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Tool for a punch press with a
laser welding apparatus

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Tool for a punch press with a
laser welding apparatus

5 The invention relates to a tool assembly for
 a punch press equipped with at least one laser welding
 apparatus, which laser welding apparatus includes at
 least one supporting block for a guided supporting of a
 focusing device of the laser welding apparatus with a
 10 predetermined focal length and a predetermined focal
 point, which tool includes a tool body with a working
 surface at which at least one recess for a die inserted
 thereinto is located, of which the cutting edge which is
 aligned with a surface portion of the working surface of
 15 the tool body, which supporting block is designed and ar-
 ranged in such a manner that a laser beam emitted by a
 focusing device mounted to the supporting block is fo-
 cused to a predetermined point at the die such to perform
 welding operations at a workpiece located thereat, and
 20 which supporting block includes at least one guiding sur-
 face for its positioning relative to the focal point.

Punch presses, of which the operation encom-
 passes also a welding by means of a laser welding appara-
 tus, are utilized, for instance, for the production of
 25 stacks of plates used in electrotechnical products. Exam-
 ples of such products are packages of plates for stators
 and rotors of electromotors. Hereto the individual plates
 are individually punched and stacked, whereby the stack-
 ing is, for instance, achieved, in that a braking member
 30 is located in or below a die cooperating with a punch.
 When stacking the consecutively punched plates, each
 plate set onto the stack is welded at at least one loca-
 tion to the previously stacked plate located thereunder,
 for instance, by means of a laser beam acting commensu-
 35 rate with the operating cycle of the punch press until a
 predetermined number of individual plates form a stack of



plates. Thereafter no welding is performed during a next following (punching) stroke such that the finally the produced stack of plates is urged out and away from the braking member by the next following punched plates.

5 The dies are generally sleeve-like products made of a hard metal, which are set into a corresponding opening in the lower tool of the punch press and having specifically a cutting edge which is aligned with the operating surface of the tool.

10 As is generally known, this cutting edge is subject to wear during operation and the tools, i.e. specifically their working surfaces, are periodically ground in order to obtain again the original sharpness of the cutting edge(s).

15 The sheets or plates, resp., which are stamped are extremely thin and due to this reason and also due to reasons of welding techniques it is necessary to set the respective welding points of the laser beam welding with tolerances of a few 1/100 mm. This demand
20 causes obviously a correspondingly precisely located mounting of the optical focussing part of the laser welding apparatus, of which the focal depth and the focal point determine the respective welding point. The optical focusing devices of laser welding apparatuses are com-
25 monly mounted to a part of the frame or also to a tool of the punch press and are initially set when setting up the punch press such as all the cutting tools thereof with a high precision.

 If now the tool is dismounted in order to
30 newly grind the working surface due to the reason mentioned above, all focusing devices mounted thereon must be adjusted newly because due to the grinding the location of the welding points are now shifted relative to the earlier focal point of the focusing device. This new
35 adjusting of the focusing devices is a tedious, time consuming process.



Here, the invention intends to provide a remedy. The invention such as described in the claims solves the object to provide a tool for a punch press with a laser welding apparatus, in which the respective supporting block for a focussing device of the laser welding apparatus is arranged with a guiding surface on a positioning surface of a supporting member which is aligned with the working surface of the tool body into which the die is set, of which the cutting edge is aligned with the working surface.

The advantages gained by the invention are substantially to be seen, in that during a grinding of the working surface of the tool body in order to resharpen the cutting edges, the positioning surface of the supporting member which is aligned with the working surface of the tool is ground, too. Thus, the height position of the supporting block for the focussing device remains also after the grinding unchanged relative to the welding point and the focal point of the laser ray beam because the cutting edge of the die and the positioning surface of the supporting member are ground down together, thus at the same magnitude. Therewith, after a resharpener of the cutting edge of the die an anewed, tedious adjusting of the supporting block, i.e. the focussing device and the corresponding trial runs of the punch press are no longer necessary.

Below, the invention will be explained closer based on drawings illustrating several embodiments.

Fig. 1 illustrates schematically a punch press equipped with a laser welding apparatus,

Fig. 2 illustrates a side view, partly in section of a part of a tool body having a focusing device held in a supporting block,

Fig. 3 illustrates a top view of a portion of a tool body having three focusing devices mounted thereonto,



Figs. 4 and 5 illustrate a side view of and a section through a checking tool for a focusing device,

Figs. 6 and 7 illustrate embodiments, in which the supporting block is mounted to a separate supporting structure mounted to the lower tool,

Fig. 8 is an illustration corresponding to Fig. 2 and depicts an embodiment of suction channels for vapors produced during welding,

Fig. 9 illustrates a detail of Fig. 8,

Fig. 10 illustrates a top view of the embodiment illustrated in Fig. 8,

Fig. 11 illustrates a side view of an embodiment having one single suction channel,

Fig. 12 illustrates a top view of the embodiment according to Fig. 11,

Fig. 13 illustrates a front view of the embodiment illustrated in Fig. 11, and

Fig. 14 illustrates the cross-sectional shapes of the two sections of the suction channel of Fig. 11.

Fig. 1 illustrates purely schematically a punch press which is equipped with a laser welding apparatus. The punch press includes a frame 1, in which an eccentric shaft or crankshaft, resp., 2 is supported for rotation in bearings 3, 4. This eccentric shaft 2 is driven according to well known principles by a not particularly illustrated driving motor, for instance, via a belt drive. According to the illustrated embodiment two connecting rods 5, 6 are supported on the eccentric shaft 2, which are pivotally connected at their lower ends to a so-called ram 7, which carries an upper tool. The frame 1 supports, furthermore, a so-called lower tool 8. Guide columns 9, 10 project downwards from the ram 7, by means of which guide columns 9, 10 the ram 7 is guided in its vertical reciprocating movement.

A punching tool 11 illustrated as example is set into mentioned upper tool which cooperates with a die



12 located in the lower tool 8 in order to stamp out of a (not illustrated) sheet metal band which is fed according to the illustration of Fig. 1 from the left to the right e.g. plates for rotors which are united in the lower tool 8 to respective stacks 13 of metal sheets. Hereby punching tool 11 and die 12 form the last tool-pair of a consecutive working of a sheet metal strip, which during being moved between the upper tool and the lower tool 8 designed as multiple press tools after earlier working performances made thereon for the production of the final product punched out of the sheet metal strip such as well known to the persons skilled in the art.

A laser generator 14 is mounted to the frame 1 which communicates via optical conductors 15 (of which only one is illustrated), e.g. glass fiber cables with a focusing device 16, which is located on the lower tool 8.

For sake of completeness it shall be mentioned, furthermore, that a braking means or member, resp., 17 is located in the die 12. This braking member 17 acts e.g. by friction onto the stamped out plates located in the die 12 in order to hold the plates in the die 12 by friction, which plates (or a respective stack of plates) are pushed down step by step by every consecutive plate punched out of the sheet metal web until the punched plates or an entire stack has passed the braking member 17 and thereafter glide or fall out of the lower tool 8 under the influence of gravity.

In operation the eccentric shaft 2 rotates and causes via the connecting rods 5, 6 the punching movement of the ram 7 together with the upper tool mounted thereto for the production of the individual plates, which remain at the last operating step in the die 12. Accordingly, during every working stroke of the ram 7 one plate is placed in the die 12 onto a preceding plate located already in the die. As soon as the punch 11 has moved away during the upwards stroke portion by a small distance from the die 12, the laser welding appa-



tus 14, 15, 16 beams a laser beam of an extremely short duration towards the point of contact between the plate which just has been deposited and the plate located thereunder such as to weld the two plates together. The
5 operating cycles of the laser welding apparatus are obviously controlled depending on the position of the punching tool 11 relative to the die 12 or generally from the rotational position of the eccentric shaft 2. After a predetermined number (e.g. 20) of individual plates have
10 been welded together, the welding apparatus is controlled such that during one punching cycle of the punching operation no welding is performed, such that the production of one stack of plates is terminated and the production of the next following stack can begin. The finally pro-
15 duced, welded stack of plates is pushed in the die further downwards by the next following plates deposited thereupon and again welded together, which stack is finally pushed past and out of the braking member.

It has now been explained initially that the
20 cutting edge of the die 12 (and obviously also of the punching tool 11) gets worn, such that the entire working surface 18 of the lower tool must be reground in order to resharpen the cutting edge of the die 12.

Conclusively, a respective welding point in
25 the die is subjected to a relative change of the location such that basically a new adjusting of at least the focusing device 16 of the laser welding apparatus is needed and specifically independent from the location where it is mounted in the punch press. By the present invention,
30 of which one exemplary embodiment is illustrated in Figs. 2 and 3, a new adjusting of the focusing device 16 is no longer necessary.

Fig. 2 illustrates a section through a part
of the lower tool 8 having a die 12, which is set into a
35 recess or through bore, resp., 19 in such a manner that its cutting edge 20 is aligned with the working surface 18 of the tool. The braking member 17 in the die 12 is



for instance a portion thereof having a somewhat decreased diameter achieved by any known procedures. A stack 13 of stamped individual plates which have been welded together are illustrated to be in the die 12.

5 According to the top view of Fig. 3 the stator plates 21 are punched and welded together to stacks. As can be seen clearly, three focusing devices 16, 16A, 16B are present, such that the respective plates are welded together at three points. Of these focusing de-
10 vices one is shown by full lines, namely device 16 and the other two focusing devices 16A, 16B are illustrated by dash dotted lines.

 The focusing devices are connected to a laser generator common to all via a respective glass fiber ca-
15 ble coupled at 22 to the respective focusing device.

 Such focusing devices are generally known and, therefore, there is no need of a detailed description thereof.

 Below, the embodiment will be described
20 merely by reference to the focusing device 16. The focusing device 16 includes a preset focal length and a predetermined focal point, which latter determines the (or one, resp.) welding point 23 at two plates 21. To this end the focusing device 16 is set into a supporting block
25 24 and includes a collar 25, via which it contacts one side surface 26 of the supporting block 24. The surface 26 acting as guiding surface for the focusing device 16 extends now precisely perpendicularly to the optical axis 38 of the focusing device 16. The supporting block 24 is
30 machined with such a preciseness and located at a position which has such a precisely determined distance from the welding point 23 and is mounted with such precisely produced mounting members to the body of the lower tool 8, that the welding point determined by the optics of the
35 focusing device 16 is maintained precisely. The preciseness is in a range of 1/100 mm. A corresponding precision is also at the contact surface of the collar 25 of the



focusing device present, which contacts surface 26 of the supporting block 24.

The supporting block 24 is basically a clamp-like structure having two jaws 27, 28, which surround the through hole for receipt of focusing device 16. At the top the two jaws 27, 28 are separated from each other by a slot 29 and interconnected by a threaded bolt 30. When tightening the threaded bolt 30, the focusing device 16 is clamped in the supporting block 24.

The working surface 18 of the body 8 of the lower tool acts as positioning surface for the supporting block 24, and this positioning surface is aligned with the cutting edge 20 of the die 12, which is set into the body of the lower tool 8. The bottom surface of the supporting block 24, via which it rests on the working surface 18, acts as guiding surface 31, because it determines at least the height position of the focusing device 16 inserted in the supporting block 24. The location and the position of the focusing device 16 in the supporting block 24 determine among others the welding point 23 at the die 12.

The horizontal distance between the supporting block 24 and the welding point 23 and accordingly specifically of the surface 26 of the supporting block 24 (measured along the working or positioning, resp., surface 18) is determined by two positioning pins 32, 33, which are set into bores arranged in the supporting block 24 and in the body of the lower tool 8. The supporting block 24 itself is mounted by means of a threaded bolt 34 to the body of the lower tool 8. The longitudinal center axis 35, 36 of the positioning pins 32, 33 and the longitudinal center axis 37 of the screw bolt 34 (due to reasons of clarity the longitudinal center axis 37 is only illustrated at the focusing device 16A in Fig. 3) are aligned with each other along a straight line, i.e. they determine a plane, in which the optical axis 38 of the focusing devices 16 lies. This allows that the supporting



block 24 can be built quite narrow such that it is possible to mount in a strongly restricted space a plurality of focusing devices 16 of the laser welding apparatus acting at one and the same die 12 such that two respective plates in the plate stack 13 can be welded together simultaneously at a plurality of points.

It is to be noted that a modified design can be present at the surface 26 of the supporting block 24. It is possible to have a disc having an outer thread screwed into the supporting block 24, which in order to precisely set the distance of the accordingly now adjustable surface 26 from the welding point 23 can be screwed further into or somewhat out of the supporting block and then be arrested in the correct, desired position.

In order to check at least at a first mounting if the position of the supporting block 24 is correct and also to check the path of the laser beam that the laser beam cannot impact onto other parts of the tool and also parts of the workpiece which are not to be welded and, specifically, to prevent an impacting onto a location ahead of the welding point a checking tool is used, which is illustrated in Figs. 4 and 5 and which can be termed checking mandrel.

The checking tool includes a main body having a first portion 39, which corresponds to the collar 25 of the focusing device 16. The shoulder 40 which is to rest onto the surface 26 of the supporting block 24 which is a guiding surface and onto which surface 26 the corresponding surface of the collar 25 of the focusing device 16 will lie when the focusing device 16 is mounted in the supporting block 24, is machined initially precisely. The shoulder 40 is followed by a cylinder shaped portion 41, of which the diameter and the length correspond exactly to the diameter and the length of that portion of the focusing device 16 which is held and supported in the supporting block 24. The next following, short cylinder



shaped portion 42 corresponds also to the corresponding portion of the focusing device 16.

An important portion is the cone-like converging portion 43 following mentioned portion 42. Its enveloping surface corresponds namely to the cone-shaped enveloping surface of the beam of rays emitted by the focusing device 16, which enveloping surface is shown and identified specifically in Fig. 3 by the broken lines identified by the reference numerals 44 and 45.

A needle 47 extends in an axial direction through the main body of the checking tool, which needle 47 has a tip portion 46. The enveloping surface of this tip portion 46 corresponds further to the enveloping surface of the beam of laser rays.

The needle 47 has an outer thread 48, by means of which it is screwed into the main body 49. The needle 47 is, furthermore, locked relative to the main body 49 by a nut 50.

For an initial setting the needle 47 is adjusted by means of a screwdriver placed into the slot 51 in such a manner that the distance between the shoulder 40 and its frontmost tip corresponds exactly to the distance between the welding point 23 in the die 12 and the surface 26 of the supporting block 24 acting as guiding surface and thereafter is locked by a tightening of the nut 50. The exactness of the set distance lies within a range of a few 1/100 mm.

The measuring tool which has been set as described above is now inserted in place of the focusing device 16 into the supporting block 24 and is clamped therein by a tightening of the threaded bolt 30. The tip of the needle 47 is then located exactly at the focal point, i.e. at the welding point at the die 12.

The enveloping surfaces of the coned shaped portion 43 and of the tip portion 46 of the checking tool play an extremely important role. These enveloping surfaces are not to contact any obstacle. Such an obstacle



can be, e.g. a part of a workpiece, a part of a tool or a part of a mounting member at the lower tool 8 and such parts would be partly exposed to the laser beam and accordingly could be heated such to be damaged and also could partly deflect the laser rays. Furthermore, such as illustrated in Fig. 3, the three beams of rays do not intersect each other, they cannot influence each other and also this arrangement of the beams of rays can be exactly checked by the checking tool.

10 After the checking has been made, the focusing device 16 or the focusing devices 16, 16A, 16B, resp., are inserted into the corresponding supporting block 24, optically connected to the laser generator 14 and thereafter the punch press can be operated.

15 If a regrinding, a resharpening of the cutting edge 20 of the die 12 (i.e. of all cutting edges present in the lower tool) is to be performed, the lower tool is removed, whereby the focusing device 16 has been removed previously and thereafter the supporting block 24 is removed from the body of the lower tool 8 by a loosening of the threaded bolt 34.

 Thereafter, the working surface 18 of the tool is reground in a manner as generally known in order to resharpen the various cutting edges. Important is now the fact that during the grinding not only the area of the body of the lower tool 8 at the die 12 but also simultaneously and by the same measure also the area of the positioning surface of the body of the lower tool 8 is ground determines the height position of the supporting block 24 and correspondingly also of the focusing device 16. Accordingly, after mentioned working the supporting block 24 can be again mounted to the body of the lower tool 8 without any further ado and the focusing device 16 can again be mounted into the supporting block 24. A time-consuming and tedious readjusting specifically of the supporting block 24 relative to the welding point



which now has not shifted relative to the positioning surface is not necessary.

Figs. 6 and 7 illustrate modifications, at which the supporting block 24 of the focusing device 16 is not directly mounted to the tool body 8. In these modifications the supporting block 24 is located on a separate supporting member 52. This blocklike supporting member 52 can be, for instance, set into the body of the lower tool 8 at an edge area thereof such as illustrated in Fig. 6 or, according to the embodiment illustrated in Fig. 7, the supporting member 52 can be mounted at a side of the body of the lower tool 8. The connection can be achieved by the exemplary illustrated threaded bolts 57, 58. It is not important where and how this supporting member 52 is mounted to the body of the lower tool 8. Decisive is that the free surface, on which the supporting block 24 of the focusing device 16 rests via its guiding surface 31 is aligned with the working surface 18 of the body of the lower tool 8 and is also ground during the regrinding of the working surface 18.

During a welding operation welding smoke and welding vapors are produced, which must be removed. Thereto it is known to form bores in the tool.

Figures 8-10 illustrate an advantageous variant, in which no such bores in the tool are needed. The supporting block 24 is equipped with suction channels 53, 54. These are designed as through bores in the supporting block 24, which receive at the side of the area of the welding short tubes having chamfered ends. At their opposite end the through bores communicate with a rigid manifold 55. A possibly flexible suction line 56 connects to this manifold 55. The illustrated embodiment is extremely effective and advantageous because the tube stubs can be dimensioned and shaped in such a manner that they can be led independently from a given welding area as close as possible to the location of the vapors produced during the welding. Furthermore, in case of a plurality of fo-



cusing devices 16, e.g. according to the arrangement of Fig. 3, not all supporting blocks 24 present must include suction channels. It is also possible to provide individual supporting blocks 24 with only one suction channel, such that a drawing off, removing of the welding vapors can be optimized in accordance with the local conditions.

Figs. 11-14 illustrate further modifications. The focusing device 16, which, as is the case of all embodiments is of a vibration-proof design and has a gas-tight, calibrated casing for an exactly positionable receipt in the supporting block 24, has one single suction channel 59. The suction channel 59 extends along the casing and includes a first portion 61, which has a somewhat elongate cross-sectional shape corresponding to a broad slit nozzle, which portion 61 is followed by a portion 62 having a circular cross-sectional shape. In comparison with the embodiment having the two suction channels 53, 54 the suction channel 59 features a larger cross section but requires not a substantially larger space.

Figs. 11-13 illustrate, furthermore, a safety arrangement which for sake of clarity has not been illustrated in the initial embodiments.

Obviously and as generally known a laser system features a considerable danger of injury to human beings because the laser beams have an extremely high energy. Therefore, it must be ensured that the laser beams are beamed only when the focusing device is mounted on the tool and that the laser generator is switched off when any focusing devices connected thereto are removed.

A cable 62 runs from the (not particularly illustrated) control apparatus of the laser generator to the focusing device, i.e. to each focusing device. Two electrical conductors forming an electrical current circuit are located in this cable 62, which circuit must be closed to allow a switching on of the laser generator.

The cable 62 ends at a plug 63, which in order to be mounted to the casing or the supporting block of the fo-



cusing device must be plugged in and screwed on. After having been plugged in and screwed on, the plug 63 contacts a plug socket 64 (Fig. 12), in which an electrical bridge is present, by means of which the electrical circuit is closed allowing a switching on of the laser generator.





Claims

1. A tool for a punch press having at least
5 one laser welding apparatus, which laser welding apparatus includes at least one supporting block (24) adapted for a guided supporting of a focusing device (16) of the laser welding apparatus which features a predetermined focal length and a predetermined focal point, which tool
10 includes a body (8) having a working surface (18), at which at least one recess (19) for a die (12) inserted thereinto is located, of which the cutting edge (20) is aligned with a surface portion of the working surface of said body (8), which supporting block (24) is designed
15 and arranged in such a manner that a laser beam emitted by a focusing device (16) mounted to the supporting block (24) is focused to a predetermined point (23) to perform welding operations at a workpiece located thereat, and which supporting block (24) includes at least one guiding
20 surface (31) for its positioning relative to the focal point (23), characterized in that the supporting block (24) rests by its guiding surface (31) on a positioning surface of the supporting member (8; 52), which positioning surface serves for setting the height position of the
25 focusing device (16) relative to the surface portion of the working body (8) which is aligned with the cutting edge (20), and is aligned with this surface portion of the body.

2. Tool according to claim 1, characterized
30 by a positioning means (32, 33) acting between the supporting member (8; 52) and the supporting block (24) fix the distance between the supporting block (24) and the focal point (23) parallel to the positioning surface in an unchangeable manner.

35 3. Tool according to claim 2, characterized in that the positioning means comprise at least two positioning pins (32, 33) inserted in such a manner into re-





cesses in the supporting block (24) and in the supporting member (8; 52), that their longitudinal center axes (35, 36) determine a plane which comprises the optical axis (38) of the focusing device (16) lined up with the focal point (23).

4. Tool according to claim 3, characterized in that the supporting block (24) includes a receptacle, in which the focusing device (16) is supported in a guided manner and a further guiding surface (26) extending perpendicularly to the optical axis (38) of the focusing device (16), that the focusing device (16) includes an abutment surface extending perpendicularly to its optical axis (38) and abutting said further guiding surface (26), whereby the distance between the further guiding surface (26) and the respective focal point is set by the positioning means.

5. Tool according to one of the preceding claims, characterized in that the supporting member is formed by said body (8).

6. Tool according to one of the claims 1-4, characterized in that the supporting member is a separate supporting structure (52) mounted to the body (8).

7. Tool according to one of the preceding claims, characterized by at least one suction channel (53, 54; 59) for a drawing off of smoke and vapors produced during a welding operation and which extends through or is located at the side of the supporting block (24).

