structure (4, 5; 4, 5, 11)
25 for the lower tool parts built with the machine bed (5), respectively, in order to produce the forces acting transverse to the punching force direction for warping the machine bed in the direction towards the press ram, and

30 wherein a clamping plate (4) arranged on the machine bed (5) is present, which is connected with the machine bed (5) such that it can transfer shear forces to the machine bed (5), and wherein the means (10a-10l, 11) for warping the machine bed (5) comprise a heating device
35 (11) arranged between the machine bed (5) and the clamping plate (4), which can be operated during the intended

operation of the press for warping the machine bed (5) in the direction towards the press ram (2) as a consequence of an introduction of shear forces produced by a thermal expansion of the clamping plate (4) into the side of the machine bed (5) facing the ram (2).

35. Punching press according to one of the claims 33 to 34, wherein the heating device (11) arranged between the machine bed (5) and the clamping plate (4) is designed such that with it the areas of the machine bed (5) or of the clamping plate (4), respectively, which adjoin the aperture (6b) can be heated stronger than the areas of the machine bed (5) or of the clamping plate (4), respectively, which adjoin their longitudinal sides.

36. Punching press according to one of the claims 16 to 35, wherein the means for warping the machine bed are built adjustable, in particular during the intended operation of the press, for enabling a specific adjustment of the warp of the machine bed.

37. Punching press according to one of the claims 16 to 36, wherein the punching press comprises a press control, by means of which the warp of the machine bed, in particular automatically, is adjustable depending on parameters of the punching process, in particular depending on a calculated or measured maximal punching force, and in particular is adjustable during the intended operation of the press.